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GUIDELINES FOR HYDROGEN FUEL BUNKERING OPERATIONS ON SHIPS

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CHAPTER 1 GENERAL

Section 1 GENERAL PROVISIONS

1.1.1 General requirements

1.1.1.1 The Guidelines for Hydrogen Fuel Bunkering Operations on Ships (hereinafter referred to as the Guidelines) are intended to provide technical reference for persons in charge of hydrogen fuel bunkering, operators, and relevant personnel, so that ship hydrogen fuel bunkering operations can be carried out in a standardised, efficient, and safe manner.

1.1.2 Application

1.1.2.1 The Guidelines apply to hydrogen fuel bunkering operations for ships at coastal and inland waterway terminals or in waters designated by the Administration, involving the hydrogen fuels specified in 1.1.3.3 of this Section. The bunkering modes adopted include shore-based hydrogen refuelling stations, mobile hydrogen refuelling facilities, and portable fuel tank swap, etc.

1.1.2.2 In addition, bunkering operations are to comply with the requirements of the relevant laws, regulations, and administrative provisions of the competent authority.

1.1.3 Definitions

Unless otherwise expressly provided in this Section, the relevant definitions in the China Classification Society (hereinafter referred to as CCS) Guidelines for Ships Using Hydrogen Fuel① apply to the Guidelines.

1.1.3.1 **Compressed hydrogen:** Gaseous hydrogen stored at a pressure higher than standard atmospheric pressure.

1.1.3.2 **Liquefied hydrogen:** Hydrogen that has been liquefied at cryogenic temperatures, i.e., hydrogen in a cryogenic liquid state.

1.1.3.3 **Hydrogen fuel:** The compressed hydrogen fuel specified in 1.1.3.1 of this Section and/or the liquefied hydrogen fuel specified in 1.1.3.2 of this Section.

1.1.3.4 **Compressed hydrogen fuel tank:** A container used for storing compressed hydrogen fuel.

1.1.3.5 **Hydrogen cylinder:** A refillable cylinder with a nominal pressure not exceeding 70 MPa used for storing compressed hydrogen. A hydrogen cylinder is a type of compressed hydrogen fuel tank, including cylinders with a nominal pressure less than or equal to 35 MPa and cylinders with a nominal pressure greater than 35 MPa and less than or equal to 70 MPa.

1.1.3.6 **Metal hydride:** A solid material formed by the reaction of hydrogen with a hydrogen-absorbing alloy.

1.1.3.7 **Metal alloy hydrogen storage:** A hydrogen storage method using intermetallic hydrides formed by the reaction of transition metals such as lanthanide series, titanium series, and vanadium series

① For any referenced document in the Guidelines without a specified edition number, the latest edition applies.

with hydrogen. Hydrogen can be released by heating or other means.

1.1.3.8 **Metal alloy hydrogen storage fuel tank:** A refillable hydrogen storage container composed of a fuel tank shell, metal hydride, pressure relief device, heating and cooling medium pipelines, shut-off valves, and other accessories and internal components, with hydrogen as the only external transfer medium.

1.1.3.9 **Liquefied hydrogen fuel tank:** A container used for storing liquefied hydrogen fuel.

1.1.3.10 **Portable fuel tank:** A hydrogen fuel tank not permanently installed on a ship, having a defined capacity, equipped with service components for fuel conditioning and structural components required for storing hydrogen fuel. A portable fuel tank is to be designed to be removed to shore for filling without dismantling its structural equipment, and it is also to include structural components for transfer and securing under laden/empty conditions. Road tankers, rail tank cars, and intermediate bulk containers are not to be considered as portable fuel tanks.

1.1.3.11 **Bunkering:** The operation process of transferring hydrogen fuel from a bunkering facility to a receiving ship.

1.1.3.12 **Tank swap:** A bunkering mode that achieves fuel replenishment for a receiving ship by replacing portable fuel tanks.

1.1.3.13 **Receiving ship:** A ship receiving hydrogen fuel bunkering services, usually a hydrogen fuel-powered ship.

1.1.3.14 **Bunkering facility:** A device with hydrogen fuel storage and transfer functions, which may be a fixed hydrogen refuelling station (e.g., shore-based hydrogen refuelling station) or a mobile hydrogen refuelling facility (e.g., hydrogen bunkering truck, mobile skid-mounted hydrogen refuelling unit).

1.1.3.15 **Shore-based hydrogen refuelling station:** An onshore fixed facility capable of bunkering hydrogen fuel to receiving ships, generally including a pressurisation system, hydrogen storage system, hydrogen dispenser, bunkering connecting equipment, etc.

1.1.3.16 **Hydrogen bunkering truck:** A vehicle capable of providing hydrogen fuel bunkering services to receiving ships at a terminal, generally including a hydrogen storage device and a bunkering device.

1.1.3.17 **Mobile skid-mounted hydrogen refuelling unit:** A general term for a pressurisation device, hydrogen storage device, bunkering device, connecting pipelines, and safety facilities, etc., installed on one or more movable bases (skids) capable of providing hydrogen fuel bunkering services to receiving ships at a terminal, which itself does not have mobility or travelling functions.

1.1.3.18 **Hydrogen dispenser:** Specialised equipment capable of providing bunkering services to receiving ships, etc., having filling and control functions, and equipped with metering and pricing devices as required, generally used in shore-based hydrogen refuelling stations.

1.1.3.19 **Hydrogen bunkering device:** Specialised equipment capable of providing bunkering services to receiving ships, etc., having filling and control functions, and equipped with metering devices as required, generally used in mobile hydrogen refuelling facilities.

1.1.3.20 **Hydrogen bunkering nozzle:** A component installed at the end of the bunkering hose for connecting to the hydrogen bunkering receptacle of the receiving ship's bunkering system.

1.1.3.21 **Dry quick coupling:** A mechanical device that can quickly connect and disconnect the hose bunkering system of a bunkering facility to the manifold of a receiving ship in a safe manner without the use of bolts. This coupling mainly consists of two parts: a bunkering end and a receiving end.

1.1.3.22 **Emergency shutdown (ESD):** An operation that safely and effectively stops all operations related to hydrogen fuel bunkering and transfer equipment in particular circumstances, terminates hydrogen fuel bunkering and brings the bunkering system to a safe state.

1.1.3.23 **Emergency release system (ERS):** A system capable of safely separating the connecting pipeline between a receiving ship and a bunkering facility by activating an emergency release coupler.

1.1.3.24 **Emergency release coupler (ERC):** A device that achieves dry disconnection of connecting equipment from a ship's connecting pipeline by applying an external force at a predetermined section or by manual/automatic activation in an emergency. This device is the main component of an emergency release system.

1.1.3.25 **Breakaway coupling:** A safety device mainly installed on bunkering hoses or metallic connecting hoses to protect the hose. When the tensile limit of the device is exceeded during bunkering, it can safely disconnect the hose and prevent hydrogen fuel from leaking from the hose through automatic closing valves at both ends.

1.1.3.26 **Insulating flange:** A special flange equipped with insulating liners, bushings, and gaskets to prevent current paths between pipelines, hoses, or loading arms.

1.1.3.27 **Person in charge:** A person exercising overall control over the bunkering operation.

1.1.3.28 **Safety zone:** The area around the bunkering facility, the bunkering station of the receiving ship, and the ship-to-shore connecting pipelines, where unauthorised personnel are not allowed to enter during bunkering, and where there are to be no ignition sources. This area is determined based on risk assessment.

1.1.3.29 **Security zone:** An area established to prevent unauthorised ships or other activities from entering or approaching the bunkering operation area.

1.1.4 Abbreviations

(1) ESD (Emergency shutdown)

(2) ERS (Emergency Release System)

(3) ERC (Emergency Release Coupler)

(4) SDS (Safety Data Sheet)

(5) IMO (International Maritime Organization)

(6) IR (Individual Risk)

(7) SR (Social Risk)

(8) PQU (Physical Quantity Unit)

Section 2 BUNKERING REQUIREMENTS

1.2.1 General requirements

1.2.1.1 A complete ship hydrogen fuel bunkering process may be divided into the planning phase, pre-operation preparation, and operation phase. The main processes and corresponding content of the Guidelines for each phase are as follows:

(1) The planning phase mainly corresponds to the compatibility assessment in this Section and the risk assessment requirements in Chapter 4 of the Guidelines.

(2) Pre-operation preparation mainly corresponds to the requirements for equipment and operations in Chapter 2 and safety protection in Chapter 3 of the Guidelines.

(3) The operation phase mainly corresponds to the requirements for bunkering operations and completion phase in Chapter 5, and the emergency response requirements in Chapter 6 of the Guidelines.

1.2.1.2 The following operations are not to be carried out simultaneously with hydrogen fuel bunkering operations:

(1) Cargo loading and unloading operations;

(2) Embarkation and disembarkation of passengers;

(3) During the bunkering operation, any other activities on the bunkering facility and the receiving ship, other than the hydrogen fuel bunkering operation, that may adversely affect the hydrogen fuel bunkering operation (such as hot work, machining, and charging of the receiving ship).

1.2.2 Bunkering facilities and receiving ships

1.2.2.1 Bunkering facilities and their use are to comply with the relevant provisions of national and industry standards, codes, and regulations.

1.2.2.2 During the operational period, the owner/operator/operating personnel of the bunkering facility is to ensure that the bunkering facility is in a safe and applicable state, and is to carry out timely inspection and maintenance in accordance with the requirements of relevant standards, codes, and regulations.

1.2.2.3 During bunkering operations, the bunkering facility and the receiving ship are to be in a stable state (e.g., vehicle engine locked in stop position, receiving ship moored, etc.), taking into account the influence of external conditions on the bunkering operation.

1.2.2.4 The bunkering facility is to be provided with the equipment necessary for ship bunkering operations.

1.2.2.5 The operations manual for bunkering operations provided by the bunkering facility is to meet the requirements of the Guidelines.

1.2.2.6 The owner or operator of the bunkering facility is to properly keep the record documents of bunkering operations for a period of not less than 1 year or the time limit required by the competent authority.

1.2.2.7 The receiving ship is to comply with the requirements of the technical regulations for the navigation area of the ship and the rules of the classification society.

1.2.3 Personnel qualifications and competence

1.2.3.1 Operating personnel are to undergo necessary safety production knowledge training, professional technical training, and practical operation training to familiarise themselves with relevant safety production rules and regulations and safe operating procedures, and to master the safety operating skills of their posts.

1.2.3.2 Operating personnel are to be familiar with the hazardous factors, preventive measures, and accident emergency measures existing in the workplace and their posts.

1.2.3.3 Operating personnel are to possess certain emergency handling capabilities, including personnel evacuation, prevention of accidental injuries, and emergency first aid in the event of emergencies such as hydrogen leakage and fire.

1.2.3.4 A person in charge is to be designated for the bunkering operation to guide and control the entire bunkering operation process. The person in charge may be the operator or relevant management personnel of the bunkering facility. The person in charge is to:

(1) Have experience in hydrogen fuel cargo loading/unloading or hydrogen fuel bunkering;

(2) Be familiar with the operating area and its surrounding geographical conditions;

(3) Master hydrogen accident emergency handling techniques, including familiarity with the equipment and resources available in the emergency response plan;

(4) Be familiar with the operating procedures of hydrogen fuel bunkering operations.

1.2.3.5 During the bunkering operation, the hydrogen-related spaces or their remote monitoring spaces on both the ship and shore sides are to be manned.

1.2.4 Personnel responsibilities

1.2.4.1 An operator organisation chart is to be developed for the bunkering facility, clearly defining the roles and responsibilities of all relevant operating personnel (including the ship-side person in charge and bunkering equipment operators).

1.2.4.2 If the person in charge is someone other than the operator of the bunkering facility, this situation does not indicate that the operator's obligations, requirements, and responsibilities are relieved or reduced.

1.2.4.3 The operator of the bunkering facility is responsible for the bunkering facility, including personnel management and safety and other issues throughout the entire bunkering process. Operations related to bunkering are only to be carried out after a consensus has been reached between the bunkering facility and the receiving ship on the bunkering operation.

1.2.4.4 The person in charge is to ensure that hydrogen fuel bunkering is carried out in accordance with applicable requirements and procedures. The responsibilities of the person in charge are to include:

(1) Ensuring that mooring, bunkering, and unmooring operations are carried out in accordance with the requirements of the bunkering operation plan and operations manual;

(2) Providing advice to the Master during mooring, bunkering, and unmooring operations;

(3) Ensuring the implementation of the emergency plan in the event of hydrogen leakage;

(4) Ensuring that reporting has been carried out in accordance with relevant requirements;

(5) Ensuring that personnel involved in all aspects of the bunkering operation are clear about their responsibilities;

(6) Ensuring that the bunkering facility and the receiving ship are approached and effective communication is established, and that no connection operations are carried out before the corresponding checks are completed;

(7) Ensuring that various safety checks before and after bunkering are carried out in accordance with the Guidelines;

(8) The person in charge is to have the authority to make the following requests:

① Suspend or terminate the hydrogen fuel bunkering operation;

② Modify the bunkering operation plan for certain specific operations.

1.2.5 Bunkering operation plan

1.2.5.1 To ensure that the bunkering operation can be carried out safely and reliably, the bunkering operation plan is to include the equipment operation instructions, compatibility assessment, bunkering operation procedures, safety checklists, safety distances, and emergency response plan, and other necessary materials or information. It may include the following applicable content:

(1) Parameters such as hydrogen fuel bunkering quantity, bunkering pressure, rate, and temperature;

(2) Potential accidents during hydrogen fuel bunkering and their handling methods, including safety equipment, personal protective equipment, and first aid measures;

(3) Description of gas asphyxiation and cryogenic hazards in the ship;

(4) Bunkering safety measures and emergency response;

(5) Schematic diagram of the hydrogen fuel bunkering system (including the description of the receiving ship's hydrogen storage system equipment);

(6) Description of relevant equipment of the bunkering facility, such as hydrogen dispensers, bunkering hoses, hydrogen bunkering nozzles, bunkering connections, communication systems, etc.;

(7) Restrictive conditions for safe operation during the bunkering process, including weather, fuel temperature, pressure, rate, etc.;

(8) Risk mitigation measures and descriptions determined by the risk assessment that are to be observed during the bunkering period;

(9) Description of hazardous areas, safety zones, and security zones, and the provisions to be observed by the receiving ship, bunkering facility, and relevant participating parties in the above areas;

(10) Content of the compatibility assessment involving the bunkering operation period;

(11) Watchkeeping arrangements;

(12) Coordinated plan for connection, inerting, purging, and disconnection between the two bunkering parties.

1.2.5.2 The hydrogen fuel bunkering operation plan for the receiving ship is to be completed before the start of the bunkering operation and signed and agreed upon by both the receiving ship and the bunkering party.

1.2.6 Information preparation, approval, and filing

1.2.6.1 Before carrying out bunkering operations, the preparation, approval, or filing of information is to be carried out in accordance with relevant provisions.

1.2.7 Compatibility assessment

1.2.7.1 Before the receiving ship arrives at the operating area for bunkering operations, the two bunkering parties are to carry out a compatibility assessment between the receiving ship and the bunkering facility. The compatibility assessment is to confirm the following:

(1) The position of the terminal or bunkering facility is to be compatible, considering the arrangement of ship fenders, ship accesses, and gangway positions, etc.;

(2) Lifting equipment is to meet the operational needs, considering working load, working range, etc.;

(3) The operating range of the bunkering hose/loading arm is to meet the operational needs, considering the changes in the ship's floating state during the bunkering operation;

(4) Bunkering control and safety systems, bunkering connection/interface dimensions, etc., are to be compatible;

(5) Hydrogen fuel and hydrogen gas-inert gas mixtures during the bunkering operation are to be capable of being safely discharged or handled;

(6) The changes in the floating state of the receiving ship during the bunkering operation are not to affect the normal bunkering operation;

(7) Under various operating conditions, the height difference between the bunkering facility and the receiving ship is to be within the operable range of the bunkering hose or hose handling equipment (boom/rack);

(8) The mooring arrangement is to meet the requirements of the mooring plan;

(9) The communication systems/signals are to be consistent;

(10) The various components of the bunkering system itself are to be matched;

(11) Mutual influences between the hazardous areas of the bunkering facility and the receiving ship, e.g., the vent mast outlet of the receiving ship is not to be located within the activity range of the bunkering facility operators and in areas where ignition sources exist. If unavoidable, additional restrictive measures are to be taken during the bunkering operation.

(12) The ship-to-shore communication link or equivalent means for automatic and manual Emergency Shutdown (ESD) communication is to be compatible;

(13) Safety equipment is to be provided to prevent incorrect connection between incompatible hydrogen bunkering nozzles and hydrogen bunkering receptacles, or between the bunkering and receiving pipeline connections;

(14) Before bunkering, information such as the bunkering parameters of the bunkering facility and the parameters of the receiving ship's hydrogen storage container (e.g., capacity, temperature, pressure) is to be confirmed, and the two parties are to be safely compatible;

(15) The characteristic parameters of the hydrogen fuel to be bunkered (e.g., temperature, pressure, hydrogen content) are to be within the acceptable range of the receiving ship.

1.2.7.2 Unless there are special circumstances, only one compatibility assessment is required for bunkering operations of the same receiving ship using the same bunkering facility in the same operating area. Shore-based hydrogen refuelling stations specifically designed and built for fixed-point and fixed-route ships may not require a compatibility assessment. When there are major changes in site conditions, equipment status, operating personnel, meteorological and hydrological conditions, or simultaneous operation arrangements, the compatibility assessment is to be re-carried out as appropriate.

1.2.8 Bunkering operation area

1.2.8.1 The selection of the operation area is to comply with the provisions of the relevant competent authority or port authority, selecting an area where safe bunkering operations can be carried out. The operating waters where the receiving ship is located are to consider the following factors:

(1) Shelter conditions, especially wind, wave, and swell conditions;

(2) Current meteorological conditions and weather forecasts;

(3) Water level or tidal changes in the bunkering waters;

(4) Isolation from nearshore facilities;

(5) Applicability of the designated operation area;

(6) Sufficient water area for activities and water depth to meet the ship's manoeuvring during berthing and unberthing;

(7) Avoidance of locations such as underwater pipelines, optical fibres, artificial reefs, or historical sites;

(8) Potential emergencies and emergency response capabilities;

(9) No accumulation of leaked hydrogen/liquefied hydrogen;

(10) Other potential safety hazards;

(11) The possibility of safe evacuation of personnel or timely arrival of external rescue forces after an accident.

1.2.8.2 When using mobile hydrogen refuelling facilities to bunker hydrogen fuel to receiving ships, the terminal operation area where the mobile hydrogen refuelling facility is located is to meet the requirements for operation areas in standards① acceptable to CCS, and the influence of road and environmental conditions (such as icy and muddy roads) is also to be considered to ensure that the mobile hydrogen refuelling facility safely arrives at the operation area.

1.2.8.3 The operation area and pedestrian walkways should be provided with anti-slip measures, such as anti-slip layers or anti-slip grilles, and are to be capable of avoiding the generation of electrostatic sparks. For liquefied hydrogen fuel bunkering, the anti-slip layer or anti-slip grille is to be made of low-temperature resistant materials.

1.2.9 Bunkering restrictions

1.2.9.1 Bunkering operation conditions are to be determined based on the bunkering operation mode, receiving ship type, meteorological and hydrological conditions of the bunkering operation, etc. Where

① E.g, GB/T 31139-2014 Safety Technical Regulations for Mobile Hydrogen Refueling Facility and General requirements of hydrogen fuelling stations.

necessary, they may be determined through ship model tests or numerical simulation analysis.

1.2.9.2 Unless otherwise specified by the port authority or competent authority, receiving ships are not to carry out bunkering operations when the Beaufort wind force is greater than 6.

1.2.9.3 The ambient temperature for bunkering operations is to be within the range of -40°C to 50°C.

1.2.9.4 Bunkering operations should be carried out during the day and should avoid, as far as possible, weather and time periods that may affect visibility, such as fog, rain, and snow.

1.2.9.5 The adverse effects of predicted and actual meteorological conditions on bunkering operations are to be considered, and corresponding contingency plans are to be prepared. Factors to be considered include, but are not limited to, visibility, wind direction and speed, wavelength, wave height, period and direction, thunderstorms, lightning, etc.

1.2.9.6 The bunkering rate and target pressure are to be determined in combination with the bunkering method and bunkering performance objectives, based on the ambient temperature adaptability of the hydrogen dispenser/hydrogen bunkering device, the ability to pre-cool hydrogen fuel, the hydrogen fuel supply capacity (pressure and flow rate), the pressure drop and heat exchange capacity of the bunkering pipeline, as well as the receiving ship's hydrogen storage capacity, hydrogen fuel tank category, initial temperature, initial pressure, and other parameters, and the corresponding process control requirements are to be matched.

1.2.9.7 During the process of bunkering compressed hydrogen fuel to compressed hydrogen fuel tanks, the maximum hydrogen bunkering rate is to meet the standards① acceptable to CCS. For hydrogen cylinders, the in-cylinder temperature during bunkering is not to exceed 85°C, and the in-cylinder pressure is not to exceed 1.1 times the nominal working pressure.

1.2.9.8 During the process of bunkering compressed hydrogen fuel to metal alloy hydrogen storage fuel tanks, monitoring of the mass flow rate and temperature of hydrogen bunkering, the inlet and outlet temperatures of the cooling system medium, and the internal hydrogen storage container temperature and pressure is to be maintained. The maximum hydrogen bunkering rate is not to exceed the safety limit specified by the manufacturer. The internal temperature of the metal alloy hydrogen storage fuel tank is not to exceed the upper temperature limit for safe operation specified by the manufacturer and is to avoid significantly limiting the hydrogen absorption rate of the hydrogen storage alloy. The internal pressure is not to exceed the rated hydrogen charging pressure specified by the manufacturer.

1.2.9.9 During the process of liquefied hydrogen fuel bunkering, monitoring of the mass flow rate of liquefied hydrogen bunkering, the temperature, pressure, and liquid level in the fuel tank is to be maintained. The initial bunkering rate must be maintained for a period of time to detect and cool the system, and the pre-cooling process is to be carried out slowly. When the fuel tank approaches the filling limit, the topping-up rate is to be appropriately controlled to prevent overfilling or overflow. The flow velocity of liquefied hydrogen in the bunkering pipeline is not to exceed 5 m/s.

① E.g., GB/T 42855-2023 Technical requirements of fuelling protocols for hydrogen fuel cell vehicles.

Section 3 BUNKERING MODES

1.3.1 Shore-based hydrogen refuelling station bunkering

1.3.1.1 Shore-based hydrogen refuelling stations providing hydrogen fuel bunkering services to receiving ships are to meet the standards① acceptable to CCS.

1.3.1.2 Shore-based hydrogen refuelling stations may use hoses and/or loading arms for bunkering to receiving ships.

1.3.1.3 Either party on the ship or shore is to be capable of activating the ESD system to stop hydrogen refuelling in an emergency.

1.3.1.4 Before the formal bunkering operation begins, the relevant safety devices are to be tested.

1.3.1.5 The schematic diagram of a shore-based hydrogen refuelling station bunkering hydrogen fuel to a receiving ship is shown in Figure 1.3.1.5 of this Section.

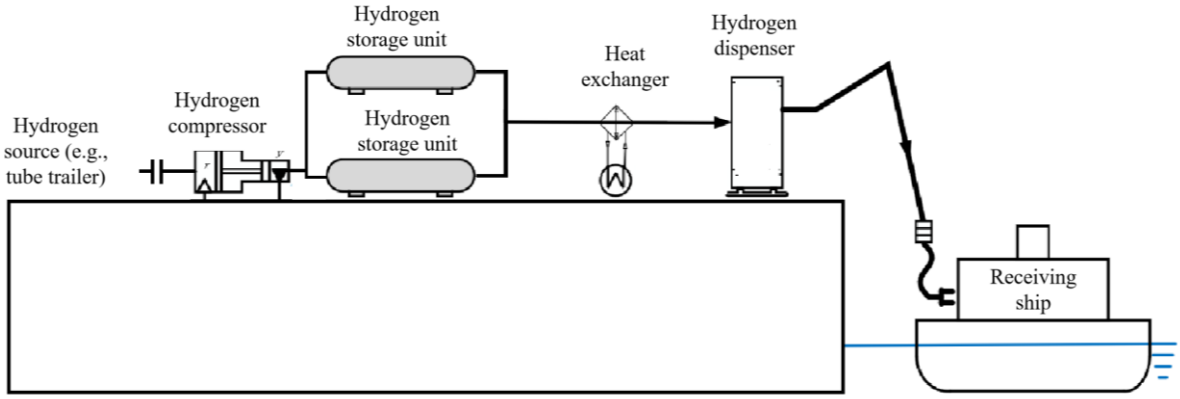

Figure 1.3.1.5 Schematic Diagram of a Shore-based Hydrogen Refuelling Station Bunkering Hydrogen Fuel to a Ship

1.3.1.6 The bunkering process may refer to the flowchart of a shore-based hydrogen refuelling station bunkering to a ship in Appendix 1 of the Guidelines.

1.3.2 Mobile hydrogen refuelling facility bunkering

1.3.2.1 Mobile hydrogen refuelling facilities and terminal operation areas for bunkering hydrogen fuel to receiving ships are to meet the applicable requirements in the standards② acceptable to CCS.

1.3.2.2 The mobile hydrogen refuelling facility is to be parked safely and stably at a designated dedicated location in the operation area, and is to ensure its stable parking throughout the entire bunkering process. The engine (if fitted) is to be turned off and the key removed. Bunkering devices powered by the vehicle engine are not to be used.

1.3.2.3 Either party on the ship or shore is to activate the ESD system to stop hydrogen refuelling in an emergency.

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① E.g., GB 50516-2010 Technical Code for Hydrogen Fuelling Station (2021 Edition), GB/T 43674-2024 General Requirements of Hydrogen Fuelling Stations and GB/T 31138-2022 Hydrogen Dispensers.
② E.g., QC/T 816-2009 Technical Specifications for Hydrogen bunkering trucks and GB/T 31139-2014 Safety Technical Regulations for Mobile Hydrogen Refueling Facility.

1.3.2.4 Before the formal bunkering operation begins, the relevant safety devices for bunkering by the mobile hydrogen refuelling facility are to be tested.

1.3.2.5 The terminal operation area is to be provided with signs for the entry and exit paths of hydrogen bunkering trucks or skid-mounted trailers, enabling them to safely evacuate the site in an emergency.

1.3.2.6 A wind sock or similar device is to be installed in a prominent position on the terminal to indicate the real-time wind direction, and the mobile hydrogen refuelling facility is to be parked facing the real-time upwind direction as far as possible.

1.3.2.7 The terminal operation area is to set up a reasonable security zone in accordance with the risk assessment report and take effective risk prevention and control measures to prevent unauthorised personnel from entering and ensure the safety of bunkering operations.

1.3.2.8 When a ship carries out hydrogen fuel bunkering operations through a mobile hydrogen refuelling facility, the operation area is to be arranged at the terminal front. Before carrying out the bunkering operation, the ship is to jointly formulate a bunkering plan with the bunkering operation unit and the terminal party, and implement safety management measures.

1.3.2.9 The schematic diagram of a mobile skid-mounted hydrogen refuelling unit bunkering hydrogen fuel to a receiving ship is shown in Figure 1.3.2.9 of this Section.

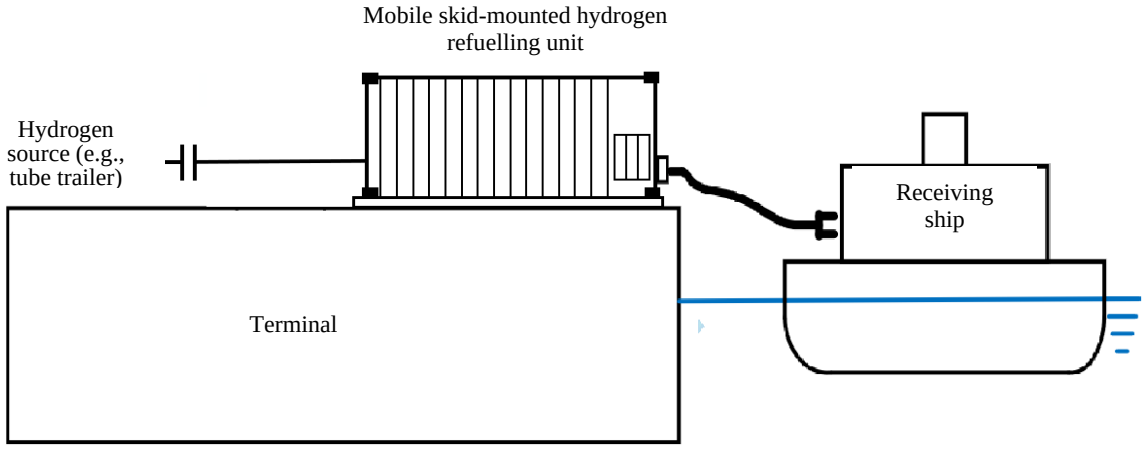

Figure 1.3.2.9 Schematic Diagram of a Mobile Skid-mounted Hydrogen Refuelling Unit Bunkering Hydrogen Fuel to a Ship

1.3.2.10 The schematic diagram of a hydrogen bunkering truck bunkering hydrogen fuel to a receiving ship is shown in Figure 1.3.2.10 of this Section.

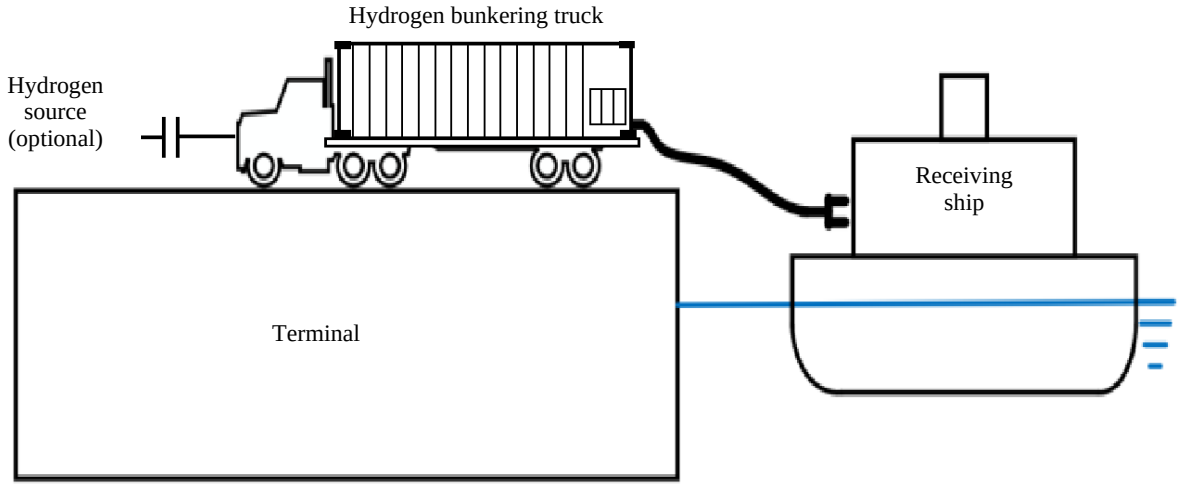

Figure 1.3.2.10 Schematic Diagram of a Hydrogen Bunkering Truck Bunkering Hydrogen Fuel to a Ship

1.3.2.11 The bunkering process of mobile hydrogen refuelling facilities may refer to the flowchart of bunkering to a ship by mobile hydrogen refuelling facilities in Appendix 1 of the Guidelines.

1.3.3 Portable fuel tank swap

1.3.3.1 The design of portable fuel tanks used for storing compressed hydrogen or liquefied hydrogen is to meet the relevant requirements of the CCS Guidelines for the Application of Hydrogen Fuel on Ships, and is to be capable of being loaded and unloaded without dismantling structural equipment. For portable liquefied hydrogen fuel tanks, they are to include components or systems for converting the stored fuel into hydrogen gas at cryogenic and normal pressure states.

1.3.3.2 The design of portable fuel tanks used for storing metal hydrides is to meet the standards① acceptable to CCS.

1.3.3.3 The loading and unloading of portable fuel tanks are to be carried out by lifting devices, and the lifting process is to comply with the lifting management regulations of the ship's berthing terminal.

1.3.3.4 For passenger ro-ro ships and ro-ro ships, if the portable fuel tanks are arranged in spaces or areas accessible to vehicles, the loading and unloading of portable fuel tanks may also be carried out by vehicle ro-ro methods.

1.3.3.5 The disassembly and installation of portable fuel tanks in the port are to be carried out in a dedicated area.

1.3.3.6 Lifting operations are to use the four-point lifting method to ensure that the four points of the portable fuel tank are evenly stressed while maintaining a tensioned state, and mechanical damage to the piping and fuel tank is to be avoided.

1.3.3.7 The schematic diagram of portable fuel tank swap is shown in Figure 1.3.3.7 of this Section.

① E.g., ISO 16111-2018 Transportable Gas Storage Devices - Hydrogen Absorbed in Reversible Metal Hydride.

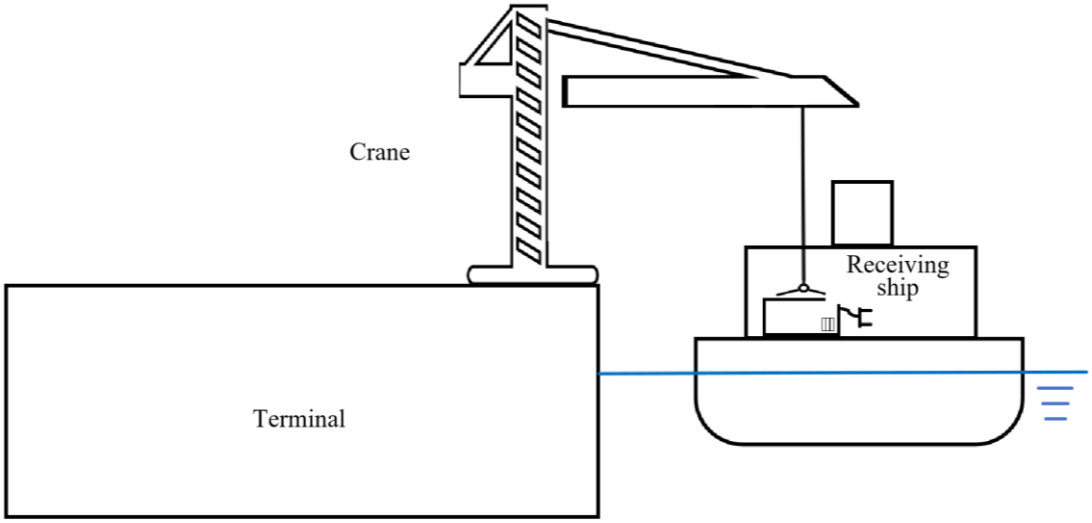

Figure 1.3.3.7 Schematic Diagram of Portable Fuel Tank Swap

1.3.3.8 The portable fuel tank swap process may refer to the portable fuel tank swap flowchart in Appendix 1 of the Guidelines.

CHAPTER 2 EQUIPMENT AND OPERATIONS

Section 1 GENERAL PROVISIONS

2.1.1 General requirements

2.1.1.1 The requirements of Sections 2 to 4 of this Chapter apply to bunkering compressed hydrogen fuel to compressed hydrogen fuel tanks.

2.1.1.2 Portable fuel tank swap is to comply with the requirements of Section 5 of this Chapter.

2.1.1.3 Bunkering compressed hydrogen fuel to metal alloy hydrogen storage fuel tanks is to comply with the requirements of Section 6 of this Chapter.

2.1.1.4 Liquefied hydrogen fuel bunkering is to comply with the requirements of Section 7 of this Chapter.

Section 2 BUNKERING CONNECTING EQUIPMENT

2.2.1 General requirements

2.2.1.1 When a bunkering facility transfers hydrogen fuel to a receiving ship, the bunkering connecting equipment generally includes main components such as hydrogen dispensers or hydrogen bunkering devices, hoses, hose handling equipment (booms/racks), breakaway couplings, hydrogen bunkering nozzles, receiving ship hydrogen bunkering receptacles, and bunkering ESD systems. The schematic diagram of the ESD connection between a shore-based hydrogen refuelling station and a receiving ship is shown in Figure 2.2.1.1 of this Section.

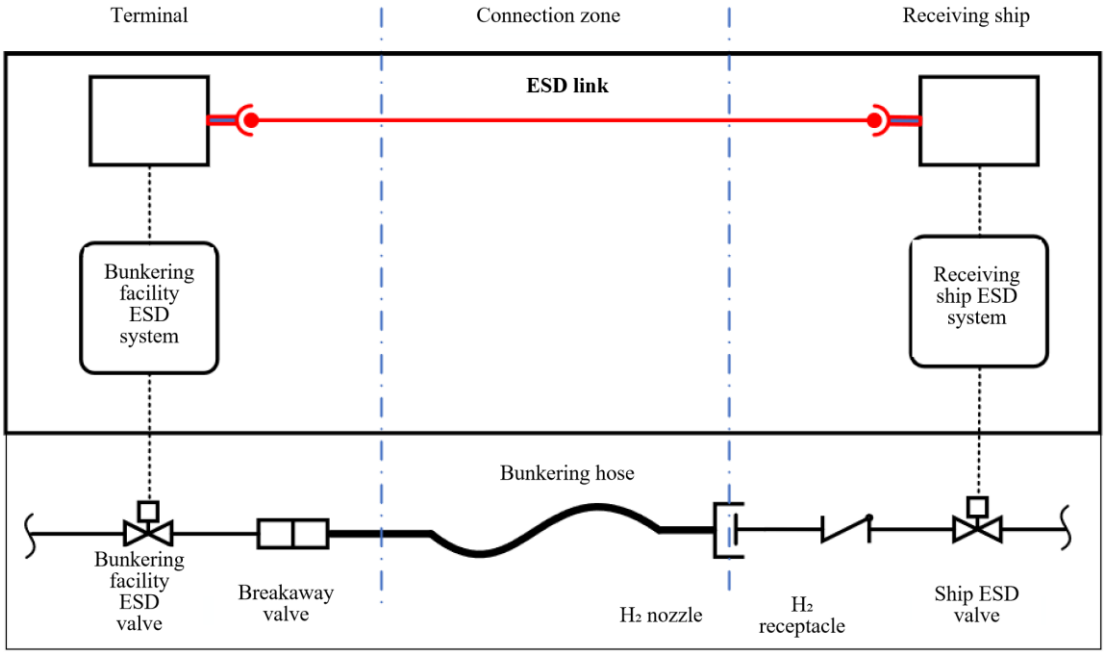

Figure 2.2.1.1 Schematic Diagram of Hydrogen Fuel Bunkering ESD Connection

2.2.1.2 Bunkering connecting equipment that is functionally normal and in good technical condition is to be used for bunkering operations. Equipment that is damaged, has missing parts, or possesses safety hazards is not to be used.

2.2.2 Hoses

2.2.2.1 Before using a hose, it is to be verified whether the following permanent markings are complete and valid, and their applicability is to be considered:

(1) Manufacturer's name or trademark;

(2) Manufacturer's technical standard specification identification code;

(3) Factory test pressure (e.g., rated working pressure, maximum working pressure, maximum allowable working pressure);

(4) Parameters such as hose inner diameter, working temperature range, and minimum bending radius;

(5) Date of manufacture and inspection;

(6) Description of electrostatic properties and electrical conductivity of the hose;

(7) Type of intended service.

2.2.2.2 Before a hose is used for bunkering operations, it is to be confirmed that its test data, such as pressure and tightness, are within the manufacturer's allowable range.

2.2.2.3 The hose diameter is to meet the requirements of the bunkering rate and the dimensions of the hydrogen bunkering nozzle.

2.2.2.4 The hose length is to be comprehensively considered based on factors such as its structural characteristics, arrangement, bunkering scenario, spatial distance between the bunkering facility and the receiving ship, and environmental conditions for bunkering. The hose length requirement is not to be met through hose splicing.

2.2.2.5 Before connecting the bunkering system, a visual inspection of the integrity and damage of each hose assembly is to be carried out.

2.2.2.6 Hoses are not to be kinked, twisted, distorted, or bent excessively.

2.2.2.7 The hose manufacturer's requirements for service life, inspection, and maintenance are to be strictly observed.

2.2.2.8 After the emergency release of the hose breakaway coupling, measures are to be taken to prevent the breakaway coupling or connecting joint from directly impacting the metal structure of the bunkering facility/receiving ship, so as to reduce the risk of sparks, personal injury, or mechanical damage.

2.2.3 Hose lifting devices and supports

2.2.3.1 Lifting devices or supports are to be equipped according to the length, weight, and actual needs of the hose, and the hose is to be prevented from being over-stretched.

2.2.3.2 The number and safe working load of lifting devices used for hose lifting and bunkering connection are to be sufficient.

2.2.3.3 Hose lifting devices and supports are to be prevented from becoming potential ignition sources.

Potential ignition sources include electrical sparks, arcs, static electricity, mechanical impact, high temperatures, etc.

2.2.3.4 The hose lifting device is to be capable of being secured by mechanical means so that it remains relatively stable during the bunkering process.

2.2.4 Hydrogen bunkering nozzles

2.2.4.1 When used for bunkering hydrogen fuel to ships, the hydrogen bunkering nozzle connected to the receiving ship's hydrogen bunkering receptacle is to meet the standards① acceptable to CCS.

2.2.4.2 hydrogen bunkering nozzles are to be properly stored and kept clean, and necessary inspections are to be carried out before use to confirm that they are in normal working condition.

2.2.4.3 For hydrogen bunkering nozzles equipped with a valve operating handle, the operating handle is also to be opened or closed in a safe state to confirm that its torque and function are in a normal state.

2.2.4.4 Hydrogen refuelling is only to be carried out when the hydrogen bunkering nozzle is correctly connected to the hydrogen bunkering receptacle, and the nozzle is only to be removed from the hydrogen bunkering receptacle after the gas between the nozzle and the hydrogen bunkering receptacle has been safely vented.

2.2.5 Hydrogen dispensers / hydrogen bunkering devices

2.2.5.1 Hydrogen dispensers/hydrogen bunkering devices used for bunkering hydrogen fuel to ships are to meet the standards② acceptable to CCS, and the safety performance of hydrogen bunkering devices is to at least meet the safety requirements of hydrogen dispensers.

2.2.5.2 Before using a hydrogen dispenser/hydrogen bunkering device, necessary inspections are to be carried out in accordance with product technical requirements. The inspection content is to at least include appearance and structural inspection, emergency shutdown system, hydrogen leakage alarm, and control system, to confirm that it is in normal working condition.

2.2.5.3 The hydrogen dispenser/hydrogen bunkering device or control room is to be capable of real-time monitoring of hydrogen fuel temperature, pressure, and bunkering rate, and is to be capable of automatically shutting off the bunkering in the event of an abnormality.

2.2.6 Receiving ship's hydrogen system

2.2.6.1 A visual inspection is to be carried out on the receiving ship's hydrogen storage system (including hydrogen fuel tanks or hydrogen cylinders, cylinder valves, cylinder tail valves, and other accessories), bunkering system (including hydrogen bunkering receptacles and protective caps/covers, valves, filters, pressure gauges, and sensors), and system piping to confirm whether they are intact and free from damage.

2.2.6.2 It is to be checked whether the local pressure display and the remote pressure display values of

① GB/T 34425-2017 Fuel Cell Electric Vehicles - Hydrogen Fuelling Nozzle.
② E.g., GB/T 42855-2023 Technical Requirements for Fuelling Protocol of Hydrogen Fuel Cell Vehicles, GB/T 43674-2024 General Requirements for Hydrogen Fuelling Station, GB/T 31138-2022 Hydrogen Fuelling Dispenser and QC/T 816-2009 Technical Specifications for Hydrogen bunkering trucks.

the hydrogen fuel tank or hydrogen cylinder are consistent, and the hydrogen pressure in the cylinder is not to be less than 2 MPa.

Section 3 SAFETY EQUIPMENT

2.3.1 Breakaway couplings

2.3.1.1 Breakaway couplings are to meet the standards① acceptable to CCS.

2.3.1.2 A visual inspection of the breakaway coupling is to be carried out before the start of the bunkering operation to confirm whether it is intact and free from damage.

2.3.1.3 Daily inspection and testing of breakaway couplings are to be carried out in accordance with the manufacturer's requirements, and test records are to be kept for reference.

2.3.1.4 The installation position of the breakaway coupling is to consider the influence of the hose length and the actual operating environment on the stress of the hose, and is to be consistent with the system design drawings.

2.3.1.5 When using a mobile skid-mounted hydrogen refuelling unit, additional breakaway couplings are also to be added between the skid modules as required.

2.3.2 Emergency shutdown (ESD) systems

2.3.2.1 Before bunkering operations, it is to be checked whether the power sources of the ESD systems of the bunkering facility and the receiving ship are in good condition, and manual functional and necessary automatic functional tests are to be carried out to ensure that the emergency shutdown valves can close promptly as required.

2.3.2.2 Hydrogen fuel bunkering operations are not to be resumed until the ship-to-shore ESD systems, control, monitoring, and safety systems have returned to normal operating conditions.

2.3.2.3 Before the ship-to-shore ESD systems are reset, both parties are to jointly confirm that the relevant risks have been effectively controlled.

2.3.3 Firefighting systems

2.3.3.1 The firefighting equipment on both the ship and shore are to be in a state of immediate availability to handle emergencies such as fires at any time.

2.3.3.2 The fixed firefighting systems and portable fire extinguishers in the receiving ship's hydrogen-related spaces, such as hydrogen cylinder rooms or hydrogen fuel tank spaces, hydrogen fuel cell spaces, spaces containing hydrogen engines, and bunkering stations, are to be in normal condition.

2.3.3.3 The receiving ship's hydrogen leakage detection and alarm system and the ship's overall fire detection and alarm system are to be in normal working condition.

2.3.3.4 The firefighting equipment in relevant spaces/areas of the bunkering facility is to be in normal condition.

① E.g., GB/T 42177-2022 and ISO19880-3: 2018, Technical Requirements and Test Methods for Hydrogen Valves of Hydrogen Fuelling Stations.

Section 4 AUXILIARY EQUIPMENT

2.4.1 Communication systems

2.4.1.1 During the bunkering operation, reliable and effective communication systems are to be equipped to achieve the transmission of data, ESD information, and voice between the bunkering facility and the receiving ship.

2.4.1.2 During the entire process of mooring and bunkering, both parties are to maintain good communication. In the event of communication interruption or failure to maintain effective contact, the operation is to be stopped.

2.4.1.3 ESD information is to be transmitted by electrical or optical fibre means, and a backup ESD information communication system is to be provided.

2.4.1.4 In general, both parties are to have at least the following two reliable and independent communication methods: VHF walkie-talkies, handheld radios, direct-line telephones, face-to-face shouting, etc. However, if the bunkering process will not be interfered with by noise, operations, and other factors, with the permission of both parties, the communication for short-term, small-scale bunkering operations may be completed solely through clear and reliable face-to-face shouting. The portable communication equipment used is to meet the requirements of 3.2.2 of the Guidelines, and its function and working frequency band are to be tested before bunkering.

2.4.2 Mooring equipment

2.4.2.1 A visual inspection of the receiving ship's mooring lines, fenders, winches, and other mooring equipment for excessive wear and damage is to be carried out.

2.4.2.2 The receiving ship is to be securely moored to prevent excessive drifting during the bunkering operation.

2.4.2.3 The storage and arrangement of mooring equipment (such as mooring lines) are to be as far away as possible from the operating area of the receiving ship's bunkering equipment, and are not to hinder the passage and operation of bunkering operators.

2.4.2.4 The operation of mooring equipment is to consider the following applicable contents:

(1) Wind;

(2) Current/tide;

(3) Waves;

(4) Swell generated by passing vessels;

(5) Icing;

(6) Changes in draught, trim, and list;

(7) Confirmation of whether the mooring equipment has excessive wear or damage.

2.4.3 Cooling equipment

2.4.3.1 The temperature and liquid level of the coolant in the heat exchanger for cooling hydrogen fuel

are to be checked.

2.4.3.2 The cooling capacity and working condition of the heat exchanger are to meet the receiving ship's requirements for the bunkering temperature limit or bunkering rate.

Section 5 PORTABLE FUEL TANK SWAP EQUIPMENT AND OPERATIONS

2.5.1 General requirements

2.5.1.1 The requirements of 2.2.2, 2.3.1, and 2.3.3 of this Chapter apply to portable fuel tank swap.

2.5.1.2 During portable fuel tank swap, the exchange/bunkering connecting equipment generally includes main components such as hoses, dry quick couplings, and breakaway couplings, as well as electrical connectors whose explosion-proof rating matches the hazardous area classification.

2.5.1.3 The portable fuel tank and the ship's hydrogen supply system are to be connected via a dry quick coupling or similar device, and appropriate measures are to be taken to ensure reliable long-term connection.

2.5.1.4 A breakaway coupling is to be provided between the portable fuel tank and the ship's hydrogen supply system. The breakaway coupling between portable fuel tanks storing compressed hydrogen or metal hydrides and the ship's hydrogen supply system is to meet the requirements of 2.3.1 of this Chapter. The breakaway coupling between portable fuel tanks storing liquefied hydrogen and the ship's hydrogen supply system is to meet the requirements of 2.7.7 of this Chapter.

2.5.1.5 The lifting devices for portable fuel tanks are to be equipped according to the size, weight, and actual needs of the fuel tanks, and their number and safe working load are to be sufficient.

2.5.1.6 The lifting devices for portable fuel tanks are to be mechanically secured to maintain relative stability during the lifting and transportation process.

Section 6 EQUIPMENT AND OPERATIONS FOR BUNKERING COMPRESSED HYDROGEN FUEL TO METAL ALLOY HYDROGEN STORAGE FUEL TANKS

2.6.1 General requirements

2.6.1.1 Except for 2.2.6 of this Chapter, the requirements of Sections 1 to 4 of this Chapter apply to bunkering compressed hydrogen fuel to metal alloy hydrogen storage fuel tanks.

2.6.2 Receiving ship's metal alloy hydrogen storage system

2.6.2.1 A visual inspection is to be carried out on the receiving ship's metal alloy hydrogen storage system (including metal alloy hydrogen storage fuel tanks, valves, and other accessories), bunkering system

(including hydrogen bunkering receptacles and protective caps/covers, valves, filters, pressure gauges, and sensors), and system piping to confirm whether they are intact and free from damage, and to confirm the absence of cracks, bulging, and deformation.

2.6.2.2 It is to be checked whether the local pressure display and the remote pressure display values of the metal alloy hydrogen storage fuel tank are consistent, and the hydrogen pressure during storage is not to be higher than the maximum allowable working pressure of the metal alloy hydrogen storage fuel tank.

2.6.3 Cooling system

2.6.3.1 In addition to the provisions of 2.4.3 of this Chapter, before bunkering compressed hydrogen fuel to the metal alloy hydrogen storage fuel tank, key parameters such as the flow rate, conductivity, and temperature of the cooling medium supplied by the cooling system are to be checked to confirm that they meet the bunkering heat exchange requirements of the metal alloy hydrogen storage fuel tank.

Section 7 LIQUEFIED HYDROGEN FUEL BUNKERING EQUIPMENT AND OPERATIONS

2.7.1 General requirements

2.7.1.1 Except for 2.2.4.1, 2.2.5.1, 2.2.6, and 2.3.1.1 of this Chapter, the requirements of Sections 1 to 4 of this Chapter apply to liquefied hydrogen fuel bunkering.

2.7.1.2 The liquefied hydrogen fuel bunkering connecting equipment usually consists of main components such as hoses/loading arms, bunkering connections, and breakaway couplings, and is used for the bunkering facility to bunker liquefied hydrogen fuel to the receiving ship.

2.7.1.3 Bunkering connecting equipment such as hoses, bunkering connections, and breakaway couplings are to be provided with effective insulation measures (such as vacuum insulation structural forms) or equivalent measures to prevent air condensation and oxygen enrichment.

2.7.1.4 If the bunkering connecting equipment adopts a vacuum insulation structural form, a protective device to prevent vacuum failure is to be provided.

2.7.2 Hoses

2.7.2.1 Marine liquefied hydrogen cryogenic hoses are to comply with recognised standards①.

2.7.3 Loading arms

2.7.3.1 Before using a loading arm, its overall condition is to be checked, and a visual inspection of the piping, swivel joints, etc., on the loading arm is to be carried out to confirm that there is no leakage in the various hydraulic oil pipes on the loading arm.

2.7.3.2 It is to be checked that all inert gas purging connections on the loading arm are in normal condition and free from looseness.

① E.g., ISO 21012) Cryogenic Vessels - Hoses, etc.

2.7.3.3 Before operating the loading arm, it is to be confirmed that the receiving ship's bunkering manifold is within the working envelope of the loading arm. When the receiving ship is in an extreme position, it is to be adjusted to a suitable position.

2.7.3.4 The loading arm connection is to match the receiving ship. If it does not match, a spare connecting pipe is to be used to connect to the receiving ship before connecting to the loading arm.

2.7.3.5 Before connecting the loading arm, it is to be checked whether there are foreign objects in the loading arm. If so, they must be removed. Connection operations are only to be carried out after confirming that there are no foreign objects in the arm.

2.7.4 Hydrogen bunkering nozzles, hydrogen dispensers, and hydrogen bunkering devices

2.7.4.1 When used for bunkering liquefied hydrogen fuel to ships, the hydrogen bunkering nozzle connected to the receiving ship's hydrogen bunkering receptacle and the hydrogen dispenser/hydrogen bunkering device used for bunkering hydrogen fuel to ships are to meet the standards① acceptable to CCS, and the safety performance of the hydrogen bunkering device is to at least meet the safety requirements of the hydrogen dispenser.

2.7.5 Bunkering connections

2.7.5.1 Bunkering connections are to be suitable for liquefied hydrogen fuel bunkering operations and are to withstand the design temperature and design pressure.

2.7.5.2 For daily bunkering operations using hoses, dry quick couplings are recommended.

2.7.5.3 If the bunkering connection adopts a flange connection type, it is to be properly stored and kept clean, and all flange faces are to be ensured to be dry before use.

2.7.5.4 Before using a bunkering connection, necessary inspections are to be carried out to confirm that its sealing performance is good and it is in normal working condition.

2.7.6 Emergency release couplers (ERC)

2.7.6.1 The ERC is to be capable of normal use, and its control, alarm, and release functions are to be in working condition. Its integrity is to be checked before the bunkering operation.

2.7.6.2 Daily inspection and testing of the ERC are to be carried out in accordance with the manufacturer's requirements, and test records are to be kept for reference.

2.7.7 Breakaway couplings

2.7.7.1 The breakaway coupling is to be capable of achieving the release function under a certain external force and/or remote control drive. The hydrogen spilled after the breakaway coupling is cut off is to be as little as possible, and it is not to cause cryogenic damage to the surrounding hull.

2.7.7.2 The breakaway coupling may refer to the relevant requirements of the standards② acceptable to CCS. The materials of the breakaway coupling and its accessories and seals are to be compatible with

① E.g., T/CCGA 40010-2021 Technical Specifications for Safe Use of Liquid Hydrogen Dispensers, etc.
② E.g., GB/T38520-2020 Marine Ultra-low Temperature Breakaway Coupling and GB/T 45027-2024 General Specification for Liquid Hydrogen Valves, etc.

liquefied hydrogen and are to meet the functional requirements of 2.7.7.1 of the Guidelines at temperatures not higher than -253°C.

CHAPTER 3 SAFETY PROTECTION

Section 1 PERSONNEL PROTECTION

3.1.1 General requirements

3.1.1.1 Personnel in hydrogen-related spaces or operating hydrogen-related equipment are to select appropriate protective equipment based on the possible consequences of accidents (such as hydrogen flame thermal radiation and liquefied hydrogen cryogenic temperatures) to reduce possible personal injury.

3.1.1.2 During other operations, necessary personal protective equipment is also to be selected according to the on-site conditions, such as equipping the bunkering operation area with appropriate portable hydrogen detection equipment.

3.1.2 Personal protective equipment

3.1.2.1 Personnel involved in hydrogen fuel bunkering operations are to wear personal protective equipment, including but not limited to: life jackets, anti-static clothing, safety helmets, anti-static safety shoes, etc. Portable hydrogen detection equipment and explosion-proof lighting (if necessary) are to be provided.

3.1.2.2 In addition to the requirements of 3.1.2.1 of this Section, the personal protective equipment worn by personnel involved in liquefied hydrogen fuel bunkering operations is also to provide cryogenic protection.

3.1.2.3 Personal protective equipment provided by both the ship and shore are to be kept in appropriate locations that are easily accessible and clearly marked, and are to be properly maintained for immediate use.

3.1.2.4 Operating personnel are to undergo appropriate training to master the use of relevant protective equipment and its storage location.

3.1.3 Personnel management

3.1.3.1 After the ship has completed mooring and berthing, except for personnel involved in bunkering operations, bunkering watchkeeping, emergency response, and other bunkering operation participants, passengers and other irrelevant personnel are not to enter the safety zone and are to stay away from the bunkering operation area.

3.1.3.2 Except where necessary for work, irrelevant personnel are to be prohibited from moving within the safety zone between the ship and shore.

3.1.3.3 Personnel are not to bring any potential ignition sources when entering hazardous areas and safety zones.

3.1.3.4 Personnel are to wear life jackets when moving between the ship and shore.

3.1.3.5 A safe access for operating personnel is to be provided between the ship and shore. The access is to be as far away as possible from the bunkering manifold and hoses, and the evacuation needs of personnel in the event of an emergency are to be considered.

3.1.3.6 Bunkering operation personnel are to use explosion-proof tools during inspections and operations.

Section 2 FIRE AND EXPLOSION PROTECTION

3.2.1 Open flames, smoking and high-temperature equipment

3.2.1.1 Welding, hot work, smoking, and other activities that generate open flames are not to be carried out on the open deck areas of the bunkering facility and the receiving ship, and in any other areas where an explosive gas atmosphere may exist.

3.2.1.2 The bunkering facility and the receiving ship are not to use kitchen stoves and other kitchen utensils that generate open flames during bunkering operations.

3.2.1.3 Flammable and explosive materials such as fireworks and firecrackers are not to be stored in the bunkering operation area.

3.2.1.4 If the exhaust temperature of combustion equipment that needs to remain in operation during the bunkering process (such as engines and boilers) is too high, or if flames/sparks appear in the exhaust pipe, the bunkering operation is to be stopped immediately.

3.2.2 Portable electrical equipment

3.2.2.1 Portable electrical equipment used in hazardous areas is to be of an approved and certified explosion-proof type.

3.2.2.2 The explosion-proof category and temperature class of explosion-proof equipment used in explosive gas atmospheres that may contain hydrogen are not to be lower than IIC, T1.

3.2.2.3 The use of flexible cables is to be restricted unless it is for essential operational needs and complies with the relevant requirements of IEC 60092-502.

3.2.2.4 Measures are to be taken to prevent the conductors of portable equipment from any possible mechanical damage.

3.2.2.5 Only approved and certified explosion-proof equipment is to be used during bunkering operations, and electrical and electronic equipment that may be brought into the bunkering operation area is to be strictly controlled. Strictly controlled electrical and electronic equipment includes, but is not limited to, the following non-explosion-proof electrical equipment: flashlights, lighting fixtures, battery power sources, UHF/VHF portable radio walkie-talkies, cameras and video cameras, mobile phones, sports bracelets, sports watches, radios, and other portable electrical equipment that is prone to arcing.

3.2.3 Earthing devices

3.2.3.1 When the insulation resistance monitoring alarm of the switchboard indicates an abnormally low insulation resistance and alarms, the bunkering operation is to be stopped as soon as possible, and the fault point is to be traced and isolated to avoid the formation of electric sparks in the bunkering area.

3.2.3.2 It is to be confirmed that all hydrogen refuelling equipment and pipelines within the hydrogen bunkering facility are properly earthed, and that the earthing devices, earthing conductors, earthing wires and

earthing points are in good contact without looseness. The resistance value between the connection parts of the earthing system is not to be greater than 0.10Ω. The static electricity earthing should preferably share the earthing body with other earthings. If a dedicated static electricity earthing is adopted, the hydrogen earthing resistance is not to be greater than 10Ω, and the liquefied hydrogen earthing resistance is not to be greater than 1Ω. Flange connections on hydrogen pipelines are to be bonded with metal wires, and the bonding resistance is to be less than 0.03Ω.

3.2.4 Current between shore and ship

3.2.4.1 The entire bunkering pipeline is to be maintained earthed to the ship or to the shore. When an insulating flange is used, all metal pipelines between the insulating flange and the bunkering party are to maintain an earthing connection with the earthing point of the bunkering party, and all metal pipelines between the insulating flange and the receiving ship are to maintain earthing with the hull of the receiving ship.

3.2.4.2 When using a bonding cable, the connection point of the cable is to be arranged away from the safety zone where the bunkering hose is located, and the bonding cable is to be connected to the earthing point of the bunkering party through an explosion-proof switch. The switch is only to be closed after the bonding cable is properly secured. The bonding cable is to be connected before the bunkering operation and is only to be removed after the bunkering operation is completed.

3.2.4.3 Insulation measures are to be taken at necessary locations to avoid the formation of electrical paths. These locations include, but are not limited to: mooring lines, gangways or ramps between the two ships, lifting slings, trolleys and hooks, and ropes and chains used for securing fenders.

3.2.5 Ship radio equipment

3.2.5.1 During bunkering operations, if flammable gas may exist in the area of the transmitting antenna, radio transmission is not to be carried out.

3.2.5.2 Radio antennas are to be reliably earthed.

3.2.5.3 When using VHF and UHF walkie-talkies in the bunkering safety zone during bunkering operations, their transmitting power is to be set to low power (less than or equal to 1W).

3.2.5.4 When bunkering from a shore station to a ship, if a direct-line telephone connection is provided, the telephone cable is to be arranged outside the hazardous area.

3.2.6 Gas accumulation

3.2.6.1 The fixed gas detection systems of the bunkering operation area and the receiving ship, and the portable equipment used for hydrogen leakage detection, are to be in normal working condition.

3.2.6.2 When hydrogen leakage occurs, the bunkering operation must be stopped. The bunkering operation can only be restarted after the leakage has stopped, the gas detection device has indicated that the hydrogen has dissipated, and the cause of the leakage has been identified and properly handled.

Section 3 SAFETY MANAGEMENT

3.3.1 Enclosed spaces

3.3.1.1 During normal hydrogen fuel bunkering operations, personnel are not to enter hydrogen fuel tank spaces, hydrogen cylinder rooms, fuel tank connection spaces, fuel cell spaces, spaces containing hydrogen engines, or other hydrogen-related spaces where hydrogen or flammable gas may accumulate. When operating personnel truly need to enter such enclosed spaces due to bunkering operation needs or other special circumstances, fixed or portable equipment is to be used to confirm that there is sufficient oxygen in the space and no flammable hydrogen environment exists.

3.3.1.2 During hydrogen fuel bunkering operations, the openings of accommodation spaces leading to the open deck are to be kept closed.

3.3.1.3 Doors used for personnel access are to be kept away from the range that may be affected by gas, and the doors are to be closed immediately after personnel pass through.

3.3.1.4 Air conditioning systems with fresh air ventilation functions are to be set to self-circulation mode to avoid the accidental entry of flammable gas.

3.3.1.5 The ship's safe operation manual or similar documents are to contain safety management requirements and instructions related to bunkering operations.

3.3.2 Unauthorised craft

3.3.2.1 During hydrogen fuel bunkering operations, unauthorised craft are prohibited from berthing within the bunkering security zone.

3.3.3 Safety signs

3.3.3.1 The receiving ship and the terminal are to use different warning signs (such as warning tapes and notice boards) to identify the bunkering safety zone and security zone, except for water areas.

3.3.3.2 The bunkering safety zone is to have signs displaying No Smoking or Open Flames, No Use of Non-Explosion-Proof Electronic Equipment, and No Carrying of Ignition Sources.

3.3.3.3 Hazardous areas are to have signs displaying No Wearing of Synthetic Fibre Clothing and No Wearing of Nailed Shoes.

3.3.3.4 The bunkering operation area or spaces are to use signs such as Caution, Danger of Explosion, and Danger of Fire.

3.3.3.5 Distribution rooms and electrical equipment that may pose an electric shock hazard are to have signs displaying Danger of Electric Shock.

CHAPTER 4 RISK ASSESSMENT

Section 1 ASSESSMENT METHODS

4.1.1 General requirements

4.1.1.1 The risk assessment of bunkering operations is to be carried out in accordance with the requirements of relevant standards①. The objectives of the risk assessment include:

(1) To mitigate or eliminate potential risks to personnel and the environment, and to propose mitigation measures where necessary;

(2) To provide relevant information and assistance for determining the bunkering safety zone and security zone.

4.1.1.2 To achieve these objectives, the risk assessment of bunkering operations is to include at least the following aspects:

(1) Preparation, approach, and mooring prior to the ship's arrival;

(2) Preparation, testing, and connection of equipment;

(3) Hydrogen fuel transfer, including potential disconnection of the breakaway coupling during transfer;

(4) Disconnection of equipment after completion;

(5) Personnel and the environment.

4.1.1.3 For portable fuel tank swap operations, the requirements of 4.1.1.2 (3) and (4) of this Section do not apply. The risk assessment of such operations is also to include at least the following aspects:

(1) Loading/unloading using lifting equipment, including potential damage during the loading/unloading process;

(2) Connection and disconnection with the ship's hydrogen supply system, monitoring system, and venting system;

(3) Testing of equipment and systems.

4.1.2 Qualitative risk assessment

4.1.2.1 A qualitative risk assessment is to be carried out before developing a new bunkering operation procedure. Qualitative methods include What-if analysis, Hazard and Operability Study (HAZOP), Failure Mode and Effects Analysis (FMEA), Fault Tree Analysis (FTA), and Event Tree Analysis (ETA), etc.

4.1.2.2 If the bunkering operation is one of the following three bunkering modes and has no deviation from the Guidelines and relevant standards, only a qualitative risk assessment is required:

(1) Bunkering to ships from shore-based hydrogen refuelling stations;

(2) Bunkering to ships from mobile hydrogen refuelling facilities;

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① E.g., CCS Guidelines for Quantitative Risk Assessment for Oil & Gas, CCS Guidelines for Risk Assessment of Hydrogen-powered Ships, and IEC 31010: 2019 Risk Management - Risk Assessment Techniques, etc.

(3) Portable fuel tank swap.

4.1.2.3 The qualitative risk assessment may refer to Chapters 1 to 5 of the CCS Guidelines for Risk Assessment of Hydrogen-Powered Ships.

4.1.3 Quantitative risk assessment

4.1.3.1 The quantitative risk assessment of bunkering operations is a systematic method for quantitatively analysing the frequency and consequences of accidents in operational activities and comparing them with risk acceptance criteria.

4.1.3.2 A quantitative risk assessment is to be carried out under the following circumstances, including:

(1) Non-standard bunkering modes;

(2) Design, arrangement, and operations that differ from the Guidelines;

(3) When required by the competent authority.

4.1.3.3 The quantitative risk assessment is to use internationally or domestically recognised mathematical models for consequence analysis, capable of calculating and analysing the impact range of hazards. This is to typically include at least the following hazard types and hazard degree calculations:

(1) Hydrogen dispersion;

(2) Thermal radiation;

(3) Explosion shock wave.

4.1.3.4 The quantitative risk assessment may also be further evaluated based on actual needs and can be used to determine the overall risk level (which is generally not included in qualitative risk assessment), such as evaluating design options and mitigation options, and providing support for narrowing the safety zone and/or security zone.

4.1.3.5 The quantitative risk assessment may refer to the CCS Guidelines for Risk Assessment of Hydrogen-Powered Ships.

4.1.4 Minimum requirements

4.1.4.1 The minimum requirements for risk assessment in 4.1.2 and 4.1.3 of this Section are to include:

(1) Systematic identification of potential accidents/events that may cause casualties or environmental damage during bunkering operations;

(2) Determination of the worst consequences of the accidents/events in 4.1.4.1(1) of this Section, based on the degree of single and multiple casualties and environmental damage;

(3) The likelihood or probability of the worst consequences occurring from the accidents/events;

(4) Risk analysis and recommendations for risk control measures.

4.1.4.2 The risk assessment is to be conducted by a team composed of members with appropriate qualifications and extensive experience. The members are to be experts in risk assessment application, engineering design, emergency response, and bunkering operations. The assessment team members are to include, but are not limited to, professionals specializing in ship safety, process, materials, electrical, instrumentation, equipment, and process operations, as well as Computational Fluid Dynamics (CFD) analysts.

Section 2 HAZARD ACCEPTANCE CRITERIA

4.2.1 Hydrogen dispersion

4.2.1.1 The acceptance criteria for hydrogen dispersion volume concentration are to comply with the provisions of Table 4.2.1.1 of this Section.

Acceptance Criteria for Vapour Cloud Dispersion Concentration Table 4.2.1.1

Hydrogen Dispersion	Volume Concentration	Remarks
	2%	50% of the lower explosion limit of hydrogen

4.2.2 Thermal radiation

4.2.2.1 The acceptance criteria for thermal radiation heat flux and thermal dose are to comply with the provisions of Table 4.2.2.1 of this Section.

Acceptance Criteria for Thermal Radiation Table 4.2.2.1

Fire	Maximum thermal radiation intensity (kW/m^2)	Maximum thermal radiation dose[1] ($[kW/m^2]^{4/3}\cdot s$)	Remarks
	5.0	500	In the event of not less than 10% of skin exposure to a fire for 30 seconds, second-degree burns to at least 10 persons.
	5.0	300	In the event of not less than 10% of skin exposure to a fire for 30 seconds, second-degree burns to at least one person in the building.
	32	Not applicable	Loss of strength (significantly decreased loading capacity) of steel structures exposed to a fire during sustained burning.
Note 1: The thermal radiation dose criteria are derived based on specific scenario assumptions. The values of 500 and 300 are based on an external fire scenario with a gathering of 50 or more people outdoors and an external fire scenario with one person inside a building, respectively. In the actual calculation of social risk, the criteria may be adjusted based on the actual personnel distribution on the ship.			

4.2.3 Explosion shock wave

4.2.3.1 The acceptance criteria for the shock wave pressure of explosion disasters are to comply with the provisions of Table 4.2.3.1 of this Section.

Acceptance Criteria for Explosion Shock Wave Pressure Table 4.2.3.1

Explosion	Overpressure Value Corresponding to Damage (Pa)		Overpressure Damage Category
	Lower Limit	Upper Limit	
	250	4000	Damage to window glazing

	5000	10000	Damage to doors and covers and personal injury
	15000	20000	Serious structural damage
	25000	50000	Serious casualties

Section 3 RISK ACCEPTANCE CRITERIA

4.3.1 General requirements

4.3.1.1 The risk assessment should preferably use the risk acceptance criteria recommended in this Section.

4.3.1.2 The acceptance criteria for quantitative risk assessment are divided into individual risk acceptance criteria and social risk acceptance criteria. Individual risk assessment is normally to be carried out, and social risk assessment is also to be carried out when the bunkering operation risk involves 10 or more people.

4.3.2 Individual risk acceptance criteria

4.3.2.1 The individual risk acceptance criteria are to comply with the provisions in Table 4.3.2.1 of this Section.

Individual Risk (IR) Acceptance Criteria Table 4.3.2.1

Tolerable frequency / year	Location Category
$IR \leq 10^{-5}$	1. Bunkering operation locations (crew, bunkering operators); 2. Industrial sites in new development zones (pump rooms, factories).
$IR \leq 10^{-6}$	1.Residential densely-populated places (such as residential areas, hotels, resorts, etc.); 2.Public gathering places (such as office places, markets, restaurants, entertainment places, etc.).
$IR \leq 3\times10^{-7}$	1.High-sensitive places (such as schools, hospitals, kindergartens, nursing homes, etc.); 2.Important targets (such as party and government organs, military restricted zones, culture relic protection sites, etc.); 3.Special densely-populated areas (such as large stadiums, major transportation hubs, etc.).

4.3.3 Social risk acceptance criteria

4.3.3.1 The social risk acceptance criteria are to comply with the provisions in Figure 4.3.3.1 of this Section.

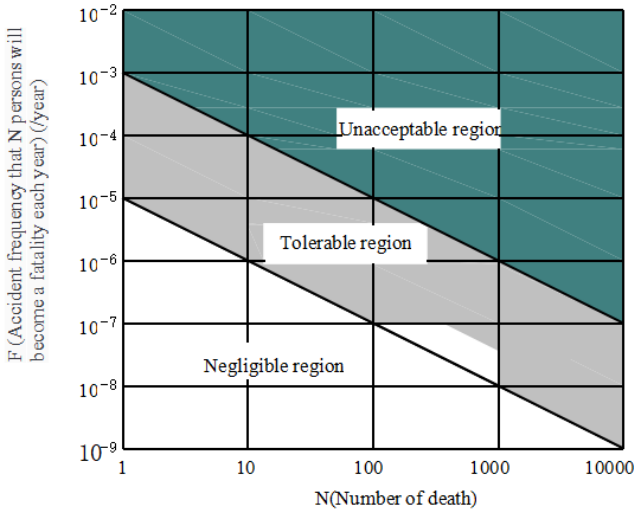


Figure 4.3.3.1 Social Risk (SR) Acceptance Criteria

Section 4 SAFETY DISTANCES

4.4.1 General requirements

4.4.1.1 In addition to hazardous areas, safety zones and security zones shall also be established during the hydrogen fuel bunkering operations. The schematic diagrams for the division of relevant areas for bunkering operations are shown in Figure 4.4.1.1(1) and Figure 4.4.1.1(2) of this Section.

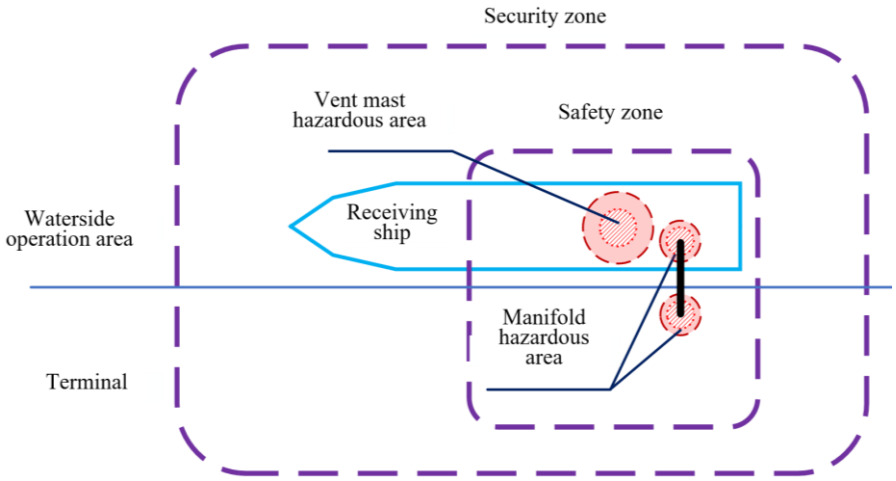


Figure 4.4.1.1(1) Schematic Diagram of Area Division for Ship Hydrogen Fuel Bunkering (Non-Tank Swap) Operations

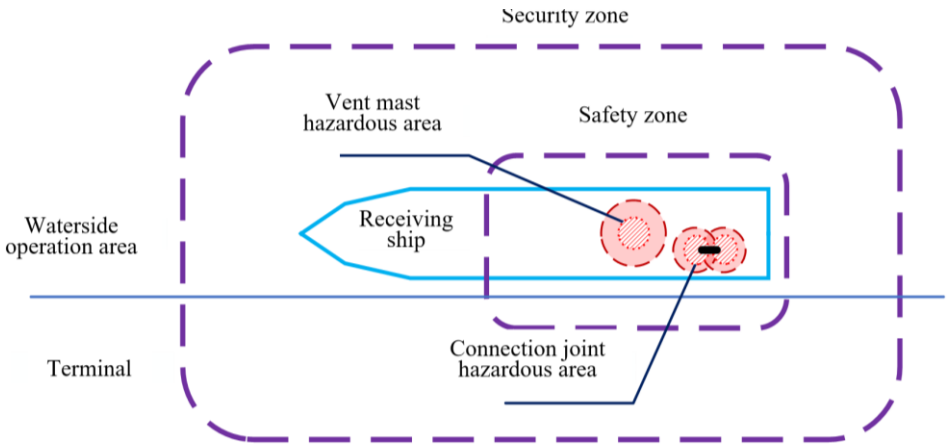


Figure 4.4.1.1(2) Schematic Diagram of Area Division for Ship Hydrogen Fuel Bunkering (Tank Swap) Operations

4.4.1.2 The safety zone and security zone are to be marked in accordance with 3.3.3 of the Guidelines and monitored during bunkering operations. During non-bunkering periods, this area is not a mandatory requirement.

4.4.1.3 The safety zone is only to be accessed by essential operating personnel, and potential ignition sources are to be controlled. Essential operating personnel refer to those who monitor and control the bunkering operation. The ship/port traffic within the security zone is to be monitored and controlled.

4.4.1.4 The establishment of safety zones and security zones will help reduce the possibility of hydrogen fuel leakage and ignition, and further protect life and property safety through physical isolation.

4.4.2 Hazardous areas

4.4.2.1 Attention is to be paid to the extent of hazardous areas related to bunkering and the arrangement of equipment within these areas. Hazardous areas include the Zone 1 and Zone 2 hazardous areas specified below:

(1) Areas specified in Chapter 9, Section 2, Part 1 of the CCS Guidelines for the Application of Hydrogen Fuel on Ships;

(2) Hazardous areas specified in other applicable codes①;

(3) Areas where fuel leakage may occur during bunkering operations.

4.4.2.2 Hazardous areas are also to include similar areas such as shore-based hydrogen refuelling stations or mobile hydrogen refuelling facilities. Depending on the risk assessment results and details of the bunkering process (equipment, transfer rate, and pressure), the extent of the hazardous areas may increase.

4.4.3 Safety zones

4.4.3.1 Deterministic methods and probabilistic methods are typically used to determine the extent of

① E.g., GB 50516-2010 Technical Code for Hydrogen Fuelling Station (2021 Edition), GB 50058-2014 Code for Design of Electrical Installations in Explosive Hazardous Atmospheres, etc.

safety zones. In addition, other areas where flammable gas may exist are also to be classified as safety zones based on the actual operational scenarios and conditions.

4.4.3.2 The deterministic method means that the safety zone is to be set according to the flammable gas dispersion range of the maximum credible leakage/release scenario, but specific requirements proposed by the state and competent authority are to be complied with.

4.4.3.3 The flammable gas dispersion range refers to the dispersion range where the gas/vapour reaches 50% of the lower explosion limit (LEL) in the atmosphere. For hydrogen, the lower explosion limit value of hydrogen in air is 4% (volume concentration).

4.4.3.4 The selection of the maximum credible leakage/release scenario is to include at least the following information:

(1) Physical properties of the released fuel;

(2) Climatic conditions at the bunkering site, such as wind speed, wind direction, humidity, and air temperature. The selected conditions are to reflect the flammable gas dispersion range under the most severe conditions; for wind speed selection, both the transport and dilution effects of wind force on hydrogen are to be considered.

(3) The roughness of the ground surface to which the vapour/gas/liquid leaks;

(4) Release rate, release direction, total inventory, evaporation rate, etc.

4.4.3.5 The safety zone is to consider the height of the released hydrogen and its dispersion height, for example, personnel may be located at vertical heights, cabins arranged several meters above the receiving ship's bunkering station, etc.

4.4.3.6 The setting of the safety zone is to consider the suppression or alteration of the dispersion path by large objects such as buildings and ships, cliffs, and terrain structures protruding from the ground. Where necessary, the shape and extent of the safety zone may be verified by fluid dynamics software.

4.4.3.7 The probabilistic method means using quantitative risk assessment to analyse representative potential release scenarios predicted to occur, thereby proposing the extent of the safety zone. This method is usually called the probabilistic method or risk-based method.

4.4.3.8 Unless otherwise proven by safety analysis or agreed by the port authority or competent authority, during bunkering operations, within the safety zone:

(1) Smoking is strictly prohibited;

(2) Open flames, non-explosion-proof mobile phones and cameras, and other non-intrinsically safe portable electrical equipment are strictly prohibited;

(3) Operation of cranes and other lifting facilities is strictly prohibited. Exceptions are made for lifting facility operations necessary for portable fuel tank swap;

(4) Vehicles unrelated to the bunkering operation are strictly prohibited from appearing in the safety zone;

(5) Other ships or aircraft (such as drones) are strictly prohibited from entering the safety zone;

(6) All possible ignition sources are to be eliminated;

(7) Only approved personnel are allowed to enter the safety zone.

4.4.4 Security zones

4.4.4.1 The security zone is to be established based on ship/port operations, and its establishment is to consider at least the following matters:

(1) Movement of other ships;

(2) Roadside traffic conditions, industrial installations, factories, and public facilities;

(3) Crane and other cargo handling equipment operations;

(4) Construction and maintenance operations;

(5) Radio communication activities.

4.4.4.2 The extent of the security zone is to be established with reference to the content of the risk assessment.

CHAPTER 5 OPERATING PROCEDURES

Section 1 GENERAL PROVISIONS

5.1.1 General requirements

5.1.1.1 The requirements of Sections 1 to 5 of this Chapter apply to bunkering compressed hydrogen fuel to compressed hydrogen fuel tanks.

5.1.1.2 Portable fuel tank swap is to comply with the requirements of Section 6 of this Chapter.

5.1.1.3 Bunkering compressed hydrogen fuel to metal alloy hydrogen storage fuel tanks is to comply with the requirements of Section 7 of this Chapter.

5.1.1.4 Liquefied hydrogen fuel bunkering is to comply with the requirements of Section 8 of this Chapter.

5.1.1.5 The typical operating procedures for the first hydrogen fuel bunkering by both the bunkering facility and the receiving ship are shown in Figure 5.1.1.5 of this Section.

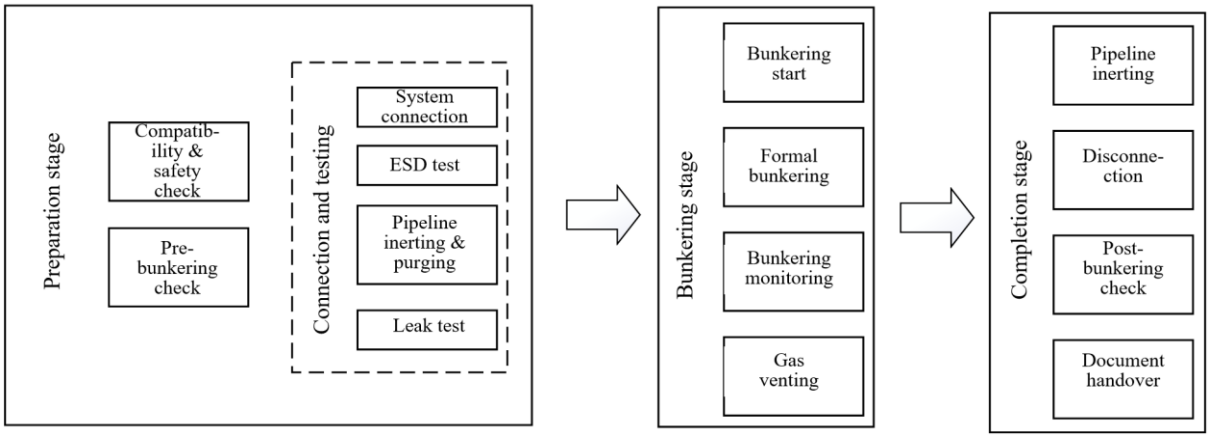


Figure 5.1.1.5 Typical Operating Procedures for Hydrogen Fuel Bunkering

5.1.1.6 The operating procedures may be adjusted according to the actual conditions of both the ship and shore, but are not to adversely affect the safety of bunkering operations.

Section 2 PREPARATION PHASE

5.2.1 General requirements

5.2.1.1 The preparation phase begins with the first bunkering communication between the receiving ship and the bunkering facility, and ends with the connection of the bunkering pipeline to the bunkering facility.

5.2.1.2 The preparation phase aims to prepare and complete the safe connection between the bunkering facility and the receiving ship.

5.2.1.3 The preparation phase is to confirm that the receiving ship and the bunkering party possess the bunkering conditions required in Chapter 1, Section 2 of the Guidelines.

5.2.1.4 The preparation phase is to confirm that personnel and equipment meet the requirements of the emergency response plan.

5.2.1.5 For the first bunkering before the receiving ship is put into operation, preparation procedures such as inerting and hydrogen purging of the hydrogen fuel tank or hydrogen cylinders are also to be considered.

5.2.2 Compatibility and safety checks

5.2.2.1 The following items are to be confirmed before each bunkering operation:

(1) Whether the bunkering operation in the port meets the relevant requirements of the port authority;

(2) Whether the emergency response plans of the competent authority, the bunkering party, and the receiving party are coordinated and consistent;

(3) Whether the risk control measure recommendations proposed through the risk assessment have been closed out;

(4) Whether the various items in the compatibility assessment have been verified (if applicable);

(5) Whether both bunkering parties have reached a consensus on the established bunkering operation procedures;

(6) Whether both bunkering parties have reached a consensus on the bunkering and vapour management plan (if applicable);

(7) Whether both bunkering parties have reached a consensus on the electrical insulation method;

(8) Whether an agreement has been reached on the division of operation safety distances;

(9) Whether the communication system is unobstructed and the communication language has been agreed upon;

(10) Whether the bunkering operation plan has been agreed upon and signed by both bunkering parties.

5.2.3 Pre-bunkering checks

5.2.3.1 Verifications and checks are to be carried out on requirements related to bunkering conditions, such as approval documents, predicted and actual meteorological conditions, personnel qualifications and responsibilities, and bunkering restrictions.

5.2.3.2 Bunkering to the receiving ship by mobile hydrogen refuelling facilities is also to meet the requirements of 1.2.8 of the Guidelines and all of the following:

(1) Auxiliary equipment or systems (such as parking systems) to prevent displacement of the mobile hydrogen refuelling facility during bunkering are to be safe and reliable;

(2) The mobile hydrogen refuelling facility is to be electrically earthed;

(3) After the hydrogen bunkering truck is parked and before all hydrogen refuelling operation procedures are completed, it is strictly prohibited to start the vehicle engine;

(4) It is to be checked whether a spark arrestor is installed at the exhaust pipe outlet of the hydrogen bunkering truck;

(5) The emergency response plan is to take into account the situation where multiple hydrogen bunkering trucks are present in the bunkering area simultaneously.

5.2.3.3 Pre-bunkering checks are to be carried out on systems such as hydrogen storage, hydrogen refuelling equipment, and safety protection in accordance with the applicable requirements of Chapters 2 and 3 of the Guidelines, to ensure that these equipment are in normal and immediately available conditions.

5.2.3.4 Before each bunkering, the bunkering facility and the receiving ship are to be checked in accordance with the bunkering preparation phase checklist in Appendix 2 of the Guidelines, and the checklist is to be signed and acknowledged by both bunkering parties.

Section 3 CONNECTION AND TESTING

5.3.1 General requirements

5.3.1.1 Operating personnel are to wear and use personal protective equipment and complete the release of human static electricity before carrying out bunkering operations.

5.3.1.2 The connection and testing of the bunkering system are intended to increase the reliability and safety of the connection between the two parties and to detect leakage points as early as possible, thereby reducing the consequences of hydrogen leakage accidents and the difficulty of leakage analysis and troubleshooting during the bunkering phase.

5.3.1.3 The discharge of hydrogen during inerting and hydrogen purging processes is to meet the requirements of 5.4.5 of this Chapter.

5.3.2 Bunkering system connection

5.3.2.1 Each pipeline connection in the bunkering system is to be earthed. Before the hose with the hydrogen bunkering nozzle is connected, it is not to contact any unearthed parts to avoid possible electric sparks.

5.3.2.2 Appropriate protection is to be provided for the bunkering hose and hydrogen bunkering nozzle to avoid mechanical or frictional damage during lifting and connection.

5.3.2.3 The bunkering hose is not to cross, bypass, or be wrapped around other equipment.

5.3.2.4 Before removing the protective cap and connecting the hydrogen bunkering nozzle to the receiving ship's hydrogen bunkering receptacle, it is to be confirmed that:

(1) The hydrogen dispenser is properly powered and in normal working condition after leakage diagnostics;

(2) The filling control valve of the receiving ship's hydrogen fuel bunkering station and the shore-side hydrogen bunkering pipeline control valve are both in the closed position;

(3) The working pressure and dimensions of the hydrogen bunkering nozzle and the receiving ship's hydrogen bunkering receptacle are compatible with each other.

5.3.2.5 For communication bunkering where there is data exchange between the hydrogen dispenser and the receiving ship's hydrogen storage system, the following conditions are also to be confirmed:

(1) Effective communication conditions are available;

(2) The receiving ship's hydrogen storage system has not issued a termination signal;

(3) After considering the influence of sensor and system calculation deviations, the initial pressure of the receiving ship's hydrogen storage system transmitted by communication is consistent with the measured initial pressure.

5.3.2.6 When connecting the hydrogen bunkering nozzle to the receiving ship's hydrogen bunkering receptacle, the contact surfaces of the connector are to be kept free of contamination and debris.

5.3.2.7 The hydrogen bunkering nozzle and the receiving ship's hydrogen bunkering receptacle are to be correctly connected in accordance with the product manual requirements, and the connection is to be secure and reliable.

5.3.2.8 After the connection is completed, the hose lifting device or support is to be secured near the receiving ship's bunkering station via an emergency release device to prevent the hose from exceeding its allowable range of movement. An earthing test for the static electricity connection is to be carried out after connection.

5.3.3 ESD connection testing

5.3.3.1 The length of the ESD connection line is to be considered based on factors such as the ship-to-shore distance, height difference, normal drift and floating state of the ship, and water level changes.

5.3.3.2 The ESD system between the bunkering facility and the receiving ship is to be correctly connected in accordance with the requirements of 2.4.1.3 of the Guidelines.

5.3.3.3 After the bunkering system connection and ESD system association are completed between the receiving ship and the bunkering facility, manual functional and automatic functional tests are to be carried out on the ESD system connection of both parties to verify the effectiveness, compatibility, reliability, and availability of the ESD connection used for hydrogen fuel bunkering.

5.3.3.4 The ESD signals issued by either the receiving ship or the bunkering facility are to be tested separately, and both are to be safely shut down within the set time. Before the test, both the receiving ship and the bunkering facility are to be informed and their consent obtained.

5.3.4 Inerting and leakage testing of bunkering pipelines

5.3.4.1 After the bunkering system piping is connected, if the oxygen volume concentration in the pipe is less than or equal to 0.5% (two consecutive sampling analyses are qualified or other confirmation methods), the inerting operation may not be carried out; otherwise, the bunkering pipeline is to be inerted. If the hydrogen fuel supply pipeline is part of the bunkering pipeline, this part of the pipeline is also to be inerted. For shore-based refuelling stations, except for the first bunkering or bunkering after a long period of non-use, after the bunkering system piping is connected, the inerting operation of the pipeline between the hydrogen refuelling station and the hydrogen bunkering nozzle may not be carried out.

5.3.4.2 Bunkering pipelines requiring inerting and hydrogen purging are to be reliably isolated from systems not participating in the bunkering operation, and notice boards with obvious warning signs are to be set up at the isolation devices.

5.3.4.3 The bunkering pipeline may be inerted by filling it with an inert gas (such as nitrogen) and then discharging it, and repeating this multiple times, subject to the following requirements:

(1) The oxygen volume concentration in the inert gas is not to exceed 0.5%;

(2) The inert gas pressure is to be not less than 0.2 MPa and less than the working pressure of the pipeline section;

(3) Inerting is to be thorough to prevent residual oxygen at dead ends;

(4) After inerting, the oxygen content in the bunkering pipeline is to be analysed and qualified at least twice consecutively, i.e., the oxygen volume concentration in the bunkering pipeline is less than or equal to 0.5%, or the inerting is completed after repeating the filling and discharging of inert gas 4 times and passing the oxygen analysis.

5.3.4.4 Before bunkering hydrogen fuel to the receiving ship, if it is impossible to determine or prove that there is no leakage in the bunkering pipeline, an inert gas is to be used for leakage testing to check the leakage of the bunkering pipeline. Locations with a higher risk of leakage include welds and pipeline connections, valves and their joints, hydrogen bunkering nozzle and hydrogen bunkering receptacle connections, instrument connections, and breakaway couplings.

5.3.4.5 The test pressure of the inert gas used for the leakage test may be determined based on actual test conditions under the premise of ensuring safety. It is to be maintained at the test pressure for at least 5 min. It is judged as qualified when no leakage is detected and no pressure drop occurs.

5.3.4.6 After the bunkering pipeline passes the leakage test, the nitrogen pressure in the pipe is to be maintained at a safe value not less than 0.2 MPa and less than the working pressure of the pipeline section.

5.3.5 Hydrogen fuel purging

5.3.5.1 After meeting the inerting requirements, hydrogen is required to purge the nitrogen by hydrogen in the bunkering pipeline to remove the nitrogen. If the impact of the residual nitrogen in the bunkering pipe on the receiving ship is within an acceptable range, the bunkering party and the receiving party may, after negotiation, not carry out this hydrogen purging operation.

5.3.5.2 The nitrogen in the bunkering pipeline may be purged by filling the pipeline with high-pressure hydrogen and then discharging it, and repeating this multiple times (the number of hydrogen purging cycles depends on factors such as the pressure of the filled hydrogen and the pressure of the nitrogen in the purged pipe).

Section 4 BUNKERING PHASE

5.4.1 General requirements

5.4.1.1 The bunkering phase begins with the completion of inerting and hydrogen purging by the bunkering facility and the receiving ship and the opening of the bunkering control valve and hydrogen bunkering nozzle handle, and ends with the completion of the bunkering phase and the closing of the bunkering control valve.

5.4.1.2 The bunkering phase mainly includes the following main operations: bunkering start-up, formal bunkering, and bunkering process monitoring.

5.4.1.3 This Section applies to the bunkering phase of typical bunkering operations. If the actual operation is different, it is to be ensured that all necessary operations are equivalent to the relevant requirements of this Section.

5.4.1.4 The main process of the bunkering phase and the trend of bunkering pressure changes are shown in Figure 5.4.1.4 of this Section.

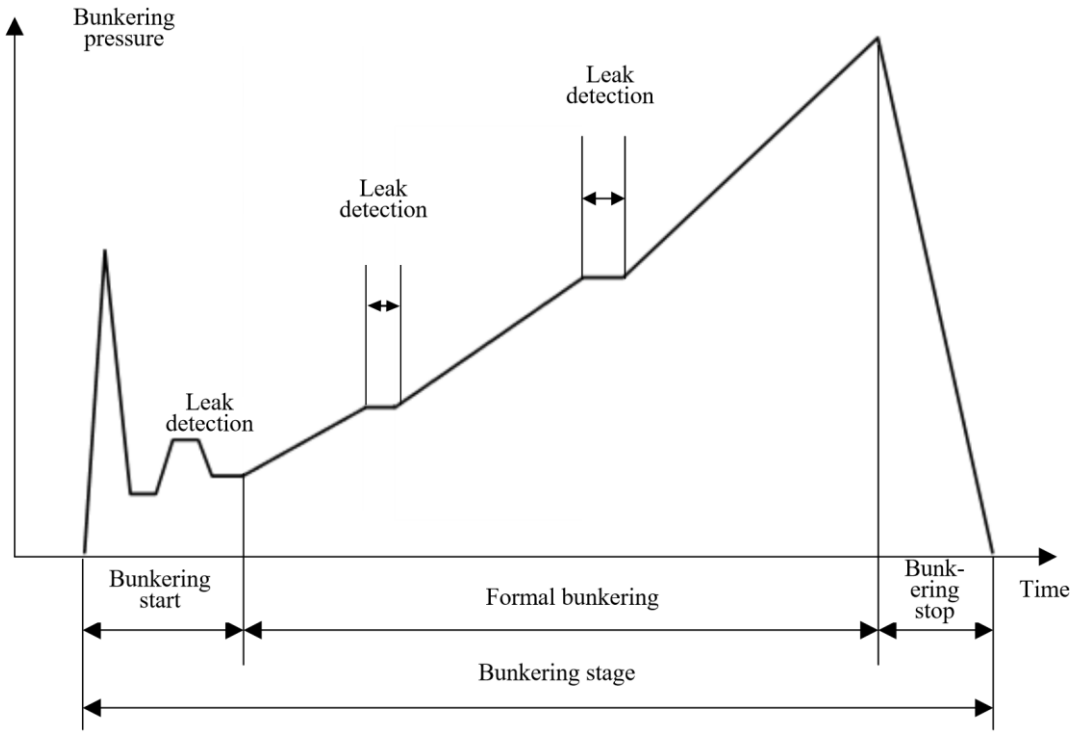


Figure 5.4.1.4 Schematic Diagram of the Hydrogen Refuelling Process

5.4.2 Bunkering start-up

5.4.2.1 Bunkering start-up mainly includes processes such as initial tightness check, initial pressure measurement of the ship's hydrogen storage system, and volume measurement.

5.4.2.2 After confirming that all bunkering control valves between the receiving ship's hydrogen bunkering receptacle and the hydrogen storage container cylinder valve are open, and other hydrogen system control valves (including bunkering pipeline vent valves) other than the bunkering control valve are reliably closed, both bunkering parties may issue a ready signal through the agreed communication method.

5.4.2.3 When non-operating personnel have evacuated outside the bunkering equipment operation area and the ready signal has been given, the operator may open the hydrogen inlet valve of the hydrogen dispenser.

5.4.2.4 The hydrogen dispenser may only be started after parameters such as the bunkering temperature, communication, ambient temperature, and initial pressure of the receiving ship's hydrogen fuel tank meet the bunkering conditions.

5.4.2.5 At least one leakage detection is to be carried out during the bunkering start-up process. The

hydrogen dispenser is to bunker a small amount of hydrogen to the receiving ship's hydrogen storage system and then stop bunkering. After 5s, the pipeline pressure change is to be checked. If a rapid pressure drop is detected or leakage is suspected, bunkering is to be stopped.

5.4.3 Formal bunkering

5.4.3.1 After the initial tightness detection confirms that there is no leakage in the bunkering pipeline and the receiving ship's hydrogen storage system, the formal bunkering process may begin.

5.4.3.2 During the formal bunkering process, operators are not to operate the hydrogen bunkering nozzle at will and are not to leave the receiving ship's bunkering station without authorisation.

5.4.3.3 In the 35 MPa bunkering process, when the hydrogen bunkering receptacle pressure reaches 10 MPa, 20 MPa, and 30 MPa, a leakage detection is to be carried out respectively. In the 70 MPa bunkering process, when the hydrogen bunkering receptacle pressure reaches 20 MPa, 40 MPa, and 60 MPa, a leakage detection① is to be carried out respectively. The leakage detection pressure and frequency may also be increased according to actual conditions. For bunkering at a shore-based hydrogen refuelling station, if the receiving ship and the bunkering connection have not changed, leakage detection may not be carried out during each bunkering process, but regular leakage detection is to be carried out in combination with actual operating conditions to confirm that the equipment and bunkering connection are in good condition.

5.4.3.4 In bunkering processes at other pressures, leakage detection is to be carried out with reference to the requirements of 5.4.3.3 of this Section, except for working conditions where the pressure is greater than the maximum bunkering pressure.

5.4.3.5 Bunkering monitoring is to be carried out in accordance with the requirements of 5.4.4 of this Section. In the event of an abnormal situation, the ESD is to be triggered manually or automatically and the bunkering operation is to be stopped immediately. Bunkering can only be restarted after the inspection is completed and the corresponding risks are eliminated. Abnormal situations include, but are not limited to:

(1) Gas detection alarm (gas concentration higher than 40% of the lower explosion limit) or fire detection alarm in the receiving ship's bunkering area;

(2) Gas detection alarm near the hydrogen dispenser (gas concentration higher than 40% of the lower explosion limit);

(3) High temperature alarm (alarm temperature threshold set not higher than 85°C) and high pressure alarm issued by the hydrogen fuel tank or hydrogen cylinder;

(4) Ventilation failure or gas detection alarm (gas concentration higher than 40% of the lower explosion limit) in the hydrogen fuel tank connection space or hydrogen fuel tank space;

(5) Ventilation failure or gas detection alarm (gas concentration higher than 40% of the lower explosion limit) issued by the outer ventilation duct of the bunkering pipeline;

(6) Alarm from the receiving ship's fire detection system;

(7) Ambient temperature below -40°C or above 50°C;

(8) Hydrogen fuel temperature of the bunkering facility exceeds the pre-cooling temperature;

① The criteria for determination are to refer to the applicable requirements of relevant standards such as GB/T 42626-2023 Periodic Inspection and Evaluation of Fully-wrapped Fiber Reinforced Compressed Hydrogen Gas Cylinders for Vehicles.

(9) Hydrogen pressure reaches 1.1 times the working pressure of the receiving ship's hydrogen cylinders;

(10) The flow rate or flow velocity of hydrogen bunkering exceeds the limit required by the bunkering party.

5.4.4 Bunkering process monitoring

5.4.4.1 During formal bunkering, bunkering operation personnel from both the bunkering facility and the receiving ship are to continuously monitor parameters related to the bunkering operation and the operating status of the equipment, and are to include at least the following monitoring items:

(1) Hydrogen fuel bunkering pressure;

(2) Hydrogen fuel bunkering flow rate;

(3) Hydrogen fuel temperature;

(4) Pressure and temperature of the receiving ship's hydrogen fuel storage system;

(5) Gas detection and fire detection alarm systems in spaces related to the receiving ship's hydrogen fuel storage and bunkering (such as hydrogen fuel tank spaces and bunkering stations);

(6) Operating status of the ventilation system in spaces related to the receiving ship's hydrogen fuel storage and bunkering;

(7) Leakage of valves and pipelines in the bunkering system;

(8) Operating status of equipment such as hydrogen dispensers/hydrogen bunkering devices in the bunkering connecting equipment area;

(9) Factors such as ship movement, tides, and currents.

5.4.5 Gas discharge management

5.4.5.1 Gas discharge management includes the discharge of gas during inerting, hydrogen purging, and bunkering.

5.4.5.2 It is to be ensured that the gas discharged during the inerting and hydrogen purging processes does not cause the vent mast outlet of the receiving ship to be located within the activity range of the bunkering facility operators and in areas where ignition sources exist. Otherwise, other measures that can ensure the safe discharge of hydrogen are to be taken.

5.4.5.3 During the bunkering process, the pressure and temperature in the receiving ship's hydrogen fuel tank are to be monitored in real time to prevent the safety relief device from activating.

5.4.5.4 Gas discharge management is to consider the type of hydrogen fuel tank, operating conditions, and equipment manufacturer requirements.

Section 5 COMPLETION PHASE

5.5.1 General requirements

5.5.1.1 The completion phase begins with the completion of bunkering and the closing of the hydrogen fuel bunkering control valve, and ends with the safe disconnection of the receiving ship and the bunkering facility and the completion of signing all relevant documents.

5.5.1.2 When the receiving ship's hydrogen fuel tank reaches the target pressure, and the receiving ship or the bunkering facility issues a stop bunkering signal, bunkering is to be stopped immediately and the hydrogen dispenser bunkering control valve is to be closed.

5.5.1.3 No hydrogen leakage is to occur during the safe disconnection of the bunkering facility's hydrogen bunkering nozzle from the receiving ship's hydrogen bunkering receptacle.

5.5.2 Inerting of bunkering pipeline

5.5.2.1 After bunkering is completed, to avoid the potential hazard of residual flammable gas in the pipeline, the bunkering pipeline is to be subjected to hydrogen venting and inerting before closing all bunkering control valves and removing the hydrogen bunkering nozzle from the receiving ship's hydrogen bunkering receptacle. The specific steps are as follows:

(1) Discharge the high-pressure hydrogen in the bunkering pipeline until the pressure in the pipe drops to 0.2 MPa, and then close the bunkering pipeline vent control valve;

(2) Inert the bunkering pipeline in accordance with the requirements of 5.3.4.3 (1) and (2) of this Chapter. After inerting is completed, detection is to be carried out at the bunkering manifolds of both parties to confirm that the volume concentration of hydrogen does not exceed 0.2%; otherwise, a second inerting operation is to be carried out until it meets the requirements.

5.5.2.2 After the inerting of the bunkering pipeline is completed, the inert gas in the pipeline is to be safely vented until the inert gas pressure in the pipe is reduced to a safe value not less than 0.2 MPa and less than the working pressure of the pipeline section.

5.5.2.3 The above inerting operation may be operated in the control room through a remote control system.

5.5.2.4 The receiving ship meeting the requirements of 5.5.3.4 of this Section may carry out the inerting operation of the bunkering pipeline after safely removing the hydrogen bunkering nozzle. Pipelines shared by the receiving ship's hydrogen fuel supply pipeline and the bunkering pipeline may not be inerted, but the impact of not inerting is to be evaluated.

5.5.3 Disconnection of hydrogen bunkering nozzle and hydrogen bunkering receptacle

5.5.3.1 After confirming compliance with the post-bunkering checklist in Appendix 2 of the Guidelines, the operator is to slowly turn the handle to the closed position. After the internal pressure of the hydrogen bunkering nozzle connection port is fully released and it is determined that there is no ignition source around, the hydrogen bunkering nozzle and the receiving ship's hydrogen bunkering receptacle are to be disconnected. Operators are also to pay attention to the possible gas pressure at the pipeline connection during the operation to avoid potential injuries.

5.5.3.2 After confirming that the bunkering hose can be freely moved from the receiving ship to the bunkering facility, the bunkering hose is to be removed from the support and protection facilities, and the hose is to be placed or secured in the specified storage position. After covering the hydrogen bunkering nozzle with the protective cap or cover, it is to be firmly secured on a dedicated bracket.

5.5.3.3 There are not to be any sharp-edged objects in the bunkering hose operation area.

5.5.3.4 If the bunkering system meets all of the following conditions, the hydrogen bunkering nozzle may be removed from the hydrogen bunkering receptacle before the inerting of the bunkering pipeline in accordance with the hydrogen bunkering nozzle operating instructions:

(1) Both the ship and shore parties and the hydrogen bunkering nozzle and hydrogen bunkering receptacle suppliers permit disconnection when low-pressure (less than 1 MPa) hydrogen is present inside;

(2) Relevant documents (such as test data), tests, or proven experience can demonstrate that the hydrogen bunkering nozzle and hydrogen bunkering receptacle will not leak hydrogen during the disconnection process, and the internal pressurised hydrogen will not cause harm to operators;

(3) There are to be no ignition sources (such as electrical ignition sources, thermal ignition sources, mechanical ignition sources) near the receiving ship's bunkering station, and only the hydrogen bunkering nozzle operators of both the ship and shore parties are present in the operation area of the receiving ship's bunkering station.

5.5.4 Post-bunkering checks

5.5.4.1 After the venting and inerting of the bunkering pipeline are completed, the control valves of the bunkering pipelines of both parties are to be closed, and the remote control valves are to be closed first.

5.5.4.2 The pipelines and related instruments of the receiving ship's bunkering station are to be inspected for abnormalities such as leakage.

5.5.4.3 A visual inspection of the hydrogen storage containers, valves, pressure gauges, and bunkering pipelines in the receiving ship's hydrogen fuel tank spaces is to be carried out to check for abnormalities such as leakage.

5.5.4.4 The hydrogen temperature in the receiving ship's hydrogen fuel tank is to be re-checked.

5.5.4.5 Both bunkering parties are required to fill in the post-bunkering checklist after the bunkering operation is completed, and each party is to sign and retain it. See the post-bunkering checklist in Appendix 2 of the Guidelines for details.

5.5.5 Cable and communication disconnection

5.5.5.1 If there is a wired communication connection between the two parties, it is to be disconnected and then retracted after bunkering is completed.

5.5.5.2 The bonding cable is to be disconnected after bunkering is completed.

5.5.6 Documentation handover

5.5.6.1 The bunkering party is to fill in the Bunker Delivery Note (in duplicate), clearly stating the quantity and quality of the bunkered hydrogen fuel, and then sign it by the responsible person for confirmation and deliver it to the receiving party. Both documents need to be signed and confirmed by the person in charge of the receiving ship, with one copy kept on the receiving ship and the other returned to the bunkering party. The Bunker Delivery Note is to include at least the content specified for the hydrogen fuel Bunker Delivery Note in Appendix 3 of the Guidelines.

5.5.6.2 For dedicated shore-based hydrogen refuelling stations used only for specific receiving ships,

the content and form of the Bunker Delivery Note may be determined according to actual conditions.

Section 6 PORTABLE FUEL TANK SWAP OPERATING PROCEDURES

5.6.1 General requirements

5.6.1.1 Except as otherwise provided in this Section, the requirements of other subsections of this Chapter do not apply to portable fuel tank swap.

5.6.1.2 A risk assessment is to be carried out and a procedural document is to be developed for the method of bringing the portable fuel tank on board the ship, such as lifting, trailer installation, and other operations, and this is to be included in the fuel operations manual.

5.6.1.3 Horizontal transport machinery entering the operation site is to be equipped with a spark arrestor, and is to be evacuated from the operation site promptly after the operation is completed.

5.6.1.4 When disassembling and installing the portable fuel tank, explosion-proof electrical equipment and tools that do not generate sparks by friction are to be used.

5.6.1.5 If lightning, thunderstorms, or a nearby fire occur during the operation, the operation is to be stopped immediately, and the portable fuel tank is to be properly handled.

5.6.2 Preparation phase

5.6.2.1 Confirm that the receiving ship and the bunkering party possess the bunkering conditions required in Chapter 1, Section 2 of the Guidelines.

5.6.2.2 Confirm that personnel and equipment meet the requirements of the emergency response plan.

5.6.2.3 Carry out a visual inspection of the portable fuel tanks on the ship and at the terminal to confirm that the tank body and its connecting accessories are intact.

5.6.2.4 Confirm that all hydrogen supply systems connected to the portable fuel tank to be replaced on the ship are completely shut off.

5.6.2.5 Checks are to be carried out in accordance with the pre-tank swap checklist in Appendix 2 of the Guidelines, and the checklist is to be signed and acknowledged by both the bunkering party and the receiving party.

5.6.3 Disassembly operations

5.6.3.1 Before disassembling the portable fuel tank connection system, it is to be checked whether the fuel tank is in good condition, and it is to be ensured that the fuel tank to be removed is not involved in any fuel supply and that all valves connected to the ship's fixed devices are closed.

5.6.3.2 Purge the hydrogen connection pipeline with inert gas to prevent hydrogen leakage during the disassembly process. The purging of inert gas is to meet the requirements of 5.5.2.1 (2) of this Chapter. For portable liquefied hydrogen fuel tank swap, if there is a possibility that the inert gas will solidify or condense due to excessively low temperature in the hydrogen connection pipeline, hydrogen is to be used to purge and

warm the connection pipeline before the inert gas purging.

5.6.3.3 Cut off the connecting valves, unplug the explosion-proof electrical plugs, disconnect all connections between the portable fuel tank and the ship's fixed system, and remove the fuel tank securing devices. The removed devices are to be collected in containers provided by the ship or at designated storage areas. Check whether all connecting devices and securing devices have been released.

5.6.4 Lifting operations

5.6.4.1 If a cold box is provided, before the portable fuel tank is lifted, it is to be confirmed that all equipment and pipelines in the cold box of the tank container are in an inerted state.

5.6.4.2 Before the lifting operation, the lifting device is to be subjected to no-load operation, heavy-load slight lifting and braking tests to confirm that the machinery is in good technical condition.

5.6.4.3 When non-operating personnel have evacuated outside the tank swap operation area and are ready, the lifting operation may begin.

5.6.4.4 Lift the portable fuel tank vertically and check whether the fuel tank is dragged on the ground or on the top of the lower tier container.

5.6.4.5 After lifting the portable fuel tank a certain distance (usually about 300 mm) from the support surface, the lifting is to be paused to check the connection between the lifting gear and the fuel tank. The operation may continue only after an automated indicating device or visual confirmation confirms that the connection is secure.

5.6.4.6 Lift the portable fuel tank to a sufficient height, and pay attention to the surrounding operating environment to strictly prevent collision with the lower tier or adjacent portable fuel tanks and other obstacles.

5.6.4.7 When the portable fuel tank is in position, it is to be placed gently and landed smoothly. The fuel tank is not to be placed outside the vertical landing point by swinging the lifting gear. The lifted portable fuel tank is not to be left hanging in the air waiting.

5.6.4.8 Lifting and unloading operations are generally to be carried out position by position and layer by layer from the land side to the sea side, and loading operations are generally to be carried out position by position and layer by layer from the sea side to the land side, placed according to the loading plan.

5.6.4.9 The ship is to be properly moored to prevent excessive swaying during the lifting of the portable fuel tank.

5.6.4.10 During the lifting operation, the hull is to be kept balanced, and the trim and list angles of the ship are not to exceed the ship's allowable inclination angle of 3°.

5.6.4.11 In the event of unclear visibility during the lifting operation, or when the connection between the lifting gear and the portable fuel tank requires manual cooperation, a dedicated person is to direct the operation.

5.6.4.12 The lifting and loading/unloading of portable fuel tanks are also to meet the requirements of relevant standards① for container handling and port container operations.

① E.g., GB/T 17382-2023 Series 1 freight containers - Handling and securing, GB 16994.4-2023 Safety Requirements for Port Operation — Part 4: General Cargo Containers, etc.

5.6.5 Securing operations

5.6.5.1 After the portable fuel tank is lifted to the designated position on the ship, it is to be checked whether the fuel tank and its valves and accessories are damaged or leaking to ensure that the fuel tank is in good condition.

5.6.5.2 The bottommost portable fuel tank is to be securely fastened to the ship's deck. If there is stacking, the upper fuel tanks are also to be securely fastened to the lower fuel tanks. At the same time, the securing method is not to cause damage to the fuel tanks.

5.6.6 Connection operations

5.6.6.1 Before the portable fuel tank is connected to the ship's fuel system, the temperature and pressure in the tank are to be verified to ensure that the fuel tank is not damaged.

5.6.6.2 Connect the hydrogen connector, hose, and explosion-proof electrical plug to achieve the connection of the hydrogen supply system, venting system, and safety system between the portable fuel tank and the ship's fixed devices. Tests are to be carried out to ensure the effectiveness of the electrical plug connection of the safety system, and the test results may be determined through the monitoring data of the ship's monitoring platform.

5.6.6.3 Operations are to be carried out cautiously during the connection process, and any damage or leakage found is to be reported immediately.

5.6.7 Post-connection checks

5.6.7.1 The pipelines and related instruments of the portable fuel tank are to be inspected for abnormalities such as leakage.

5.6.7.2 Before the portable fuel tank is put into use, a tightness test is to be carried out on the pipeline system between the fuel tank and the ship's hydrogen supply system. Helium or a mixture of 5% hydrogen and 95% nitrogen is to be used as the test medium for the tightness test. For portable liquefied hydrogen fuel tanks, if a mixed gas is used as the test medium, nitrogen in the pipeline system is to be purged with hydrogen after the tightness test is completed.

5.6.7.3 Both bunkering parties are required to fill in the post-tank swap checklist after the tank swap operation is completed, and each party is to sign and retain it. See the post-tank swap checklist in Appendix 2 of the Guidelines for details.

5.6.7.4 The bunkering party is to fill in the Bunker Delivery Note (in duplicate), clearly stating the quantity and quality of the bunkered hydrogen fuel, and then sign it by the responsible person for confirmation and deliver it to the receiving party. Both documents need to be signed and confirmed by the person in charge of the receiving ship, with one copy kept on the receiving ship and the other returned to the bunkering party. The Bunker Delivery Note is to include at least the content specified for the portable fuel tank swap delivery note in Appendix 3 of the Guidelines.

Section 7 OPERATING PROCEDURES FOR BUNKERING COMPRESSED HYDROGEN FUEL TO METAL ALLOY HYDROGEN STORAGE FUEL TANKS

5.7.1 General requirements

5.7.1.1 Except for 5.4.1.4, 5.4.3.3, 5.4.3.4, 5.4.3.5, and 5.4.4.1 of this Chapter, the requirements of Sections 1 to 5 of this Chapter apply to bunkering compressed hydrogen fuel to metal alloy hydrogen storage fuel tanks.

5.7.2 Bunkering phase

5.7.2.1 In addition to the applicable requirements of Section 4 of this Chapter, the bunkering of compressed hydrogen fuel to metal alloy hydrogen storage fuel tanks during the bunkering phase is also to meet the requirements of 5.7.2.2 to 5.7.2.12 of this Section.

5.7.2.2 When carrying out the inert gas medium leakage test required by 5.3.4.4 of this Chapter, the test pressure is to be as close as possible to the maximum bunkering pressure.

5.7.2.3 Before bunkering hydrogen fuel, it is to be confirmed that parameters such as the temperature and flow rate of the cooling medium in the cooling system meet the requirements of the bunkering conditions, and the temperature and flow rate of the cooling medium are to be appropriately adjusted according to the bunkering rate requirements.

5.7.2.4 Before bunkering hydrogen fuel, check the pressure and temperature of the bunkering tank, hydrogen dispenser, metal alloy hydrogen storage fuel tank, and its cooling system.

5.7.2.5 For the first bunkering, appropriate measures (such as vacuuming) are to be taken before bunkering hydrogen fuel to prevent residual impurity gases in the pipeline from poisoning the metal alloy.

5.7.2.6 After converting the hydrogen into a state that meets the pressure and temperature requirements, the set hydrogen mass flow control value is to be checked again before delivering the compressed hydrogen fuel to the metal alloy hydrogen storage fuel tank.

5.7.2.7 The opening of the bunkering valve and the filling interface valve of the metal alloy hydrogen storage fuel tank is to be carried out slowly, and attention is to be paid to listening for abnormal noises in the device. The bunkering operation is to be performed in accordance with the requirements of the bunkering party.

5.7.2.8 If nitrogen is used as the medium for the inert gas test in 5.7.2.2 of this Section, hydrogen leakage detection is to be carried out during the bunkering process. The pressure and frequency of the leakage detection are to be determined in combination with actual conditions such as the bunkering duration and bunkering pressure.

5.7.2.9 During the bunkering process, the internal temperature of the metal alloy hydrogen storage fuel tank is to be maintained within the suitable bunkering temperature range required by the manufacturer, and the surface temperature of the metal alloy hydrogen storage fuel tank is to be monitored. The inlet and outlet

temperatures of the cooling medium in the cooling system are to be maintained within the set temperature range. When the temperature is too high, the cooling system is to be automatically adjusted for cooling.

5.7.2.10 During the bunkering process, continuously monitor the pressure in the metal alloy hydrogen storage fuel tank. When the pressure approaches the preset target value, the bunkering flow rate is to be gradually reduced. After the pressure stabilises at the termination set value, the hydrogen delivery is to be ended immediately. The preset target value and termination set value of the pressure are to be specified in the bunkering agreement.

5.7.2.11 Bunkering monitoring is to be carried out in accordance with the requirements of 5.7.2.12 of this Section. In the event of the following abnormal situations, the ESD is to be triggered manually or automatically and the bunkering operation is to be stopped immediately, and bunkering can only be restarted after the inspection is completed and the corresponding risks are eliminated. Abnormal situations include, but are not limited to:

(1) Gas detection or fire detection alarm in the receiving ship's bunkering area;

(2) Gas detection alarm near the hydrogen dispenser;

(3) High temperature or high pressure alarm issued by the metal alloy hydrogen storage fuel tank;

(4) Ventilation failure or gas detection alarm in the hydrogen fuel tank connection space or hydrogen fuel tank space;

(5) A ventilation failure or gas detection alarm is triggered in the outer ventilation duct of the bunkering pipeline;

(6) The fire detection system of the receiving ship gives an alarm;

(7) The ambient temperature in the space where the metal alloy hydrogen storage fuel tank is located is below -40°C or above 65°C;

(8) The hydrogen fuel temperature of the bunkering facility exceeds the pre-cooling temperature (if applicable);

(9) The bunkering pressure exceeds the range allowed by the manufacturer;

(10) The bunkering flow rate exceeds the range allowed by the manufacturer.

5.7.2.12 During the bunkering process, the bunkering operation personnel of both the bunkering facility and the receiving ship are to continuously monitor the parameters related to the bunkering operation and the operating status of the equipment, and at least the following monitoring items are to be included:

(1) Hydrogen fuel bunkering pressure;

(2) Hydrogen fuel bunkering flow rate;

(3) Cumulative bunkering quantity of hydrogen fuel;

(4) Hydrogen fuel temperature;

(5) Pressure and temperature of the receiving ship's metal alloy hydrogen storage fuel tank;

(6) Gas detection and fire detection alarm systems in spaces related to the receiving ship's hydrogen fuel storage and bunkering (such as hydrogen areas);

(7) Leakage of valves and pipelines in the bunkering system;

(8) Operating status of equipment in the bunkering connection equipment area;

(9) Leakage of valves and pipelines of the cooling system;

(10) Pressure, temperature, and flow rate of the cooling medium;

(11) Factors such as ship movement, tide, and current.

5.7.3 Cooling system disconnection

5.7.3.1 After the bunkering operation is completed, the cooling medium in the receiving ship's hydrogen storage system and the external cooling system is to be drained.

5.7.3.2 After the cooling medium in the receiving ship's hydrogen storage system is drained, the connection between the heat exchange pipeline of the hydrogen storage system and the external cooling medium pipeline is to be disconnected.

Section 8 LIQUEFIED HYDROGEN FUEL BUNKERING OPERATING PROCEDURES

5.8.1 General requirements

5.8.1.1 Except for 5.2.1.5, 5.4.1.1, 5.4.1.4, 5.4.2 to 5.4.5, 5.5.1, 5.5.2, and 5.5.3.4 of this Chapter, the requirements of Sections 2 to 5 of this Chapter apply to liquefied hydrogen fuel bunkering.

5.8.1.2 The typical operating procedures for ship liquefied hydrogen fuel bunkering are shown in Figure 5.8.1.2 of this Section.

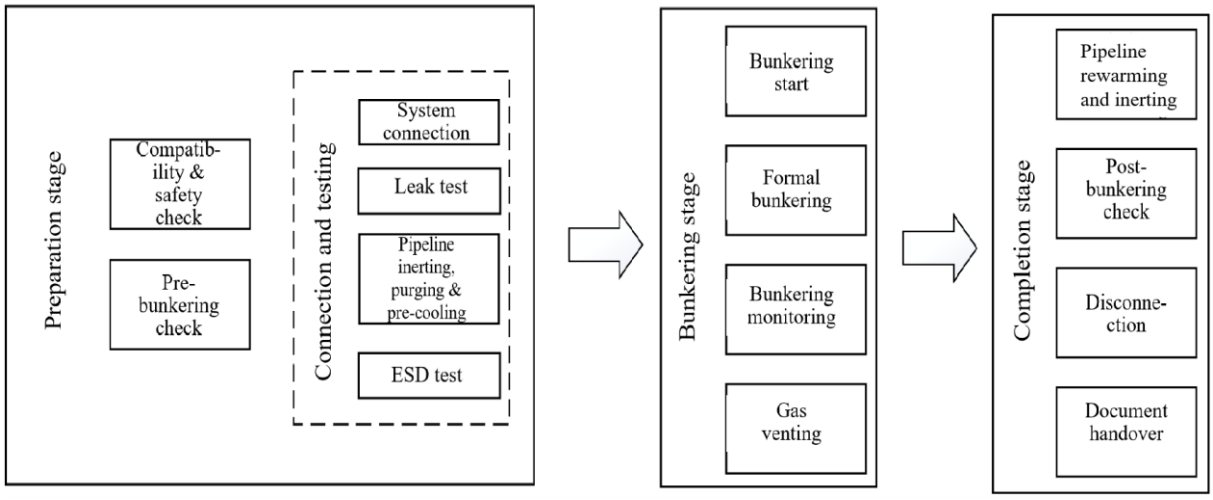


Figure 5.8.1.2 Typical Operating Procedures for Liquefied Hydrogen Fuel Bunkering

5.8.1.3 The operating procedures in this Section apply to the daily liquefied hydrogen fuel bunkering of receiving ships. The first bunkering of a receiving ship also requires consideration of preparation procedures such as drying, inerting, hydrogen purging, and pre-cooling of the fuel tank.

5.8.2 Preparation phase

5.8.2.1 Before each bunkering operation, it is necessary to confirm whether the cryogenic protection systems are compatible, such as the water curtain and hose saddle.

5.8.3 Bunkering system connection

5.8.3.1 Every pipeline connection in the bunkering system is to be earthed. The receiving ship is to be equipped with an insulating flange at the connection to avoid stray currents causing a fire. Hoses with connectors are not to come into contact with any unearthed part before they are connected, to avoid possible electric sparks.

5.8.3.2 When arranging the bunkering hose, appropriate support is to be provided to maintain the minimum allowable bending radius and avoid exceeding the bending limit of the hose. No part of the hose is to come into contact with the deck. If the arrangement is indeed difficult, appropriate protective measures may be provided to prevent the low temperature of the hose from causing cryogenic damage to the deck during bunkering. The hose arrangement design is to leave sufficient margin to avoid damage caused by displacement between the bunkering facility and the receiving ship.

5.8.4 Inerting and hydrogen purging of bunkering pipelines of the bunkering facility

5.8.4.1 After the connection of the bunkering system pipeline is completed, before the bunkering operation, a suitable inert gas (such as helium) is to be used to dry and inert the bunkering pipeline to remove possible air and moisture in the pipeline.

5.8.4.2 If nitrogen is used as the inert gas, after meeting the inerting requirements, normal-temperature hydrogen is to be used to purge the nitrogen in the bunkering pipeline to remove the nitrogen from the bunkering pipeline.

5.8.4.3 When carrying out the inert gas medium leakage test required by 5.3.4.4 of this Chapter, the test pressure is to be as close as possible to the maximum bunkering pressure.

5.8.4.4 During the hydrogen purging process, the venting of hydrogen is to meet the relevant requirements of the competent authority.

5.8.4.5 When helium is used as the inert gas, if the influence of the helium retained in the bunkering pipeline on the receiving ship is within an acceptable range, the bunkering party and the receiving party may, after negotiation, not carry out this hydrogen purging operation.

5.8.4.6 After hydrogen purging, hydrogen leakage detection is to be carried out on the bunkering pipeline and connections.

5.8.5 Pre-cooling of bunkering pipelines of the bunkering facility

5.8.5.1 To prevent the pipeline, bunkering pumps, and flow meters from being subjected to cold stress and generating a large amount of boil-off gas, the bunkering pipeline is to be pre-cooled.

5.8.5.2 In the initial stage of pre-cooling, a small flow of low-temperature hydrogen is to be used to purge and pre-cool the connecting pipelines and valves. The purging time is not to be less than 7 minutes, and frosting is to be minimised during the purging process. After the hydrogen purging is completed,

liquefied hydrogen is to be used for pre-cooling, and the pre-cooling time is not to be less than 3 minutes. The temperature reached by pre-cooling is not to be higher than 25 K.

5.8.5.3 During the pre-cooling process, the pipeline temperature is to be monitored in real-time. If the pipeline experiences a rapid temperature drop or non-uniform contraction, the pre-cooling rate is to be reduced immediately or pre-cooling is to be stopped.

5.8.6 ERS testing

5.8.6.1 The ERS control signals and actuators are to be inspected and tested, and maintained readily available.

5.8.6.2 A visual inspection of the dry breakaway coupling is to be carried out to confirm that it has operable conditions.

5.8.6.3 The mechanical release device of the ERS system is to be proven operable and readily available before the formal commencement of the fuel bunkering operation.

5.8.7 ESD connection testing

5.8.7.1 After the successful completion of the pre-cooling operation, a cold ESD test is to be carried out as far as possible to ensure that the ESD valve can operate normally under the expected low-temperature conditions before the formal delivery of liquefied hydrogen fuel.

5.8.8 Formal bunkering

5.8.8.1 The bunkering phase begins with the completion of drying, inerting, hydrogen purging, and pre-cooling by the bunkering facility and the receiving ship, and the opening of the liquefied hydrogen bunkering valve of the bunkering facility, and ends with the completion of the bunkering phase and the closing of the bunkering valve of the bunkering facility.

5.8.8.2 It is to be ensured that the bunkering operation is safe and efficient and that no liquefied hydrogen and/or hydrogen gas leaks into the environment during the formal bunkering process. If a hydrogen leak occurs during the bunkering process, the liquefied hydrogen bunkering is to be cut off immediately. Operators are to close the filling valves at the top and bottom of the receiving fuel tank and stay away from the bunkering area.

5.8.8.3 After confirming that all bunkering control valves between the receiving ship's hydrogen bunkering receptacle and the manual valve of the bunkering facility's cargo tank are open, and that all other hydrogen system control valves (including the bunkering pipeline vent valve) other than the bunkering control valves are reliably closed, both bunkering parties may send a ready signal through the agreed communication method.

5.8.8.4 When personnel have evacuated the bunkering area and the ready signal has been given, the bunkering rate may be controllably increased under real-time monitoring of the system until the bunkering rate agreed by both parties is reached. This bunkering rate is to be maintained until the agreed bunkering quantity is about to be completed. During the bunkering process, both parties are to monitor the system pressure, tank capacity, and equipment operation. If a problem is found or there are signs of a problem, the

bunkering operation is to be stopped immediately, and operations can only be resumed after inspection is completed and the problem is repaired.

5.8.8.5 In the event of communication failure, the bunkering operation is to be stopped, and operations can only be resumed after effective communication is re-established.

5.8.8.6 To maintain a comparable temperature between the cargo tank of the bunkering facility and the fuel tank of the receiving ship and to reduce boil-off gas, a small-flow delivery method is required during the initial bunkering, and the receiving ship's fuel tank is pre-cooled by top filling. The entire pre-cooling process is to ensure that the bunkering pipelines and accessories of both parties reach the predetermined temperature.

5.8.8.7 When the temperature in the cargo tank of the bunkering facility and the fuel tank of the receiving ship is comparable and the pipeline is fully pre-cooled, the method can be switched from slow top filling to rapid bottom filling. During slow top filling, the bottom filling valve is to be opened first before the top valve is closed to prevent overpressure. The flow rate of the bunkering pump is to be gradually increased within the limit of the bunkering rate. If the temperature and pressure of the receiving ship's fuel tank are high, it can be switched back to the top filling method for pre-cooling, or the two methods of top filling and bottom filling can be used alternately.

5.8.8.8 When the pressure in the receiving ship's fuel tank is higher than the maximum allowable working pressure of the bunkering facility's cargo tank, measures are to be taken to reduce the pressure in the fuel tank to an appropriate level.

5.8.9 Topping-up

5.8.9.1 When the liquefied hydrogen level of the receiving ship approaches the filling limit, the bunkering rate is to be reduced to the agreed topping-up rate. During the final bunkering stage, the fuel tank level and pressure of the receiving ship are to be closely monitored. When the agreed bunkering quantity has been reached, the staff on the receiving ship are required to notify the staff on the bunkering facility through the agreed communication method.

5.8.9.2 When the receiving ship's fuel tank is at a high liquid level, operators are to take corresponding actions prior to the ESD system to cut off the bunkering process to avoid fuel tank overflow.

5.8.10 Bunkering process monitoring

5.8.10.1 During formal bunkering, the bunkering operation personnel of both the bunkering facility and the receiving ship are to continuously monitor the parameters related to the bunkering operation and the operating status of the equipment, and at least the following monitoring items are to be included:

(1) Hydrogen fuel bunkering rate;

(2) Temperature, pressure, and liquid level of the fuel tank/cargo tank;

(3) Gas detection alarm and fire detection alarm systems in the fuel tank/cargo tank and bunkering-related spaces;

(4) Operating status of the ventilation system in the fuel tank/cargo tank and bunkering-related spaces;

(5) Leakage of valves and pipelines in the bunkering system;

(6) Operating status of equipment such as hydrogen dispensers in the bunkering connection equipment

area;

(7) Factors such as ship movement, tide, and current.

5.8.11 Hydrogen emission management

5.8.11.1 Hydrogen emission management includes the emission of hydrogen during warming, inerting, hydrogen purging, and bunkering.

5.8.11.2 The hydrogen emitted during the warming, inerting, and hydrogen purging processes is to ensure that the vent mast outlet of the receiving ship is not located within the activity range of the bunkering facility operators and in areas where ignition sources exist. Otherwise, other measures capable of ensuring the safe discharge of hydrogen are to be taken.

5.8.11.3 During the bunkering process, the pressure in the receiving ship's fuel tank is to be monitored in real-time to prevent overpressure from causing the safety valve to lift.

5.8.11.4 Hydrogen emission management is to consider the tank type, operating conditions, and equipment manufacturer's requirements.

5.8.11.5 When there is no vapour return during the bunkering operation, the pressure of the cargo tank of the bunkering facility is to be monitored in real-time during the bunkering process to prevent negative pressure from damaging the tank structure.

5.8.12 Completion phase

5.8.12.1 The completion phase begins with the completion of the topping-up operation and the closing of the hydrogen fuel bunkering control valve, and ends with the safe disconnection of the receiving ship and the bunkering facility and the completion of the signing of all relevant documents.

5.8.12.2 It is to be ensured that no liquefied hydrogen or hydrogen gas leaks into the environment during the safe disconnection process between the bunkering facility and the receiving ship.

5.8.12.3 After the completion of bunkering and the closing of the hydrogen fuel bunkering control valve, before closing all valves and dismantling the connecting pipelines, to prevent the connecting pipelines from freezing, condensing, and oxygen enrichment due to contact with inert gas or the environment caused by excessively low temperatures, hydrogen is to be used to purge and warm the connecting pipelines.

5.8.12.4 Gravity or hydrogen pressure may be used to return the residual liquid in the bunkering system to the receiving ship's fuel tank or the bunkering facility's cargo tank.

5.8.12.5 To avoid the potential hazard of residual flammable gas in the pipeline, after the purging and warming of the bunkering pipeline are completed, the bunkering pipeline is to be inerted in accordance with the requirements of 5.5.2.1 (2) of this Chapter.

5.8.13 Disconnection of connecting pipelines

5.8.13.1 After confirming the post-bunkering checklist in Appendix 2 of the Guidelines and ensuring that there is no source of ignition around, the staff may disconnect the connecting piping (liquid phase pipe and gas phase pipe) on the receiving ship and carry out effective blinding. The staff are to wear protective equipment (gloves, protective clothing, etc.) and quickly disconnect the connecting joints. The staff are also

to pay attention to the low-temperature liquid that may drip during the operation to avoid frostbite.

5.8.13.2 If hoses are used for the bunkering equipment, after the bunkering hose is removed from the support, it is to be placed in the prescribed storage position. There are to be no objects with sharp edges at the position where the hose is operated.

CHAPTER 6 EMERGENCY RESPONSE

Section 1 GENERAL PROVISIONS

6.1.1 General requirements

6.1.1.1 This chapter is intended to provide general response measures and guidance for typical accident scenarios during the bunkering process.

6.1.1.2 An emergency plan is to be developed in advance for potential accidents (such as fire and explosion) during the bunkering process to maximize the control or reduction of their potential consequences and impacts.

6.1.1.3 In the event of an accident, the emergency plan is to be activated in accordance with the corresponding requirements of the local Administration. If an accident occurs during bunkering operations within the territory of China, the emergency plan is to be activated in accordance with guiding principles such as the Work Safety Law of the People's Republic of China.

6.1.1.4 All operations unrelated to accident handling are to be stopped, and preparations for firefighting and fire extinction are to be made.

6.1.1.5 The receiving party and the bunkering party are to be prepared for evacuation.

6.1.1.6 The on-scene commander is to promptly evacuate unauthorized personnel and vehicles, issue warning signals to the surrounding waters, and organize relevant personnel for emergency rescue.

6.1.1.7 The Safety Data Sheet (SDS) for hydrogen fuel is to be provided to allow relevant parties to understand the characteristics of hydrogen fuel.

6.1.1.8 Appropriate training and drills are to be conducted to ensure that emergency rescue personnel, on-site operators, and other crew members involved in the bunkering operation are familiar with the emergency plan.

Section 2 HYDROGEN LEAKAGE ACCIDENTS

6.2.1 General requirements

6.2.1.1 The ESD system is to be activated, the specific location of the leakage source is to be determined, and the leakage source is to be rapidly shut off based on actual conditions.

6.2.1.2 In the event of a pipeline leak, all valves connected to the leaking pipeline section are to be closed.

6.2.1.3 If the leakage source cannot be isolated, ventilation of semi-enclosed or enclosed spaces at the site is to be maintained, and the fire department is to be notified immediately and superior authorities reported to.

6.2.1.4 Measures are to be taken to prevent the leaked hydrogen fuel from causing harm to surrounding facilities and personnel.

6.2.1.5 Gas dispersion is to be monitored via gas detectors, and semi-enclosed or enclosed spaces at the site are to be checked for the presence of flammable gas to prevent explosions.

6.2.1.6 Surrounding ignition sources are to be strictly controlled to prevent fire and explosion accidents caused by the massive leakage and dispersion of hydrogen.

6.2.1.7 In the event of a massive leak of compressed hydrogen fuel, the fire protection system may be activated. Fire-extinguishing systems and water-spray systems, etc., may be used to cool down and provide isolation protection for facilities surrounding the leakage point, so as to eliminate ignition sources such as open flames, hot surfaces, and static electricity. The adverse effects of water spraying on surrounding equipment are to be considered.

6.2.1.8 For leakage of hydrogen storage alloy or metal hydride dust, operators wearing air breathing apparatus may identify the specific location of the leakage source and plug the leak promptly. The space or area is to be kept as dry as possible during the operation.

6.2.1.9 For leakage of liquefied hydrogen fuel, it is strictly prohibited to carry out maintenance and plugging before the leak is completely isolated. When conditions permit, the liquefied hydrogen at the leakage source is to be promptly drained and transferred to a safe location, and permanent remedial measures are to be taken after inerting the process systems related to the leakage. In the event of a massive liquefied hydrogen leak, before the leakage source is isolated, it is strictly prohibited to plug the leak, carry out maintenance, or blindly extinguish the flame. When necessary, the fire department is to be notified immediately and superior authorities reported to.

Section 3 HYDROGEN FIRE ACCIDENTS

6.3.1 General requirements

6.3.1.1 In the event of a hydrogen fire, the hydrogen leakage source is to be promptly isolated on the premise of ensuring safety.

6.3.1.2 If the hydrogen source cannot be isolated immediately, as long as hydrogen is leaking, there is no need to rush to extinguish the hydrogen flame. In addition, the hydrogen system is to be maintained in a positive pressure state to prevent flashback in the hydrogen system.

6.3.1.3 The fire water-spray system is to be activated to forcibly cool the burning equipment within the bunkering operation area, and the adverse effects of water spray on electrical equipment are to be considered.

6.3.1.4 Effective measures are to be taken to prevent the spread of fire. The fire water-spray system is to be used to spray other ignitable substances and adjacent equipment to cool structures and facilities affected by thermal radiation or flames.

6.3.1.5 Alarms are to be raised promptly and personnel in the danger zone are to be evacuated. When there is a risk of flash fire/explosion, personnel are to move to a relatively open location for shelter.

6.3.1.6 Dry powder fire-extinguishing systems may be used to extinguish pressurized jet fires. For spaces containing metal alloy hydrogen storage fuel tanks, Class D dry powder fire-extinguishing systems or CO_2 fire-extinguishing systems are to be used for fire extinction. If a CO_2 fire-extinguishing system is used

to extinguish a metal alloy fire, its applicability is to be assessed in advance.

6.3.1.7 Firefighters are to select and wear personal protective equipment in accordance with recognized standards①, and conduct firefighting from the upwind position and the side of the jet fire.

Section 4 ACCIDENT RESCUE

6.4.1 Firefighting and rescue

6.4.1.1 Rescue personnel are to wear personal protective equipment in accordance with the requirements of 3.1.1 of the Guidelines. It is strictly prohibited for personnel not wearing personal protective equipment to enter environments that may be harmful to health.

6.4.1.2 Rescue personnel are to adopt the handling methods specified in Section 3 of this Chapter or recommended by relevant departments, take immediate rescue measures, establish a security zone, and promptly evacuate non-rescue personnel within the security zone.

6.4.1.3 Hydrogen flames are not easily visible to the naked eye. Rescue personnel are to wear self-contained breathing apparatus and anti-static clothing when entering the site, and take care to prevent burns to exposed skin.

6.4.1.4 If hydrogen is present or suspected to be present in the area, rescue personnel are to be grounded before contacting or using tools to contact the hydrogen system.

6.4.1.5 In an emergency, on-site personnel who have received training in accident handling may assist firefighters in rescue operations.

6.4.2 Medical first aid

6.4.2.1 Emergency medical treatment is to be provided promptly to personnel suffering from burns or injuries in explosions, and those in serious condition are to be sent to the hospital immediately for treatment.

6.4.2.2 In the case of burns, the burned area is to be first fully cooled with clean, cool running water, and clothing is to be removed; if it adheres to the skin, the non-adherent part is to be cut off. After thorough cooling, the burn surface is to be wrapped with sterile gauze or a clean cloth and treated promptly. When sending to the hospital, the burn surface is to be loosely covered with a clean/sterile dressing, and attention is to be paid to preventing hypothermia. For those with respiratory tract burns, attention is to be paid to clearing the airway and preventing obstruction by foreign objects.

6.4.2.3 In the case of frostbite, the injured person is to be moved to a warm place, clothing is to be loosened, and the whole body is to be kept warm with towels and blankets. The frostbitten area must not be rubbed. The frostbitten area is to be immersed in warm water at 37–40 °C. If the frostbitten area adheres to clothing, it must not be forcibly torn off; it is to be immersed in warm water together with the clothing. It must not be warmed by soaking in hot water or by an open fire.

6.4.2.4 In the case of asphyxiation, the asphyxiated person is to be moved to a well-ventilated place, rapid assessment of consciousness, breathing, and circulation is to be conducted, cardiopulmonary

① E.g., XF 621-2013 Standard for Provision of Personal Protective Equipment for Firefighters.

resuscitation (CPR) is to be performed and an AED (if available) is to be used, and medical attention is to be sought promptly.

6.4.3 Protection when entering safety zones

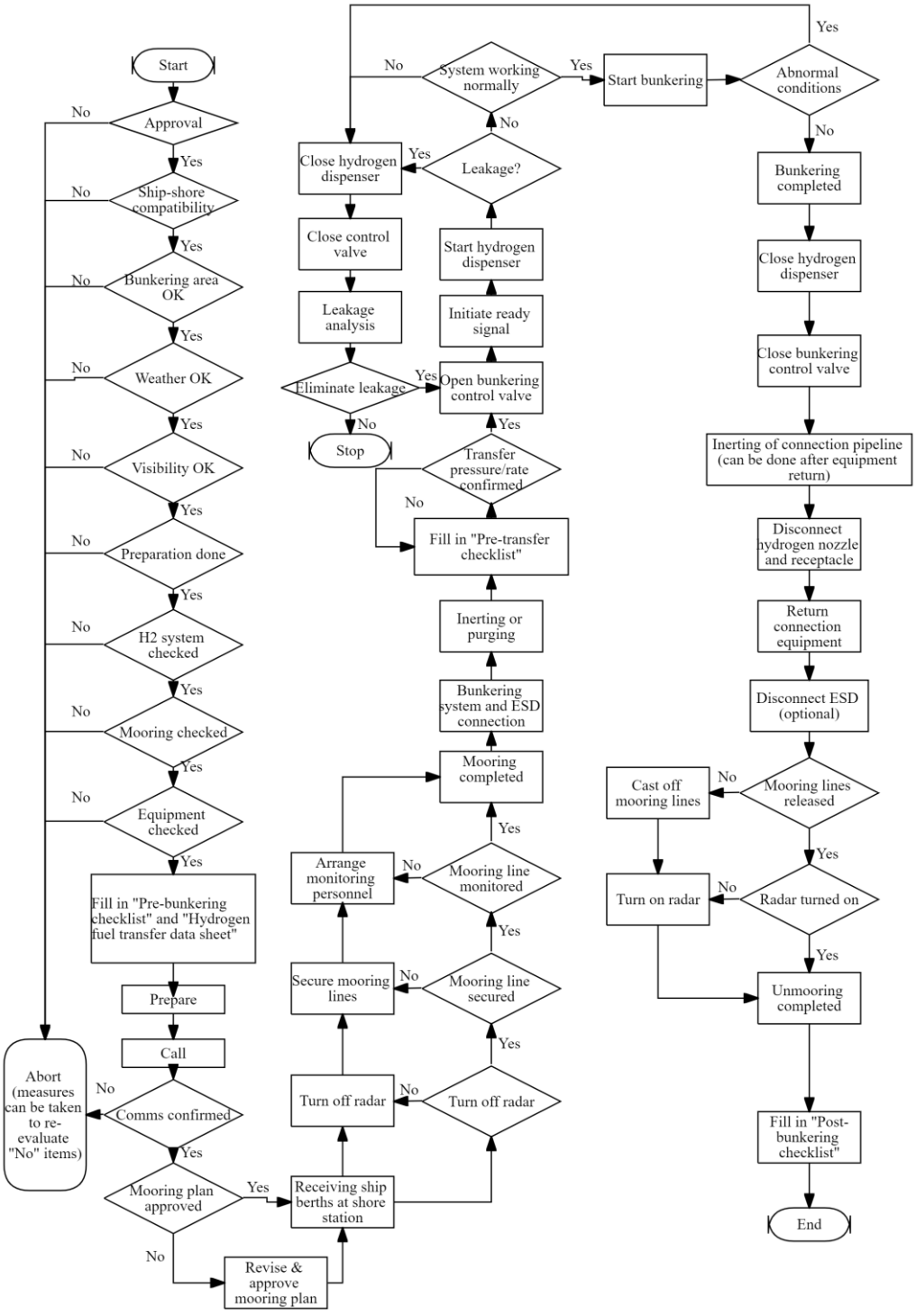
6.4.3.1 Before entering the safety zone, rescue personnel are to discharge static electricity, wear complete personal protective equipment, and use calibrated portable direct-reading instruments to detect oxygen content, hydrogen content, and toxic substance content in the safety zone. Thermal imaging equipment may be provided when necessary to confirm safety.

6.4.3.2 When rescue personnel enter the safety zone, personal communication devices must be turned off, and explosion-proof walkie-talkies must be used within the safety zone.

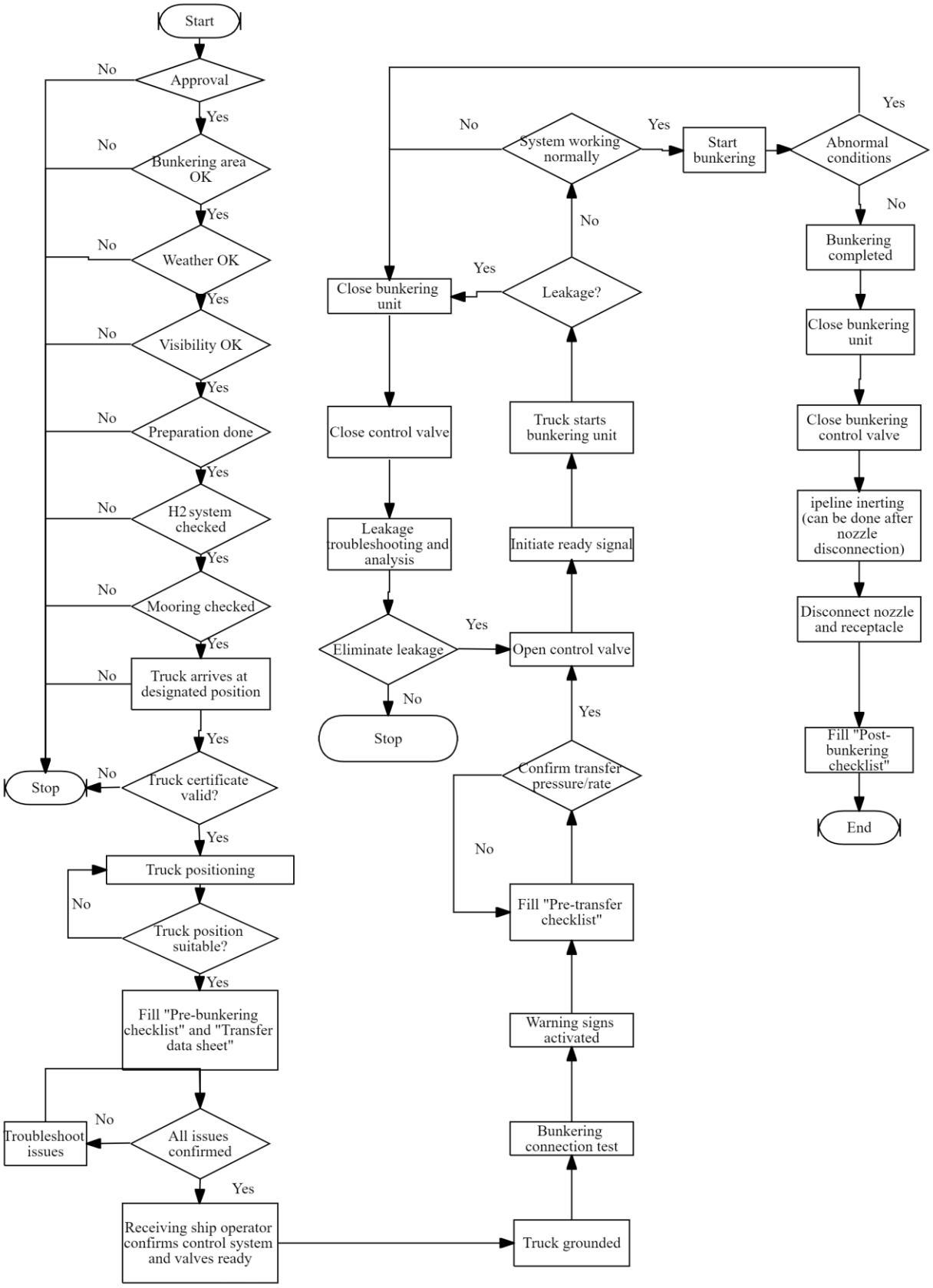
6.4.3.3 Evacuation facilities such as lifelines are to be provided for use by rescue personnel, and rescue personnel are to operate in accordance with prescribed operating procedures.

Appendix 1 FLOW CHARTS FOR HYDROGEN FUEL BUNKERING FOR SHIPS

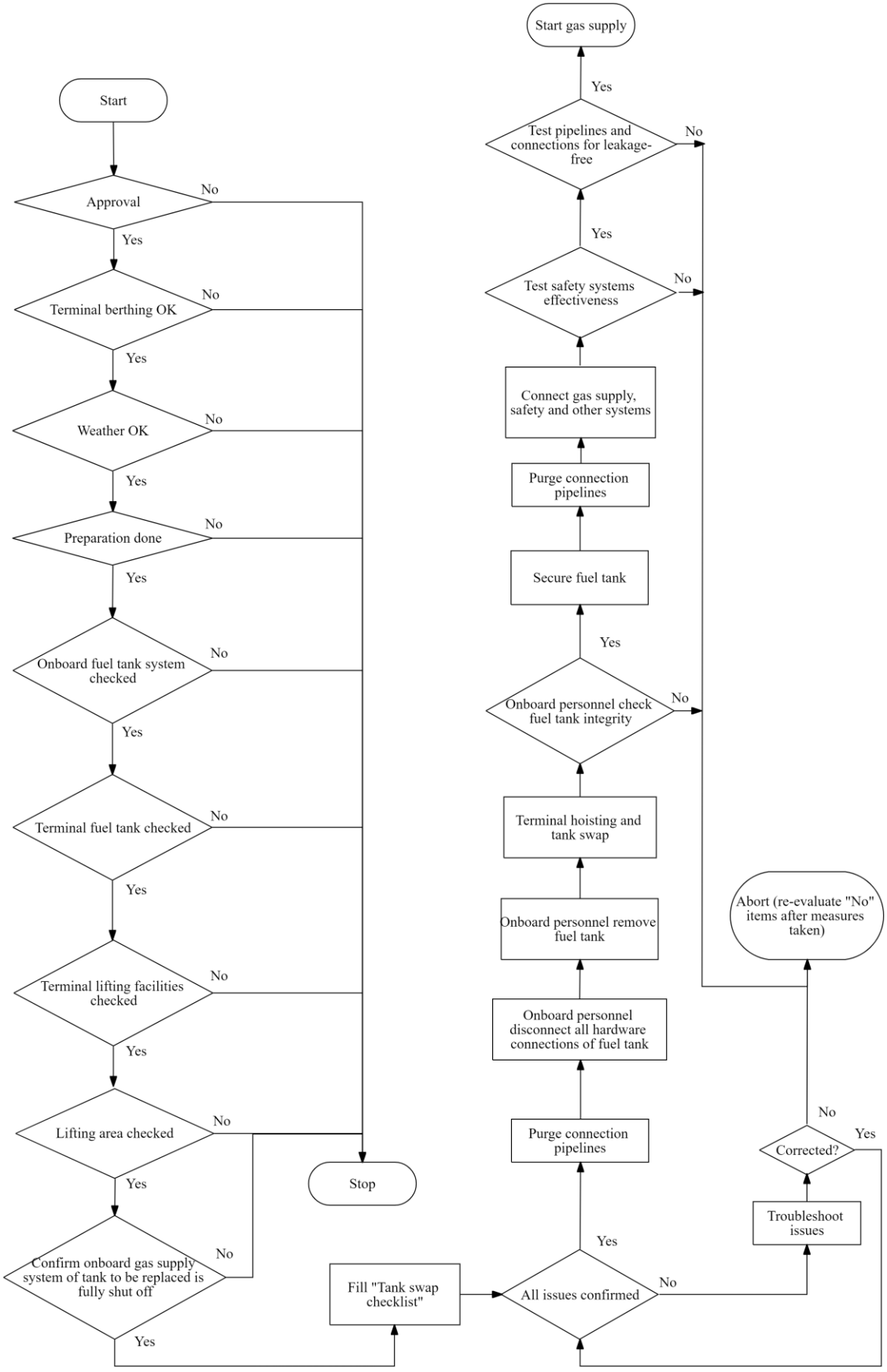
1.1 Flow chart for bunkering to ship from shore-based hydrogen refuelling station for compressed hydrogen fuel tanks and metal alloy hydrogen storage fuel tanks



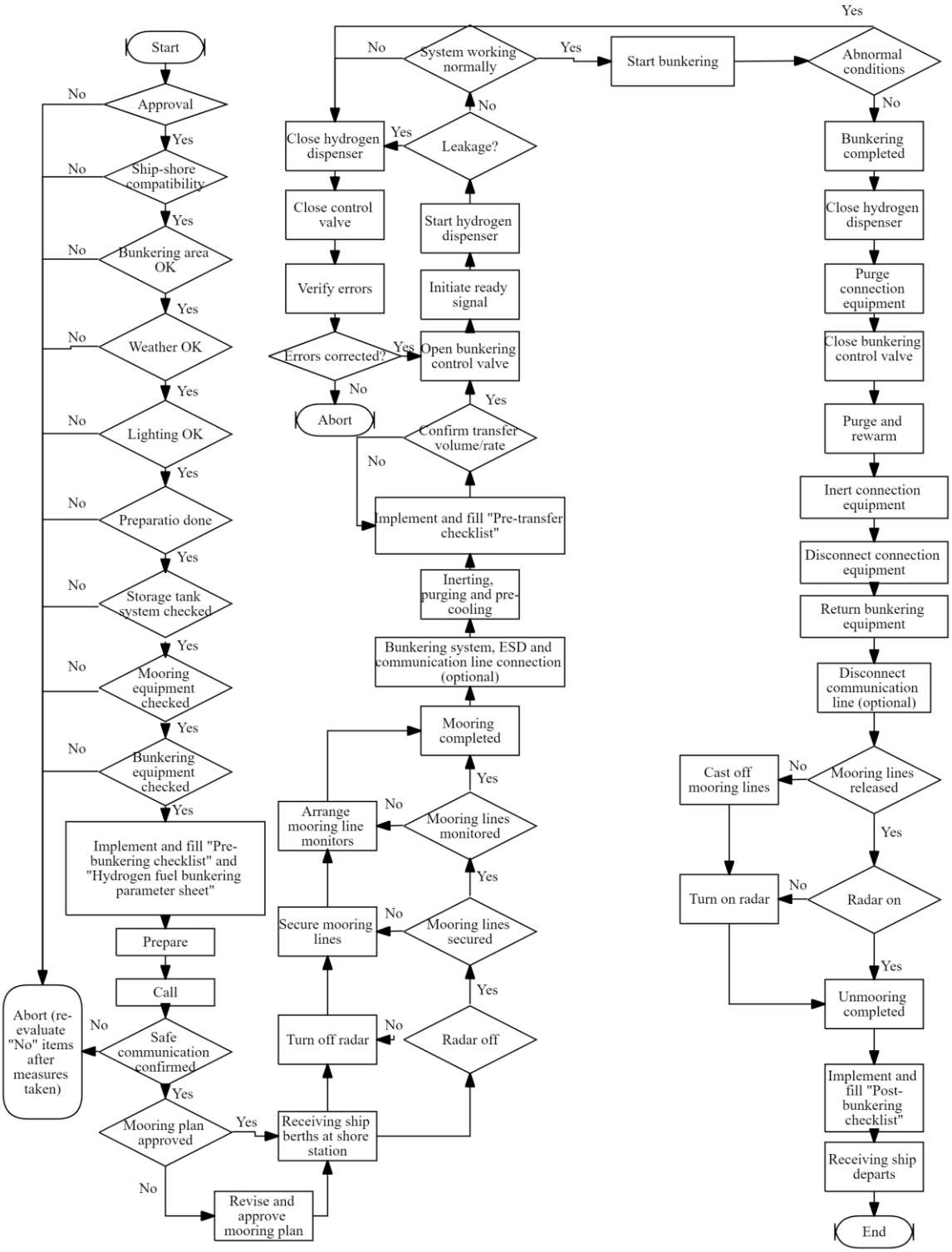
1.2 Flow chart for bunkering to ship from hydrogen bunkering truck for compressed hydrogen fuel tanks and metal alloy hydrogen storage fuel tanks



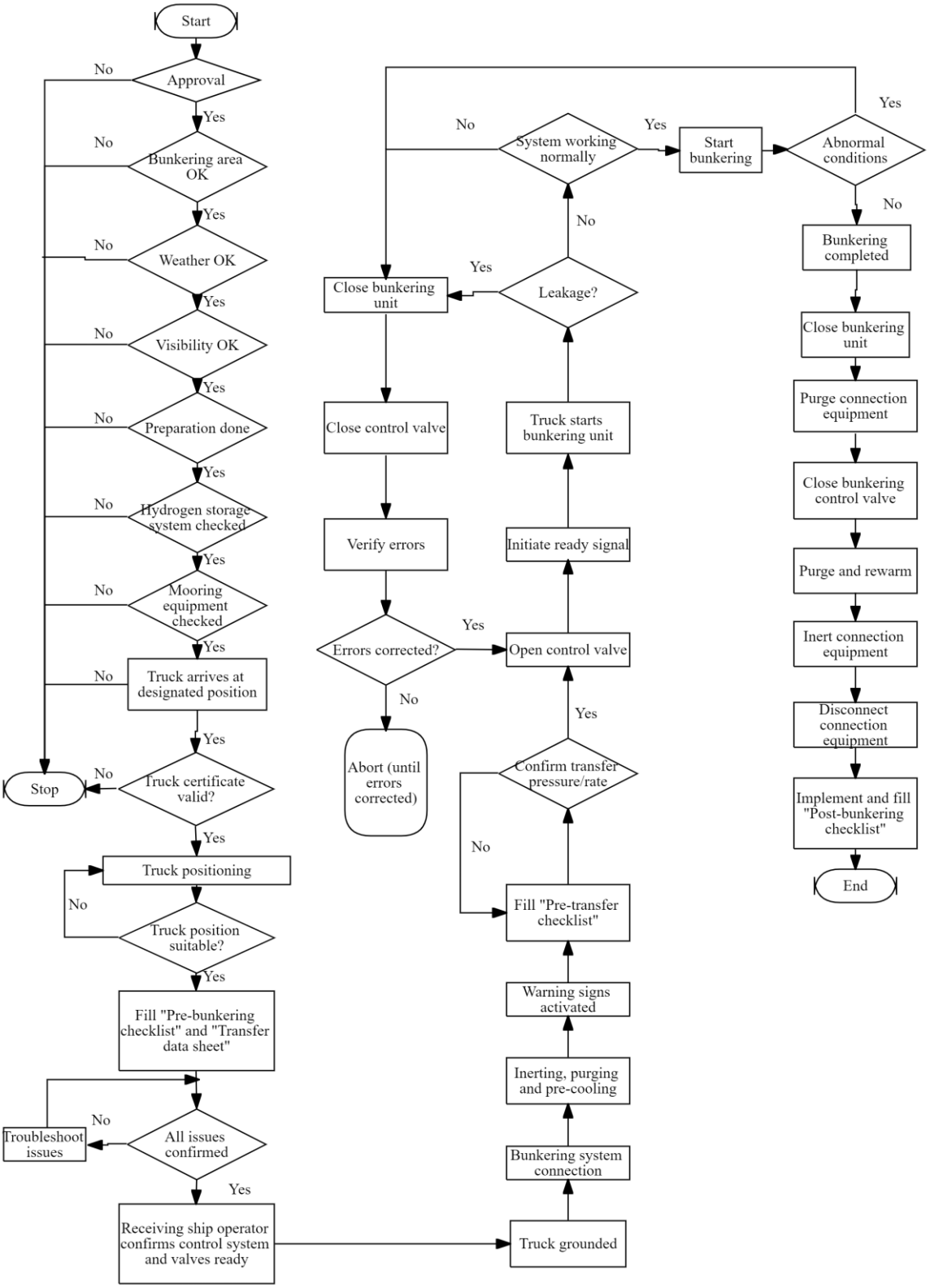
1.3 Flow chart for portable fuel tank swap



1.4 Flow chart for bunkering to ship from shore-based hydrogen refuelling station for liquefied hydrogen



1.5 Flow chart for bunkering to ship from hydrogen bunkering truck for liquefied hydrogen



APPENDIX 2 CHECKLISTS

1.1 Checklist for bunkering to ship from shore-based hydrogen refuelling station

Part A: Pre-bunkering checklist

Planned date and time: _____

Bunkering location (berth): _____

Shore-based hydrogen refuelling station: _____

Receiving ship: _____

Hydrogen type of receiving ship (compressed hydrogen, metal alloy hydrogen storage or liquefied hydrogen)

_____

No.	Check item	Receiving ship	Shore station	Remarks
1	The specific location and time of the approved hydrogen fuel bunkering operation			
2	The Administration has been notified to commence the hydrogen fuel bunkering operation in accordance with relevant requirements			Notification time: hrs
3	Requirements of the Administration and local shore station are complied with,			E.g. port regulations
4	All personnel involved in the hydrogen fuel bunkering operation have received appropriate training and have been assigned responsibility for specific hydrogen fuel bunkering equipment operations and procedures			
5	The shore station and the receiving ship are provided with approved bunkering plans and operating manuals			
6	Sufficient visibility is available in the operation area			
7	All hydrogen fuel bunkering equipment and gas detection equipment are certified, in good condition and functioning properly			
8	The shore station and the receiving ship have agreed on bunkering limits, bunkering operations and emergency response procedures			
9	The shore station and the receiving ship have agreed on the electrical insulation method			
10	The safety zone has been agreed			safety zone:
11	Relevant ignition source regulations are complied with			
12	Relevant firefighting equipment is immediately available			
Note: Tick ✓ if the condition is met, mark × if not met, and mark ○ if not applicable.				
Signature Shore station representative: Receiving ship representative:				

Part B: Hydrogen fuel transfer data sheet (This part is to be completed before the actual bunkering operation commences)

Note the agreed physical quantity unit (PQU): □MPa □kg

Agreed Initial Temperature and Pressure				
	Receiving ship hydrogen fuel tank		Shore station storage tank	
Initial temperature in tank				℃
Initial pressure in tank				MPa
Effective (remaining) pressure or capacity				PQU
Agreed Bunkering Operation				
Agreed bunkering quantity			——	PQU
Agreed bunkering rate			——	PQU /min
Initial bunkering rate			——	PQU /min
Initial bunkering pressure			——	MPa
Initial bunkering temperature			——	℃
Cooling medium temperature (only applicable to metal alloy hydrogen storage fuel tank bunkering)			——	℃
Cooling medium flow rate (only applicable to metal alloy hydrogen storage fuel tank bunkering)			——	kg/min
Agreed Maximum and Minimum Values				
	Maximum	Minimum		
Bunkering connection pipeline pressure			——	MPa
Hydrogen fuel tank pressure			——	MPa
Hydrogen fuel temperature			——	℃
Hydrogen fuel bunkering rate			——	PQU / min
Cooling medium temperature (only applicable to metal alloy hydrogen storage fuel tank bunkering)			——	℃
Cooling medium flow rate (only applicable to metal alloy hydrogen storage fuel tank bunkering)			——	kg/min

Part C: Pre-transfer checklist (This part is to be completed before the actual bunkering operation commences)

No.	Check item	Receiving ship	Shore station	Remarks
1	Part A has been completed before the actual operation			If applicable
2	Weather and wind/wave conditions meet the requirements			
3	The receiving ship is safely berthed, berthing regulations are complied with, and escort measures are in place			
4	Method for the receiving ship to safely berth alongside the shore station			
5	Relevant firefighting equipment is immediately available			
6	Lighting in the operation area is adequate			
7	The receiving ship can navigate autonomously in a safe and unobstructed direction			
8	Bunkering personnel of both the shore station and the receiving ship are in position			
9	Effective communication has been established between the operation persons in charge and supervisors of the shore station and the receiving ship, and the communication language has been agreed			VHF/UHF channel: Language: Main system: Standby system:
10	Emergency stop signals and emergency shutdown (ESD) procedures have been agreed, tested and explained to all participants. The emergency response procedures and plans and contact telephone numbers have been notified to the person in charge			Emergency stop signal:
11	The safety zone has been established and warning signs are in normal condition			
12	There are no other ships, unauthorized personnel, non-explosion-proof equipment or other ignition sources within the safety zone			
13	Effective deck observation has been established			Particular attention is to be paid to mooring and fenders.
14	Both the shore station and the receiving ship have established effective observation of hydrogen fuel bunkering.			Attention is to be paid to the receiving ship's bunkering station, bunkering hose, hydrogen bunkering nozzle connection

No.	Check item	Receiving ship	Shore station	Remarks
				and hydrogen storage control station at all times.
15	External doors, portholes and accommodation ventilation openings have been closed in accordance with the operating manual.			They must not be locked at any time.
16	Gas detection equipment has been operationally tested and is in good working condition			
17	Relevant ignition source regulations are complied with			
18	Appropriate and sufficient protective clothing and equipment are immediately available			
19	Personnel involved in connecting equipment and personnel near the operation area are to wear protective clothing and use corresponding equipment			
20	All remote-controlled valves are well maintained and in good working condition			
21	Hydrogen storage system instruments, high-temperature alarms and high-pressure alarms are operable, correctly set and in good working condition			
22	The cooling system is in good working condition and reliably connected to the heat exchange pipeline of the receiving ship's hydrogen storage system without leakage			Only applicable to metal alloy hydrogen storage fuel tank bunkering
23	The receiving ship's hydrogen fuel tank is to be protected against overpressure and overtemperature at all times; pressure and temperature are to be continuously monitored and alarm devices are to be correctly set			at intervals not exceeding min
24	All safety and control devices on the hydrogen dispenser have been inspected and tested and are in good working condition			
25	Pressure control equipment and hydrogen fuel bunkering cooling equipment are operable and in good working condition			
26	The connection and support of the bunkering pipeline are appropriate			If applicable
27	The ESD systems, automatic valves or similar devices of the shore station and the receiving ship have been tested, are in good working condition and are immediately available. The ESD systems of both parties have been connected. The parameters for triggering the ESD system (bunkering pressure,			Receiving ship ESD: s Shore station ESD: s

No.	Check item	Receiving ship	Shore station	Remarks
	bunkering rate, hydrogen fuel temperature) have been agreed by both parties			
28	The pipelines intended for hydrogen fuel bunkering have been inspected, and unused connections have been closed or properly handled and marked			
29	Bunkering hoses, fixed piping and branch pipes are in good condition, correctly assembled, supported and connected, leak tested and confirmed suitable for hydrogen fuel bunkering			
30	Hydrogen refuelling equipment and pipelines have been properly grounded, and the grounding resistance has been tested and found acceptable			
31	The bunkering system between the shore station and the receiving ship is provided with a dry-disconnect device/hydrogen bunkering nozzle			
32	The bunkering system between the shore station and the receiving ship is provided with a suitable electrical insulation device, which is in place			
33	The dry-disconnect device/hydrogen bunkering nozzle on the bunkering system has been correctly connected and visually inspected and is in good working condition			
34	The location of the receiving ship's fire control plan is familiar			Location:
35	An international shore connection is fitted			If applicable
36	The Administration and other nearby ships have been informed that the hydrogen fuel bunkering operation has commenced			
Note: Tick √ if the condition is met, mark × if not met, and mark ○ if not applicable.				
Signature Shore station representative: Receiving ship representative:				

Part D: Post-bunkering checklist (This part is to be completed after the bunkering operation is completed)

No.	Check item	Receiving ship	Shore station	Remarks
1	The bunkering connection equipment, fixed piping and manifold have been inerted (this may be carried out after removing the hydrogen bunkering nozzle) and are ready for disconnection			Applicable to inerting before disconnection

2	The hydrogen dispenser and bunkering control valve have been closed			
3	The hydrogen bunkering nozzle has been safely depressurized and is ready for disconnection from the hydrogen bunkering receptacle			
4	The cooling system and cooling medium control valve have been closed			Only applicable to metal alloy hydrogen storage fuel tank bunkering
5	The cooling medium in the heat exchange pipeline of the receiving ship's hydrogen storage system has been drained, and the cooling medium pipeline connection is ready for disconnection			Only applicable to metal alloy hydrogen storage fuel tank bunkering
6	The cooling medium pipeline connection has been disconnected			Only applicable to metal alloy hydrogen storage fuel tank bunkering
7	The bunkering connection has been disconnected, the safety zone has been released, and signs have been removed			
8	The receiving ship's bunkering pipeline has been inerted			Applicable to inerting after disconnection
9	The Administration and other nearby ships have been informed that the hydrogen fuel bunkering operation has been completed			Notification time: hrs
10	Incidents and accidents have been reported to the Administration (optional)			
Note: Tick √ if the condition is met, mark × if not met, and mark ○ if not applicable.				
Signature Shore station representative: Receiving ship representative:				

1.2 Checklist for bunkering to ship from hydrogen bunkering truck

Part A: Pre-bunkering checklist

Planned date and time: _____

Bunkering location (berth): _____

Hydrogen bunkering truck: _____

Receiving ship: _____

Hydrogen type of receiving ship (compressed hydrogen, metal alloy hydrogen storage or liquefied hydrogen) _____

No.	Check item	Receiving ship	Hydrogen bunkering truck	Terminal	Remarks
1	The Administration has approved the specific location and time of hydrogen fuel bunkering				
2	The Administration has been notified to commence the hydrogen fuel bunkering operation in accordance with relevant requirements				Notification time: hrs
3	The terminal has been notified that hydrogen fuel bunkering is about to commence				
4	Requirements of the Administration are complied with				E.g. port regulations
5	All personnel involved in the hydrogen fuel bunkering operation have received appropriate training and have been assigned responsibility for specific hydrogen fuel bunkering equipment and procedures				
6	The bunkering location is accessible to the hydrogen bunkering truck, and the total weight of the hydrogen bunkering truck does not exceed the maximum value permitted by the terminal				
7	Sufficient visibility is available in the bunkering operation area				
8	All hydrogen bunkering devices and gas detection equipment are certified, in good condition and functioning properly				
9	Both parties have agreed on the operating procedures for bunkering, inerting and hydrogen purging				
10	Both the hydrogen bunkering truck and the receiving ship have agreed on the electrical insulation system and method				
11	The safety zone has been agreed and designated				safety zone:
12	Relevant ignition source regulations are complied with				
13	Relevant firefighting equipment is immediately available				
Note: Tick √ if the condition is met, mark × if not met, and mark ○ if not applicable.					

Signature	
Hydrogen bunkering truck representative:	Receiving ship representative:

Part B: Hydrogen fuel transfer data sheet (This part is to be completed before the actual bunkering operation commences)

Note the agreed physical quantity unit (PQU): □MPa □kg

Agreed Initial Temperature and Pressure				
	Receiving ship hydrogen fuel tank		Hydrogen bunkering truck storage tank	
Initial temperature in tank				℃
Initial pressure in tank				MPa
Effective (remaining) pressure or capacity				PQU
Agreed Bunkering Operation				
Agreed bunkering quantity			——	PQU
Agreed bunkering rate			——	PQU /min
Initial bunkering rate			——	PQU /min
Initial bunkering pressure			——	MPa
Initial bunkering temperature			——	℃
Cooling medium temperature (only applicable to metal alloy hydrogen storage fuel tank bunkering)			——	℃
Cooling medium flow rate (only applicable to metal alloy hydrogen storage fuel tank bunkering)			——	kg/min
Agreed Maximum and Minimum Values				
	Maximum	Minimum		
Bunkering connection pipeline pressure			——	MPa
Hydrogen fuel tank pressure			——	MPa
Hydrogen fuel temperature			——	℃
Hydrogen fuel bunkering rate			——	PQU /min
Cooling medium temperature (only applicable to metal alloy hydrogen storage fuel tank bunkering)			——	℃
Cooling medium flow rate (only applicable to metal alloy hydrogen storage fuel tank			——	kg/min

bunkering)				

Part C: Pre-transfer checklist (This part is to be completed before the actual transfer operation commences)

No.	Check item	Receiving ship	Hydrogen bunkering truck	Terminal	Remarks
1	Part A has been completed before the actual operation				If applicable
2	Weather and wind/wave conditions meet the requirements				
3	The receiving ship is safely moored, mooring regulations are complied with, and escort measures are in place				
4	A method for the receiving ship to safely berth is available; if necessary, an emergency escape route is to be provided between the ship and the shore				
5	Relevant firefighting equipment is immediately available				
6	Sufficient visibility is available in the bunkering operation area				
7	The receiving ship can move autonomously in a safe and unobstructed direction				
8	Bunkering personnel of both the hydrogen bunkering truck and the receiving ship are in position and maintain effective observation throughout				
9	Effective communication has been established between the operation persons in charge and supervisors of the hydrogen bunkering truck and the receiving ship, and the communication language has been agreed				VHF/UHF channel: Language: Main system: Standby system:
10	Emergency stop signals and emergency shutdown (ESD) procedures have been agreed, tested and explained to all participants. The emergency response procedures and plans and contact telephone numbers have been notified to the person in charge				Emergency stop signal:
11	The safety zone has been established and warning signs are in normal condition				
12	There are no unauthorized personnel, equipment or ignition sources within the safety zone				
13	External doors, portholes and accommodation ventilation openings have been closed in accordance with the operating manual.				They must not be locked at any time.
14	Gas detection equipment has been operationally tested and is in good working condition				

15	Relevant ignition source regulations are complied with				
16	Appropriate and sufficient protective clothing and equipment are immediately available				
17	Personnel involved in hose connection and disconnection and personnel near the operation area are to wear protective clothing and use corresponding equipment				
18	Emergency release devices (including breakaway couplings) have been installed and are immediately available				If applicable
19	All control valves are well maintained and in good working condition				
20	Bunkering system instruments, high-temperature alarms and high-pressure alarms are operable, correctly set and in good working condition				
21	The cooling system is in good working condition and reliably connected to the heat exchange pipeline of the receiving ship's hydrogen storage system without leakage				Only applicable to metal alloy hydrogen storage fuel tank bunkering
22	The receiving ship's hydrogen fuel tank is to be protected against overfilling at all times; pressure and temperature are to be continuously monitored and alarm devices are to be correctly set				at intervals not exceeding min
23	All safety and control devices of the hydrogen-related system have been inspected and tested and are in good working condition				
24	Pressure control equipment and hydrogen fuel bunkering cooling equipment are operable and in good working condition				If applicable
25	The ESD systems, automatic valves or similar devices of the hydrogen bunkering truck and the receiving ship have been tested, are in good working condition and are immediately available				Receiving ship ESD: s hydrogen bunkering truck ESD: s
26	The pipelines intended for hydrogen fuel bunkering have been inspected, and unused connections have been closed and marked				
27	Bunkering hoses, fixed piping and branch pipes are in good condition, correctly installed, supported and connected, leak tested and approved for hydrogen fuel bunkering				
28	The bunkering system between the hydrogen bunkering truck and the receiving ship is provided with a dry-disconnect device/hydrogen bunkering				

	nozzle				
29	The bunkering system between the hydrogen bunkering truck and the receiving ship is provided with a suitable electrical insulation device, which is in place				
30	The dry-disconnect device/hydrogen bunkering nozzle on the bunkering system is in place, visually inspected and in good working condition				
31	Hydrogen refuelling equipment and pipelines have been properly grounded, the grounding resistance has been tested and found acceptable, and the wheels of the hydrogen bunkering truck have been chocked				
32	During the bunkering operation, the engine of the hydrogen bunkering truck is shut down				
33	The location of the receiving ship's fire control plan is familiar				Location:
34	An international shore connection is fitted				If applicable
35	The Administration and other nearby ships have been informed that the hydrogen fuel bunkering operation has commenced				
Note: Tick √ if the condition is met, mark × if not met, and mark ○ if not applicable.					
Signature Hydrogen bunkering truck representative: Receiving ship representative:					

Part D: Post-bunkering checklist (This part is to be completed after the bunkering operation is completed)

No.	Check item	Receiving ship	Hydrogen bunkering truck	Terminal	Remarks
1	The bunkering connection equipment, fixed piping and manifold have been inerted (this may be carried out after removing the hydrogen bunkering nozzle) and are ready for disconnection				Applicable to inerting before disconnection
2	The hydrogen refuelling equipment and bunkering control valve have been closed				
3	The hydrogen bunkering nozzle has been safely depressurized and is ready for disconnection from the hydrogen bunkering receptacle				
4	The cooling system and cooling medium control valve have been closed				Only applicable to metal alloy hydrogen storage fuel tank bunkering

5	The cooling medium in the heat exchange pipeline of the receiving ship's hydrogen storage system has been drained, and the cooling medium pipeline connection is ready for disconnection				Only applicable to metal alloy hydrogen storage fuel tank bunkering
6	The cooling medium pipeline connection has been disconnected				Only applicable to metal alloy hydrogen storage fuel tank bunkering
7	The bunkering connection has been disconnected, the safety zone has been released, and signs have been removed				
8	The receiving ship's bunkering pipeline has been inerted				Applicable to inerting after disconnection
9	The Administration and other nearby ships have been informed that the hydrogen fuel bunkering operation has been completed				Notification time: hrs
10	Incidents and accidents have been reported to the Administration (optional)				
Note: Tick √ if the condition is met, mark × if not met, and mark ○ if not applicable.					
Signature Hydrogen bunkering truck representative: Receiving ship representative:					

1.3 Checklist for tank swap

Part A: Pre-tank-swap checklist

Tank swap date and time: _____

Tank swap terminal: _____

Ship name: _____

No.	Check item	Ship	Terminal	Remarks
1	The specific location and time of the approved portable fuel tank swap operation			
2	The Administration has been notified to commence the tank swap operation in accordance with local regulations			Notification date:
3	Requirements of the Administration are complied with			E.g. port regulations
4	All personnel involved in the tank swap operation have received appropriate training and have been assigned responsibility for specific equipment and procedures			
5	The ship and the terminal are provided with approved tank swap plans and valid operating manuals			
6	The ship's berth is capable of carrying out lifting operations			
7	Weather and environmental conditions in the lifting operation area are favourable			
8	The safety zone has been agreed and designated, and warning signs are in normal condition			safety zone:
9	There are no other ships, unauthorized personnel, equipment or ignition sources within the safety zone			
10	All parties involved have agreed on and comply with safety procedures and mitigation measures to prevent falling objects			
11	All mandatory firefighting equipment is immediately available			
12	Appropriate and sufficient protective clothing and equipment are immediately available			
13	Personnel involved in connecting equipment and personnel near the operation area are to wear protective clothing and use corresponding equipment			
14	The portable fuel tank system on board has been inspected and found in good condition			
15	The terminal's lifting equipment has been inspected and found in			

	good condition			
16	Regulations on ignition sources are complied with			
17	All connection systems of the fuel tank to be replaced on board have been shut off. For a fuel tank with a cold box, the equipment in the cold box is to be kept inerted			
18	The Administration and other nearby ships have been informed that the tank swap operation has commenced			
Note: Tick √ if the condition is met, mark × if not met, and mark ○ if not applicable.				
Signature Ship representative: Terminal representative:				

Part B: Post-tank-swap checklist (This part is to be completed after the tank swap operation is completed)

No.	Check item	Ship	Terminal	Remarks
1	The pipelines and related instruments of the portable fuel tank have been inspected, and no leakage or other abnormalities have been confirmed			
2	The pipeline between the fuel tank and the ship's hydrogen supply system has been subjected to a tightness test, and no leakage has been confirmed			
3	It has been confirmed that the ship monitoring platform can normally receive the monitoring parameters of the portable fuel tank			
4	Visual inspection has confirmed that the portable fuel tank is normally connected to the ship's venting system			
5	Visual inspection has confirmed that the portable fuel tank is securely fastened			
6	The safety zone has been released and signs have been removed			
7	The Administration and other nearby ships have been informed that the tank swap operation has been completed			Notification date:
8	Incidents and accidents have been reported to the Administration (optional)			
Note: Tick √ if the condition is met, mark × if not met, and mark ○ if not applicable.				
Signature Ship representative: Terminal representative:				

Appendix 3 BUNKER DELIVERY NOTES

1.1 Hydrogen fuel bunker delivery note①

Hydrogen as fuel

Ship name: Ship registration number/identification number: Call sign:

IMO number (if any): Date of delivery:

1. Hydrogen properties

Item	Unit	Value
Hydrogen state (compressed hydrogen, metal alloy hydrogen storage or liquefied hydrogen)	-	
Density	kg/m^3	
Bunkering pressure	MPa	
Bunkering temperature	℃	
Temperature in hydrogen fuel tank	℃	
Pressure in hydrogen fuel tank	MPa	

2. Hydrogen composition

Item	Unit	Value
Hydrogen purity (mole fraction)[1]	%	
Total non-hydrogen components	μmol/mol	
Impurity concentration		
Water (H_2O)	μmol/ mol	
Total hydrocarbons (as methane)	μmol/mol	
Oxygen (O_2)	μmol/mol	
Helium (He)	μmol/mol	
Total nitrogen (N_2) and argon (Ar)	μmol/mol	
Carbon dioxide(CO_2)	μmol/mol	
Carbon monoxide(CO)	μmol/mol	
Total sulfur (as H_2S)	μmol/mol	
Formaldehyde (HCHO)	μmol/mol	
Formic acid (HCOOH)	μmol/mol	
Ammonia (NH_3)	μmol/mol	
Total halogenated compounds (as halide ions)	mg/kg	

① The properties and composition of hydrogen allow operators to work in accordance with the known properties of the gas and the relevant operating restrictions.

Maximum particulate concentration	mg/kg	
Note 1: If hydrogen purity is to be confirmed by sampling the bunkered cargo, the sampling is to meet the requirements of recognised standards, such as GB/T 44262-2024, ISO 14687-2025, etc.		

3. Net total delivered: kg, MJ

4. Signature (S)

Supplier name, address and contact details:

Signature:

Place/port:

Date:

Receiver:

1.2 Portable fuel tank swap delivery note

Hydrogen as fuel

Ship name: Ship registration number/identification number: Call sign:

IMO number (if any): Date of delivery:

1. Hydrogen properties

Item	Unit	Value
Hydrogen state (compressed hydrogen, metal alloy hydrogen storage or liquefied hydrogen)	-	
Density	kg/m^3	
Temperature in tank	℃	
Pressure in tank	MPa	

2. Hydrogen composition

Item	Unit	Value
Hydrogen purity (mole fraction)	%	
Total non-hydrogen components	μmol/mol	
Impurity concentration		
Water (H_2O)	μmol/ mol	
Total hydrocarbons (as methane)	μmol/mol	
Oxygen (O_2)	μmol/mol	
Helium (He)	μmol/mol	
Total nitrogen (N_2) and argon (Ar)	μmol/mol	
Carbon dioxide(CO_2)	μmol/mol	
Carbon monoxide(CO)	μmol/mol	
Total sulfur (as H_2S)	μmol/mol	
Formaldehyde (HCHO)	μmol/mol	

Formic acid (HCOOH)	μmol/mol	
Ammonia (NH_3)	μmol/mol	
Total halogenated compounds (as halide ions)	mg/kg	
Maximum particulate concentration	mg/kg	

3. Fuel tank information

Item	Unit	Value
Number	-	
Manufacturer	-	
Effective volume	m^3	
Maximum filling mass	kg	
Insulation type	-	
Design pressure	MPa	
Safety valve set pressure	MPa	
Fuel tank dimensions	mm	

4. Net total delivered: kg, MJ

5. Signature (S)

Supplier name, address and contact details:

Signature:

Place/port:

Date:

Receiver: