GUIDANCE NOTES
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CHINA CLASSIFICATION SOCIETY

GUIDELINES FOR LOADING AND UNLOADING OPERATIONS OF SHIPBORNE LIQUID CARBON DIOXIDE

2025

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Beijing

Preface

With the increasing pressure to reduce emissions in international shipping, ships will address carbon emissions through two pathways: the energy supply side and the post-treatment side. On the energy supply side, low-carbon and zero-carbon alternative fuels will be adopted, including carbon cycle fuels synthesized by hydrogenation of carbon dioxide. For the post-treatment side, shipborne carbon capture technology will be mainly used to separate and collect carbon dioxide from exhaust emissions, thereby achieving TtW carbon emission reduction. Therefore, both the production process of carbon cycle fuels and the application of shipborne carbon capture technology will drive the development of carbon dioxide transportation, loading/unloading, storage and other related operations. To improve the efficiency of carbon dioxide storage and transportation and reduce operational costs, carbon dioxide is mostly stored and transported in liquid form. Liquid carbon dioxide features high density, colorlessness, odorlessness, a triple point, and asphyxiant hazards. Its loading and unloading operations involve risks such as low-temperature frostbite, solidification blockage, overpressure explosion, and asphyxiation injuries. It is necessary to conduct in-depth research and risk analysis on aspects such as loading/unloading equipment, pipeline layout, pressure control, protective equipment and operational procedures and determine technical requirements and operating specifications suitable for different operational scenarios to minimize potential risks.

Currently, there are no technical standards or guidelines specifically for loading and unloading operations of shipborne bulk liquid carbon dioxide in both domestic and international industries. To proactively respond to the market demands for the storage, transportation, loading and unloading of shipborne liquid carbon dioxide and support emission reduction in the shipping industry, CCS has organized and conducted technical research on shipborne liquid carbon dioxide loading and unloading operations and prepared the *Guidelines for Loading and Unloading Operations of Shipborne Liquid Carbon Dioxide*. The Guidelines cover all loading and unloading operation scenarios including ship-to-ship, ship-to-shore, ship-to-tank truck and ship-to-pontoon, providing technical guidance for the loading and unloading operations of shipborne bulk liquid carbon dioxide.

The Guidelines are prepared and updated by CCS and published on the website http://www.ccs.org.cn. Users may send feedback to ig@ccs.org.cn in case of any comments on the Guidelines.

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CHAPTER 1 GENERAL

Section 1 GENERAL PROVISIONS

1.1.1 Purpose

1.1.1.1 The Guidelines are intended to provide technical guidance for shipborne liquid carbon dioxide loading and unloading operations, in order to ensure proper, efficient and safe shipborne liquid carbon dioxide loading and unloading operations.

1.1.2 Application

1.1.2.1 The Guidelines apply to bulk liquid carbon dioxide loading and unloading operations conducted in coastal or inland waterways anchorages, terminals or waters designated by the Administrations and cover loading and unloading operation modes such as ship-to-ship, ship-to-carbon dioxide shore-based storage station, ship-to-carbon dioxide tank truck, and ship-to-carbon dioxide storage pontoon. When adopting the ship-to-ship loading and unloading method, longitudinal in-line connection is excluded.

1.1.2.2 Shipborne liquid carbon dioxide loading and unloading operation is also to comply with the requirements of the Administrations.

1.1.3 Definitions

1.1.3.1 **Loading and unloading operation** is the process of loading/unloading liquid carbon dioxide via the loading and unloading system on water.

1.1.3.2 A **loading and unloading facility** refers to the facility with the capabilities of liquid carbon dioxide storage and external unloading/reception, such as carbon dioxide shore-based storage station, carbon dioxide storage pontoon, carbon dioxide carrier, ship fitted with carbon capture system and carbon dioxide tank truck. Among them, the party that unloads carbon dioxide to external parties is referred to as the "unloading party" and the party that receives and loads carbon dioxide is referred to as the "receiving party".

1.1.3.3 An **onboard Carbon Capture System** (hereinafter referred to as OCCS) is a complete system that captures carbon dioxide from the exhaust gas of ship’s combustion installations using decarbonizing agents.

1.1.3.4 A **loading and unloading system** is a system composed of connecting arrangement, loading and unloading operation pumps (if fitted) and related piping etc. and used for liquid carbon dioxide loading and unloading.

1.1.3.5 A **carbon dioxide shore-based storage station** (hereinafter referred to as shore-based station) is an onshore facility which is provided with liquid carbon dioxide storage facility, loading and unloading systems and metering equipment (if fitted) to carry out liquid carbon dioxide loading and unloading operations with ships.

1.1.3.6 A **carbon dioxide tank truck** (hereinafter referred to as tank truck) refers to a vehicle provided with an onboard carbon dioxide tank to directly carry out liquid carbon dioxide loading and unloading operations with ships at the wharf through its own or an external loading and unloading system and metering equipment (if fitted) .

1.1.3.7 A **carbon dioxide storage pontoon** (hereinafter referred to as pontoon) is a pontoon used to load and unload liquid carbon dioxide.

1.1.3.8 An **Emergency release system** (hereinafter referred to as ERS) is a system that provides a means of quick release and the safe isolation of all connecting pipelines between the unloading party and the receiving party.

1.1.3.9 An **Emergency shutdown system** (hereinafter referred to as ESD) is a system that is designed to sequentially shut down pumps and valves in an emergency to safely and effectively shut down loading and unloading operations.

1.1.3.10 An **Emergency release coupling** (hereinafter referred to as ERC) is a device that is either manually/automatically activated in case of an emergency or activated by a defined applied force on a predetermined section to achieve the separation of the loading arm or hose from the vessel’s connecting pipes. It is the main part of ERS.

1.1.3.11 A **Dry breakaway coupling** is a safety coupling which is capable of separating at a

determined break-load and/or remote control drive and sealing automatically at the both ends.
1.1.3.12 A **dry connect/disconnect coupling** (QC/DC) is a mechanical means that enables rapid connection and disconnection between the hose of the handling facility and the manifold of the receiving party in a safe manner without the use of bolts. This coupling consists of the unloading and receiving ends.
1.1.3.13 A **fender** is a large pad absorbing the impact energy to the ship while berthing, which has a sufficient width to keep the ships from contacting with each other.
1.1.3.14 **Person in Charge** (PIC) is a person who is assigned by the receiving party to be responsible for the overall management of the loading and unloading operation.
1.1.3.15 An **operation area** is an area used for loading and unloading operation. The operation area is to be in safe waters. In coastal areas, the operation area is also to be approved by the coastal Administrations and comply with the corresponding regulatory requirements.
1.1.3.16 A **restrict area** is a zone around the loading and unloading station of the handling facility and the handling system, within which irrelevant personnel are not allowed during the operation. This zone is to be subject to risk assessment.
1.1.3.17 A **security zone** is a zone where ship traffic and other activities are monitored (and controlled) to prevent entry.

Section 2 LOADING AND UNLOADING REQUIREMENTS

1.2.1 Loading and unloading facilities

1.2.1.1 Loading and unloading facilities are to comply with relevant national laws, regulations, and industry standards and their use is to comply with relevant provisions of regulatory authorities (if any).
1.2.1.2 Loading and unloading facilities are to be in a serviceable state during operations and relevant certificates are to be valid.
1.2.1.3 During operations, loading and unloading facilities are to be in a stable state, such as being anchored and moored, taking into account the effects of external conditions on loading and unloading operation.
1.2.1.4 The records of loading and unloading operation are to be retained for a period of at least three months, and not less than the time limit required by the Administrations.

1.2.2 Personnel training

1.2.2.1 The loading and unloading operators are to be subject to corresponding training. Those without training are not permitted to enter the working area during the operation.
1.2.2.2 The loading and unloading operators are to be at least subject to the training covering the following contents:
(1) emergency rescue of personnel;
(2) characteristics and hazards of carbon dioxide;
(3) risk mitigation principles for carbon dioxide loading and unloading operations;
(4) emergency response procedure for carbon dioxide loading and unloading operations;
(5) impact of impurities and their control measures;
(6) arrangement and operation procedure of the handling system;
(7) requirements for opening layout and safe operation in the restrict area on board;
(8) control range of pressure and temperature for carbon dioxide storage tanks.
1.2.2.3 Training is to be provided to the PIC of the loading and unloading operations to ensure that the PIC:
(1) has an experience in liquid carbon dioxide loading and unloading operations;
(2) is familiar with the geographic information of the operation area and its surrounding;
(3) knows the operation manual of carbon dioxide loading and unloading operations;
(4) masters the emergency handling methods for carbon dioxide loading and unloading accidents, including knowledge of the equipment and resources for the emergency response procedure.

1.2.3 Responsibilities

1.2.3.1 An organization chart is to be made by both parties of loading and unloading for the

handling facility to clarify roles and responsibilities for all operating personnel.

1.2.3.2 The ship's master/operator is to be in charge of the handling facility, including the personnel management and the safety and other issues during the whole loading and unloading process. Any operation related to loading and unloading is not permitted until both unloading and receiving parties have agreed on the loading/unloading operation.

1.2.3.3 PIC is to ensure that loading and unloading operation is carried out in accordance with appropriate requirements and procedures, and PIC is to:

(1) ensure to load and unload, moor and unmoor the ship in accordance with the loading/unloading plan and operating manual;

(2) give advice to the ship's master during loading/unloading;

(3) ensure the implementation of the emergency plan in case of carbon dioxide leakage;

(4) ensure to report in compliance with with the requirements of the competent authority;

(5) make sure that all personnel involved in loading/unloading activities have been fully aware of their responsibilities;

(6) ensure that effective communication has been established between the unloading and receiving parties and the corresponding inspections have been completed before loading and unloading operations;

(7) ensure that all safety checking before and after the loading and unloading is carried out in accordance with the Guidelines;

(8) propose to suspend or end the carbon dioxide loading and unloading operation and to modify the loading/unloading plan for some specific operations.

1.2.4 Loading and unloading operation plans

1.2.4.1 The party involved is to make a loading and unloading plan in advance of the loading and unloading operation and verify the speed, pressure, temperature and purity of the liquid carbon dioxide. Both unloading and receiving parties are to reach a consensus on the content of the plan.

1.2.4.2 The loading and unloading plan is to cover the information necessary for the safe and efficient loading and unloading operation, including compatibility assessment, operation procedures, safety checklists, safe distances and emergency response procedures.

1.2.4.3 A diagram of liquid carbon dioxide loading and unloading system is to be provided, including description of components.

1.2.5 Preparation, submission for approval and report of information

1.2.5.1 The relevant local regulations and the requirements of the Administration are to be verified in advance of the loading and unloading operation, and relevant information is to be prepared, submitted for approval and reported in accordance with these provisions.

1.2.6 Loading and unloading operation limitations

1.2.6.1 Loading and unloading areas are to be selected in accordance with the provisions of the Administration and are to be safe areas. Risk assessment is to be carried out for site selection, and the provisions of the Administration (if any) is to be complied with. Site selection is to take into account:

(1) hydrologic conditions, such as wind, wave and current;

(2) current weather conditions and weather forecast;

(3) distance to the offshore installation;

(4) availability of the designated operation area;

(5) range and depth of water sufficient for leaving berth;

(6) away from subsea pipelines, fiber optics, artificial reefs and historical sites etc.;

(7) anchorages with good grip strength;

(8) traffic densities;

(9) possible emergencies and emergency response capabilities;

(10) other potential safety problems.

1.2.6.2 It is advisable to conduct the loading and unloading operation in daylight. Where loading and unloading operations are carried out during night time, lighting should be adequately illuminating the area of loading and unloading equipment and the areas of personal activities. Lighting for facilities involved in the loading and unloading operation, manually operation

locations and means of personnel access are to comply with the requirements in Table 1.2.6.2.

Lighting requirement during the loading and unloading operation Table 1.2.6.2

Location	Reference places	Illumination standard values (lx)
Places normally attended, such as in way of pumps, compressor, valves, loading and unloading equipment and mooring bollards	Height of the operation position	100
Instrument displays, e.g. liquid meters	Height of the measuring control point	150
Carbon dioxide-related arrangements, e.g. carbon dioxide storage tanks	Top	30
Personnel accesses	Floor	30

1.2.6.3 The initial loading and unloading rate is to be maintained for a certain period of time. When the receiving party is approaching the loading limit, the loading and unloading rate is to be appropriately controlled to prevent overfilling or overflow.

1.2.7 Requirements for stopping operations

1.2.7.1 In case of the following situations, the loading and unloading operation is to be stopped:

(1) mooring ropes are loose or over-tightened;

(2) communication between the unloading and receiving parties is interrupted;

(3) the pressure and/or temperature monitored in the carbon dioxide storage tank and/or pipeline are outside the control range;

(4) leakage occurs during loading and unloading operations;

(5) a fire or explosion occurs at the wharf, anchorage, or designated operation area;

(6) other situations affecting the safety of loading and unloading operations occur.

CHAPTER 2 LOADING AND UNLOADING MODES

Section 1 MANNERS OF LOADING AND UNLOADING

2.1.1 Ship-to-ship (STS)

2.1.1.1 In general, the ship with the smaller scantling of the two ships (the unloading ship and the receiving ship) is to provide mooring lines to be moored to or unmoored from the larger, taking into account the impacts on the mooring lines caused by changes in freeboard due to carbon dioxide loading and unloading.

2.1.1.2 The pipeline connections and communication connections between the two ships are to be automatically disconnected in an emergency to make the departure of the two ships as soon as possible when necessary.

2.1.1.3 Before the official start of loading and unloading operations, the safety devices related to loading and unloading operations are to be tested.

2.1.1.4 An example of STS liquid carbon dioxide loading and unloading is given in Figure 2.1.1.5.

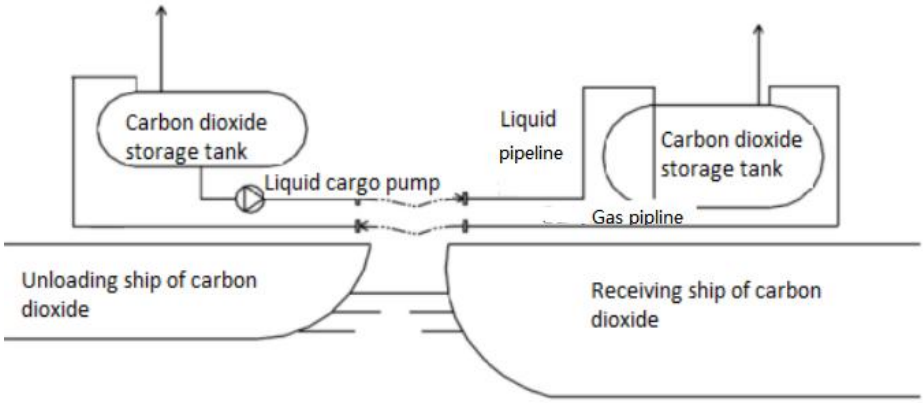

Figure 2.1.1.5 An example of STS liquid carbon dioxide loading and unloading

2.1.2 Ship-to-shore

2.1.2.1 The shore may receive the unloading of shipborne liquid carbon dioxide (as shown in Figure 2.1.2.1 (1)) and also provide liquid carbon dioxide loading services for ships (as shown in Figure 2.1.2.1 (2)).

2.1.2.2 Liquid carbon dioxide loading and unloading operations between the ship and the shore may be carried out using hoses or loading arms.

2.1.2.3 For manned shores, operators can manually close the emergency stop valve on the shore side to terminate loading/unloading in emergency situations. Unmanned shores are to verify their safety through risk assessment.

2.1.2.4 Before the official start of loading and unloading operations, the safety devices related to loading and unloading operations are to be tested.

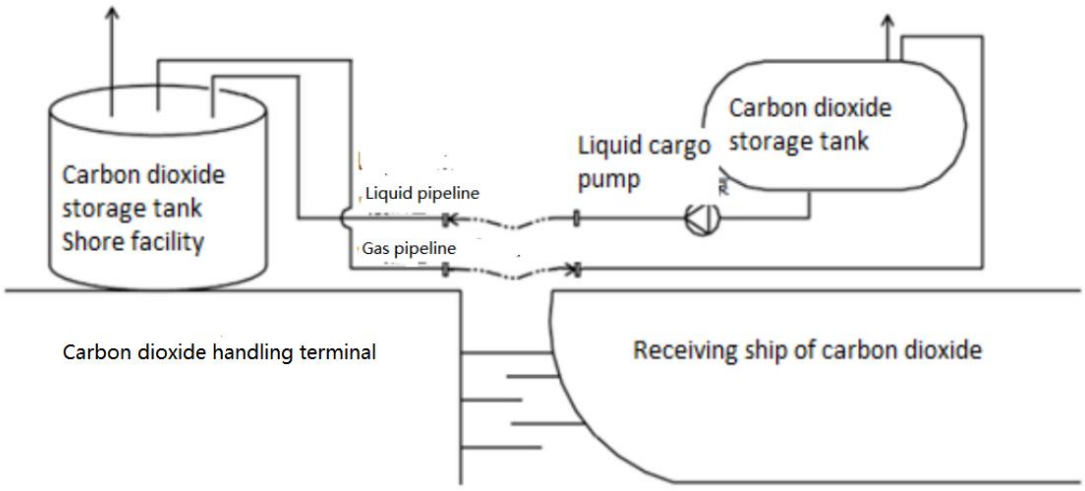

Figure 2.1.2.1(1) An example of shipborne liquid carbon dioxide unloading to shore

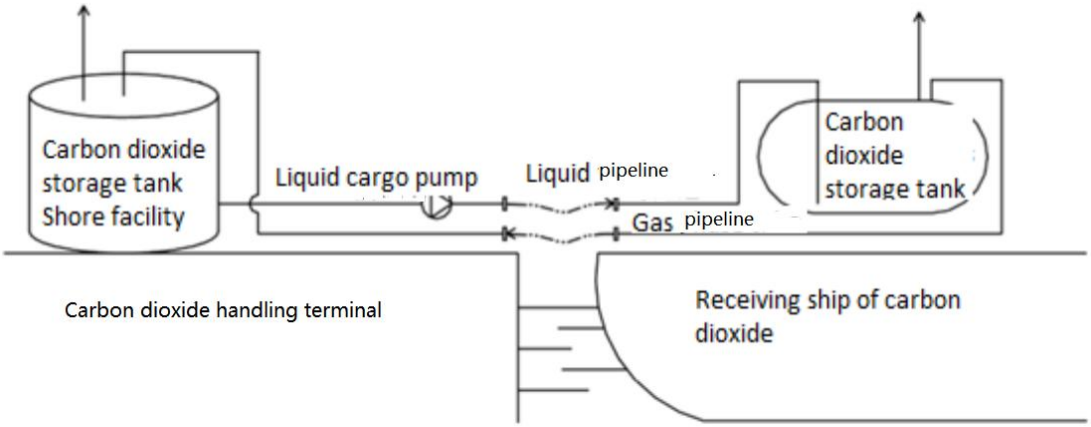

Figure 2.1.2.1(2) An example of shore-to-ship liquid carbon dioxide loading

2.1.3 Ship-to-tank truck

2.1.3.1 A satisfactory tank truck may provide liquid carbon dioxide loading and unloading service to the ship at an approved terminal.

2.1.3.2 The truck is to be correctly positioned with the engine switched off during the loading and unloading operation, and means is to be provided to prevent the tank truck from unintended starting.

2.1.3.3 Before the official start of loading and unloading operations, the safety devices related to loading and unloading operations are to be tested.

2.1.3.4 The unloading ship and tank truck are to be automatically disconnected in an emergency. The wharf operation area is to be equipped with signs indicating the entry and exit routes for tank trucks, ensuring that all tank trucks can safely evacuate the site in case of an emergency. The direction in which tank trucks depart is to, as far as possible, be upstream of the prevailing wind direction.

2.1.3.5 A wind cone or similar device is to be installed at a prominent position on the wharf to indicate the real-time wind direction, and tank trucks are to be parked as far as possible facing the upstream of the real-time wind direction.

2.1.3.6 The characteristics of truck-to-ship unloading are to be taken into account and the identification and control of corresponding risk points are to be added. For example:

(1) leakage in case of truck replacement;
(2) arrangement of safety facilities;
(3) terminal loading and unloading conditions;
(4) leakage due to more temporary appliances.

2.1.3.7 An example of truck-to-ship loading and unloading arrangement is given in Figures

2.1.3.7(1) and 2.1.3.7(2).

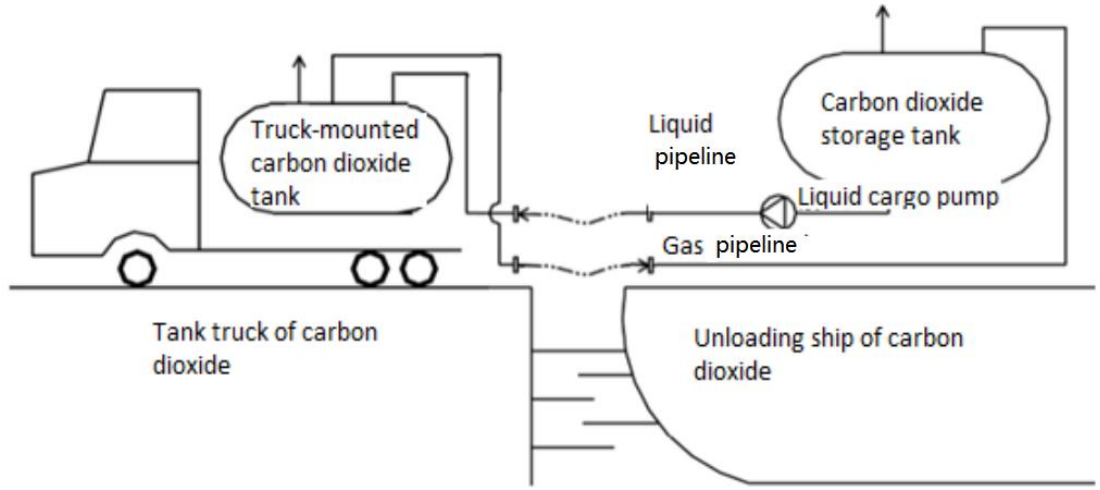

Figure 2.1.3.7(1) An example of shipborne liquid carbon dioxide unloading to tank truck

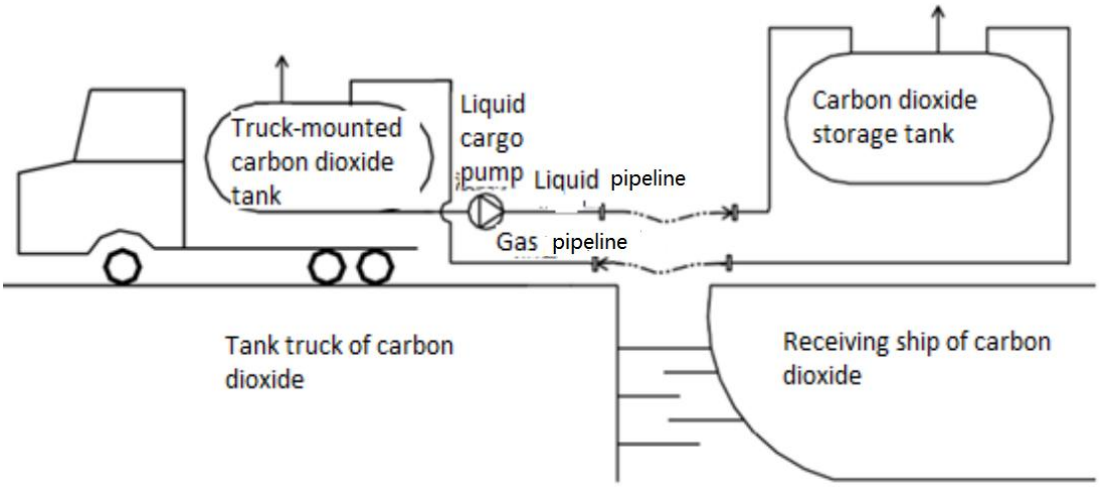

Figure 2.1.3.7(2) An example of tank-truck-to-ship liquid carbon dioxide loading

2.1.4 Ship-to-pontoon

2.1.4.1 A pontoon may provide liquid carbon dioxide loading and unloading service to a ship at wharf-side or a position in water.

2.1.4.2 The ship is to provide mooring lines to be moored to or unmoored from the pontoon, taking into account the impacts on mooring lines caused by changes in freeboard due to carbon dioxide loading and unloading and severe weather.

2.1.4.3 The mooring lines, transfer lines and communication connections between the ship and the pontoon are to be automatically released in an emergency to allow departure of the ship as soon as possible.

2.1.4.4 Before the official start of loading and unloading operations, the safety devices related to loading and unloading operations are to be tested.

Section 2 SIMULTANEOUS OPERATIONS (SIMOPS)

2.2.1 General requirements

2.2.1.1 Simultaneous operation means carrying out shipborne liquid carbon dioxide loading and unloading operations concurrently with the following operations:

(1) cargo handling;
(2) bunkering;
(3) passenger embarkation/disembarkation;

(4) any other activities apart from the above that may pose a potential hazard during the loading and unloading operation.

2.2.1.2 Any simultaneous shipboard operations or testings that may affect the safe loading/unloading of the ship or weaken the emergency response capability, such as change of the mooring conditions and testing of power generation systems and ballast systems, are not to be carried out during loading and unloading operations, unless it is necessary.

2.2.2 Operation requirements

2.2.2.1 In general, SIMOPs are not permitted inside the restrict area unless the risk is considered acceptable after a risk assessment.

2.2.2.2 Passenger embarking/disembarking is not to be permitted simultaneously with the loading and unloading operations inside the restrict area.

2.2.2.3 The risk assessment is to include, but not limited to the following:

(1) the application scope of the assessment, including the type of SIMOPs and ships;
(2) geography, weather, hydrology and channel conditions;
(3) the probability of liquid and gas carbon dioxide leakage;
(4) arrangement of accesses and exits;
(5) evacuation routes and time;
(6) dropped objects;
(7) hazardous cargo handling or restrictions;
(8) existing risk control and mitigation measures;
(9) the area for SIMOPs.

2.2.2.4 The restrictions for SIMOPs are to comply with the relevant provisions of the local Administration.

2.2.2.5 When there is a need for SIMOPs, both the unloading and receiving parties are to be provided with SIMOP procedures and emergency response procedures.

CHAPTER 3 EQUIPMENT OPERATION

Section 1 GENERAL PROVISIONS

3.1.1 General requirements

3.1.1.1 Liquid carbon dioxide loading and unloading equipment include connecting equipment, safety equipment, transfer equipment and auxiliary equipment, and all of them are to satisfy the loading and unloading service and are suitable for liquid carbon dioxide.

3.1.1.2 ERC or dry breakaway coupling can be adopted for emergency release of the loading and unloading system.

3.1.1.3 The loading and unloading system may be connected by flexible connection equipment or loading arm.

3.1.1.4 The unloading and receiving parties are to agree upon a list of equipment for use during loading and unloading operations and performance parameters before the loading and unloading operations. The list is to at least comprise:

(1) connecting equipment;
(2) ESD systems (if fitted);
(3) capacity and head of pumps;
(4) maximum working pressure of the loading and unloading system;
(5) ERC / dry breakaway coupling.

Section 2 CONNECTION EQUIPMENT

3.2.1 Flexible connecting equipment

3.2.1.1 Flexible connecting equipment means the connecting equipment normally consisting of hoses, hose handling equipment (booms/racks) and connecting joints, which is used for loading and unloading liquid carbon dioxide and maintaining pressure balance.

3.2.1.2 The following information is to be checked before operation with hoses:

(1) validity period of hose certificate / hose test report;
(2) identification code of nominal specification of the manufacture;
(3) factory test pressure (equivalent to rated working pressure, maximum working pressure and maximum allowable working pressure);
(4) diameter, range of working temperature range and minimum bend radius, etc.;
(5) date of manufacture and manufacturer’s serial number;
(6) designed service object type.

3.2.1.3 The hose test report is to be confirmed within the validity period before loading and unloading operations.

3.2.1.4 The diameter of the liquid phase hose is to be determined based on the flow and the sizing of the handling connection. The diameter of the gaseous phase hose is to be determined based on the pressure balance of the carbon dioxide storage tank.

3.2.1.5 The hose is to have length sufficient on a case-by-case basis, and the length is, in general, to be taken as twice the maximum height difference between the main pipe joints of the unloading party and the receiving party.

3.2.1.6 Before the connection of flexible connecting equipment, each hose assembly is to be visually examined to determine it is in good condition.

3.2.1.7 During the use of the hose, sufficient support is to be provided to prevent excessive bending of the hose.

3.2.1.8 The hose manufacturer’s requirements regarding lifetime, inspection and maintenance are to be strictly followed.

3.2.1.9 Injuries to personnel or mechanical damages caused by the hose after an emergency release are to be avoided.

3.2.2 Loading arms

3.2.2.1 The whole condition of the loading arm is to be checked before the operation, and the

pipes and swivels on the arm are to be visually examined to verify that no leakage occurs on each hydraulic oil piping of the arm.
3.2.2.2 Before operation of the loading arm, it is to be confirmed that the loading and unloading main pipe is within the working envelope of the loading arm. If it is in the extreme position, it is to be adjusted to a proper position.
3.2.2.3 The connection of the loading arm is to be compatible with the mating loading and unloading facilities.
3.2.2.4 The loading arm is to be inspected for foreign objects inside it prior to its connection. If any, they are to be removed and the connection operation can only be carried out after confirming that there are no foreign objects in side the arm.

3.2.3 Loading and unloading connections
3.2.3.1 The use of dry disconnect couplings is recommended for loading and unloading operations using hoses.
3.2.3.2 Dry disconnect couplings are to comply with the applicable requirements of relevant recognized standards.
3.2.3.3 If the loading and unloading connections are of a flange joint type, they are to be properly stored, kept clean, and all flange faces are to be dry before use.
3.2.3.4 Necessary examination is to be carried out before use to verify that the loading and unloading connections have good tightness and are in good working condition.

Section 3 SAFETY EQUIPMENT

3.3.1 ERS
3.3.1.1 An ERS is to be capable of working properly, and its control, alarm and release functions are to be in order. The integrity of the system is to be checked prior to the loading and unloading operation.

3.3.2 ERC
3.3.2.1 The regular inspections and testing of ERCs are to be carried out according to the manufacturer’s requirements and the records are to be remained for information.

3.3.3 Dry breakaway couplings
3.3.3.1 A passive coupling is to be capable of being released under the external force while an active coupling is to be capable of being released by remote control signal.
3.3.3.2 The shutoff of coupling is to make carbon dioxide escape as few as possible and no low temperature harm is to be caused to surrounding hull structures. The coupling’s integrity is to be checked before use.
3.3.3.3 The breakaway couplings are to comply with the applicable requirements of relevant recognized standards.
3.3.3.4 The regular inspections and testing of breakaway couplings are to be carried out according to the manufacturer’s requirements and the records are to be remained for information.

3.3.4 ESD
3.3.4.1 The ESD is to be able to stop the loading and unloading pumps and close the ESD valves. The ESD is to be activated at least in the event of:
(1) detection of carbon dioxide leakage (in liquid form or as vapour);
(2) overfillage of the receiving carbon dioxide storage tank indicated by the high high-level alarm;
(3) loading arm or hose falling off;
(4) The pressure in the loading and unloading pipeline deviates from the working pressure range (either higher or lower).
3.3.4.2 The ESD, if fitted, is to be properly connected before the loading and unloading operation and its availability and compatibility is to be verified.
3.3.4.3 When the activation of ESD causes liquid carbon dioxide to be trapped in the pipeline between two closed valves, a pressure relief valve or other pressure relief measures are to be

installed in this section of the pipeline.
3.3.4.4 The loading and unloading operation is not to be resumed until the operating conditions of the loading and unloading system and its associated safety system have been reinstated after the activation of ESD.

3.3.5 Pressure monitoring alarm

3.3.5.1 During the loading and unloading of carbon dioxide, the pressure in the loading and unloading pipeline is to be continuously monitored. Pressure displays and high/low pressure alarms are to be installed in the ship's bridge/cargo control room and the loading and unloading operation position. The high-pressure alarm setting is to be lower than the set pressure of the safety valve and the low-pressure alarm setting is generally to be 0.05MPa higher than the triple point of carbon dioxide.

Section 4 TRANSFER EQUIPMENT

3.4.1 Pump

3.4.1.1 The pump used for loading and unloading operation is generally to be provided by the unloading party.
3.4.1.2 The selection of the pump is to give full considerations to factors including the flow, pressure and temperature of liquid carbon dioxide.
3.4.1.3 The pumps used for loading and unloading operations may be either pumps fixedly connected to the carbon dioxide storage tank of the unloading party or mobile temporary pumps, which are to be effectively secured during operation.

Section 5 AUXILIARY EQUIPMENT

3.5.1 Mooring equipment

3.5.1.1 The ship is to be provided with roller chocks with reasonable arrangement and sufficient strength. Approved panama canal chocks are to be used on board. Mooring equipment are to comply with relevant standards (such as IMO MSC.1/Circ.1175). The mooring arrangement is shown in Figure 3.5.1.1.

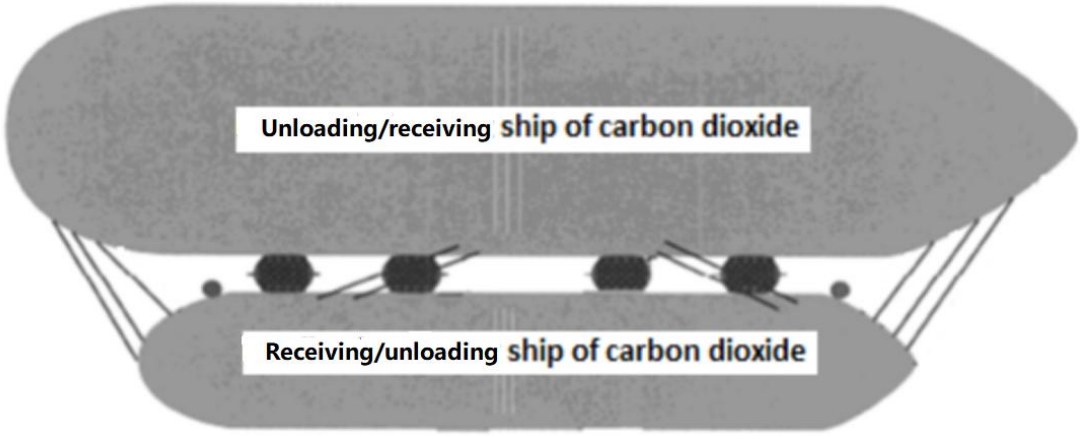

Figure 3.5.1.1 An example of the mooring arrangement

3.5.1.2 The mooring equipment are to be so arranged that the mooring lines will not accommodate excessive tension due to the ship’s movement or the change in freeboard during the operations.

3.5.2 Fenders

3.5.2.1 The ship or carbon dioxide loading and unloading wharf (pontoon) is to be provided with fenders. The fenders are to be so arranged as to help berthing the ship and distribute the expected

maximum impact force to the structures in contact with the fenders and their arrangement is shown in Figure 3.5.2.1.

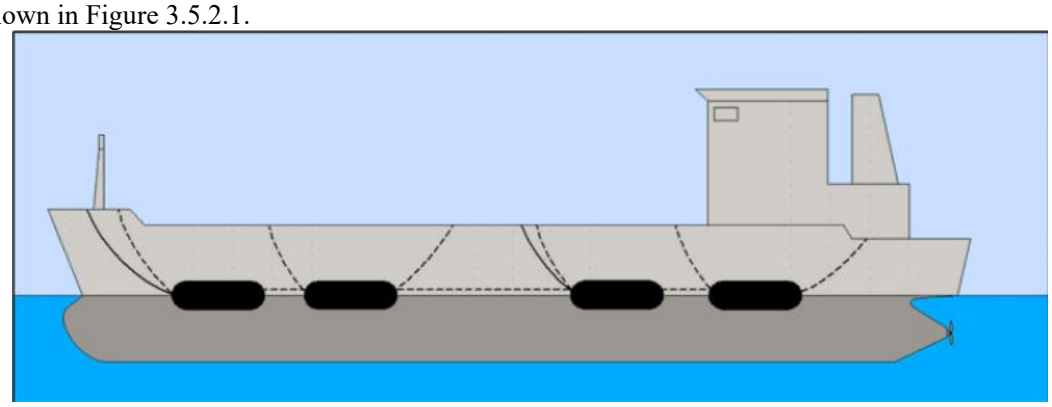

Figure 3.5.2.1 An example of the arrangement of fenders

3.5.2.2 The fenders are to be regularly monitored for any adjustment needed to ensure that they will not be too loose or too tight and will be free from displacement.

3.5.3 Communication systems

3.5.3.1 Effective communication is to be kept at all times during mooring and loading and unloading. No mooring or loading and unloading operation is to begin until effective communication has been confirmed by both partied involved.

3.5.3.2 Effective voice communication is to be provided between the unloading and receiving parties, including VHF walkie-talkies, hand-held radios and wire telephone.

3.5.3.3 Electrical, fiber-optic, pneumatic and their combination may be used to achieve the transmission of data, ESD info and ERS info between the unloading and receiving parties.

3.5.4 Measurement equipment

3.5.4.1 The impact on the safety of the loading and unloading system from any equipment used for the measurement of liquid carbon dioxide quantity during the operation is to be considered. The measurement method selected and equipment used (e.g. flow meters) are to minimize disruption of the flow of liquid carbon dioxide, so as to prevent pressure fluctuations or pressure loss in the loading and unloading system.

CHAPTER 4 SAFETY PROTECTION

Section 1 PERSONAL PROTECTION

4.1.1 General provisions

4.1.1.1 The following personal protection equipment provided on the ship may also be used for carbon dioxide loading and unloading operations.

4.1.2 Protection of operators

4.1.2.1 Personal protective equipment (PPE) are to be available for the personnel engaged in carbon dioxide loading and unloading operations, including at least:

(1) protective clothing;
(2) face shield;
(3) protective gloves;
(4) ankle boots;
(5) self-contained positive pressure air-breathing apparatus (the storage location is to allow for immediate access).

4.1.2.2 Personnel entering enclosed/semi-enclosed spaces where carbon dioxide leaks occur are to wear low-temperature-resistant safety equipment. Each set of safety equipment is to consist of:

(1) protective clothing;
(2) face shield;
(3) protective gloves;
(4) boots;
(5) steel-cored rescue line with belt;
(6) self-contained positive pressure air-breathing apparatus.

4.1.2.3 Both parties involving the loading and unloading operations are to be provided with necessary emergency protective equipment and medical first-aid equipment:

(1) self-contained positive pressure air-breathing apparatus and protective equipment;
(2) facilities such as oxygen resuscitation equipment and medical oxygen gas to deal with asphyxia;
(3) medicine and medical supplies to prevent cold injury.

4.1.2.4 The locations storing personal protective equipment are to be clearly marked.

4.1.2.5 Anti-slip coating or non-slip grilling are to be provided in the operation areas and walkways.

4.1.2.6 Personnel operating in the operation area are to be provided with emergency escape breathing devices and eye protection equipment suitable for use during emergency escape.

4.1.3 Openings of the living area

4.1.3.1 Doors and windows from the accommodation space to the operation areas are to be kept closed during the loading and unloading operation.

4.1.3.2 Doors used as a personnel access are to be kept closed and are to be immediately closed when transit through the door is complete.

4.1.4 Control of restrict area on board

4.1.4.1 The following restrictions are to apply in the restrict area during the loading and unloading operation, but not limited to:

(1) Access to the restrict area is restricted to the operating staff;
(2) All doors, windows and other openings and air inlets within the restrict area are to be kept closed;
(3) Warning signs for loading and unloading operations are to be set up.

Section 2 STRUCTURE PROTECTION

4.2.1 Carbon dioxide storage tank

4.2.1.1 Effective measures are to be taken to prevent moisture in the air from entering the carbon dioxide storage tank during the loading and unloading process, so as to minimize corrosion.

4.2.2 Loading and unloading pipelines

4.2.2.1 The loading and unloading pipelines are to be able to withstand high pressure and low temperature and are to be provided with thermal insulation protection to ensure that temperature changes do not exceed the controlled range.

4.2.2.2 Necessary mechanical protection measures are to be taken for carbon dioxide loading and unloading pipelines.

Section 3 LEAKAGE PROTECTION

4.3.1 Leakage protection

4.3.1.1 Equipment used to contain leakages are to be made of materials resistant to low temperatures and corrosion.

4.3.1.2 Pipe joints are to be able to withstand the low-temperature and deformation damages caused by dry ice.

4.3.2 Leakage handling

4.3.2.1 During the loading and unloading process, dry ice formed due to carbon dioxide leakage may be mitigated by means of heating, etc. Meanwhile, effective measures are to be taken to ensure that the temperature and pressure of the carbon dioxide storage tank and related pipelines do not exceed the design limits.

4.3.2.2 Fire hoses are to be provided in the carbon dioxide loading and unloading operation areas, which are used to spray water in the leakage area to prevent low-temperature embrittlement damage caused by direct contact between dry ice and the ship's hull.

Section 4 OVERPRESSURE EXPLOSION PROTECTION

4.4.1 Pressure relief

4.4.1.1 During loading and unloading operations, the mesh cover (if provided) at the outlet of the ventilation mast of the carbon dioxide storage tank is to be removed.

4.4.1.2 Pipelines for transporting liquid carbon dioxide that may be in a fully enclosed state are to be equipped with pressure relief valves or other relief measures.

4.4.2 Pressure control

4.4.2.1 During loading and unloading of carbon dioxide, the impacts of atmospheric temperature and geographical location is to be taken into account and appropriate pre-cooling measures are to be adopted to prevent overpressure caused by the evaporation of liquid carbon dioxide.

CHAPTER 5 RISK ASSESSMENT

Section 1 RISK ASSESSMENT APPROACHES

5.1.1 General provisions

5.1.1.1 The risk assessment of shipborne liquid carbon dioxide loading and unloading operation is to be undertaken in accordance with standards acceptable to CCS[①]. Its objective is to eliminate or mitigate the risks that carbon dioxide loading and unloading may pose to personnel, ships and the environment, and propose risk control measures when necessary.

5.1.1.2 If there is any change in the operation conditions and presumptions, the assessment is to be performed again for the changed part and the affected part.

5.1.1.3 Based on the type of loading and unloading operations, qualitative or quantitative assessment methods may be adopted for risk assessment, and the adopted method is to be approved by CCS.

5.1.1.4 The risk assessment is to be conducted by a group of members with appropriate qualifications and rich experience and these members are to be experts in the application of risk assessment, engineering design, carbon dioxide loading and unloading operations, and emergency response, etc.

5.1.2 Qualitative risk assessment (QualRA)

5.1.2.1 When the loading and unloading method complies with the requirements of the Guidelines and there is no simultaneous operation, only a qualitative risk assessment is required.

5.1.2.2 A Qualitative Risk Assessment (QualRA) is to be undertaken prior to introduction of a new loading and unloading operation procedure.

5.1.3 Quantitative risk assessment (QRA)

5.1.3.1 A quantitative risk assessment (QRA) is to be required where:

(1) the loading and unloading method differs from that given in the Guidelines;

(2) design, arrangements and operations differ from that given in the Guidelines;

(3) there are simultaneous operations;

(4) required by the Administration.

5.1.3.2 Quantitative risk assessment is a systematic approach for analyzing quantificationally the probability and consequence of accidents/incidents for comparison with risk acceptance criteria.

5.1.3.3 Quantitative risk assessment is to be able to calculate and analyze the damage scope, and in general, at least the following categories of hazards and extents of damage are to be covered:

(1) the dispersal of carbon dioxide;

(2) thermal radiation;

(3) explosion shock wave.

Section 2 ASSESSMENT CONTENTS

5.2.1 Risk assessment scenarios

5.2.1.1 As a minimum, the risk assessment scenarios of loading and unloading operation are to cover the following operations:

(1) preparations before and on ship's arrival, ship approach and mooring;

(2) preparation, testing and connection of equipment;

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① "Standards acceptable to CCS" refer to CCS Guidelines for Quantitative Risk Assessment for Oil and Gas (2020), CCS Guidelines for Application of Formal Marine Safety Assessment, and ISO 31010 Risk management -- Risk assessment techniques and other industrial standards and/or relevant rules requirements.

(3) loading and unloading of carbon dioxide;
(4) disconnection of equipment after completion of loading and unloading.

5.2.2 Risk assessment scope

5.2.2.1 As a minimum, the qualitative or quantitative risk assessments are to detail:
(1) systematic identification of potential accidents/incidents that could result in casualty or damage to the loading and unloading facilities and the environment;
(2) the probability or frequency with which the worst case consequences might occur;
(3) proposed risk control measures according to the analysis results.

5.2.3 Main risk points

5.2.3.1 The main risk points for loading and unloading operations of liquid carbon dioxide include:
(1) suffocation of personnel;
(2) cold injury to personnel due to low temperature;
(3) damage to the structure due to low temperature;
(4) solidification and blocking;
(5) overpressure explosion.

5.2.4 Risk assessment report

5.2.4.1 The risk assessment report is to at least include:
(1) schematic diagram and layout diagram of loading and unloading system
(2) risk identification;
(3) explanation of accident scenarios;
(4) assessment criteria adopted;
(5) risk models and assessment methods;
(6) assessment results and risk control measures;
(7) information on members of the risk assessment group.

Section 3 ASSESSMENT CRITERIA

5.3.1 Qualitative risk assessment criteria

5.3.1.1 Qualitative risk assessment involves expert groups providing judgments on variables (the probability of risk and the severity of consequences), and the following risk matrix may be referred to:

(1) Classification of probability of occurrence:

Level of probability	Definition	Probability
1	Very scarce	Less than or equal to once per million every year
2	Impossible	From once per million to once per hundred thousand every year
3	Very unlikely	From once per hundred thousand to once per ten thousand every year
4	Unlikely	From once per ten thousand to once per thousand every year
5	Likely	From once per thousand to once per hundred every year

(2) Classification of consequence severity levels:

Level of consequence	Loading and unloading facilities	Personnel
D	All lost	Multiple casualties
C	Badly damaged	Single death or multiple serious injuries
B	General damage	Multiple or serious injuries
A	Local equipment damage	Single or minor injury

(3) Risk matrix:

D1	D2	D3	D4	D5	Level of risk	Color
C1	C2	C3	C4	C5	High	
B1	B2	B3	B4	B5	Medium	
A1	A2	A3	A4	A5	Low	

5.3.2 Quantitative risk assessment criteria

5.3.2.1 The frequency of accidents/incidents generally needs to be determined based on industry standard data, with data sources including:

(1) failure database applicable to the carbon dioxide industry;

(2) historical statistical data, including previous failure/accident statistical data of the Administration, industry or shipping companies;

(3) failure probability database based on reliability;

(4) other data sources.

5.3.2.2 For the probability of accidents/incidents, please refer to Chapter 4 of CCS Guidelines for Quantitative Risk Assessment of Oil and Gas, if appropriate.

5.3.2.3 For the hazard acceptance criteria, please refer to Chapter 5 of CCS Guidelines for Quantitative Risk Assessment of Oil and Gas, if appropriate.

5.3.2.4 For the risk acceptance criteria, please refer to Chapter 6 of CCS Guidelines for Quantitative Risk Assessment of Oil and Gas, if appropriate.

CHAPTER 6 OPERATIONAL PROCEDURES

Section 1 PREPARATION PHASE

6.1.1 General provisions

6.1.1.1 The preparation phase starts from the first communication between the unloading and receiving parties, and ends with the physical connection of the loading and unloading pipelines.

6.1.1.2 The preparation phase is intended to prepare for and complete the safe connection between the loading and unloading facilities.

6.1.1.3 The arrangement of the restrict area and the security zone is to be confirmed.

6.1.2 Compatibility assessments

6.1.2.1 A compatibility assessment is to be undertaken prior to confirming the loading and unloading operation in order to identify any aspects that require particular management. Except in special circumstances, only one compatibility assessment is sufficient prior to the loading and unloading operation. The following is to be checked prior to engaging further in any loading and unloading operation:

(1) Compatibility of the loading and unloading control and safety systems with the connections;

(2) Whether the unloading and receiving parties have agreed on and harmonised their safety and emergency response procedures;

(3) Whether the unloading and receiving parties have doubts about the established operational procedures;

(4) Whether the risk control measures from the risk assessment have been handled and closed out;

(5) Whether the change in the ship floating state has affected the loading and unloading operations;

(6) Whether the difference between the heights of the unloading and receiving parties is within the range of the operating envelope of the loading and unloading hose/loading arm under different operating conditions;

(7) Whether the communication systems/signals are consistent;

(8) Whether the components of the loading and unloading system are suitable;

(9) The compatibility of ESD systems between the unloading and receiving parties (if fitted);

(10) Whether the loading and unloading system is subjected to a leak test prior to loading and unloading;

(11) Confirm that an isolation device, such as a stop valve, is installed between the liquid-phase pipeline and the gas-phase pipeline;

(12) Whether the volume, pressure and temperature of the carbon dioxide storage tanks of both parties are confirmed prior to the loading and unloading operation;

(13) Whether the characteristic parameter of liquid carbon dioxide intended to be loaded/unloaded is accepted by the receiving party.

6.1.3 Confirmation of loading and unloading conditions

6.1.3.1 Both the unloading and receiving parties are to check in accordance with the planning stage checklist of Annex 1 of the Guidelines prior to the loading and unloading, which are to be signed by both parties.

6.1.3.2 Both the unloading and receiving parties are to check in accordance with the simultaneous operation checklist of Annex 1 of the Guidelines prior to the loading and unloading and the checklist is to be signed by both parties.

6.1.3.3 The forecast and present hydro-meteorological conditions are to be within the operating limits for the loading and unloading system. Meteorological conditions that may affect the loading and unloading operation include, but not limited to, the following:

(1) visibility;

(2) wind direction and wind speed;
(3) height, period and direction of wave;
(4) current direction, current speed and tide;
(5) thunderstorms.

6.1.3.4 In order to avoid misoperation, the language of communication is to be agreed on before the operation. Where there is a language gap during communication, effective measures are to be adopted, such as a clear visual signal accepted by all persons involved. Where a VHF/UHF walkie-talkie or a hand-held radio is used, the equipment and the operating frequencies are to be tested prior to the loading and unloading. In case of communication failure, loading and unloading operations are to be stopped and not resumed until communication is re-established.

6.1.3.5 Lighting is to cover at least the following areas:
(1) liquid carbon dioxide loading and unloading system;
(2) ESD system call points (if fitted);
(3) arrangement position of communication equipment;
(4) storage location of personal protective equipment;
(5) passage ways/gangways intended to be used by the loading and unloading operation personnel, and
(6) vent mast(s) of carbon dioxide storage tank.

6.1.3.6 Ship mooring is to be ensured to be carried out in accordance with the approved mooring plan, taking into account:
(1) hydrologic conditions such as wind, wave and current;
(2) icing;
(3) the change in draft, trimming and rolling;
(4) wear or damage of the mooring equipment.

6.1.3.7 Consideration is to be given to the following prior to the loading and unloading operation between ship and truck:
(1) The loading and unloading ground and environmental conditions, such as road icing, are to be capable of guaranteeing safe operation of the truck;
(2) The truck is to be parked by a reliable parking device and auxiliary equipment to prevent from displacement during the loading and unloading operation;
(3) It is to be considered in the emergency response plan that several trucks present at one time in the loading and unloading area.

6.1.3.8 Safe accesses with signs are to be provided for the operation personnel between the unloading and receiving parties, which are to be positioned as far away from the liquid carbon dioxide loading and unloading manifolds as practicable. Safe accesses are to be kept clear.

6.1.4 Loading and unloading operation procedure

6.1.4.1 A loading and unloading operation procedure is to be provided and agreed by both parties involved in the loading and unloading operation, which is at least to include the following information:
(1) the amount of carbon dioxide intended to be loaded and unloaded;
(2) the details of the loading and unloading system, e.g. the quantity, maximum pressure and capacity of pumps and the capacity of pressure relief devices of loading and unloading system;
(3) loading and unloading rate (initial rate, maximum rate and rate for supplying to full) and notices during the rate change;
(4) maximum loading limit of the receiving party's carbon dioxide storage tank;
(5) normal shutdown and ESD procedures (where applicable);
(6) emergency and leakage operational procedures;
(7) on-duty arrangement;
(8) key stage of the operation;
(9) coordinated plan for the connection, purging, and disconnection of the loading and unloading system.

6.1.5 Drying of the loading and unloading facility's lines

6.1.5.1 The loading and unloading facility's lines are to be dried prior to the connection, ensuring no water remained in the lines.

6.1.6 Connection of loading and unloading systems

6.1.6.1 Inspections of flexible connection equipment and loading arms are to be carried out in accordance with the requirements of 3.2.1 and 3.2.2 of the Guidelines.

6.1.7 ERS (if fitted)

6.1.7.1 The ERS control signals and actuators are to be checked and tested and to be ready for use.

6.1.7.2 The ERC of the ERS system is to be ready for use before the loading and unloading operation commences.

6.1.8 Dry breakaway coupling (if fitted)

6.1.8.1 The dry breakaway coupling is to be checked to ensure it is operable.

6.1.9 ESD (if fitted) connection testing

6.1.9.1 It is to be ensured that a linked ESD system is connected, tested and ready for use.

6.1.9.2 The ESD system is to be tested following the connecting of the loading and unloading system and link of ESD. The testing is to take place between the unloading and receiving parties prior to commencement of operation to confirm that the systems are compatible and correctly connected.

Section 2 LOADING AND UNLOADING PHASE

6.2.1 General provisions

6.2.1.1 The loading and unloading phase begins after the safe connection of loading and unloading pipelines is completed, the gas-phase pipeline valve is opened, and the pressure of the carbon dioxide storage tanks on both the unloading and receiving sides is balanced. It proceeds with opening the liquid-phase pipeline loading and unloading valve and starting the loading and unloading pump (if any), and terminates when the loading and unloading operation ends and the liquid carbon dioxide loading and unloading valves on both the unloading and receiving sides are closed.

6.2.1.2 If the actual loading and unloading mode is different from that the Guidelines apply to, it is to be ensured that all necessary operations is are equivalent to the relevant requirements of the Guidelines.

6.2.2 Purging of loading and unloading pipelines

6.2.2.1 The loading and unloading pipelines are to be purged before the loading and unloading operation. The purging medium is generally carbon dioxide gas from the gas-phase pipeline. If other inert gases are used, they are to be used only after evaluation by both the unloading and receiving parties.

6.2.3 Loading and unloading operation

6.2.3.1 The operator of the unloading party is to slowly open the gas-phase pipeline valve and the liquid-phase pipeline valve in sequence. After confirming that there is no leakage in the loading and unloading pipelines and that the loading and unloading pressures of both parties are consistent, the unloading party is to send a ready signal through the agreed communication method.

6.2.3.2 After the pressure of the gas-phase pipeline stabilizes, the operator of the receiving party opens the gas-phase pipeline valve.

6.2.3.3 After the pressure of the carbon dioxide storage tank on the receiving party balances with that on the unloading party, the receiving party opens the liquid-phase pipeline valve, and then starts the loading and unloading pump or adopts differential pressure for unloading.

6.2.3.4 The loading and unloading rate is to be gradually increased until it reaches the rate agreed upon by both parties.

6.2.3.5 The system pressures, temperature, liquid level and equipment conditions are to be continuously monitored by both parties for the duration of the loading and unloading operation. If there is any abnormity, the loading and unloading operation is to be immediately stopped and not

resumed until it returns to normal.
6.2.3.6 If communications fail, all loading and unloading operations are to be suspended immediately and not resumed until communication has been re-established.

6.2.4 Topping up of the tank

6.2.4.1 The loading and unloading flow rate is to be reduced to the agreed topping up transfer rate when the receiving liquid carbon dioxide level approaches the loading limit. Where the agreed loading and unloading quantity is reached, the operator of the receiving party is to notify those of the unloading party in a predetermined communication manner.
6.2.4.2 Where the receiving carbon dioxide storage tank is at a high liquid level, the operating personnel is to take appropriate action to stop loading and unloading prior to ESD (if fitted) activation.

6.2.5 Supervision

6.2.5.1 The operation condition of loading and unloading pump or differential pressure for loading and unloading is to be continuously monitored.
6.2.5.2 The pressure, temperature and liquid level of carbon dioxide storage tank is to be monitored continuously.
6.2.5.3 Any leak during the loading and unloading operation is to be monitored.

Section 3 LOADING AND UNLOADING COMPLETION PHASE

6.3.1 General provisions

6.3.1.1 The loading and unloading completion phase begins once the liquid carbon dioxide loading and unloading valve has been closed. It ends once the unloading and receiving parties have safely separated and all required documentation has been completed.

6.3.2 Purging of loading and unloading lines

6.3.2.1 The hoses are to be purged before disconnection and closure of all valves to prevent from a risk from the residual liquid/gas after the completion of the loading and unloading operation. It is recommended to use carbon dioxide in gas-phase pipelines for cleaning the loading and unloading lines. If other inert gases are used for purging, they are to be used only after evaluation by both the unloading and receiving parties.

6.3.3 Check after loading and unloading

6.3.3.1 Valves on the pipes of both parties are to be closed after completion of purging.
6.3.3.2 A post-loading/unloading checklist is to be completed and signed by both parties after the loading and unloading operation. Details are specified in the Post Loading and Unloading Checklist of Annex 1 of the Guidelines.

6.3.4 Disconnection of pipes

6.3.4.1 After confirmation of the Post Loading/unloading checklist mentioned in 6.3.3.2 of the Guidelines, the operating personnel may disconnect and blind off the connecting pipes of the receiving party (liquid and vapor pipes).
6.3.4.2 Where a hose is used for loading and unloading facilities, the hose is to be stored in the specified location after being removed from its supports.

6.3.5 Disconnection of communications

6.3.5.1 Where wired communications are used, they are to be disconnected and recovered after completion of the loading and unloading.

6.3.6 Alert relief

6.3.6.1 The pipeline and communication connections are to be disconnected. After checking and confirming safety, the restrict area and the security zone are to be lifted and the signs are to be

removed.

6.3.7 Document handover and report

6.3.7.1 After the completion of carbon dioxide loading and unloading, both the unloading and receiving parties are to conduct the handover of relevant documents, which is to include at least the liquid carbon dioxide loading and unloading Delivery Note or similar documents, with each party retaining one copy.

6.3.7.2 The completion of liquid carbon dioxide loading and unloading operation is to be reported to the Administration (if applicable).

CHAPTER 7 EMERGENCY RESPONSE

Section 1 EMERGENCY RESPONSE PROCEDURES

7.1.1 General provisions

7.1.1.1 The emergency procedure is to cover all possible emergencies and considerations are to be given to at least the following:

(1) procedure and emergency signals for sounding the alarm;
(2) stopping operation during the emergencies;
(3) procedures for notification and reporting;
(4) action by personnel;
(5) personnel protection;
(6) responsibilities of relevant personnel;
(7) information table on external rescue.

7.1.1.2 Where feasible, both the unloading and receiving parties are to conduct appropriate drills within 24 hours before the start of the loading and unloading operation (and in no case shall it exceed 7 days), so that the relevant personnel can understand the emergency response procedures.

Section 2 EMERGENCY ACCIDENT HANDLING

7.2.1 General provisions

7.2.1.1 After an accident occurs, accident handling is to be carried out immediately with safety protection for personnel and equipment.

7.2.1.2 The person in charge (PIC) is to immediately evacuate unrelated personnel, give warning signals to the neighbouring areas and organize rescue.

7.2.2 Emergency responses to carbon dioxide leakage

7.2.2.1 If an ESD is fitted, the ESD system is to be activated to stop the operation and determine the location of the leakage source.

7.2.2.2 If no ESD is fitted, all the valves connected to the leaking pipe section are to be closed immediately, and proper measures are to be taken for personnel protection.

7.2.2.3 Repairs to the leak point may be carried out only after the pipe section is depressurized. Protective tools must be used for repairs and direct contact with the hand is forbidden.

7.2.2.4 Emergency response operations are to be carried out at the upwind position of the carbon dioxide leakage point.

7.2.2.5 The cause is to be identified and repairs are to be carried out. Loading and unloading operations can only be conducted after the loading and unloading system returns to normal.

7.2.3 Emergency responses to overpressure explosion

7.2.3.1 If an ESD is fitted, the ESD system is to be started to stop the operation and determine the location of the explosion for isolation.

7.2.3.2 If no ESD is fitted, all the valves connected to the pipe section of explosion source are to be closed immediately, explosion locations are to be isolated and measures are to be taken for personnel protection.

7.2.3.3 The person in charge (PIC) is to immediately organize a search and rescue team, evacuate personnel to a safe area upwind of the explosion site, and simultaneously determine the nature and level (or status) of the incident. If external rescue is required, emergency rescue is to be requested in accordance with the emergency response procedures.

7.2.3.4 Emergency response operations are to be carried out at the upwind position of the explosion source.

7.2.3.5 The cause is to be identified and repairs are to be carried out. Loading and unloading operations can only be conducted after the loading and unloading system returns to normal.

7.2.4 Personnel protection and on-site first aid

7.2.4.1 The emergency responders are to wear safety equipment as specified in 4.1.2.2 of the Guidelines.

7.2.4.2 In case of cold injury to personnel, the following measures may be adopted on site:

(1) move the injured to warm places, loosen the clothes, use towels and blankets to keep the body warm and do not rub the frostbitten areas;

(2) immerse the frostbitten areas in the lukewarm water at 37 to 40℃ and do not use hot water soaking or open flames for heating;

(3) take targeted treatment measures according to the situation of personnel injuries and send them to the hospital for treatment as soon as possible if necessary.

7.2.4.3 In case of personnel suffocation, the following measures may be adopted on site:

(1) quickly move the person suffering from asphyxiation from the high-concentration carbon dioxide environment to a well-ventilated place with fresh air, loosen the collar, belt and other restrictive items of the person suffering from asphyxiation, and maintain an unobstructed airway;

(2) foreign objects and secretions in the nasal cavity and oral cavity of the person suffering from asphyxiation are to be removed to ensure that the respiratory tract is unobstructed;

(3) targeted treatment measures are to be adopted based on the condition of the person suffering from asphyxiation and send them to the hospital for treatment as soon as possible if necessary.

7.2.4.4 In case of other personnel injuries, the following measures may be adopted on site:

(1) targeted treatment measures are to be adopted according to the situation of personnel injuries, such as hemostasis, bandaging and cardiopulmonary resuscitation (CPR);

(2) send them to the hospital for treatment as soon as possible if necessary.

ANNEX 1 THE CHECKLIST

Part A Planning Stage Checklist

Planning date and time:
Designated loading and unloading location:
Unloading party (□ carbon dioxide transport ship/ □ ship fitted with OCCS/ □ carbon dioxide shore-based storage station/ □ carbon dioxide storage pontoon/ □ carbon dioxide tank truck):
Receiving party (□ carbon dioxide transport ship/ □ carbon dioxide shore-based storage station/ □ carbon dioxide storage pontoon/ □ carbon dioxide tank truck):

	Check	Unloading party	Receiving party	Remarks
1.	All mandatory emergency equipment are ready for immediate use.			
2.	All carbon dioxide detectors have been tested and calibrated, in good condition and in good working order.			
3.	Operating personnel have worn PPE.			
4.	Instrumentation and control, shutdown and safety equipment are in order.			
5.	Loading and unloading operation plans, operation manuals and emergency response procedures are available.			
6.	All operators have the appropriate training and are familiar with the operation procedures for relevant equipment.			
7.	Both parties have agreed on the mooring and fender arrangement.			
8.	The operation area is sufficiently illuminated.			
9.	The procedures for transfer and purging operations have been agreed upon by both parties.			
10.	The restrict area has been agreed upon.			restrict area:
Additional remarks:				
Signature Unloading party: Receiving party: Date: Date:				

Part B Liquid Carbon Dioxide Transfer Data (if applicable)

(This Part is to be completed before actual loading and unloading operations start)
Planned date and time:
Designated loading and unloading location:
Unloading party:
Receiving party:
Note the agreed Physical Quantity Unit (PQU): □ m^3 □ tonne

Agreed start pressure				
	Unloading party	Receiving party		Unit
Receiving party				bar/psi*（rel）
Available (rest) capacity				PQU
Agreed loading and unloading operations				
Agreed quantity to be unloaded				PQU
Start pressure at the manifold				bar/psi*（rel）
Start rate				PQU per hour
Max loading and unloading rate				PQU per hour
Topping-up rate				PQU per hour
Max pressure at the manifold				bar/psi*（rel）
Agreed maximums and minimums				
		Maximum	Minimum	
Pressure during loading and unloading	——			bar/psi*（rel）
Pressure in the carbon dioxide storage tanks	——			bar/psi*（rel）
Filling limits of the carbon dioxide storage tanks	——			%
Agreed end pressure				
	Unloading party	Receiving party		
End pressure				bar/psi*（rel）
Effective (rest) capacity				PQU
Signature Unloading party: Receiving party: Date: Date:				

*: if applicable.

Part C Simultaneous Operations Checklist (if applicable)

Planning date and time:
Designated loading and unloading location:
Unloading party (□ carbon dioxide transport ship/ □ ship fitted with OCCS/ □ carbon dioxide shore-based storage station/ □ carbon dioxide storage pontoon/ □ carbon dioxide tank truck):
Receiving party (□ carbon dioxide transport ship/ □ carbon dioxide shore-based storage station/ □ carbon dioxide storage pontoon/ □ carbon dioxide tank truck):

	Check	Unloading party	Receiving party	Remarks
1.	Planned simultaneous bunker operations of fuels during the loading and unloading of liquid carbon dioxide are in compliance with ship's approved simultaneous operational manuals for carbon dioxide loading and unloading and fuel bunkering.			If applicable
2.	Planned simultaneous cargo operations during the loading and unloading of liquid carbon dioxide are in compliance with ship's approved simultaneous operational manuals for carbon dioxide loading and unloading and cargo operations.			If applicable
3.	Planned simultaneous operations for passengers boarding and disembarking the ship during the loading and unloading of liquid carbon dioxide are in compliance with ship's approved simultaneous operational manuals for carbon dioxide loading and unloading and passengers boarding and disembarking the ship.			If applicable
4.	Other planned simultaneous operations during the loading and unloading of liquid carbon dioxide are in compliance with ship's approved simultaneous operational manuals.			If applicable
5.	The Administration has granted permission for simultaneous bunkering and/or cargo operations and/or passengers boarding and disembarking the ship whilst loading and unloading of liquid carbon dioxide.			If applicable
6.	Safety procedures and mitigation measures for simultaneous activities are agreed upon and are being observed by all parties involved.			If applicable
Signature Unloading party: Receiving party: Date: Date:				

Part D Post Loading and Unloading Checklist

(This Part is to be completed after loading and unloading operations have been completed)
Planned date and time:
Designated loading and unloading location:
Unloading party:
Receiving party:

	Check	Unloading party	Receiving party	Remarks
1.	Valves are closed and ready for disconnection.			
2.	Hoses/loading arms and pipelines for loading and unloading of liquid carbon dioxide have been purged and are ready for disconnection.			
3.	Remote and manually controlled valves are closed and ready for disconnection			
Additional remarks:				
Signature Unloading party: Receiving party: Date: Date:				