I. General Measures for LNG fuelled Ships

Report

June 2013

Review Committee for Comprehensive Measures toward Disseminating/Promoting LNG Fuelled Ships

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Note: (Predecessor)

General Measures for LNG fuelled Ship

Contents

Study Result ①

Safety requirements for high pressure gas supply system

Safety requirements for high pressure gas supply system

1 Fuel piping system – functional requirements

- Supply gas pressure control function

  Automatic control function for matching the actual supply pressure with the gas supply pressure required on the engine side for controlling engine rpm/load, and adequate supply capacity to suit the engine governor performance are necessary.

  With regard to gas fuel supply capacity, considerations to prevent loading/gasification of LNG on the suction side are necessary for the LNG fuel system from the LNG tank to the LNG high pressure supply pump so that it satisfies the suction capability (net suction head: N.P.S.H.) required in the high pressure pump.

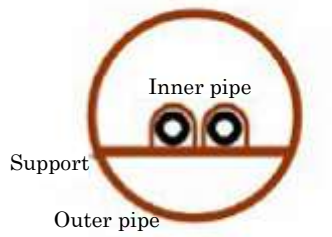
- Pressure pulsation reducing function in the high pressure gas supply system

  Even if the supply volume of the LNG supply pump and the consumption volume of the engine vary, a buffer function is necessary in the system to ensure that the pressure variation in the supply system does not become excessive. The volume needs to be adjusted depending on the length/volume of the high pressure supply system; however, allowable pressure variation of ±0.5 MpaG should be selected as to suit the requirements of the gas engine.

- Thermal expansion and absorption function for double wall pipe

  High pressure gas pipe and purge pipe are maintained at the center of the outer pipe in the double wall pipe. A support structure is necessary that allows relative sliding of the outer pipe in the double wall pipe and the high pressure gas pipe due to thermal expansion and vibration. The outer pipe in the double wall pipe needs to be provided with a flexible joint at the required location.

  Systems as shown in Fig. ①-1.1 and Fig. ①-1.2 may be considered for supporting the inner pipes.



Double wall pipe (cross section)

Fig. ①-1.1 U-band system

Fig. ①-1.2 Slide support system

- Emergency stop function

  Emergency stop signal is emitted in case of the following events; a system needs to be configured such that the supply system side and the engine side can automatically and safely stop the gas operation.

  - When a problem occurs in the supply system, such as an LNG pump fault
  - When a problem occurs on the engine side
  - When leak is detected in the double compartment
  - Push button signal other than the above is emitted, when a person has perceived danger.

1.1 Functional requirements of fuel supply double wall pipe in gas-safe machinery space

- Exhaust system

  If the vent air inlet of the exhaust system and the exhaust discharge outlet are both arranged in a safe space outside the engine room, even if a large amount of gas leaks occurs, there is no leak within the engine room. Moreover, the detection of gas by HC sensor is also instantaneous, and the rise in pressure within the system is very small; therefore, there is no effect on equipment such as shut-off valve and pressure sensor in the engine room.

- Pressurization system

  The pressurization system needs to be provided with means to relieve pressure quickly (safety valve, or rupture disk, etc.) since the pressure in the space rises quickly. Also, the withstanding pressure in the outer pipe must be made the same as that in the inner pipe; similar considerations are necessary for equipment in the space.

  For closing the internal part of the outer pipe, systems proposed by IGF include the pressurization system, the method of pressurizing with inert gas at higher pressure than gas fuel, and the method of shutting off fuel supply when a vacuum loss occurs after monitoring at all times the vacuum condition, and purging the piping. For the former system, the outer pipe and the equipment in the system need to be at a design pressure of 30 MPaG or greater. Similar to the considerations this time, the latter system needs to be provided with means to relieve pressure quickly (safety valve, or rupture disk, etc.) since the pressure in the space can rise quickly. Moreover, the withstanding pressure in the outer pipe must be made the same as that in the inner pipe; similar considerations are necessary for equipment in the system.

1.2 Design of outer pipe and ventilation duct for gas leak in inner pipe

- Outer pipe wall measurement requirement

  Pressure design ensuring adequate safety can be attained by maintaining appropriate distance from the inner pipe. The diameter of the outer pipe in a double wall pipe can be calculated based

on the equation below (equation of ultimate pressure of the inner wall of the outer tube).

$$P = Ap\frac{r_0}{r}$$

P：Ultimate pressure (MPa), A：Constant (0.23), p： Burst pressure (Example：30 MPa), r_0：Inner radius of inner pipe (mm), r：inner radius of outer pipe (mm)

- When gas leaks, temperature may decrease due to expansion; however, if the requirement of distance from the inner pipe is satisfied as mentioned in the previous section, low-temperature steel pipe doesn't need to be used as the material of the outer pipe.

Study result ②

Safety requirements during operation, entry or departure from port of LNG fuelled ship not receiving fuel supply

Safety requirements during operation, entry or departure from port of LNG fuelled ship not receiving fuel supply

With regard to the response performance of main engine with fuel in natural gas form, it has been confirmed that the load response is gradual during normal use. This is adequate for normal operation, so the effect on maneuverability of the ship is considered to be small.

With regard to other factors, safety equivalent to that in conventional ships using heavy fuel oil can be guaranteed by international standards such as the IMO standards. Therefore, even if LNG is used as fuel, the ship can operate, enter and leave port similar to conventional ships.

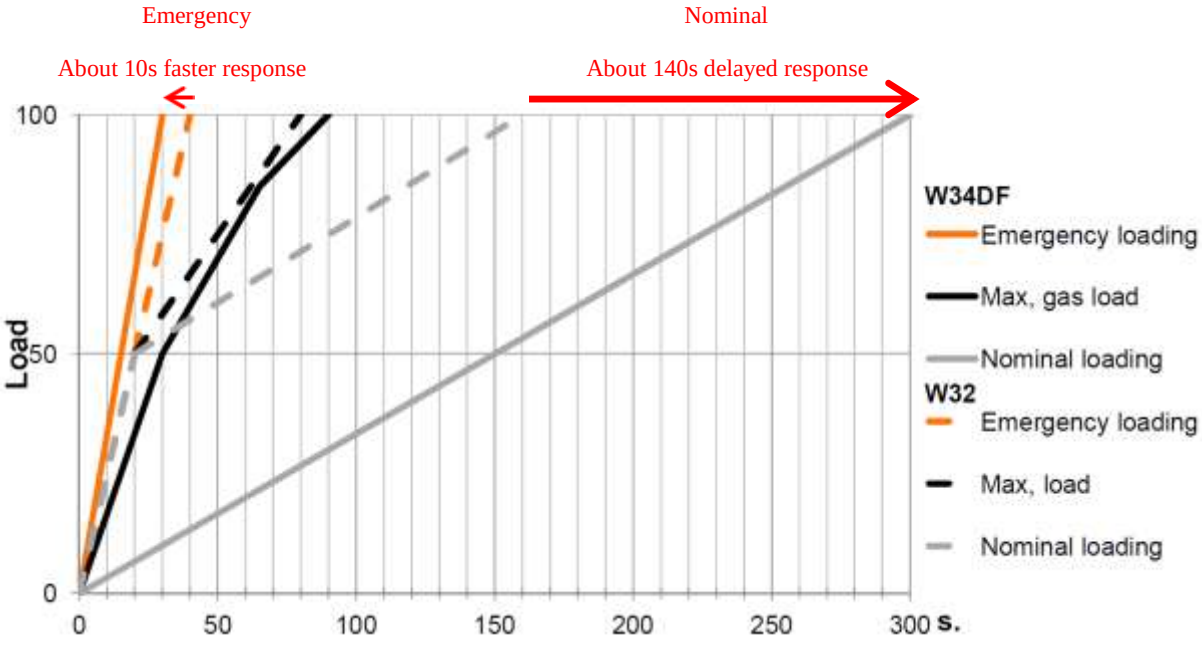


Fig. ②-1.1 Performance comparison of DF engine (W34DF) and heavy fuel oil engine (W32)

Study result ③

LNG fuel transfer guidelines and operation manual

LNG fuel transfer guidelines and operation manual

1 Guidelines and Operation Manual for Ship-to-Ship LNG Transfer

Guidelines specifying standard procedures, safety measures for machinery and equipment to be used as basic guidelines for safely supplying LNG fuel, and operation manual describing the work for supplying LNG fuel were formulated for LNG transfer by the Ship to ship system from an LNG bunker ship to a LNG fuelled ship.

The composition of the guidelines and operation manual is as given below; the safety management system and safety measures required for LNG transfer by the Ship to Ship system are prescribed in these documents.

For more details, refer to the separate "Ship-to-ship LNG Transfer Guidelines" and the "Operation Manual for Ship-to-Ship LNG Transfer."

Table ③-1.1 Composition of Ship to ship LNG Transfer Guidelines

Chapter 1	General overview	Chapter 7	LNG fuel transfer equipment, materials and machinery
Chapter 2	Safety measures	Chapter 8	Emergency response
Chapter 3	Communications	Chapter 9	Earthquake and tsunami measures
Chapter 4	Works before the LNG fuel transfer	Chapter 10	Flow chart of LNG fuel transfer by the StS System
Chapter 5	LNG fuel transfer work	Chapter 11	Checklist
Chapter 6	Works after the LNG fuel transfer work	Chapter 12	References

Table ③-1.2 Composition of Operation Manual for Ship to Ship LNG Transfer

1. Coming alongside preparations	8. ESDS functional test at normal temperature	15. Methane purging (liquid)
2. Preparations before start of berthing and transfer	9. Line cool-down	16. Measurement after LNG transfer
3. Discussion before start of transfer	10. ESDS functional test at low temperature	17. Methane purging (vapor)
4. Hose connection	11. Start of transfer	18. Hose disconnection
5. O_2 purging	12. Steady-state transfer	19. Meeting after completion of transfer
6. Leak test	13. Transfer completion	20. Leaving ship's side
7. Measurement before LNG transfer	14. Draining	

2 Guidelines and Operation Manual for Shore to Ship LNG Transfer

Guidelines specifying standard procedures, safety measures and machinery and equipment to be used as basic guidelines for a LNG fuelled ship to safely receive LNG supply from shore facilities (Shore to Ship LNG transfer) after the ship reaches the quay or berth capable of supplying LNG fuel, and operation manual describing the work of supplying LNG fuel were formulated.

The composition of these guidelines and the operation manual is as given below. The safety management system and safety measures required for LNG transfer by the shore to ship system are prescribed in these documents.

For more details, refer to the separate "Shore to ship LNG Transfer Guidelines" and the "Operation Manual for Shore to Ship LNG Transfer."

Table ③-2.1 Composition of Shore to Ship LNG Transfer Guidelines

Chapter 1	General overview	Chapter 7	LNG fuel transfer equipment, materials and machinery
Chapter 2	Safety measures	Chapter 8	Emergency response
Chapter 3	Communications	Chapter 9	Earthquake and tsunami measures
Chapter 4	Before the LNG fuel transfer	Chapter 10	Flow chart of LNG fuel transfer by the Shore to Ship System
Chapter 5	LNG fuel transfer work	Chapter 11	Checklist
Chapter 6	After the LNG fuel transfer work	Chapter 12	References

Table ③-2.2 Composition of Shore to Ship LNG Transfer Guidelines

1. Preparations before entering port	8. ESDS functional test at normal temperature	15. Methane purging (liquid)
2. Preparations before start of berthing and transfer	9. Line cool-down	16. Measurement after LNG transfer
3. Discussion before start of transfer	10. ESDS functional test at low temperature	17. Methane purging (vapor)
4. Hose/arm connection	11. Start of transfer	18. Hose/arm disconnection
5. O_2 purging	12. Steady-state transfer	19. Meeting after completion of transfer
6. Leak test	13. Transfer completion	20. Unberthing
7. Measurement before LNG transfer	14. Draining	

3 Guidelines and Operation Manual for Truck to Ship LNG Transfer

Guidelines specifying standard procedures, safety measures and machinery and equipment as basic guidelines for a LNG fuelled ship to safely receive LNG supply from shore based LNG truck (Truck to Ship LNG transfer) after it reaches the quay or berth capable of supplying LNG fuel, and an operation manual describing the work of supplying LNG fuel were formulated.

The composition of these guidelines and the operation manual is as given below; the safety management system and safety measures required for LNG transfer by the truck to ship system are prescribed in these documents.

For more details, refer to the separate "Truck to Ship LNG transfer guidelines" and the "Operation Manual for Truck-to-Ship LNG Transfer."

Table ③-3.1 Composition of Truck to Ship LNG Transfer Guidelines

Chapter 1 General overview	Chapter 7 LNG fuel transfer equipment, materials and machinery
Chapter 2 Safety measures	Chapter 8 Emergency response
Chapter 3 Communications	Chapter 9 Earthquake and tsunami measures
Chapter 4 Before the LNG fuel transfer	Chapter 10 Flow chart of LNG fuel transfer by the Truck to Ship System
Chapter 5 LNG fuel transfer work	Chapter 11 Checklist
Chapter 6 After the LNG fuel transfer work	Chapter 12 References

Table ③-3.2 Composition of Operation Manual for Truck to Ship LNG Transfer

1. Preparations before entering port	8. ESDS functional test at normal temperature	15. Methane purging (liquid)
2. Preparations before start of berthing and transfer	9. Line cool-down	16. Measurement after LNG transfer
3. Discussion before start of transfer	10. ESDS functional test at low temperature	17. Methane purging (vapor)
4. Hose connection	11. Start of transfer	18. Hose disconnection
5. O_2 purging	12. Steady-state transfer	19. Meeting after completion of transfer
6. Leak test	13. Transfer completion	20. Unberthing
7. Measurement before LNG transfer	14. Draining	

Study result ④

Safety measures for navigation related to Ship-to-Ship LNG fuel transfer

Safety measures for navigation related to Ship-to-Ship LNG fuel transfer

Standard safety measures for navigation as given below were formulated in relation to safety requirements to be generally considered to ensure safety of the LNG bunker ship (which supplies LNG fuel to LNG fuelled ships) while entering/leaving port, when coming alongside/leaving ship's side, maneuvering and mooring.

The safety measures formulated here are based on the studies related to 2.1 "Studied ships" at the end of this document; therefore, in case the LNG fuelled ship has a special hull form, or if the vessel is a small craft with overall length that does not go up to 100 m[1], and if the LNG bunker ship is extremely small compared to a coastal LNG ship (tank capacity 2,500 m3), it may not be appropriate to apply these safety measures. In such cases, separate additional studies may be necessary.

Actions based on the safety measures prescribed here shall be formulated for receiving commands, instructions, and permissions based on Regulations 21 to 23 of the Act on Port Regulations for the LNG bunker ship. At the same time, studies shall be conducted if necessary, at individual operating location (port) in relation to special external forces specific to that area (long-period waves, strong tidal currents, etc.) and the usage conditions in port.

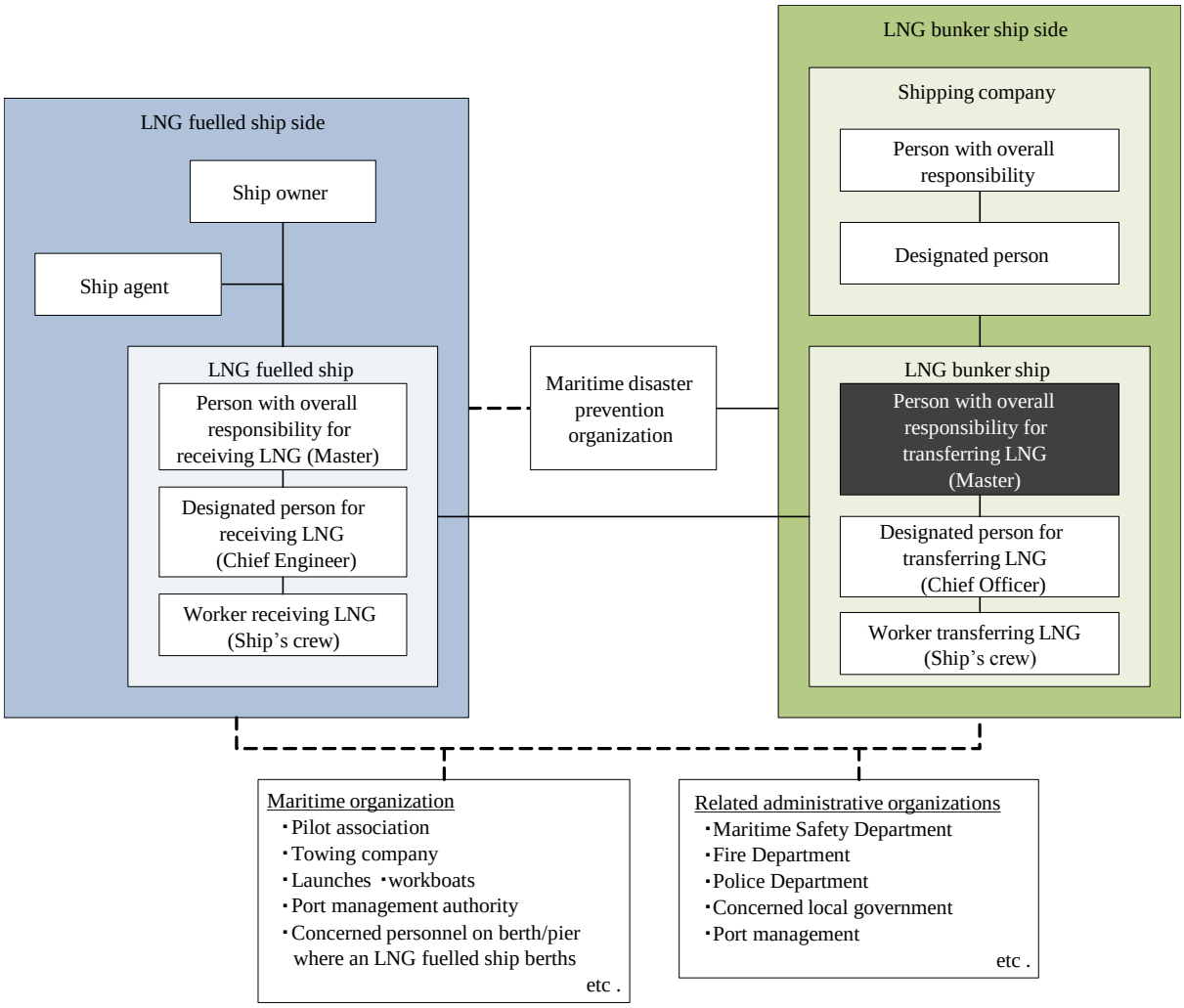
1 Safety measures for navigation

1.1 Provision of safety management system

A safety management system shall be provided that has unified jurisdiction over communications and coordination with maritime authorities and other related organizations for the collection of necessary information such as weather and sea conditions and ship traffic within ports. Such a system is required to ensure safety during maneuvering, mooring and transfer of LNG by the StS system between LNG fuelled ships and LNG bunker ships. Fig. ④-1.1 shows an example of a safety management system.

The roles and duties of every person in this system are given below.

[1] Results of mooring simulation of bunker ships (overall length of about 100 m) showed that motion tended to be comparatively large for small ships. Thus, if the natural gas carrier is about the same size or smaller than a bunker ship, the relative motion between the two ships may become very large.



* Solid lines indicate formation of a communication system at each implementation and dashed lines the same at implementation if necessary

Fig. ④-1.1 Safety Management System related to StS LNG transfer

(1) Shipping company (LNG bunker ship)

① Person with overall responsibility

The person with the highest responsibility shall be the overall in charge of the related work. This person shall command and supervise the designated persons.

② Designated person

The designated person shall manage matters related to implementation, safety and disaster prevention during LNG transfer by the StS system under the command and supervision of the person with overall responsibility

(2) LNG bunker ship

① Person with overall responsible for transferring LNG (Master)

As the person with the highest responsibility on board the LNG bunker ship, the master is responsible for the LNG transfer and shall have total responsibility for the LNG transfer work. For this purpose, the master shall have a firm grasp of the latest weather and sea conditions, forecasts, and other essential information (hereafter referred to as "latest weather information") at all times. The master shall make all judgments necessary from the time of approach and coming alongside through the start, completion, continuation and suspension of the LNG transfer including emergency unberthing, until the LNG bunker ship leaves the ship's side.

If required, the master shall give assistance to the LNG fuelled ship.

② Designated person for transferring LNG (Chief Officer)

The Chief Officer is the designated person for LNG transfer on the LNG bunker ship. He shall command and manage crew members on the ship and assume responsibility for the LNG transfer work on the LNG fuelled ship.

③ Worker transferring LNG

Shall implement LNG transfer work on board the LNG bunker ship.

(3) LNG fuelled ship

① Person with overall responsibility for receiving LNG (Master)

As the person with the highest responsibility on board the LNG fuelled ship, the master shall unify tasks related to LNG transfer and its safety. For this purpose, the master shall firmly grasp the latest weather information and ensure safety of the ship.

When adjustments to the cargo operation and timings of the ship are necessary, the master shall ensure safety so that no human/physical errors occur.

② Designated person for receiving LNG (Chief Engineer)

The Chief Engineer is the designated person for receiving LNG on the LNG fuelled ship. He shall command and manage crew members on the ship and assume responsibility for the LNG receiving work on the LNG fuelled ship.

③ Worker receiving LNG

Shall perform LNG receiving work on board the LNG fuelled ship.

(4) Other LNG transfer related organizations and personnel

① Maritime disaster prevention organization

A system shall be built beforehand so that the support of the maritime disaster prevention organization can be obtained during an emergency such as LNG leak or fire occurrence during LNG transfer by the StS system.

② Shipping agent (LNG fuelled ship)

The shipping agent shall make adjustments, notifications and communications, etc., related to LNG transfer when a request is received from the person with overall responsibility or the designated person, the person with overall responsibility for receiving LNG or the shipping company of the LNG fuelled ship. The shipping agent shall also make arrangement for pilots, towing boat, linesmen, etc., if required, and make adjustments, notify and communicate with concerned personnel.

1.2 Operating standards for reference

Table ④-1.1 shows the operating standards for reference. Table ④-1.2 shows the operating standards for LNG transfer limit conditions and for wave heights and wave periods for reference.

The operating standards here are based on assumption of a general LNG fuelled ship and LNG bunker ship as indicated in 2.1 "Studied ships" at the end of this document. For this reason, in the cases below and when the above-mentioned conditions are to be relaxed, separate studies are necessary.

- In special sea areas where effects of strong tidal current and effects of noticeably long period waves are received
- If the LNG fuelled ship is of special form and if it is a small craft with overall length less than about 100 m
- If the LNG bunker ship is an extremely small ship compared to a standard coastal LNG ship (tank capacity 2,500 m^3)
- If the LNG bunker ship is designed to not have adequate transverse motion capability (not provided with bow thruster or if provided, its power is inadequate; if one shaft and normal rudder is provided)
- If the navigator of the LNG bunker ship is not experienced in StS berthing operation, and if there is no equipment supporting transverse motion of the ship (stern thruster, joy stick navigating station based on appropriate controls)
- If mooring line cannot be arranged with proper balance as in the standard mooring plan shown in Fig. ④-1.2, or if the fender cannot be positioned to properly balance it in the parallel bodies of the two ships

Table ④-1.1 Operating conditions according to wind velocity conditions for reference

<table>
<tr><td rowspan="2">Wind Speed (m/sec)</td><td colspan="6">LNG fuelled ship</td></tr>
<tr><td colspan="3">anchored</td><td colspan="3">moored</td></tr>
<tr><td>15</td><td></td><td></td><td></td><td></td><td></td><td></td></tr>
<tr><td>14</td><td></td><td></td><td></td><td></td><td></td><td></td></tr>
<tr><td>13</td><td></td><td></td><td></td><td></td><td></td><td></td></tr>
<tr><td>12</td><td></td><td rowspan="3">LNG transfer condition</td><td rowspan="3">Leaving ship's side condition</td><td></td><td rowspan="3">LNG transfer condition</td><td rowspan="3">Leaving ship's side condition</td></tr>
<tr><td>11</td><td></td><td></td></tr>
<tr><td>10</td><td rowspan="3">Coming alongside condition</td><td rowspan="3">Coming alongside condition</td></tr>
<tr><td>9</td><td></td><td></td><td></td></tr>
<tr><td>8</td><td></td><td></td><td></td><td></td><td></td></tr>
</table>

Note: Limit of wave height is taken as 1.0 m

Table ④-1.2 LNG transfer limit conditions of studied ships obtained from mooring simulation

LNG fuelled ship	External force	LNG bunker ship	Coastal LNG ship
Anchored	Wind speed	12m/sec	12m/sec
	Wave height	1.0m	1.0m
	Wave period	8sec	6sec
Moored	Wind speed	12m/sec	12m/sec
	Wave height	1.0m	1.0m
	Wave period	5sec	5sec

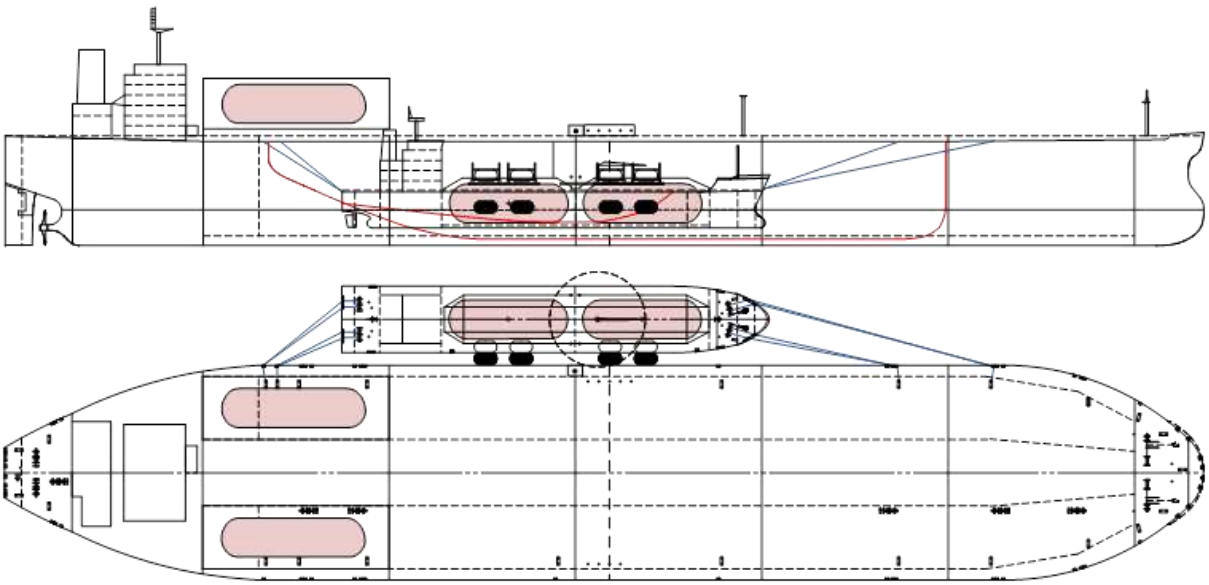


Fig. ④-1.2 Standard mooring (example)

1.3 Safety measures for ship operation

1.3.1 Navigation of LNG fuelled ship

LNG fuelled ships shall navigate according to the existing operating standards of ports and harbors, quays and piers used and sea areas navigated, and according to traffic rules of routes, and obligation to report, etc., similar to conventional ships carrying oil.

1.3.2 Navigation of LNG bunker ships

LNG bunker ships shall navigate according to the existing operating standards of ports and harbors used and sea areas navigated, and according to traffic rules of routes, obligation to report, etc., and other rules and regulations such as the Act on Port Regulations, the Maritime Traffic Safety Act, etc., similar to conventional ships carrying dangerous goods.

1.4 Safety measures for maneuvering

1.4.1 Maneuvering of LNG fuelled ship when entering/leaving port

(1) Standard maneuvering methods

The study assumes that the LNG fuelled ship operates under standards and rules that are the same as for conventional similar type and similar form ships. For this reason, maneuvering of the LNG fuelled ship shall follow the same flow as that of conventional ships.

(2) Precautions related to maneuvering while entering port

Precautions related to maneuvering while entering port are given below.

① Wind pressure effect

Depending on the position of the LNG fuel tank installed on deck, the wind pressure area of the ship increases. In such cases, care shall be taken to avoid excessive speed while berthing after carefully considering the position and attitude of the ship and the pressure flow effect at the time of berthing.

② Main engine characteristics

Presently, there are main engines installed in LNG fuelled ships that have delayed response performance during normal operation compared to conventional engines with heavy oil as fuel. For such engines, precautions are needed when reducing speed at the time of maneuvering to enter port. However, special steps are not necessary because in the event of an emergency, these engines also demonstrate response performance equivalent to or greater than that of engines using heavy oil as fuel.

(3) Precautions related to maneuvering while leaving port

Precautions related to maneuvering while leaving port are given below.

① Wind pressure effect

When turning around, pay attention to the pressure flow of the hull due to wind; make efforts to grasp the distance separating the ship from other ships or obstacles in the vicinity, and turn the ship while controlling its position and attitude.

② Main engine characteristics

Presently, there are main engines installed in LNG fuelled ships that have delayed response performance during normal operation compared to conventional engines with heavy oil as fuel. Therefore, for such engines, pay attention to pressure flow on the lee side after turning the ship and navigating on its course until the control speed for holding course is obtained. However, special steps are not necessary because in the event of an emergency, these engines also demonstrate response performance equivalent to or greater than that of engines using heavy oil as fuel.

1.4.2 Maneuvering when coming alongside/leaving ship's side by LNG bunker ship (when LNG fuelled ship is moored)

(1) Standard maneuvering method

The standard maneuvering method is given below.

Lateral speed control, attitude control (turning moment control) and forward-aft positioning control are necessary for the LNG bunker ship to come alongside/leave ship's side. For parallel and correct control of these parameters, good skills are necessary. Enhancement in the skills of the navigator is naturally expected for routinely bringing the LNG bunker ship alongside/leaving the ship's side. However, if dependence is not to be placed on the skills of the navigator for coming alongside/leaving alongside in a stable manner, the control function for lateral maneuvering should be split into "lateral control system (bow thruster and stern thruster)" and "longitudinal control system (propeller)," or automatic controls (such as lateral maneuvering using joystick system based on appropriate control system) should preferably be introduced. In recent years, podded propellers are being used, and the control level for maneuvering when coming alongside is being further enhanced; therefore, the use of a podded propeller may be studied.

[Maneuvering to come alongside (without turning)]

① The approach course is to head close to the bow of the ship to be come alongside, about 40 to 80 m off the ship's side (2B to 4B where B: Breadth of the ship).

② The approximate approach speed is as given below.

- Gradually reduce speed to about 3 knots when the remaining distance is about 400 m (about 4L where L: Length of ship)
- Gradually reduce speed to about 2 knots when the remaining distance is about 200 m (about 2L)
- Adjust the speed to about 2 knots when the remaining distance is about 100 m (about 1L)
- Ship should practically be at a standstill when the lateral distance is 40 m to 80 m

③ At about 40 m from the side of the ship while mooring, take the head line and the bow spring line.

④ Control the attitude and the lateral shift with the bow thruster and propeller and rudder (or stern thruster), and come alongside at an alongside speed of less than 15 cm/sec.

⑤ Adjust the fore and aft position by the head line, bow spring line and propeller.

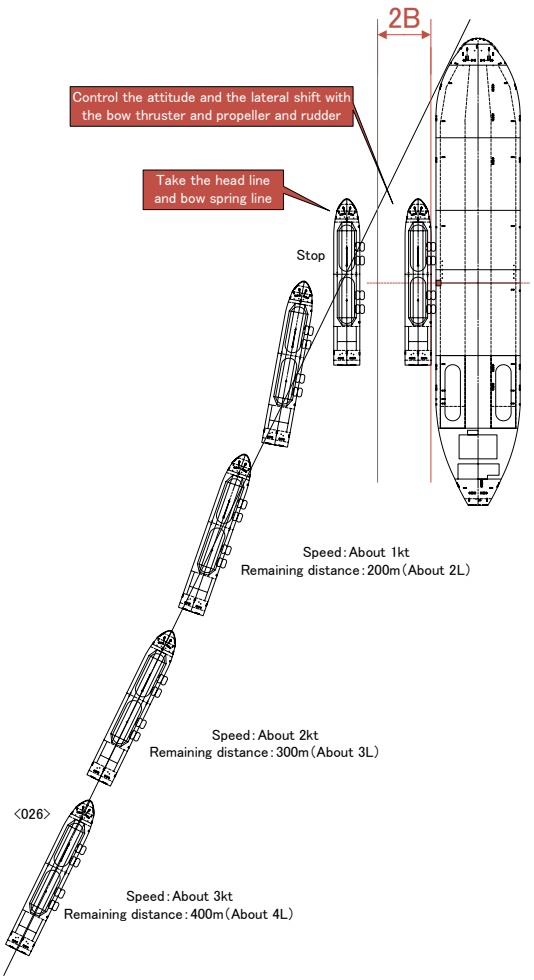


Fig. ④-1.3 Standard maneuvering method of LNG bunker ship (coming alongside, without turning)

[Maneuvering to come alongside (with turning)]

① The approach course is to head to the area forward of the bow of the ship to be come alongside, about 200 m off the ship's side (2L).

② The approximate approach speed is as given below.

- Gradually reduce speed to about 3 knots when the remaining distance is about 400 m (about 4L)
- Gradually reduce speed to about 2 knots when the remaining distance is about 200 m (about 2L)
- Adjust the speed to about 1 knot when the remaining distance is about 100 m (about 1L)

③ Start turning when about 200 m off the ship's side

④ At about 40 m from the side of the ship, control the turning angular speed while mooring, and take the head line and the bow spring line.

⑤ Control the attitude and the lateral shift with the bow thruster and propeller and rudder (or stern thruster), and come alongside at an alongside speed of less than 15 cm/sec.

⑥ Adjust the fore and aft position by the head line, bow spring line and propeller.

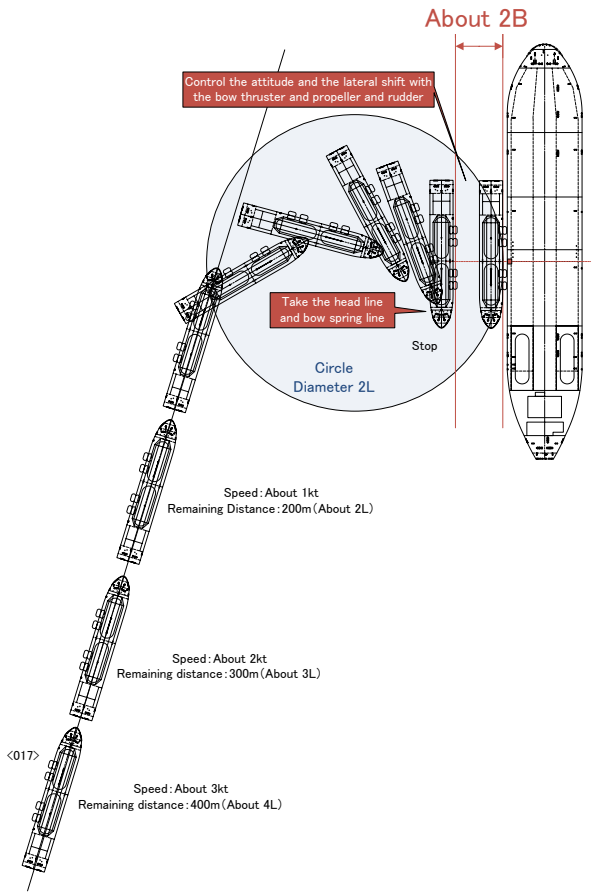


Fig. ④-1.4 Standard maneuvering method of LNG bunker ship (coming alongside, with turning)

[Leaving ship's side (without turning)]

① Use bow thruster and propeller/rudder to move away from ship's side

② When the distance after leaving the ship's side becomes 1B to 2B, use propeller and rudder for course control.

③ Increase speed while performing course control.

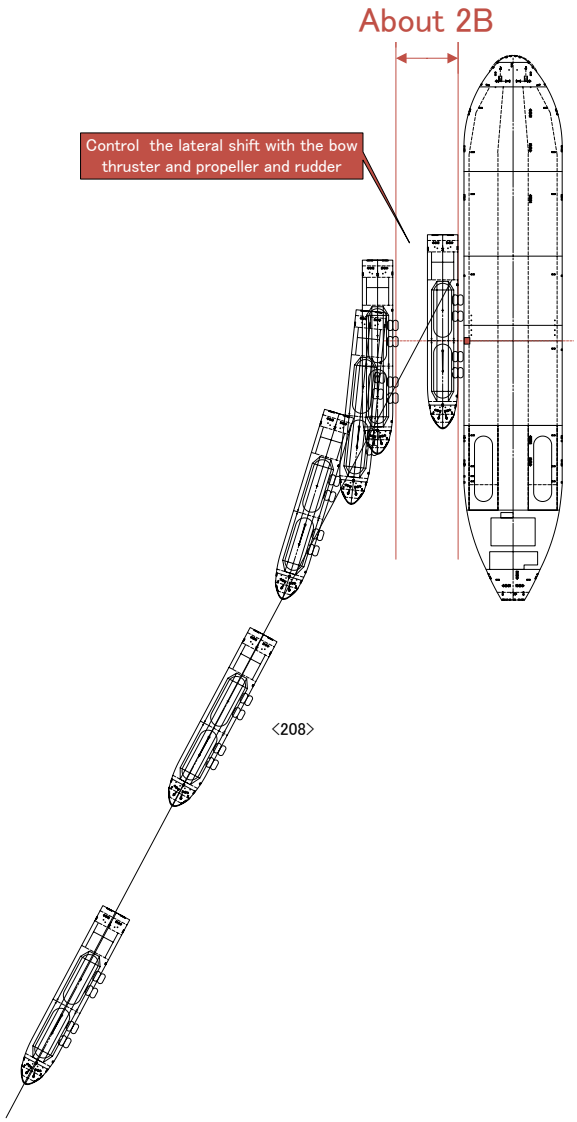


Fig. ④-1.5 Standard maneuvering method of LNG bunker ship (leaving ship's side, without turning)

[Leaving ship's side (with turning)]

① Use bow thruster and propeller/rudder to move away from ship's side

② When the distance after leaving the ship's side becomes 1B to 2B, use bow thruster and propeller to go ahead and make a turn.

③ After completing the turn, increase speed.

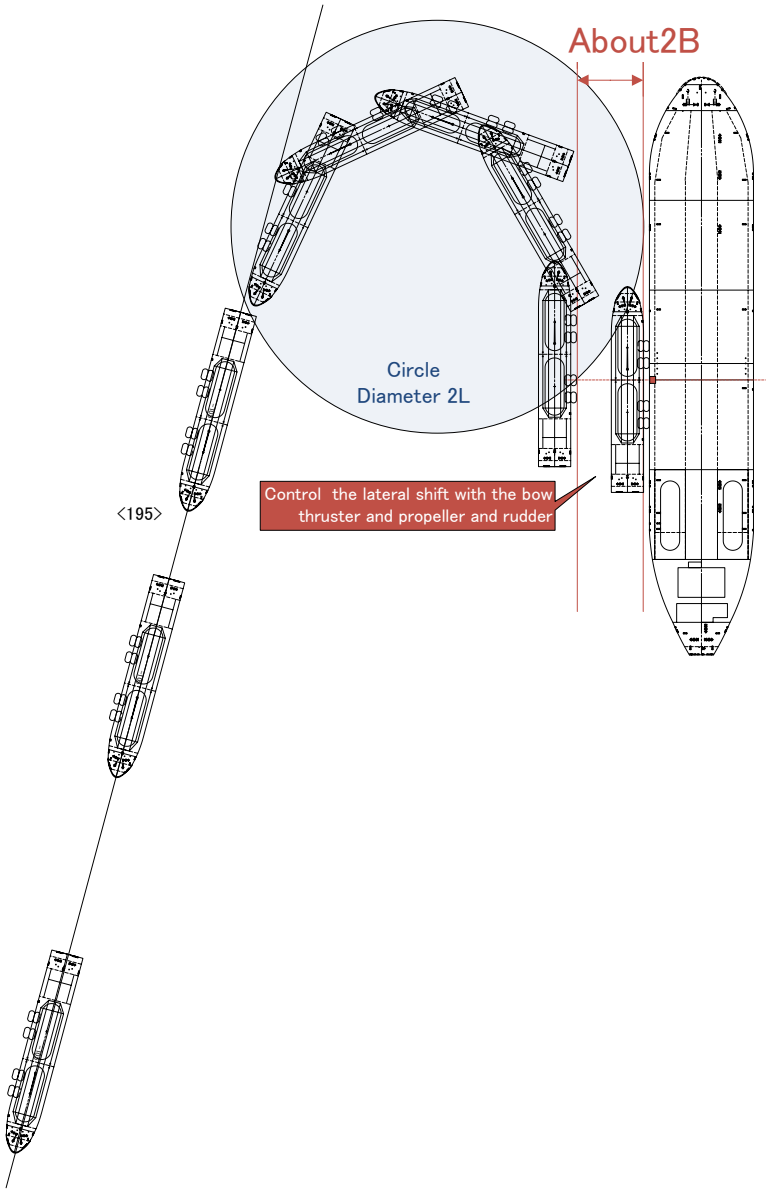


Fig. ④-1.6 Standard maneuvering method of LNG bunker ship (leaving ship's side, with turning)

(2) Precautions related to maneuvering while coming alongside

Precautions related to maneuvering while coming alongside are given below.

① Wind pressure effect

After considering the wind pressure effect, take care to hold the course and control the position and attitude of the ship in strong winds. Moreover, take care to adequately consider the position and attitude of the ship and pressure flow effects when coming alongside, and ensure that the speed for coming alongside is not excessive.

② Detecting speed for coming alongside

If the turning speed of the LNG bunker ship is negligible, the coming alongside speed can be easily discerned by eye measurement to be in the range of about 10 to 15 cm/sec. However, when coming alongside an anchored LNG fuelled ship, care is necessary during maneuvering since the lateral speed of the anchored ship also needs to be considered. The points below shall be considered especially if the anchored ship is swinging, coming alongside shall be avoided while waiting for the swinging motion to stop. It is also preferable to maintain close communications between the two ships, with the LNG bunker ship to come alongside receiving information on the status (bow heading, swinging, etc.) from the LNG fuelled ship.

- Change the relative speed for coming alongside according to the direction of swing of the anchored ship
- Ascertaining the relative speed for coming alongside and the change in status is difficult.
- There is a chance that the speed for coming alongside may become excessive when the anchored vessel is approaching.
- If the anchored ship has receded, the speed for coming alongside may be insufficient, and maneuvering to come alongside may become troublesome.
- Depending on the external forces (wind and tidal current, etc.) and loading condition of the anchored ship, the heading of the anchored ship may not be in the windward direction.

Even during daytime, coming alongside is difficult if the ship swings around. Considering that visibility is restricted, especially at night time, measures should preferably be adopted against the swinging of the ship, such as the use of a dynamic information system.

(3) Precautions related to maneuvering while leaving the ship's side

Precautions related to maneuvering while leaving the ship's side are given below.

① Lateral speed when leaving the ship's side

If the LNG bunker ship has a single shaft and a single rudder, the main engine has to be set for ahead motion of the ship to obtain side thrust at the stern; therefore, care is necessary to

avoid excessive headway when going ahead.

If the ship is berthed on its port side, it is convenient to use the port turning moment when going astern. In contrast, if the ship is berthed on its starboard side, care is necessary to avoid the aft part of the ship from approaching the LNG fuelled ship due to the port turning moment when the ship goes astern.

② Wind pressure effect

When turning around, pay attention to the pressure flow of the hull due to wind; make efforts to grasp the distance separating the ship from other ships or obstacles in the vicinity, and turn the ship while controlling its position and attitude.

1.4.3 Coming alongside at night time

Points to be considered when coming alongside at night time are as below.

- Such work shall preferably be carried out during daytime by crew except when experienced personnel are available for StS work at night time.
- When coming alongside at night, deck lights shall be used to illuminate the ship side up to the water line so as to properly grasp the distance between the ships. Moreover, the working lights on the LNG bunker ship shall be switched on when moving from the approach to the ship's side so as to correctly understand the speed to come alongside.
- When coming alongside an anchored vessel, information shall be exchanged closely between the ships, and efforts shall be made to minimize the difference in heading of the two ships.
- Coming alongside an anchored vessel is difficult if the ship swings around, especially at night time when visibility is restricted. Considering this point, measures should preferably be adopted against the swinging of the ship, such as by using a dynamic information system.

1.4.4 Consideration on the need for a tugboat

If the maneuvering performance of the LNG bunker ship has deteriorated, arranging for a tugboat may be studied, if necessary, after considering the operating conditions, conditions of the sea area, etc.

1.5 Safety measures for mooring

1.5.1 Mooring plan

For mooring of the two ships with the StS system, the proper mooring and arrangement of fenders for the parallel bodies of the two ships shall be studied beforehand so that the movement of the two ships is reduced as far as possible.

If mooring at the parallel bodies of the two ships is difficult, the balance when the two ships are moored shall be considered, and proper mooring means shall be devised. Especially, if the LNG bunker

ship comes alongside and moors with the LNG fuelled ship at its bow or at the flared part at the stern, the points below shall be considered, and installation of additional fenders shall be studied; these matters shall be adequately studied beforehand and safety measures shall be adopted.

(1) Freeboard height of LNG bunker ship

The freeboard of an LNG bunker ship is higher compared to the conventional oil bunker ship (see （Fig. ④-1.7). For this reason, when coming alongside and mooring at the flared part of the LNG fuelled ship, the probability of contact of the hull of the LNG bunker ship (particularly, the house part) with the hull of the LNG fuelled ship increases.

(2) Fenders and mooring lines between the two ships

If the LNG bunker ship comes alongside the LNG fuelled ship at a position away from the parallel body (offset position), it may become difficult to arrange the required number of fenders that are satisfactorily balanced for coming alongside and mooring at the desired position. At the same time, the balance in mooring force also might be unsatisfactory. For this reason, recognizing that ship oscillation may increase excessively during LNG fuel supply with restrictions in changing the positions of the two ships compared to the conventional oil bunker ship, safety measures may be necessary (see Fig. ④-1.8).

Fig. ④-1.7 Image of the two ships alongside with parallel bodies offset

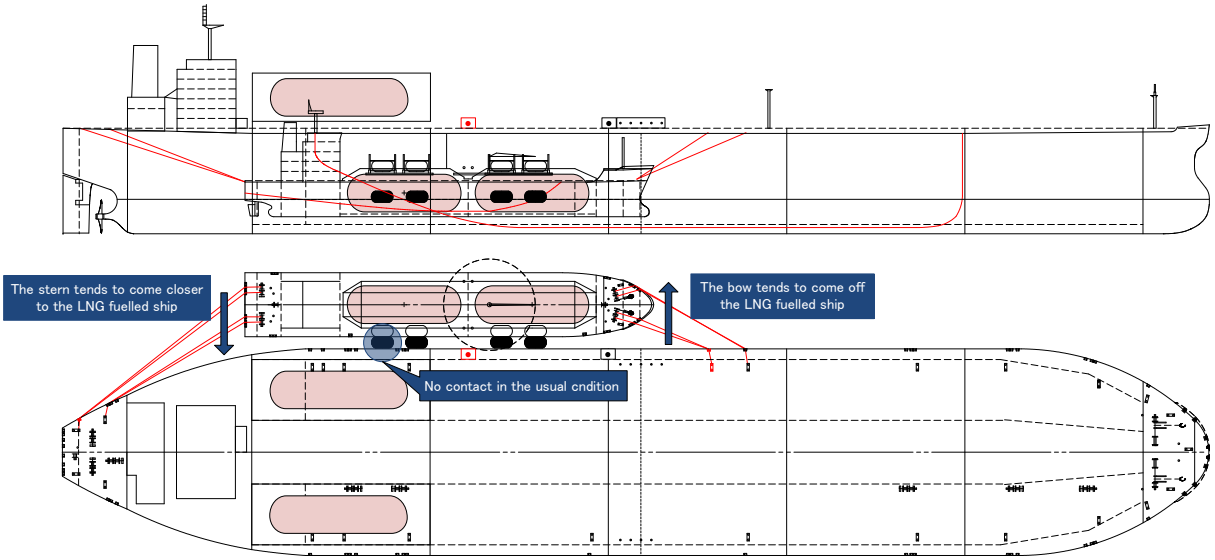


Fig. ④-1.8 Image of mooring (aft side mooring) with parallel bodies offset in the study

1.5.2 Ensuring safety distance between the ships

Safety distance shall be maintained between the LNG bunker ship and other ships on the water surface within 30 m around the ship during LNG fuel transfer following the Standards for Permission to Handle Dangerous Goods (see Fig. ④-1.9). (The requirement to maintain safety distance between ships is excluded for LNG fuelled ship that receives the LNG fuel). The value of safety distance between ships may be changed after considering the size of the LNG bunker ship, ships anchored, and kinds, sizes and congestion status of ships navigating in the vicinity.

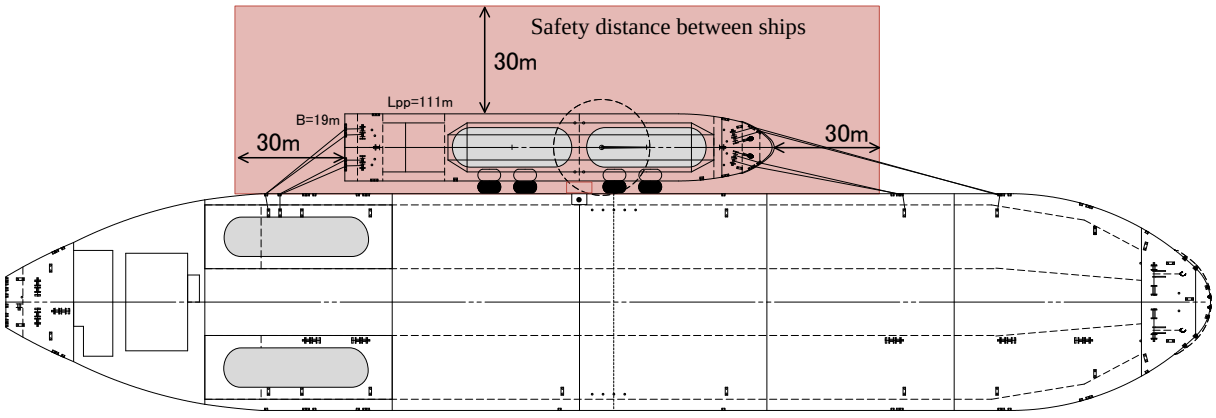


Fig. ④-1.9 Safety distance between ships according to the Standards for Permission to Handle Dangerous Goods (Example)

1.5.3 Suspending LNG transfer

For LNG transfer when two ships are moored in the StS system, safety has been confirmed up to wind speeds of 12 m/sec. and wave heights of up to 1.0 m.

However, if the conditions mentioned below occur, the LNG transfer shall be suspended.

- When LNG leakage accident has occurred
- When other accident or event has occurred that makes continuation of transfer dangerous.

1.5.4 Suspending mooring

If wind speed increases before, after or during LNG transfer, and if the conditions are expected to exceed the LNG transfer limiting conditions when leaving the ship's side of wind speed 12 m/sec. and wave height of 1.0 m, then LNG transfer shall be immediately suspended, and the ship shall evacuate to a safe sea area after moving away from the ship's side.

1.5.5 Safety measures for mooring equipment

Safety measures indicated below shall be adopted for ensuring safety of the equipment during mooring.

- The ship on the side where mooring lines are used shall periodically check the status of the mooring lines, and ensure equal tension in all mooring lines as far as possible. If necessary, the mooring lines shall be made taut and the mooring force increased.
- To avoid hull contact with the LNG fuelled ship due to ship motion, secondary fender materials (baby fenders, etc.) shall be installed on the LNG bunker ship.
- The status of damage to contact parts of fairleads for mooring lines on both ships shall be periodically checked. If necessary, the mooring lines shall be replaced or renewed, and efforts made to maintain the required mooring force.
- Measures for cold region shall be adopted on both ships if the temperature drops in winter at that location.

1.5.6 Preventing shifting of the ship[2]

To prevent unexpected shifting of the ship, the necessary measures shall be adopted so that the propulsive forces of the two ships do not act when not needed during the LNG fuel transfer.

1.5.7 Effect of navigation of other ships

LNG fuel transfer by the StS system shall be implemented in a sea area where the height of waves generated by other ships plying in the vicinity does not exceed 50 cm, and where the safe working load of mooring line is not exceeded by external forces due to suction effect, so as to ensure safety of the two moored ships.

In VLCCs, etc., where ship-generated waves and suction effect increases, it was confirmed that

[2] Main engine shall be kept warmed up since engine has to be started quickly in an emergency.

safety can be ensured if a distance of 500 m was maintained from ships navigating in the vicinity.

If the distance is less than the distance mentioned above, separate individual study is necessary.

1.5.8 Response in rough weather

If external forces such as wind become stronger, and if LNG transfer limiting conditions with the StS system between the two ships and the leaving ship side conditions (wind speed 12 m/sec. and wave height 1.0 m) are not expected to be exceeded based on the information acquired, then the person with overall responsibility for transferring LNG shall judge whether to continue LNG transfer or not, after considering the judgments of the masters in the two ships on whether mooring should be continued or discontinued. If continuing the LNG transfer is judged to be difficult, the LNG transfer shall be stopped, the ship shall leave the ship's side, and retreat to a safe sea area. Even if the LNG transfer is to be continued, the latest information on weather conditions and sea conditions shall be carefully monitored, and preparations shall be made to leave the ship's side anticipating sudden change in the weather.

On the other hand, if the forecast on weather and sea conditions shows that the mooring limiting conditions are likely to be exceeded, the LNG transfer shall be quickly stopped under instructions from the person with overall responsibility for transferring LNG, the ship shall leave the ship's side and seek refuge in safe sea area.

If continued mooring is decided even in rough weather, the operation shall always be performed on the side of safety considering the limits of maneuvering of the LNG bunker ship to leave the ship's side and the sudden changes in the weather.

1.6 Acquiring information on weather and sea conditions

The person with overall responsibility shall acquire accurate weather and sea condition forecast about four times a day and arrange to offer this information to the person with overall responsibility for transferring LNG (Master of the LNG Bunker Ship) and the person with overall responsibility for receiving LNG (Master of the LNG fuelled ship) to enable them to judge whether to leave the ship's side, continue mooring or continue LNG transfer during the LNG transfer by the StS system.

The designated person shall continually collect information on weather and sea conditions at site, supervise the sharing of information with the overall in charge of LNG transfer and the person with overall responsibility for receiving LNG, and shall personally share this information.

Sometimes conflicts may arise in the forecast values from the Weather Bureau and the measured values at site. Therefore, these sets of values shall be continually compared, and efforts shall be made to improve accuracy related to collection of weather and sea conditions data so that no delay occurs in the implementation of safety measures.

1.7 Seafarers' system

1.7.1 Seafarers' system during navigation

(1) Seafarers' system on the LNG fuelled ship

The fuel in the LNG fuelled ship under navigation has changed over from heavy fuel oil to natural gas; but basically the conventional seafarers' system and operating methods shall be followed.

The results of studies by the IMO shall also be considered and the actual operation decided.

(2) Seafarers' system on the LNG bunker ship

Similar to the coastal LNG ship, the number of seafarers of the LNG bunker ship shall be determined based on the Mariners' Act (Article 117.3, etc.).

1.7.2 Seafarers' staffing during LNG fuel supply

(1) Seafarers' staffing on the LNG fuelled ship

LNG is used as fuel on board the LNG fuelled ship unlike the LNG carrier in which the cargo is burnt. Therefore, the engineer mainly manages the seafarers' system during LNG fuel supply similar to conventional heavy fuel oil. As a result, the cargo handling of this ship will be implemented mainly by the ship's officer; therefore, from the point of view of personnel, the LNG fuelled ship can receive LNG fuel supply in parallel with cargo handling. Also, it shall be noted carefully that the same number of personnel in conventional ocean-going ships can be used for this purpose.

(2) Seafarers' staffing on the LNG bunker ship

Officers shall mainly manage and handle the cargo (LNG) on the LNG bunker ship, similar to the conventional LNG carrier.

1.8 Education and training of seafarers

All crew members on both the LNG fuelled ship and the LNG bunker ship shall be familiar with disaster prevention related to LNG before they board the ships. The Machinery Department of the LNG fuelled ship and the Deck Department of the LNG bunker ship especially responsible for the LNG transfer work shall receive skills and training related to all aspects of LNG fuel transfer before they perform the actual work. The Master, Chief Officer or Watch Officer, Chief Engineer and Engineer or Watch Officer of the LNG bunker ship shall be adequately qualified as personnel responsible for handling dangerous goods, based on 117.3 of the Mariners' Act.

The IMO is presently studying the education and training of crew in LNG fuelled ships. When national laws and regulations, based on the results of the IMO studies are ready, they shall be followed.

1.9 Emergency response

Emergency response related to implementation of LNG transfer by the StS system is shown below.

In this study, simulation for leaving the ship's side (under own power without assistance from tugboat) assuming emergency unberthing was implemented, and it was confirmed that the ship could safely leave the ship's side up to a wind speed of 12 m/sec. and wave height of 1.0 m. However, this does not hold good for a ship with propeller having a maneuvering performance inferior to ship with single shaft Schilling rudder or twin-shaft and twin-rudder ships considered in this study.

Moreover, the emergency response here is mainly for LNG transfer by the StS system; therefore, the safety of cargo handling and mooring in a LNG fuelled ship shall follow the operating standards of mooring facilities for berthing and the ports used.

1.9.1 Response when a ship fire occurs

The following responses shall be taken if a fire breaks out:

① The first person who discovers the fire shall immediately notify the master.

② The master shall promptly activate the ESD and suspend the transfer operation.

③ The said person shall blow the whistle and notify the crew members of both ships and others in the vicinity the occurrence of the emergency situation.

④ Both ships shall close the doors connecting to the upper deck or the LNG receiving manifold, stop the ventilation fans, close all kinds of openings to ensure that gas does not enter within the ship, and again establish fire controls.

⑤ Both ships shall man the firefighting stations immediately and start fire extinguishing activities.

⑥ If necessary, water spray shall be activated.

⑦ The Maritime Safety Department, the fire brigade, the police, the port controller and other concerned administrative organizations shall be notified.

⑧ Approach of other ships shall be prevented through radio, external speakers and so on.

1.9.2 Measures against abnormal approach and collision with other ships

(1) Warnings to other ships operating in the vicinity

The LNG bunker ship shall put up warning banners on the side of the ship opposite to the side where it is alongside with the LNG fuelled ship indicating that LNG fuel transfer operation is under way to other ships operating in the vicinity.

During LNG fuel transfer operation at night time, adequate illumination shall be provided so that ships operating in the vicinity can recognize the warning banners.

Also, appropriate warnings shall be given to ships plying in the vicinity through VHF if necessary, considering the conditions in the sea area and the status of operation of ships in the vicinity.

From the LNG bunker ship, the large LNG fuelled ship is very likely to be an obstruction for

stationing a watch during LNG transfer by the StS system; therefore, the officer of the watch on the LNG fuelled ship shall be mainly responsible for look-out duties.

(2) Response during a collision

During LNG transfer by the StS system, if a collision occurs in spite of adequate measures, the relevant authority shall be notified. If a fire, etc., has occurred because of the collision, appropriate fire extinguishing measures shall be adopted based on the section above.

1.9.3 Response when mooring-related equipment is damaged

If mooring-related equipment is damaged during LNG transfer by the StS system, and if spare equipment is available, such equipment shall be used and the original situation restored as far as possible. If appropriate usable equipment is not available, the LNG transfer may be suspended and the ship should leave the ship's side after referring to the opinions of the overall in charge of LNG transfer and the person with overall responsibility for receiving LNG, and after considering external forces such as wind and waves.

1.9.4 Earthquake and tsunami measures

(1) Collecting information when earthquake or tsunami occurs

Efforts shall be made to collect earthquake and tsunami information the moment an earthquake is felt. The moment the Weather Bureau announces earthquake and tsunami information, it is received by NAVTEX through the Japan Coast Guard. The LNG fuelled ship and the LNG bunker ship shall acquire this information. This information shall be automatically printed on recording paper. The alarm settings for notifying receipt of this information may be used, if necessary.

When offshore, it may not be possible to feel an earthquake while on board; also, earthquake information cannot be acquired easily. Therefore, in addition to NAVTEX, a system to receive earthquake and tsunami information as soon as possible should be set up through satellite telephones, etc., so that the LNG fuelled ship can receive such information from the shipping agent and the LNG bunker ship from the operating company.

(2) Response when an earthquake or tsunami occurs

If either of the ships receives earthquake and tsunami information, it shall immediately share the information with the other ship.

When a tsunami warning or alert is issued, the masters of both ships shall immediately suspend the LNG transfer operation and if necessary, disconnect the transfer hose/arm and judge whether to leave the ship's side urgently or not.

(3) Measures when tsunami occurs

Drills shall be implemented so that the following actions can be quickly and safely performed: transfer pump shall be stopped, hose/arm purged, valves closed and hose/arm disconnected. At the same time, the time required for this series of operations shall be noted down beforehand.

Depending on the conditions, emergency stoppage of transfer and hose-arm disconnection may be anticipated when ESD or ERS is set off. Therefore, drills related to these activities shall be regularly implemented, proficiency of work itself enhanced, and the procedure and time required for disconnection confirmed and noted beforehand.

The frequency of LNG fuel transfer work for the LNG bunker ship especially is high, and a higher proficiency is anticipated; therefore, a system should be in place that enables proper instructions to be issued to the LNG fuelled ship.

2 References

2.1 Studied ships

For this study, a LNG fuelled ship and an LNG fuel supply ship (LNG bunker ship) were assumed, bearing in mind the generalization of the results of the study (no special ship type or form) as far as possible. More specifically, the ship forms to be studied were set as given below.

2.1.1 LNG fuelled ship

(1) Particulars

For LNG fuelled ships, freeboard becomes an important factor in operational work aimed at LNG transfer. Therefore, a VLCC that has the largest freeboard difference due to loading conditions was taken as the ship to be studied. Moreover, the mooring of two ships on the sea becomes important in LNG transfer by the StS system; therefore, the PCC with high freeboard and large wind receiving area was set as the ship to be studied.

In this study, VLCC and PCC ships with the main particulars shown in Table ④-2.1 were set as the ships to be studied. Fig. ④-2.1 and Fig. ④-2.2 shows the general arrangements of the two ships.

Table ④-2.1 Main particulars of the LNG fuelled ships (VLCC and PCC) taken as the ships to be studied

	LNG fuelled ship	
	VLCC	PCC
Length between perpendicular (m)	320.0	192.0
Moulded breadth (m)	58.0	32.3
Moulded depth (m)	29.0	35.0
Full load draft (m)	20.5	9.6
Tank capacity (m^3)	5,000	5,000

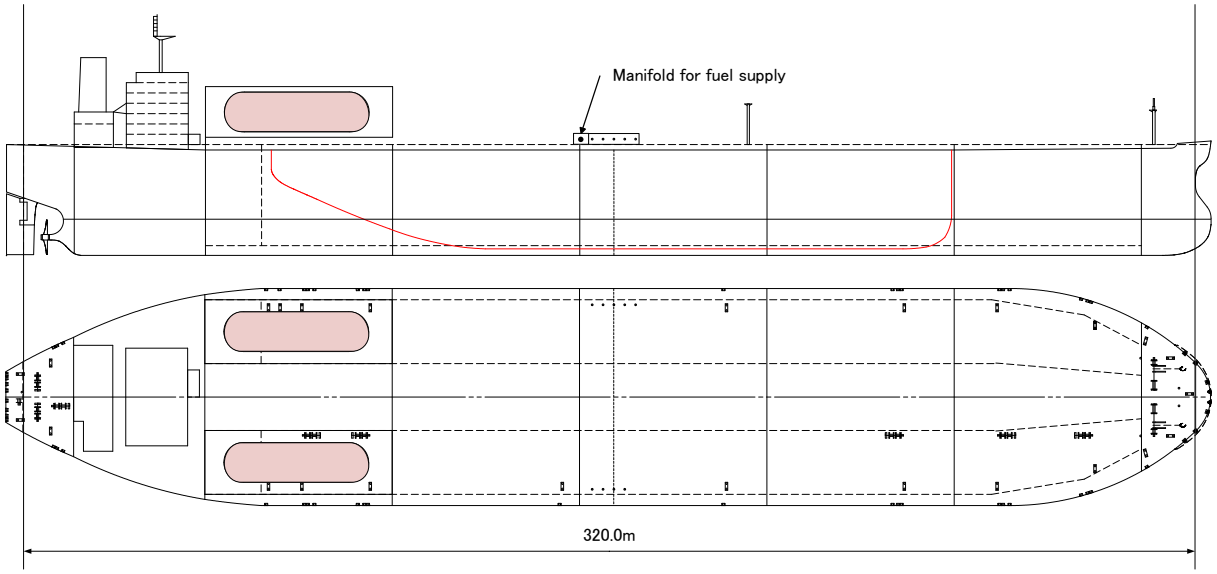


Fig. ④-2.1 LNG fuelled ship (VLCC) to be studied

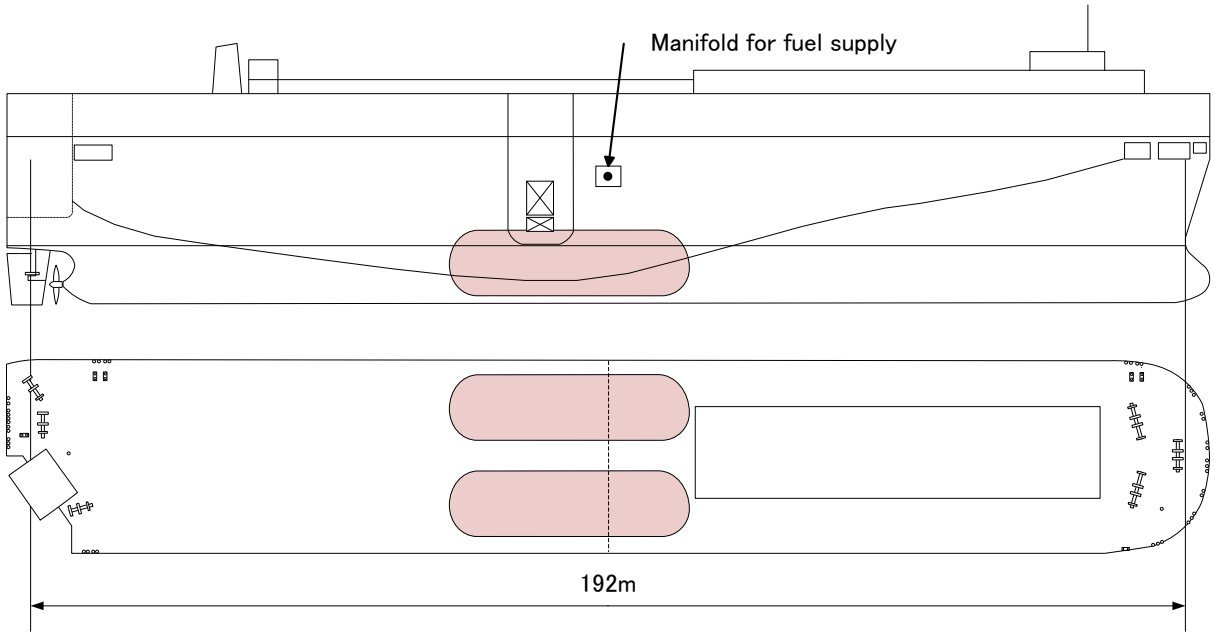


Fig. ④-2.2 LNG fuelled ship (PCC) to be studied

2.1.2 Hull structure and safety equipment

Satisfying the requirements specified in the IGF Code presently being discussed at the IMO was taken as the prerequisite for hull structure and safety equipment of the LNG fuelled ship.

2.1.3 Operating mode

The LNG fuelled ship that uses LNG as fuel does not fall under “ships carrying dangerous goods” from the viewpoint of domestic rules and regulations; therefore, the prerequisite was that it would be

treated similar to a general merchant ship.

2.2 LNG bunker ship

2.2.1 Particulars

Assuming that the LNG supply ship (bunker ship) is equivalent to an existing coastal LNG ship, and that a large LNG fuelled ship is provided with larger LNG fuel tanks, the ship to be studied was taken as a ship with tank capacity expanded to as much as 5,000 m^3.

For this study, the ships with the main particulars shown in Table ④-2.2 were set as the ships to be studied. Fig. ④-2.3and Fig. ④-2.4 shows the general arrangements of the two ships.

Table ④-2.2 Main particulars of the LNG bunker ships to be studied

	Bunker ship	
	Designed LNG bunker ship	General coastal LNG ship
Length between perpendicular (m)	111	80
Moulded breadth (m)	19	15
Moulded depth (m)	10	7
Full load draft (m)	5	4
Tank capacity (m^3)	5,000	2500
Propulsion system	Two shafts, two rudders, CPP	One shaft, one rudder, CPP
Rudders	Normal	Schilling
Bow thruster (ton)	10	5

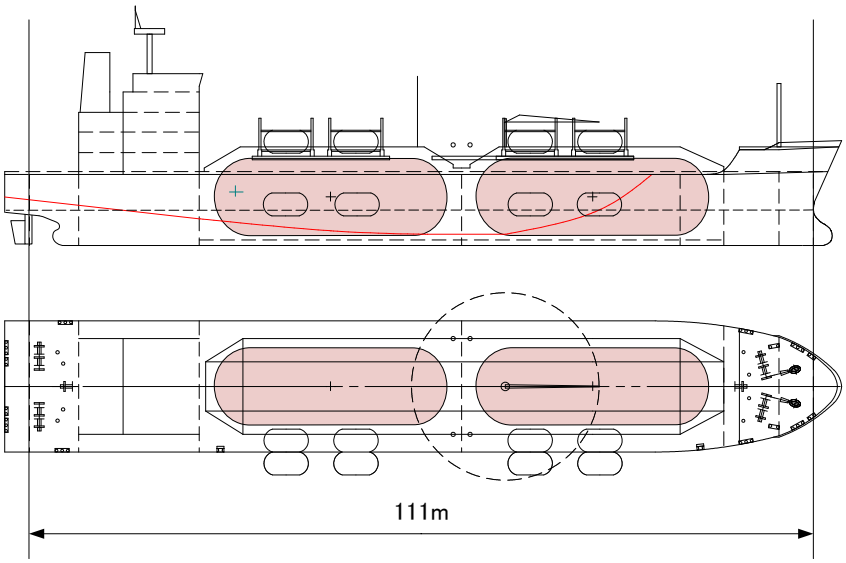


Fig. ④-2.3 LNG bunker ship to be studied

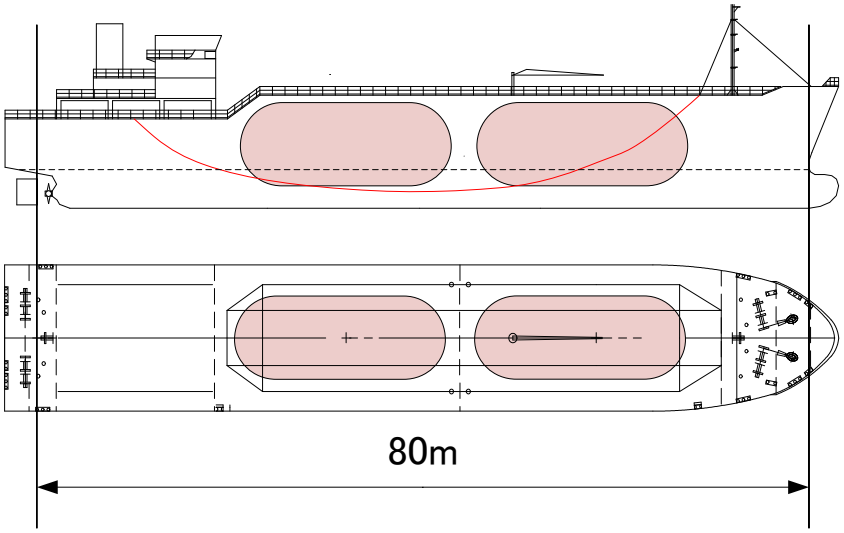


Fig. ④-2.4 Ship equivalent to existing coastal LNG ship to be studied

2.2.2 Hull structure and safety equipment

The prerequisite is that the hull structure and safety equipment of LNG bunker ship is to satisfy the requirements of the IGC Code and Chapter 3 of the Regulations for the Carriage and Storage of Dangerous Goods in Ships based on the Ship Safety Law.

2.2.3 Operating mode

Since the ship falls under the category of ship carrying dangerous goods in national laws, the pre-requisite for operation of this ship is that adequate safety is ensured based on the relevant laws.

Study result ⑤

Measures for prevention of maritime disaster related to LNG fuel transfer by the Ship to Ship System

Measures for prevention of maritime disaster related to LNG fuel transfer by the Ship to Ship System

1 Maritime disaster prevention measures

1.1 LNG transfer system

A total of two transfer hoses consisting of one liquid hose and one gas hose, or a transfer arm is assumed to be connected to the manifolds of the LNG fuelled ship and the LNG bunker ship, and using this system, LNG liquid is transferred and gas is sent back.

The diameter of the transfer hose is assumed as 8 inches (200 mm) and diameter of the hose arm as 10 inches (250 mm).

If the two ships move away from each other in a strong gust of wind or the like, the LNG transfer pump shall be stopped. Safety equipment such as the Emergency Shut Down System (ESDS) for closing valves at both ends of transfer arm or transfer hose, and the Emergency Release Coupling (ERC) for separating the transfer arm or the transfer hose may be used as safety measures.

Fig. ⑤-1.1 shows the connection diagram of the transfer hose and Fig. ⑤-1.2 shows the connection diagram of the transfer arm between the VLCC and the LNG bunker ship.

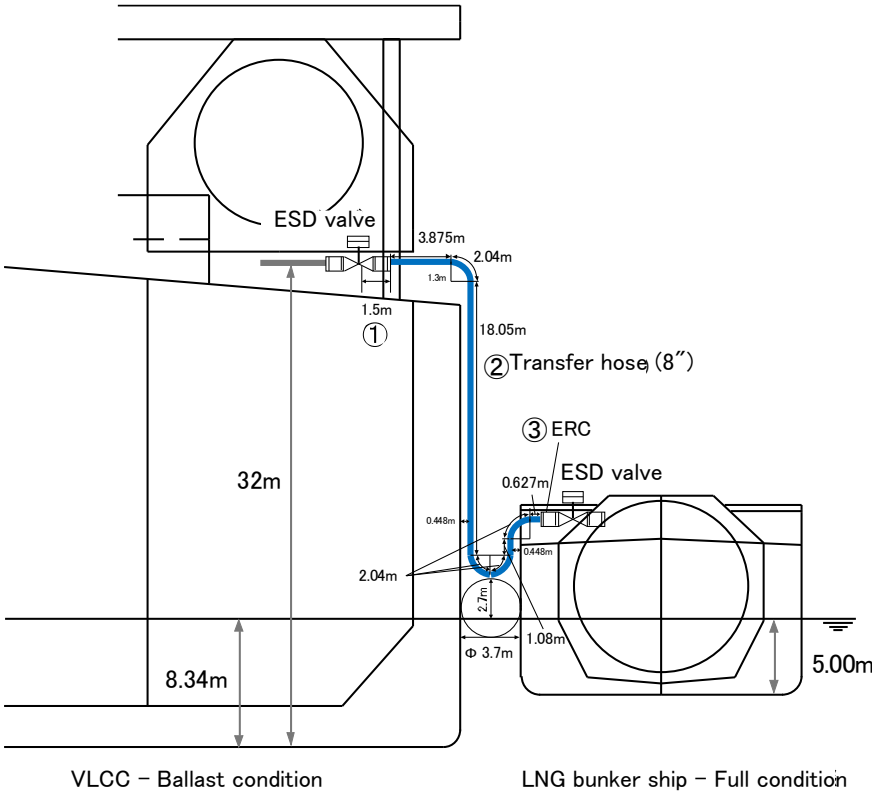


Fig. ⑤-1.1 Transfer hose connection diagram

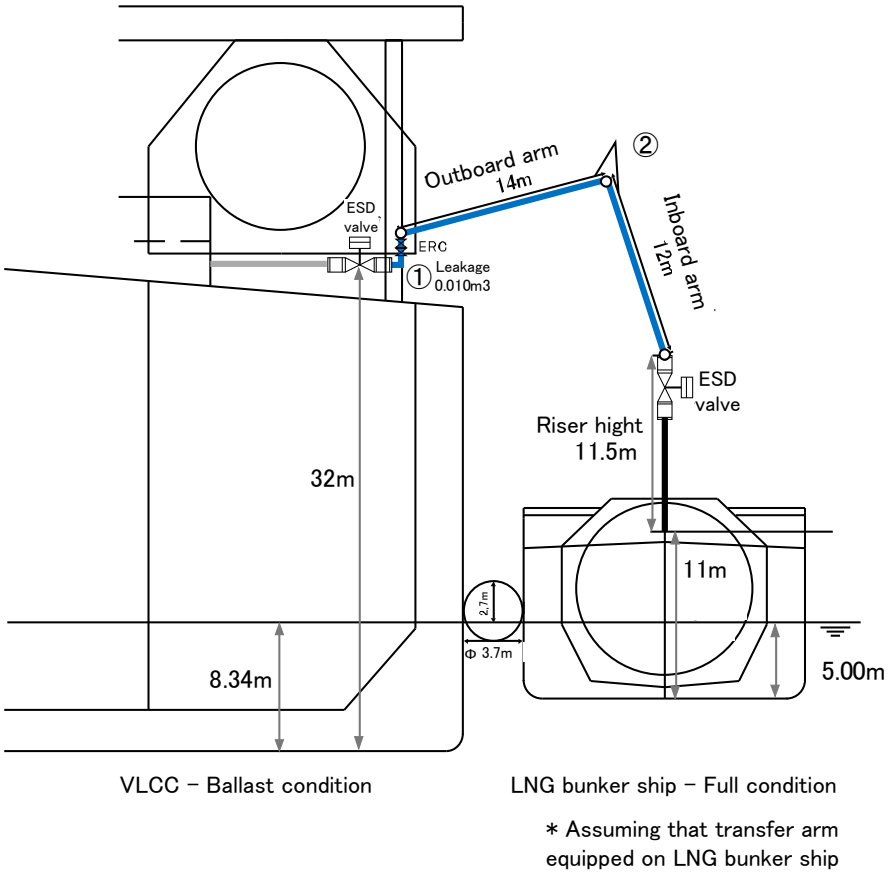


Fig. ⑤-1.2 Transfer arm connection diagram

1.2 LNG transfer work

The transfer work flow and the transfer work description of the LNG bunker ship and the LNG fuelled ship (VLCC) are shown below.

(1) LNG transfer work flow

Fig. ⑤-1.3 shows an example of LNG transfer work flow.

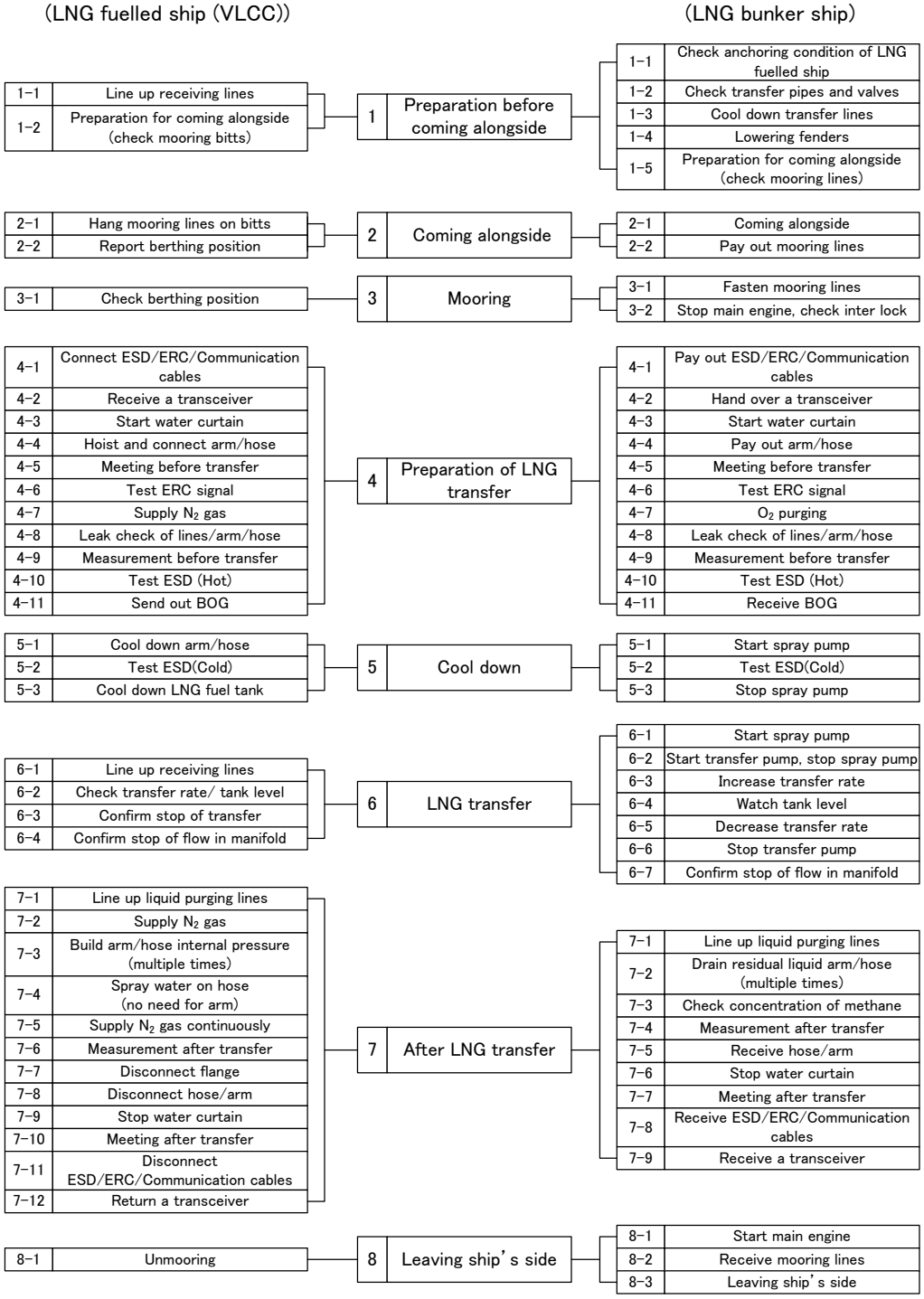


Fig. ⑤-1.3 LNG transfer work flow (example)

(2) LNG transfer work

An example of LNG transfer work is given below.

① Preparations before coming alongside

The LNG bunker ship shall confirm the mooring conditions of the LNG fuelled ship at anchor or at breakwater or quay. Also, preparations for paying out LNG transfer hose, and arm, and preparatory work for materials and equipment shall be made as the line up and line cool-down work for LNG transfer progresses. For coming alongside and mooring with the LNG fuelled ship, preparations shall be made for paying out mooring line and lowering fenders, etc.

The LNG fuelled ship shall make preparations for hoisting the hose by crane, preparations for flange connection and preparations for coming alongside and mooring with the LNG bunker ship while proceeding with line up for receiving LNG.

② Coming alongside

Maneuvers to come alongside and pay out mooring lines shall be carried out in the LNG bunker ship, while fastening mooring lines to bitts shall be carried out in the LNG fuelled ship.

③ Mooring

Mooring lines shall be fastened while checking the mooring position in the LNG bunker ship, and after the main engine stops, the main engine interlock shall be checked.

④ LNG transfer preparations

a) Cable connections

Communication cables and ESD/ERC electrical cables shall be paid out from the LNG bunker ship, while these cables shall be received and connected in the LNG fuelled ship.

b) Test of communications between the ships

Test of communications shall be conducted using communication cables and transceivers between the two ships, and results shall be recorded.

c) Meeting before the transfer

LNG transfer associated personnel from the LNG bunker ship shall board the LNG fuelled ship and confirm the LNG transfer volume, tank conditions, transfer procedure, schedule, weather conditions, and safety measures with the relevant personnel on the ship.

d) LNG transfer hose/arm connection

The manifold and crane on the LNG fuelled ship shall be operated and the end of the

LNG transfer hose shall be hoisted from the LNG bunker ship and connected to the flange.

e) ERC working test

ERC working test shall be conducted and results recorded.

f) O_2 purging /leak test

N_2 gas shall be supplied from the LNG fuelled ship and the pressure in the transfer hose/arm raised/lowered repetitively so as to replace air in the hose/arm with N_2. At the same time, soap test (gas leak check) of the flange connection shall be carried out when the pressure is raised.

g) Measurement before LNG transfer

Measurement (measurement before LNG transfer) shall be carried out according to the prescribed procedure on the LNG fuelled ship. This measurement shall be carried out on the LNG bunker ship as well.

h) ESD test (hot condition)

The ESD working test shall be conducted at normal temperature conditions on both ships according to the prescribed procedure and results shall be recorded.

i) Lowering LNG tank pressure in the LNG fuelled ship

The BOG in the LNG tank of the LNG fuelled ship shall be sent to the LNG bunker ship, and the LNG fuel tank pressure in the LNG fuelled ship shall be lowered. However, if the BOG cannot be sent because of the combination of tank types or for some other reason, then it may be treated on board the ship by combustion, etc.

j) Start of water curtain

Water spray of the shell plating by water curtain equipment shall be started in both the LNG fuelled ship and the LNG bunker ship.

⑤ Cool-down

a) LNG transfer hose/arm and LNG fuelled ship line cool-down

Spray pump of the LNG bunker ship shall be started, and cool-down of the LNG transfer hose/arm and liquid line of the LNG fuelled ship shall be carried out.

b) ESD test (cold condition)

The ESD working test shall be conducted at low temperature conditions on both ships according to the prescribed procedure and results shall be recorded.

c) Cool-down of tank in the LNG fuelled ship

Cool-down of tank in the LNG fuelled ship shall be carried out.

⑥ LNG transfer

a) Start of LNG transfer

After line up of the LNG delivery/receiving lines, the spray pump of the LNG bunker

ship shall be started, and LNG transfer shall be started. Leak checks in the LNG transfer hose/arm and liquid line shall be carried out occasionally.

b) Rate increase

The LNG pump of the LNG bunker ship shall be started and delivery of LNG shall be started. The spray pump shall be stopped. The rate shall be gradually increased by adjusting the valve opening of the LNG pump discharge valve, and leak checks in the LNG transfer hose/arm and liquid line shall be carried out occasionally.

c) Steady state rate

The pump rate shall be set in the LNG bunker ship, the delivery line, LNG hose/arm conditions, tank level and tank pressure shall be continuously monitored. The receiving flow rate shall be confirmed in the LNG fuelled ship, and the LNG hose/arm, receiving line, tank level and tank pressure shall be continuously monitored. BOG shall be returned, or it shall be combusted in the LNG fuelled ship.

d) Rate reduction

When the tank liquid in the LNG fuelled ship reaches a specific level, the transfer rate shall be reduced gradually by adjusting the opening of the LNG pump discharge valve of the LNG bunker ship. The changeover operation of the receiving tanks shall be performed in the LNG fuelled ship so as to adjust the liquid level in the fuel tanks.

e) Completion of loading

When the tank liquid in the LNG fuelled ship reaches a specific level, the LNG pump in the LNG bunker ship shall be stopped, and the stoppage of liquid flow in the manifold shall be confirmed.

⑦ Work after LNG transfer

a) Liquid purging

Vapor or N2 shall be supplied from the LNG fuelled ship to perform liquid purging. The liquid remaining in the hose shall be recovered in the LNG bunker ship.

b) Methane purging

N_2 gas shall be supplied from the LNG fuelled ship and the pressure in the LNG transfer hose/arm raised/lowered repetitively so as to replace vapor in the hose with N_2.

c) Measurement after LNG transfer

Final measurement (measurement after LNG transfer) shall be carried out according to the prescribed procedure.

d) Disconnection of LNG transfer hose/arm

The flange at the end of the LNG transfer hose on the LNG fuelled ship side shall be disconnected. The manifold crane on the LNG fuelled ship side shall be operated, and the hose shall be stored in the LNG bunker ship.

e) Stopping the water curtain

Water spray of the shell plating by water curtain equipment shall be stopped in both the LNG fuelled ship and the LNG bunker ship.

f) Stopping the ERC from activating

The ERC shall be stopped from activating.

g) Closing down work

Communication cables and ESD/ERC electric cables shall be disconnected and stored on the LNG bunker ship.

h) Meeting after the transfer

LNG transfer associated personnel from the LNG bunker ship shall board the LNG fuelled ship and confirm the LNG transfer work results with the relevant personnel on the ship.

⑧ Leaving the ship's side

After the main engine test, mooring lines shall be released, and the ship shall be maneuvered to leave the ship's side/leave port.

1.3 LNG transfer work safety management system

It is important to build and establish a safety management system on both the LNG bunker ship and the LNG fuelled ship to ensure safety when "coming alongside," "mooring," "LNG transfer," and "leaving the ship's side" and ensure smooth LNG transfer operation.

The masters of both ships shall set up the crew manning system when coming alongside/leaving the ship's side and the safety management system for LNG transfer during the transfer. For LNG transfer, the masters shall check the work processes, exchange essential information related to weather and sea conditions, and ensure safe LNG transfer.

Fig. ⑤-1.4 shows an example of the safety management system for LNG transfer work.

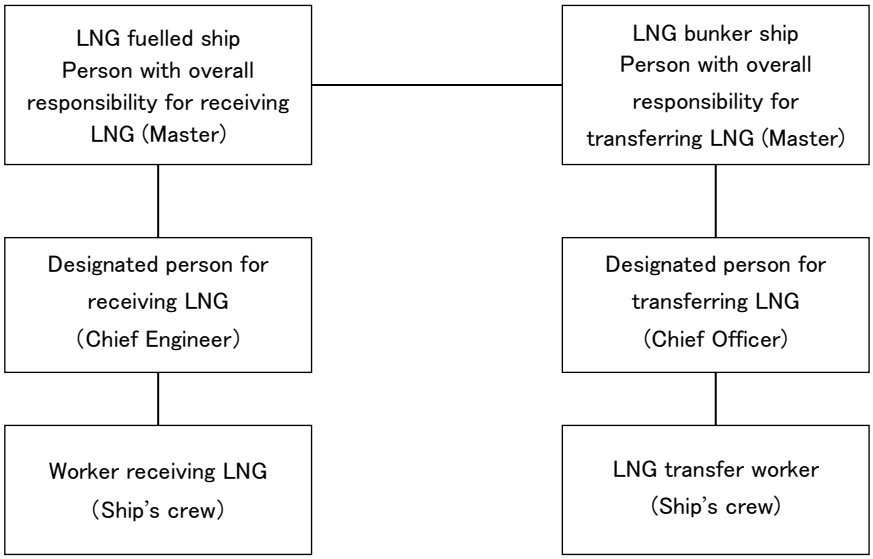


Fig. ⑤-1.4 LNG transfer work safety management system (example)

(1) LNG transfer management system of LNG fuelled ship and LNG bunker ship

① LNG fuelled ship

a) Person with overall responsibility for receiving LNG (Master)
As the person with the overall responsibility for the LNG fuelled ship, the master shall take the final decision related to coming alongside, mooring and leaving the ship's side of the LNG bunker ship. The master also is in overall charge of duties related to safety of LNG transfer work on the LNG fuelled ship.

b) Designated person for receiving LNG (Chief Engineer)
The Chief Engineer is the designated person for receiving LNG on the LNG fuelled ship. He shall command the responsible engineers, and assume responsibility for the LNG receiving work on the LNG fuelled ship.

c) Worker receiving LNG (member of the ship's crew)
Shall perform work to receive LNG as an LNG transfer worker on the LNG fuelled ship.

② LNG bunker ship

a) Person with overall responsibility for transferring LNG (Master)
As the person with the overall responsibility for the LNG bunker ship, the master shall take the final decision related to coming alongside, mooring and leaving the ship's side of the LNG bunker ship. The master also is in overall charge of duties related to safety of LNG transfer work on the LNG bunker ship.

b) Designated person for transferring LNG (Chief Officer)

The Chief Officer is the designated person for LNG transfer on the LNG bunker ship. He shall command the Deck Department and the responsible engineers, and assume responsibility for the LNG transfer work on the LNG bunker ship.

c) Worker transferring LNG (member of the ship's crew)

Shall implement LNG transfer work on board the LNG bunker ship as the LNG transfer worker.

(2) Safety measures before LNG transfer

It is important that the masters of the LNG fuelled ship and the LNG bunker ship prepare checklists as indicated below based on the "Guidelines for systems and installations for supply of LNG as fuel to ships" recommended for formulation in PT1 (LNG loading equipment for ship fuel) of WG10 (International standards for LNG equipment) of ISO TC67 (Materials, equipment and offshore structures for petroleum, petrochemical and natural gas industries), after referring to the "LNG Ship to Ship Transfer Guidelines : SIGTTO," and confirm safety before LNG transfer.

a) "Checklist on information specific to each ship" before the first time of LNG transfer work
b) "Checklist on safety before start of work" just before the start of LNG transfer work
c) "Checklist on safety before coming alongside and mooring" before the LNG bunker ship comes alongside
d) "Checklist on safety before start of work" just before the start of LNG transfer work
e) "Check list on safety before unmooring and leaving ship's side" before the LNG bunker ship leaves ship's side.

(3) Check items for LNG transfer work

① Preparations for LNG bunker ship before coming alongside

- Continually acquire information on weather and sea conditions and grasp future forecasts
- Check scheduled coming alongside time of LNG bunker ship
- Check conditions (draught, tank pressure, etc.) when the LNG bunker ship comes alongside
- Confirm that preparations (lowering fenders, preparations for receiving mooring lines, etc.) for the LNG bunker ship to come alongside have been completed.
- Check that machinery and equipment on the LNG bunker ship are working normally
- Check stationing of personnel on the LNG bunker ship
- Check communications between the two ships
- Check by masters of both ships that preparations for coming alongside have been

completed

② LNG transfer preparatory work

- Confirm that the LNG bunker ship has come alongside
- Confirm that the mooring lines of the two ships are properly extended
- Confirm the results of communications test that has been carried out
- Confirm that the LNG transfer hose has been handed over and received and preparations for connecting arm have been completed
- Confirm that the connection of the transfer hose/arm are satisfactory (no excessive bend)
- Confirm the results of ESD/ERC test that has been carried out
- Confirm that the firefighting equipment of the two ships are in the standby condition
- Confirm whether the preparations for water curtain for protecting the hulls of the two ships have been made
- Confirm that the cool-down is satisfactory
- Checks by the masters of both ships that preparations for LNG transfer work have been completed

③ Implementing LNG transfer work

- Check for liquid leaks in the lines and monitor the liquid transfer speed and tank level
- Check if tank pressures in both ships are normal
- Confirm that periodic gas detection is being implemented

④ Implementing work after LNG transfer

- Check whether preparations for disconnecting transfer hose/arm have been completed
- Confirm that the liquid line and the vapor line have been disconnected

⑤ Unmooring of LNG bunker ship

- Check whether the engine of the LNG bunker ship is in the standby condition
- Check whether preparations for removing mooring lines have been made
- Confirm that the LNG bunker ship has left the ship's side

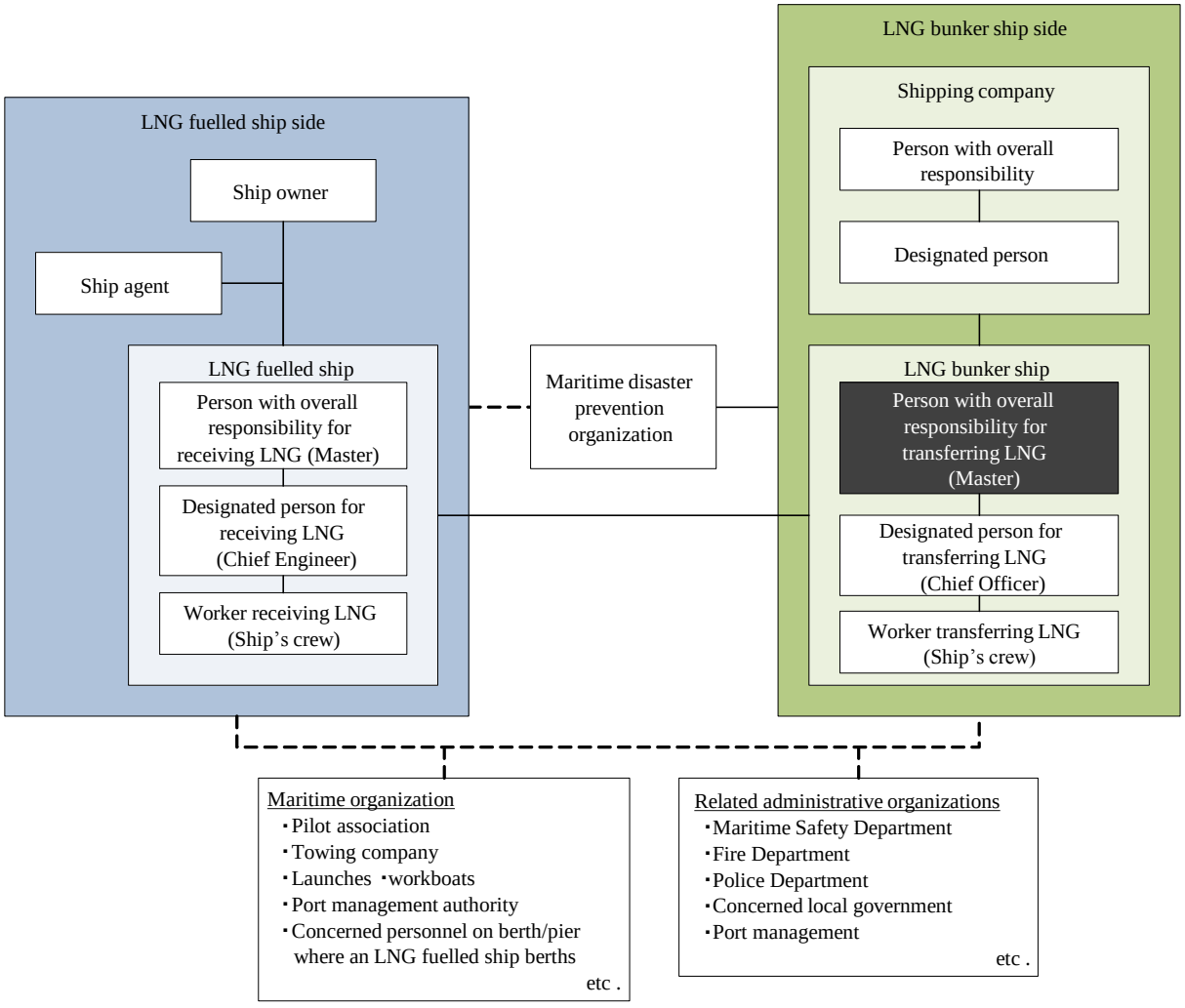
⑥ Others

- Check whether inspections are being carried out according to the checklist step by step for each task

1.4 Maritime disaster prevention system

If an LNG leak, fire, oil spill, contact with another ship or other situations (hereafter referred to as "emergency situations") occur in the LNG fuelled ship and the LNG bunker ship or in either one of the ships during LNG transfer work, the crew members of the two ships shall immediately take the necessary actions, and cooperate with each other to reduce the magnitude of the disaster to a minimum.

Although it is preferable to perform cargo transfer at a special berth where assistance from LNG terminal can be received like general LNG tankers, in case of LNG transfer at a berth other than a special berth, it may be necessary to set up a reliable system such as forming a coordination system with maritime disaster prevention organizations so that appropriate response can be taken in an emergency situation such as leakage of LNG or fire.



* Solid lines and dashed lines indicate formation of a communication system at each implementation and implementation as required respectively

Fig. ⑤-1.5 LNG transfer work disaster prevention system (example)

1.5 Firefighting equipment and systems in the LNG bunker ship and the LNG fuelled ship

(1) Fire extinguishing equipment and systems in the LNG bunker ship

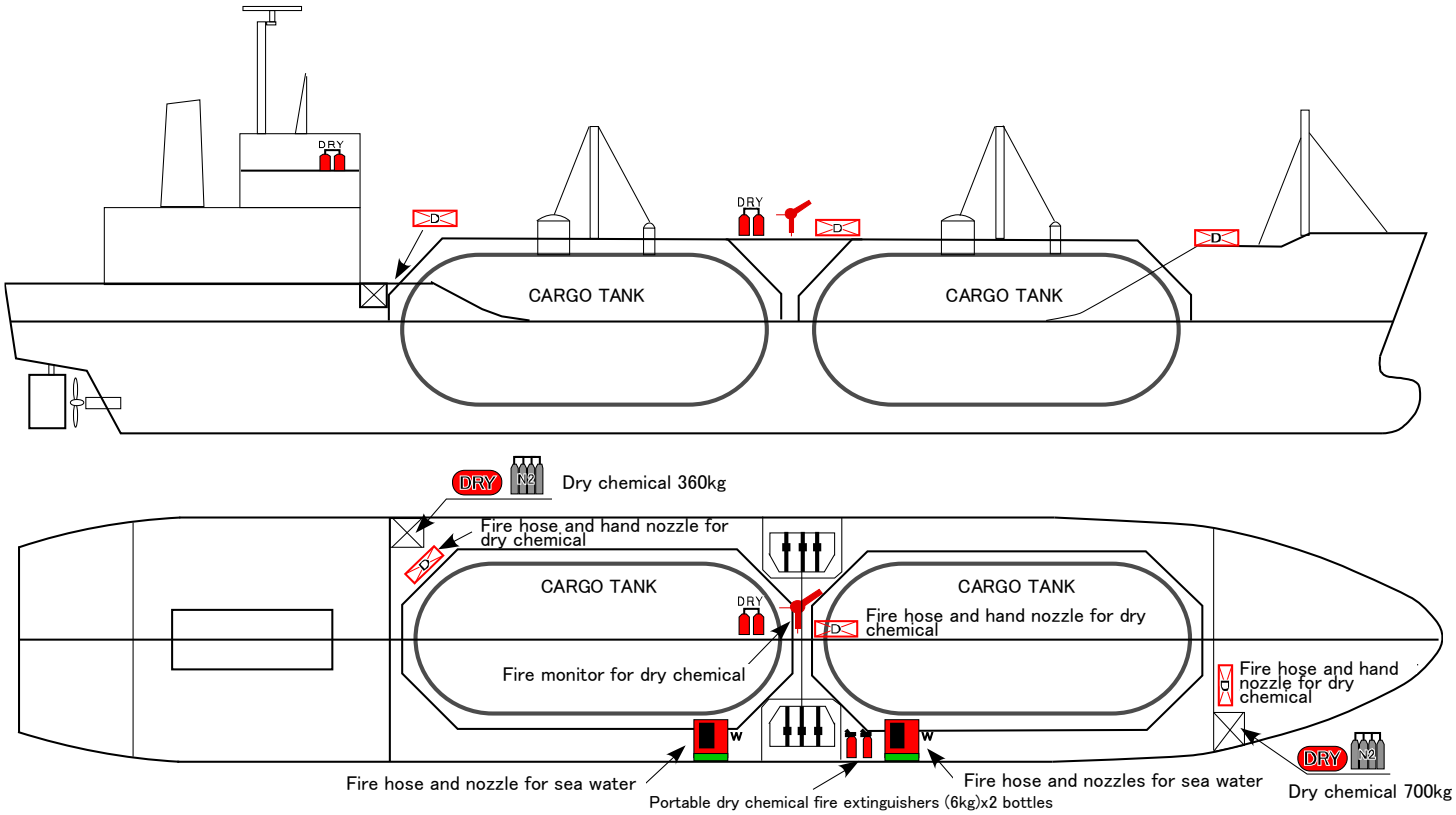
The Ship Safety Law and the Regulations for the Carriage and Storage of Dangerous Goods in Ships apply to LNG bunker ships. Fire extinguishing equipment similar to those installed in coastal LNG tankers already in operation may be considered for installation on LNG bunker ships.

The fire extinguishing systems on the ocean-going LNG tanker and coastal LNG tanker during StS implementation at the Tomakomai Higashi Port in the winter of 2011 and 2012 included two hoses from the seawater fire hydrant near the manifold, fixed dry chemical fire extinguishing monitor, one hand nozzle for dry chemical fire extinguishing system ready for use, and two portable fire extinguishers.

The fire extinguishing system on the LNG bunker ship during LNG transfer should be installed referring to the Tomakomai StS already with a track record. Fig. ⑤-1.6 shows an example of standby fire extinguishing equipment in the coastal LNG tanker at the time of implementing the Tomakomai StS.

[Fire extinguishing system in LNG bunker ship during LNG transfer referring to the Tomakomai StS]

a) Gas detection shall be periodically performed near the manifold of the LNG bunker ship
b) Portable dry chemical fire extinguishers (6 kg x 2 no.) shall be installed near the manifold of the LNG bunker ship such that they can be used immediately.
c) Hose shall extend from the sea water fire hydrant near the manifold of the LNG bunker ship. Arrangement shall be capable of discharging two jets of water immediately.
d) Arrangements shall be made such that the cover of one monitor for fixed type dry chemical fire extinguishing system of the LNG bunker ship can be removed and the system can be used immediately for the manifold.
e) Arrangements shall be made such that one hand nozzle for dry chemical fire extinguishing system on the LNG bunker ship can be used immediately.



Legend	Item	#	Installation place
DRY	Dry chemical starter	1	Wheel house
		1	Erection deck (center)
	Fire monitor for dry chemical	1	Erection deck (center)
D	Fire hose and hand nozzle for dry chemical	3	Where required
W	Fire hose and nozzles for sea water	2	Upper deck

Legend	Item	#	Installation place
DRY	Dry chemical tank	1	Dry chemical tank room (bow)
		1	Dry chemical tank room (stern)
N2	N2 bottle (for dry chemical starter)	—	Dry chemical tank room (bow)
		—	Dry chemical tank room (stern)
	Portable dry chemical fire extinguishers (6kg)	2	Upper deck

Fig. ⑤-1.6 Standby fire extinguishing equipment on coastal LNG tanker at the time of Tomakomai StS

(2) Fire extinguishing equipment and systems on the LNG fuelled ship

Appropriate fire extinguishing system should be installed for LNG transfer work based on the requirements of the IGF Code being discussed presently at the IMO, and the necessary fire extinguishing equipment installed on the LNG fuelled ship.

The fire extinguishing system during LNG transfer work shall consist of at least dry chemical fire extinguishing system in the area where LNG leaks may occur at the bunker station near the fuel manifold for receiving LNG, and also portable dry chemical fire extinguishers that can be used immediately when required.

Fig. ⑤-1.7 shows an example of arrangement of fire extinguishing equipment on a LNG fuelled ship (VLCC) while Fig. ⑤-1.8 shows an example of arrangement of fire extinguishing equipment on a LNG fuelled ship (PCC).

[Fire extinguishing system on LNG fuelled ship during LNG transfer work]

a) Gas detection shall be periodically performed near the manifold of the LNG fuelled ship
b) Arrangements shall be made such that sea water fire hydrant can be used immediately
c) A fixed dry chemical fire extinguishing system shall be installed near the bunker station and a portable dry chemical fire extinguisher (5 kg x 1 no.) shall be installed near the manifold of the LNG fuelled ship such that they can be used immediately.

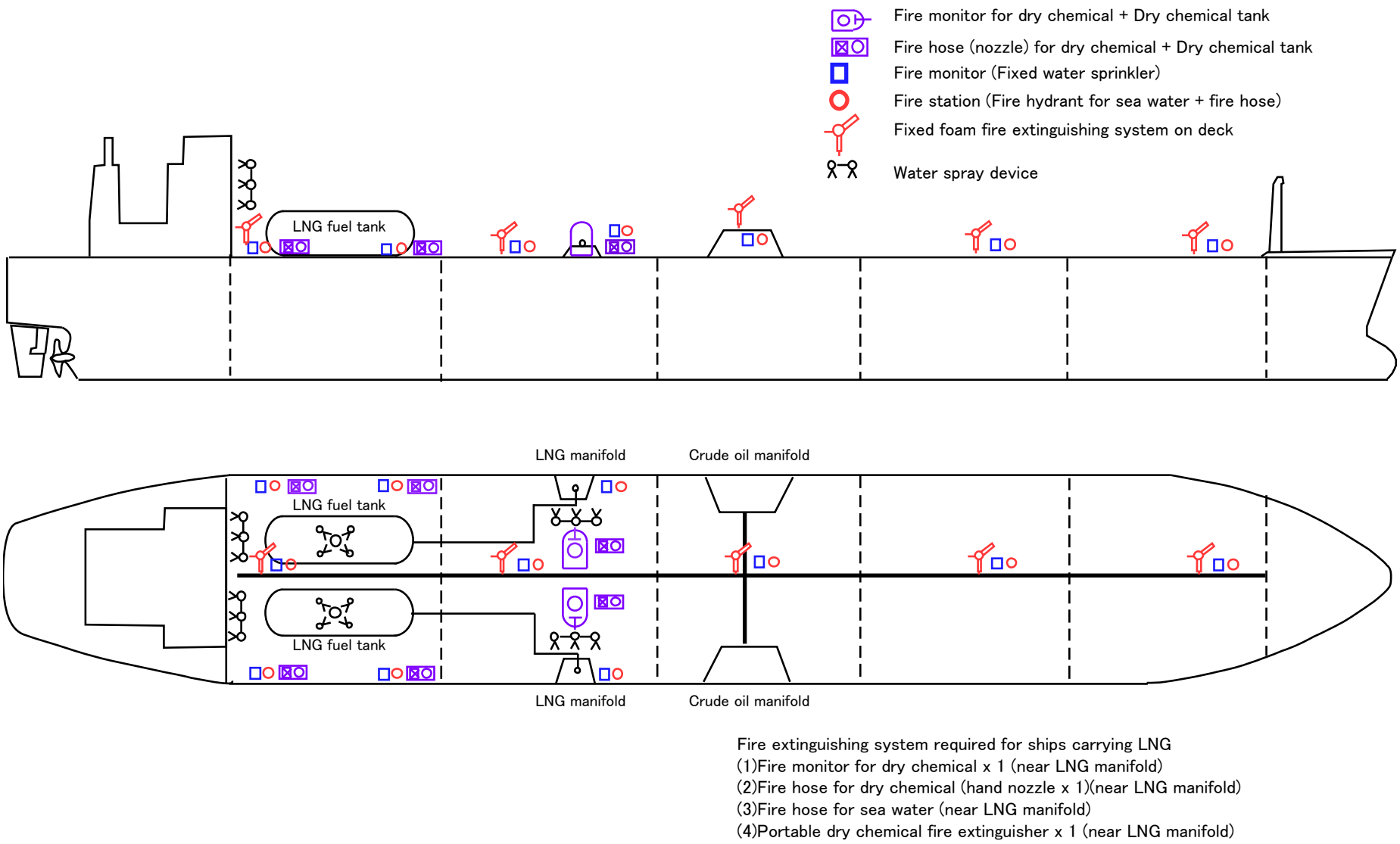


Fig. ⑤-1.7 Example of arrangement of fire extinguishing equipment in a LNG fuelled ship (VLCC)

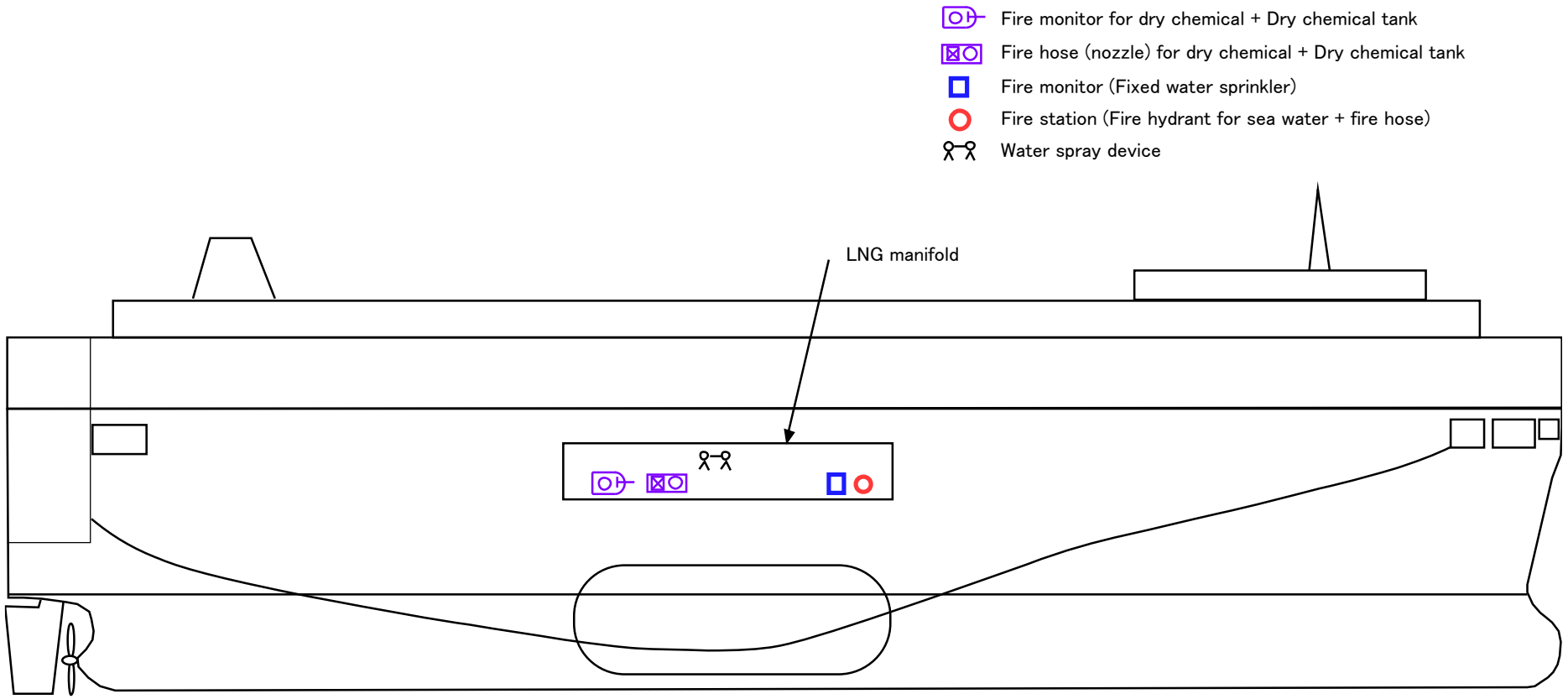


Fig. ⑤-1.8 Example of arrangement of fire extinguishing equipment in a LNG fuelled ship (PCC)

1.6 Skills training

All crew members associated with LNG transfer work on the LNG fuelled ship and the LNG bunker ship shall be give skills training so that they acquire the necessary technical knowledge and skills to prevent the occurrence and spread of a disaster during the LNG transfer work.

All items of the skills training shall be completed before the start of the first LNG transfer work. The masters of the two ships shall confirm the status of fulfilment of the safety measures in the skills training, and if any deficiency or defect is found, they shall correct and improve before the start of the transfer work. The masters shall make all possible preparations to properly implement the safety measures in actual work.

Table ⑤-1.1 shows an example of the items and content of skills training.

Table ⑤-1.1 Training plan table of LNG transfer work (example)

	Training item	Description
Disaster prevention training	Transfer management organization Shift to disaster prevention organization	Chart showing LNG transfer safety management organization, shift to disaster prevention organization, putting into operation disaster prevention departments, and communications system when an accident occurs
	Communications and contacts Use of radio	Confirming communication procedure and contact destinations when an accident occurs Connection of communication cables between two ships, use of transceiver, etc.
	Use of fire extinguishing equipment	Use of dry chemical extinguisher, dry chemical hand nozzle, dry chemical monitor, fixed water jet equipment (fire monitor), fire hydrant, fire hose, water spray system, etc.
	Fire extinguishing and prevention	Method of extinguishing LNG fires (assume LNG spill, spread of liquid surface, gas dispersion and pool fire analysis results, spraying cry chemical from the windward side, protection from radiant heat by water spray, accelerating evaporation of LNG by spraying water)
	ESD and ERC operations	ESD working principle (automatic operation, manual switch) ERC working principle (automatic operation, manual switch) Connecting ESD/ERC electric cables
Transfer work training	①Work before coming alongside	Line up for transfer, line cool-down, preparations for transfer equipment/materials and equipment at manifold, preparations for coming alongside and mooring
	②Coming alongside work	Preparations and pay-out of mooring lines (LNG bunker ship), bitt securing (LNG fuelled ship)
	③Mooring work	Tightening mooring lines, interlock after stopping main engine, fitting ladders
	④Transfer preparatory work	Pay out, receiving and connecting of communication cables, and ESD/ERC electric cables Communication tests between the two ships and recording of results Meeting before the transfer, removal of ladders Handing over transfer hose, crane operation and arm pay out Flange connection ERC working test O2 purging in transfer hose/arm, gas leak checks of flanged parts Measurement before LNG transfer ESD test (hot condition) Drop in tank pressure of LNG bunker ship Activation of water curtain
	⑤Cool-down	Start spray pump of the LNG bunker ship, and cool down the LNG transfer line of the LNG fuelled ship and the transfer hose ESD test (cold condition) Cool-down of tank in the LNG fuelled ship
	⑥LNG transfer	Start spray pump of LNG bunker ship and check for leakage Increase rate, start transfer pump and stop spray pump Monitor steady state rate, tank level and tank pressure; return BOG Decrease rate, adjust transfer pump discharge valve, change over tank in LNG fuelled ship Completion of loading, stoppage of transfer pump
	⑦Completion of transfer work	Liquid purging, supply of N_2 from LNG fuelled ship, Methane purging, replacing by N_2 in the hose/arm Measurement after LNG transfer Removal of transfer hose/arm, disconnection of flanges, crane operation, storage of hose/arm Stop water curtain Stop ERC activation Closing down work, disconnection and storage of communication cables, and ESD/ERC electric cables
	⑧Leaving the ship's side	Main engine test, removing the mooring lines, leaving ship's side/leaving port

1.7 Earthquake and tsunami measures

When the Weather Bureau announces earthquake and tsunami information, the same is received by NAVTEX (system that automatically receives on ship the information for maritime safety such as weather, navigation or rescue information that is broadcast in service areas without 300 nautical miles off Japan's coastline; ship equipment regulations) through the Japan Coast Guard, and is automatically printed out on records. The ship can also set an alarm notifying receipt of such information.

Earthquake and tsunami information is also broadcast by NHK TV; therefore, efforts shall be made to collect such information wherever an earthquake is sensed.

When tsunami warnings or cautionary messages are acquired, transfer shall be suspended based on standards for suspending transfer and mooring; if deemed necessary, the ship shall seek refuge away from the ship's side.

(1) Earthquake measures

When offshore, it may not be possible to feel an earthquake while on board; also, earthquake information may not be acquired easily in sea areas insensitive to digital TV broadcasts. Therefore, in addition to NAVTEX, a system to quickly receive earthquake and tsunami information (for instance, through satellite telephones) should be set up so that the LNG fuelled ship can receive such information from the shipping agent and the LNG bunker ship can receive information from the operating company. From the end of March 1996, NTT has commenced satellite ship telephone service, and this service covers sea areas up to 200 nautical miles from the coast.

Arrangements shall be made such that if either of the ships receives earthquake and tsunami information, it shall immediately exchange this information with the other ship.

When tsunami warning or other warning is issued, the masters of both ships shall suspend LNG transfer work in accordance with the standards for suspending LNG transfer after discussions with each other. Moreover, they shall also judge on when to disconnect the transfer hose or arm and whether to leave the ship's side immediately or not.

(2) Tsunami measures

① Always keep the working hours in mind

Drills shall be conducted beforehand to safely and swiftly perform work such as stopping transfer pump from the LNG transfer condition, closing valves, purging arm/hose and lines, and disconnecting the arm/hose. Also, the time required for performing such a series of tasks shall be recorded. If the arm/hose is decided to be disconnected in an emergency, crew members of both ships shall be ordered to immediately disconnect the arm/hose.

Depending on the conditions, after activating ESD or ERS, hose-arm disconnection may be anticipated. Therefore, drills related to these activities shall be regularly implemented, and the

procedure and time required for disconnection shall be confirmed.

② Loading arm/hose decoupling drills

The masters of the LNG bunker ship and the LNG fuelled ship shall conduct drills assuming normal decoupling or the use of ESD and ERC, and enhance the proficiency of the crew members of their own ship. Especially, since the frequency of LNG fuel transfer work for the LNG bunker ship is high, a system should be in place such that proper instructions are issued to the LNG fuelled ship.

1.8 Actions in an emergency such as LNG leak, etc.

If an LNG leak, fire, contact with another ship or other accidents occur in the LNG fuelled ship and the LNG bunker ship or in either one of the ships during LNG transfer work, the crew members of the two ships shall immediately take the necessary actions, and cooperate with each other to reduce the magnitude of the accident to a minimum.

(1) Actions to be taken when an LNG leak occurs

① The first person who discovers the LNG leak shall immediately notify the master.
② The master shall promptly activate the Emergency Shut Down System (ESD) and suspend the transfer operation.
③ The said person shall blow the whistle and notify the crew members of both ships and others in the vicinity the occurrence of the emergency situation.
④ Both ships shall take up the specific emergency arrangements, close the doors connecting to the upper deck or the LNG receiving manifold, stop the ventilation fans, ensure that gas does not enter the ship, and again establish fire controls.
⑤ Both ships shall station personnel in the firefighting department in preparation for a fire break-out.
⑥ The Maritime Safety Department, the fire station, the police, the port controller and other concerned administrative organizations shall be notified.
⑦ Approach of other ships shall be prevented through radio, external speakers and so on.

(2) Actions to be taken when a fire breaks out

① The first person who discovers the fire shall immediately notify the master.
② The master shall promptly activate the Emergency Shut Down System (ESD) and suspend the transfer operation.
③ The said person shall blow the whistle and notify the crew members of both ships and others in the vicinity the occurrence of the emergency situation.

④ Both ships shall close the doors connecting to the upper deck or the LNG receiving manifold, stop the ventilation fans, close all kinds of openings to ensure that gas does not enter within the ship, and again establish fire controls.

⑤ Both ships shall man the firefighting stations immediately and start fire extinguishing activities.

⑥ If necessary, water spray shall be activated.

⑦ The Maritime Safety Department, the fire brigade, the police, the port controller and other concerned administrative organizations shall be notified.

⑧ Approach of other ships shall be prevented through radio, external speakers and so on.

1.9 Summary of disaster prevention measures related to LNG transfer work

Table ⑤-1.2 shows the summary of disaster prevention measures related to LNG transfer work.

Table ⑤-1.2 Summary of disaster prevention measures related to LNG transfer work

StS of LNG in Tomakomai (Example)		LNG Fuel Transfer	
Ocean-going LNG tanker (sending side)	Coastal LNG tanker (receiving side)	LNG bunker ship (sending side)	LNG fuelled ship (receiving side)
LNG transfer equipment ・Transfer hose (lowering by the ocean-going ship side) ・Hose support saddle ・Manifold crane (in case of using hose) ・Water curtain equipment ・ Night time lighting (ensure intensity of illumination for the manifold part)	LNG transfer equipment ・Hose receiving, connection by coastal ship Same as left ・Not installed on coastal ship side Same as left ・ Night time lighting (ensure intensity of illumination for the manifold part)	LNG transfer equipment ・Transfer hose/arm ・Hose support saddle (in case of using hose) ・Manifold crane (in case of using hose) ・Water curtain equipment ・ Night time lighting (ensure intensity of illumination for the manifold part)	LNG transfer equipment Same as left Same as left ・Required for VLCC Same as left Same as left
Communications equipment between the two ships ・Communications cable (hot line: between CCR of two ships) ・ESD electric cable ・ERC (estrangement detecting wire equipment between the two ships) ・Transceiver	Communications equipment between the two ships Same as left Same as left ・ ERC drive hydraulic system installed on coastal ship side Same as left	Communications equipment between the two ships ・Communications cable (hot line, etc.: between CCR of two ships) ・ESD/ERC electric cable ・ERC drive hydraulic system installed on bunker ship side ・Transceiver	Communications equipment between the two ships Same as left Same as left Same as left Same as left
Safety Equipment ・ESD ・ERC	Safety Equipment Same as left Same as left	Safety Equipment ・ESD ・ERC、BAC（Break Away Couplings）	Safety Equipment Same as left Same as left

Qualification requirements of seafarer ・Person who is the Certified Hazardous Material Handling Supervisor (liquefied gas) should be on board (under the Mariners Act, Regulation 117.3) from Master of liquefied gas tanker, Chief Officer or Watch (No. 4 duty), Chief Engineer and First Engineer or Watch (No. 5 duty), other responsible personnel for handling dangerous substances or toxic substances carried on board liquefied gas tanker.	Qualification requirements of seafarer Same as left	Qualification requirements of seafarer ・Person who is the Certified Hazardous Material Handling Supervisor (liquefied gas) should be on board (under the Mariners Act, Regulation 117.3) from Master of liquefied gas tanker, Chief Officer or Watch (No. 4 duty), Chief Engineer and First Engineer or Watch (No. 5 duty), other responsible personnel for handling dangerous substances or toxic substances carried on board liquefied gas tanker.	Qualification requirements of seafarer The following international trends shall be closely observed: ・Study of IGF Code (rules for international gas fuelled ships) ・Study of the Standards for Training and Watchkeeping (STW) Committee of IMO
LNG transfer skills training ・LNG transfer training shall be implemented for all crew members before the start of LNG transfer (including ESD/ERC activation, handling of fire extinguishing equipment)	LNG transfer skills training Same as left	LNG transfer skills training ・LNG transfer training shall be implemented for all crew members before the start of LNG transfer (including ESD/ERC activation, handling of fire extinguishing equipment)	LNG transfer skills training Same as left
LNG transfer safety management system ・Safety management system shall be maintained by Master, Chief Officer and crew during LNG transfer work.	LNG transfer safety management system Same as left	LNG transfer safety management system ・Safety management system shall be maintained by Master, Chief Engineer, Chief Officer and crew during LNG transfer work.	LNG transfer safety management system Same as left
Disaster prevention system during LNG transfer work ・Standby fire extinguishing equipment (near fuel manifold) Dry chemical fire extinguishing equipment (monitor, hand nozzle), sea water fire hose and nozzle, portable dry chemical fire extinguisher ・Arrange one tugboat equipped with dry chemical fire extinguishing agent (Another tugboat standby) ・Conclude disaster prevention agreement with Maritime Disaster Prevention Center at the office	Disaster prevention system during LNG transfer work Same as left Same as left Same as left	Disaster prevention system during LNG transfer work ・Standby fire extinguishing equipment (near fuel manifold) Dry chemical fire extinguishing equipment (monitor, hand nozzle), sea water fire hose and nozzle, portable dry chemical fire extinguisher ・System for coordinating with maritime disaster prevention organizations	Disaster prevention system during LNG transfer work Same as left Same as left

Earthquake and tsunami measures ・Establish system for acquiring earthquake and tsunami information ・Implement arm/hose release training (including release using ESD/ERC) ・Study the time required for releasing arm/hose	Earthquake and tsunami measures Same as left Same as left Same as left	Earthquake and tsunami measures ・Establish system for acquiring earthquake and tsunami information (such as by introducing satellite mobile telephones) ・Implement arm/hose release training (including release using ESD/ERC) ・Study the time required for releasing arm/hose	Earthquake and tsunami measures Same as left Same as left Same as left

Study result ⑥

Requirements for docking, etc., of LNG fuelled ship

Requirements for docking, etc., of LNG fuelled ship

1 Requirements aimed at inspections

When a LNG fuelled ship is docked for inspection, the relevant onboard machinery and equipment shall be gas-freed in principle. However, this does not apply when the inspections do not to cover LNG fuel tanks and associated machinery and equipment.

The prerequisite for a ship to dock without gas-freeing the LNG fuel tanks is that the soundness of the tanks should be capable of being confirmed by recorded logs of conditions in tanks and external visual inspections before docking of the ship. At the same time, the pressure within the fuel tanks expected to rise during the period in dock (from the date of docking to the date of leaving the dock) shall be estimated beforehand; it shall also be confirmed that this pressure would be less than the design pressure of the tanks. Appropriate margin in time (no. of days) is necessary assuming an emergency response that could extend the period in dock. If these can be confirmed, the ship can dock retaining the LNG in the tanks after gas freeing the piping from the LNG fuel tank master valve to the engine.

On site, adequate management system shall be provided as indicated below.

(1) Measure gas concentration in the space where work is to be carried out and in the vicinity of the fuel tanks beforehand and confirm safety.

(2) The space around the fuel tanks shall be permanently monitored through gas detection and alarm functions. Gas detection shall be carried out at least twice a day.

(3) Fire extinguishing equipment shall be kept in a ready-to-use state at all times.

(4) Escape routes shall be ensured and notified to all in anticipation of an emergency.

The content of the IGF Code established, and when the plan for the LNG fuelled ship is finalized, detailed items of ship inspection and safety measures related to associated work shall be studied.

2 Requirements aimed at repair

When a LNG fuelled ship enters the dock for repairs, basically machinery and equipment on board shall be gas-freed. If certain conditions such as confirmation of soundness of LNG fuel tank can be satisfied, the ship can be docked with the LNG retained in the tanks. However, in case of hot work during repairs, a tank may necessarily have to be gas-freed depending on the positional relationship between the hot work location and the said tank. In such cases, too, if the LNG tank is a highly safe, vacuum insulation Type C tank, LNG can be retained in the said tank while the ship enters dock by providing an adequate management system.

(1) Measure gas concentration in the space where work is to be carried out and in the vicinity of the fuel tanks beforehand and confirm safety.

(2) Station adequate number of persons near the fuel tank to monitor the work.

(3) Keep fire extinguishing equipment in a ready-to-use state at all times.

(4) Ensure and notify to all escape routes in anticipation of an emergency.

3 Requirements for entering dock

The most important requirement for a LNG fuelled ship to enter dock is the ability of the ship to navigate safely from outside the port to the dock. The location for carrying out the gas-freeing operation of piping and associated equipment from the fuel tank to the engine of the LNG fuelled ship becomes important with respect to this requirement.

The requirements are given below according to the type of the engine.

① For dual fuel (DF) engine

If the LNG fuelled ship is equipped with a DF engine, and even if the gas-freeing work is carried out at a safe sea area with no effect on other ships similar to the LNG carrier, ‡the ship can enter the dock under its own power after gas freeing and after changing over the fuel to heavy fuel oil. However, either low-sulfur fuel oil should be used or scrubber shall be installed during navigation under own power with heavy fuel oil so as to comply with the 0.1% and 0.5% SOx regulations.

② For gas mono-fuel combustion engine

If the LNG fuelled ship is equipped with a gas mono fuel combustion engine, and if the gas-freeing work is carried out at a safe sea area with no effect on other ships similar to the LNG carrier, and if the ship is installed with a back-up diesel engine, then the ship can enter the dock under its own power after changing over the fuel to heavy fuel, similar to ships with DF engine. A method used in Norway may be used for using the back-up diesel engine; there is no report of any accident after using this method, and ship can enter the dock safely. However, it should be noted that this method is restricted to small ferries and OSVs. Meticulous study is necessary to check whether navigation can be carried out safely based on the ability of the back-up diesel engine after considering the ocean, ship traffic and operating environments within port, sea and weather conditions in the operating area, and external force conditions.

‡ Avoidance of gas freeing work in LNG carriers in sea areas with congested traffic and prior submission of documents on work implementation area and time are requirements in the administrative guidelines of the Japan Coast Guard “Standards for Safety and Fire Prevention Measures for Large Tankers and Large Tanker Berths.”

On the other hand, when the ship is not installed with a back-up diesel engine, operation under own power is lost along with the gas freeing of pipes or fuel tanks, and the ship becomes a so-called dead ship. When the ship becomes a dead ship, it has to receive support services such as a tugboat to tow it from the gas-free implementation area to the dock.

In addition to implementing gas freeing in a safe sea area without affecting other ships, if incineration facility such as boiler of suitable scale is available on board, the ship can navigate normally under its own power on LNG fuel up to the dock, and can then implement gas freeing of piping, etc., after berthing.

Also, no LNG fuelled ships are in operation in Japan currently, so onshore treatment facilities for burning LNG gas do not exist. However, among ocean going ships that will touch Japanese ports and coastal ships operating in Japan, there may be a fair number of ships using LNG as fuel, therefore the demand for such shore treatment facilities is likely to intensify.

Consequently, when shore facilities, such as LNG treatment facilities within shipyards are provided in the near future, it may be possible to implement gas freeing in such facilities within port subject to the condition that the necessary power is supplied from shore during the work.

The operating flow when a LNG fuelled ship enters dock can be summarized as shown in Fig. ⑥-1.1 below.

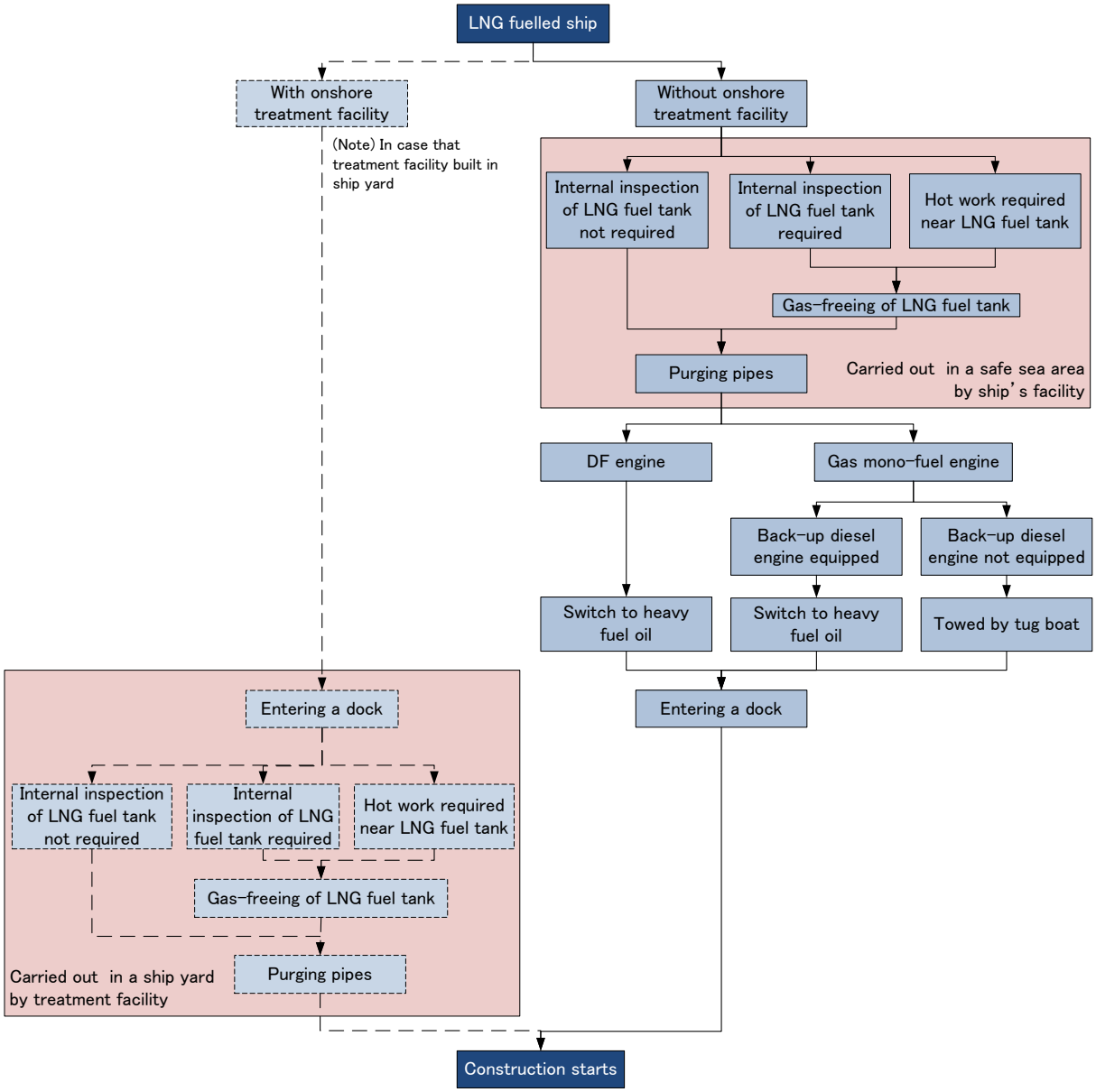


Fig. ⑥-1.1 Operating work flow for a LNG fuelled ship entering dock

4 Conclusion

The necessity of the gas-freeing operation before entering dock is given in Table ⑥-4.1, while safety measures when the ship enters dock without gas-freeing the LNG fuel tanks are summarized in Table ⑥-4.22.

Table ⑥-4.1 Necessity of gas-freeing operation before entering dock

	Description	Necessity of gas-freeing operation
1	Gas-freeing operation before entering dock	Gas freeing before entering dock is essential
2	Piping associated with fuel tanks	Associated piping shall always be gas-freed (necessary) regardless of whether fuel tanks are gas-freed or not.
3	When major repairs are anticipated	Gas freeing to be implemented (necessary)
4	Fuel-tank associated work exists	Gas freeing to be implemented (necessary)
5	Work on piping associated with fuel tank exists	Gas freeing to be implemented (necessary)
6	Minor repairs with no work on fuel tanks and associated piping	Gas freeing not to be implemented (not necessary)
7	Open up inspection of pumps/valves outside the fuel tank	The two points below shall be satisfied: 1. Valves on the fuel tank side are sound; blocking achieved by two or more valves. 2. After removing pump/valve, blind plate shall be fitted to both ends of the flange (to be capable of taking immediate response anticipating emergency)

Table ⑥-4.2 Safety measures when ship enters dock without gas-freeing LNG fuel tanks

	Description	Safety measures
1	Fuel tank management	Pre-requisite is that manual operations such as agitating are not required.
2	Number of days for pressure to accumulate in fuel tank	The pressure in fuel tank that can be raised during the docking period (including the day of entry into and day of departure from dock) shall be below the design pressure and days as margin confirmed beforehand. During this period, pressure in fuel tank shall be confirmed at all times.
3	Remote monitoring system, onsite measuring instruments	Shall be in the monitoring status at all times including gas detection and alarm functions. Relevant locations shall be gas detected at least 2 times a day.
4	Hot work and cold work	For work near fuel tank agreed to by the shipyard, gas detection shall be implemented and adequate number of personnel shall be stationed especially full time watches. If necessary, fuel tank water dispersing equipment should be used.
5	Emergency response (Response adopted when LNG fuel tank reaches upper limit of accumulated pressure)	Other than discharge to the atmosphere which is the last resort, implementation of either of the methods below shall be ensured. 1. Operations managed by generator and main engine 2. Incinerating equipment (GCU, boiler, etc.) 3. Transfer to other LNG tank (if multiple tanks exist) 4. Transfer to the CNG tank 5. Arrange for LNG trucks (several trucks may be required depending on the capacity and condition of fuel tanks)