

【DESCRIPTION】

【Invention Title】

LNG CARGO HOLD TEST METHOD, OFFSHORE STRUCTURE TO WHICH
SAME IS APPLIED, AND LIQUID NITROGEN SUPPLY SYSTEM OF
5 OFFSHORE STRUCTURE

【Technical Field】

[0001] The present disclosure relates to an LNG cargo hold test method, an offshore structure to which the same is applied, and a liquid nitrogen supply system of the offshore structure.

10 【Background Art】

[0002] After a liquefied natural gas (LNG) cargo hold of an offshore structure is built, a primary barrier global test is performed on a secondary barrier onshore. Then, the offshore structure is transported to an offshore site, and a cool-down operation is performed by spraying LNG, which is received
15 from an LNG bunker or directly produced offshore, into the LNG cargo hold. Once a cold shock is induced by the cool-down operation, a secondary barrier tightening test is performed on the secondary barrier of the LNG cargo hold.

[0003] In order to perform the primary barrier global test on the secondary barrier onshore and then perform the secondary barrier tightening test on the
20 secondary barrier as described above, the offshore structure needs to be transported to the offshore site.

[0004] For example, among the offshore structures, in the case of a floating liquefied natural gas (FLNG) facility without navigational ability, it is impossible to enter an LNG terminal, and thus filling and discharging of LNG
25 are difficult. Thus, filling and discharging of LNG is performed by LNG bunkering or directly producing LNG at the offshore site in a state where the FLNG facility is located offshore at an FLNG facility installation site.

[0005] However, an approval procedure of the operation of the LNG cargo hold test upon receiving LNG offshore is complex and expensive. In addition, it is difficult to quickly respond to an emergency situation occurring offshore.

[0006] Also, among the offshore structures, in the case of a vessel having the navigation ability, the vessel should leave a shipyard where the vessel is built after performing the primary barrier global test on the secondary barrier, enter an LNG terminal to receive LNG as a refrigerant, and return to the shipyard for a test performed on an LNG cargo hold test, and these processes are time consuming and expensive.

10 **【Disclosure】**

【Technical Problem】

[0007] Provided are LNG cargo hold test methods capable of reducing costs and increasing work efficiency by performing the LNG cargo hold test processes onshore, offshore structures to which the same is applied, and liquid nitrogen supply systems of the offshore structures.

【Technical Solution】

[0008] In accordance with an aspect of the present disclosure, a method for testing a liquefied natural gas (LNG) cargo hold includes: (a) performing a primary barrier global test on a secondary barrier of the LNG cargo hold after the LNG cargo hold of a floating liquefied natural gas (FLNG) facility is built; (b) performing a cool-down operation on the inside of the LNG cargo hold; and (c) performing a secondary barrier tightening test on the secondary barrier of the LNG cargo hold, wherein the operations (a) to (c) are performed on the LNG cargo hold of the FLNG facility in a state where the FLNG facility is located onshore, and the operation (b) is performed using at least one refrigerant except for LNG.

[0009] In accordance with another aspect of the present disclosure, a method for testing a liquefied natural gas (LNG) cargo hold includes: (a)

performing a primary barrier global test on a secondary barrier of the LNG cargo hold after the LNG cargo hold of a vessel is built; (b) performing a pipe cold test on a pipe connected to the LNG cargo hold and performing loading or unloading of LNG; (c) performing a cool-down operation on the inside of the LNG cargo hold; and (d) performing a secondary barrier tightening test on the secondary barrier of the LNG cargo hold, wherein the operations (a) to (d) are performed on the LNG cargo hold in a state where the vessel is located onshore, and the operations (b) and (c) are performed using liquid nitrogen.

[00010] The performing of the cool-down operation may include a process of controlling an internal temperature of the LNG cargo hold to be maintained at $-158^{\circ}\text{C}\pm 5^{\circ}\text{C}$ for a preset time by spraying liquid nitrogen into the LNG cargo hold at room temperature.

[00011] The method may further include performing a pumping test on a pump provided in the LNG cargo hold by filling liquid nitrogen in the LNG cargo hold onshore after performing the cool-down operation, and performing a process of testing offloading of liquid nitrogen from the inside of the LNG cargo hold to another vessel using a loading arm.

[00012] The method may further include performing a pumping test on a pump provided inside of the LNG cargo hold by filling LNG in the LNG cargo hold after performing the secondary barrier tightening test, and performing a process of testing offloading of LNG from the inside of the LNG cargo hold to another vessel using a loading arm, wherein the FLNG facility is tested in a state of being located offshore and a vessel having navigational ability is tested in a state of being located at an onshore terminal.

[00013] In accordance with another aspect of the present disclosure, a method for testing a liquefied natural gas (LNG) cargo hold includes: (a) performing a primary barrier global test of an LNG cargo hold; (b) performing a primary barrier global test on a secondary barrier of the LNG cargo hold; (c) performing a pipe cold test on a pipe connected to the LNG cargo hold; (d) performing a cool-down operation on the inside of the LNG cargo hold; (e) performing a warm-up operation to raise an internal temperature of the LNG

cargo hold to room temperature; (f) performing visual inspection on the inside of the LNG cargo hold after discharging a fluid contained in the LNG cargo hold and injecting dry air into the LNG cargo hold; and (g) performing a secondary barrier tightening test on the secondary barrier of the LNG cargo hold, wherein the operations (a) to (g) are performed on the LNG cargo hold of an offshore structure in a state where the offshore structure including a vessel is located onshore.

[00014] The operations (b) and (g) may be performed by a process including: filling nitrogen gas in a lower insulation space of the second barrier and an upper inter barrier space of the second barrier with different pressures; measuring pressure changes between the lower insulation space of the second barrier and the upper inter barrier space of the second barrier after a preset time; and determining integrity of the secondary barrier based on the measured pressure changes.

[00015] The operation (d) may include a process of controlling the internal temperature of the LNG cargo hold to be maintained at $-158^{\circ}\text{C}\pm 5^{\circ}\text{C}$ for a preset time by spraying a refrigerant into the LNG cargo hold.

[00016] The primary barrier global test may be performed by a process including applying an ammonia reactant to welded areas of a primary barrier, filling ammonia gas in a space between the primary barrier and a secondary barrier, and determining integrity of the primary barrier based on discoloration of the ammonia reactant, and the pipe cold test may be performed by flowing the refrigerant to the pipe and measuring whether contraction and expansion displacement of the pipe is within an allowable range.

[00017] In accordance with another aspect of the present disclosure, provided is an offshore structure to which the method for testing the LNG cargo hold is applied.

[00018] In accordance with another aspect of the present disclosure, a liquid nitrogen supply system of an offshore structure includes: a buffer tank configured to supply liquid nitrogen to an LNG cargo hold for an operation of testing the LNG cargo hold of an offshore structure located onshore; and a

controller configured to adjust an amount of liquid nitrogen sprayed into the LNG cargo hold to maintain an internal temperature of the LNG cargo hold within a predetermined temperature range for a preset time.

5 [00019] The liquid nitrogen supply system may further include a tank lorry configured to receive the liquid nitrogen from a liquid nitrogen production facility producing liquid nitrogen, move to a yard where the buffer tank is located, and supply the liquid nitrogen to the buffer tank.

10 [00020] The liquid nitrogen supply system may further include: a liquid nitrogen injection pipe connecting the buffer tank to the LNG cargo hold; a spray configured to cool down the LNG cargo hold by spraying the liquid nitrogen supplied through the liquid nitrogen injection pipe into the LNG cargo hold; a control valve located in the liquid nitrogen injection pipe; and a temperature sensor configured to measure an internal temperature of the LNG cargo hold, wherein the controller controls an amount of liquid nitrogen sprayed
15 into the LNG cargo hold by the spray by controlling a degree of opening and closing of the control valve based on measured temperature values.

[00021] The controller may adjust an amount of liquid nitrogen sprayed into the LNG cargo hold to maintain an internal temperature of the LNG cargo hold at $-158^{\circ}\text{C}\pm 5^{\circ}\text{C}$.

20 【Advantageous Effects】

[00022] According to the LNG cargo hold test methods, the offshore structure, to which the same is applied, and the liquid nitrogen supply system of the offshore structures according to an embodiment of the present disclosure, costs may be reduced and work efficiency may be increased by performing the
25 processes of testing the LNG cargo hold onshore. Particularly, by performing large-scale test operations that should be performed offshore conventionally onshore, simplicity, stability, and efficiency of operations may be improved and a work schedule may be shortened.

[00023] The effects of the present disclosure are not limited to the aforementioned effects, and other effects, which are not mentioned above, will be clearly understood by those skilled in the art from the claims.

【Description of Drawings】

5 [00024] FIG. 1 is a flowchart of a process of testing an LNG cargo hold of an offshore structure performed onshore.

[00025] FIG. 2 is a flowchart of a process of testing the LNG cargo hold of the offshore structure performed after the LNG cargo hold test of FIG. 1.

10 [00026] FIG. 3 is a block diagram of a liquid nitrogen supply system according to an embodiment of the present disclosure.

【Modes of the Invention】

[00027] Hereinafter, embodiments of the present disclosure will be described in detail with reference to the accompanying drawings. These embodiments are provided to fully convey the scope of the invention to those skilled in the art.

15 The present disclosure may, however, be embodied in many different forms and should not be construed as limited to the exemplary embodiments set forth herein. For clear description of the present disclosure, parts unrelated to the descriptions are omitted from the drawings. In the drawings, widths, lengths, thicknesses, and the like of components may be enlarged for the descriptive

20 convenience. Throughout the specification, like reference numerals denote like elements.

[00028] FIG. 1 is a flowchart of a process of testing an LNG cargo hold of an offshore structure performed onshore according to an embodiment of the present disclosure.

25 [00029] The process of testing the LNG cargo hold illustrated in FIG. 1 is performed to test the LNG cargo hold of the offshore structure in a state where the offshore structure is located onshore.

[00030] The offshore structure according to an embodiment of the present disclosure may include offshore structures including an LNG cargo hold with no navigational ability such as a floating liquefied natural gas (FLNG) facility, a floating storage regasification unit (FSRU), a floating storage unit (FSU), and an LNG re-gasification vessel (LNG-RV) and vessels having navigational ability.

[00031] As used herein, the term "onshore" refers to land including a yard indicating a shipyard. That is, the onshore is used in a broader sense than the yard. Performing an LNG cargo hold test at the yard means that the LNG cargo hold test is performed at the shipyard where the offshore structure is built, and performing the LNG cargo hold onshore means that the LNG cargo hold test is performed not only at the yard, i.e., the shipyard, but also at a berthing location away therefrom.

[00032] Hereinafter, although it is described that the process of testing the LNG cargo hold of the offshore structure is performed onshore in the embodiment of the present disclosure, the process may also be performed at the yard onshore, i.e., shipyard.

[00033] Referring to FIG. 1, a primary barrier global test (PBGT) is performed on the LNG cargo hold of the offshore structure onshore (S201). This process (S201) may be performed by applying an ammonia reactant to welded areas of a primary barrier, filling ammonia gas in the space between the primary barrier and a secondary barrier, and determining integrity of the primary barrier based on discoloration of the ammonia reactant. For example, in the case where the ammonia reactant applied to the welded areas of the primary barrier reacts with the ammonia gas filled in the space between the primary barrier and the secondary barrier due to grooves formed at the welded areas of the primary barrier, resulting in discoloration, the primary barrier may be determined to be defective.

[00034] Subsequently, a first secondary barrier tightening test (SBTT) is performed on the LNG cargo hold of the offshore structure onshore (S202). This process (S202) may be performed by filling nitrogen gas in a lower insulation space (IS) of the second barrier and an upper inter barrier space (IBS) of the

second barrier with different pressures, measuring pressure changes between the lower insulation space of the second barrier and the upper inter barrier space of the second barrier after a preset time, and determining integrity of the secondary barrier based on the measured pressure changes. In this case, the pressures applied to the lower insulation space of the second barrier and the upper inter barrier space of the second barrier may be measured by a pressure gauge (not shown) installed in each of the spaces. For example, when the measured pressures of the lower insulation space of the second barrier and the upper inter barrier space of the second barrier are the same, the secondary barrier may be determined to be defective.

[00035] Subsequently, a pipe cold test is performed on a pipe, which is connected to the LNG cargo hold of the offshore structure for loading or unloading of LNG onshore (S203). This process (S203) may be performed by flowing a refrigerant into the pipe and measuring contraction and expansion displacement of the pipe using a displacement meter (not shown). In this regard, the refrigerant may include, for example, liquid nitrogen. The pipe may be a pipe connected to a filling pipe and a discharging pipe of a pump tower to perform loading or unloading of LNG, and the pipe cold test may be performed in a state where the pipe is installed on a deck of a hull of the vessel. In the case where the contraction and expansion displacement of the pipe measured by the displacement meter is within an allowable range, the pipe may be determined as normal.

[00036] Subsequently, a cool-down operation to cool down the inside of the LNG cargo hold of the offshore structure is performed onshore (S204). This process (S204) may be performed using a refrigerant except for LNG, and liquid nitrogen may be used in the same manner as in the pipe cold test as described above. When liquid nitrogen comes into contact with an LNG cargo hold at room temperature, most of the liquid nitrogen is immediately vaporized to generate convection inside the LNG cargo hold. This process (S204) may include a process of controlling an internal temperature of the LNG cargo hold to be maintained at $-158^{\circ}\text{C}\pm 5^{\circ}\text{C}$ by spraying liquid nitrogen into the LNG cargo hold at room temperature.

[00037] Subsequently, a warm-up operation to raise the internal temperature of the LNG cargo hold of the offshore structure to room temperature is performed onshore (S205). This process (S205) may be performed by raising the internal temperature of the LNG cargo hold using a heater 180 (FIG. 3) by a process of heating a fluid inside the LNG cargo hold using the heater 180 and re-injecting the heated fluid into the LNG cargo hold.

[00038] Subsequently, after discharging the fluid inside the LNG cargo hold of the offshore structure and injecting dry air into the LNG cargo hold, visual inspection is conducted on the inside of the LNG cargo hold onshore (S206). In the case where the internal temperature of the LNG cargo hold is raised to room temperature using the above-described heater 180, only nitrogen in a gas state is mostly present inside of the LNG cargo hold. Therefore, because an inspector needs to go inside the LNG cargo hold for the visual inspection, the nitrogen contained in the LNG cargo hold is discharged and dry air (oxygen concentration of 20%) at room temperature is injected into the LNG cargo hold.

[00039] Subsequently, a second secondary barrier tightening test is performed on the LNG cargo hold of the offshore structure onshore (S207). This process (S207) may be performed by filling nitrogen gas in a lower insulation space of the second barrier and an upper inter barrier space of the second barrier with different pressures, measuring pressure changes between the lower insulation space of the second barrier and the upper inter barrier space of the second barrier after a preset time, and determining integrity of the secondary barrier based on the measured pressure changes.

[00040] When the LNG cargo hold is a Mark-III type, unlike the primary barrier, the secondary barrier is constructed by an adhesive not by welding. The reason why the secondary barrier tightening test is performed twice, i.e., first and second secondary barrier tightening tests, as described above is that the LNG cargo hold undergoes rapid temperature change (hereinafter, referred to as cold shock) in the case where the liquid nitrogen is sprayed into the LNG cargo hold for the cool-down operation after the first secondary barrier tightening test is performed in the process of building the LNG cargo hold. In this case, materials of the secondary barrier inside the LNG cargo hold are contracted and

relaxed, and thus integrity of the secondary barrier needs to be inspected once more by the secondary barrier tightening test.

[00041] That is, the above-described first secondary barrier tightening test process (S202) is performed after the process of building the LNG cargo hold is completed, and the second secondary barrier tightening test process (S207) is performed after the LNG cargo hold undergoes the cold-chock conditions. In the embodiment of the present disclosure, when the inside of the LNG cargo hold is cooled down by spraying liquid nitrogen thereinto as described above in the operation S204, a cold shock may be applied thereto while maintaining the internal temperature at $-158^{\circ}\text{C}\pm 5^{\circ}\text{C}$ for a preset time (e.g., 22 hours).

[00042] As described above, by performing the processes of testing the LNG cargo hold of the offshore structure onshore according to an embodiment of the present disclosure, costs may be reduced and work efficiency thereof may be increased. Particularly, by performing large-scale tests, which have been performed offshore conventionally, onshore, simplicity, stability, and efficiency of operations may be improved and a work schedule may be shortened.

[00043] Also, the above-described processes of testing the LNG cargo hold of the offshore structure (S201 to S207) may be performed at a yard (shipyard). That is, the above-described processes (S201 to S207) may be performed onshore at a shipyard where the offshore structure is built. In this case, because migration of the offshore structure is minimized, costs may be reduced and work efficiency thereof may be increased.

[00044] After performing the LNG cargo hold test operations onshore as described above in FIG. 1, a remaining LNG cargo hold test may be performed offshore in the case of an LNG cargo hold of an offshore structure without the navigational ability (e.g., FLNG facility) and at an onshore terminal in the case of an LNG cargo hold of an offshore structure having the navigational ability (e.g., LNG carrier). Hereinafter, an FLNG facility will be described as an example of the offshore structure without the navigational ability and an LNG carrier will be described as an example of the offshore structure having the navigational ability.

[00045] FIG. 2 is a flowchart of a process of testing the LNG cargo hold of the offshore structure performed after the LNG cargo hold test of FIG. 1.

[00046] Referring to FIG. 2, the inside of the LNG cargo hold is filled with LNG and then a pumping test is performed on a pump provided inside the LNG cargo hold (S208). For example, this process (S208) is performed in a state where the FLNG facility is located offshore in the case of the FLNG facility without the navigational ability, and this process (S208) is performed in a state where the LNG carrier is located at an onshore terminal in the case of the LNG carrier having the navigational ability.

[00047] In addition, in the case of the FLNG facility, after producing LNG offshore, the produced LNG is filled in the LNG cargo hold, and then a pumping test may be immediately performed on a pump (not shown) provided inside the LNG cargo hold. Also, as another example, after the FLNG facility receives LNG by an LNG bunkering method, the pumping test may be performed on the pump provided inside the LNG cargo hold.

[00048] In this case, the aforementioned pump may be an LNG offload pump installed at the pump tower, and the test may be performed in a state where the inside of the LNG cargo hold is filled with LNG.

[00049] Subsequently, a test of offloading LNG inside the LNG cargo hold to another LNG vessel using a loading arm is performed (S209). This process (S209) is also performed offshore in the case of the FLNG facility and performed onshore in the case of the LNG carrier as described above.

[00050] In the above-described processes of testing the LNG cargo hold of the offshore structure (S208 to S209), the tests were performed using LNG. However, the embodiment is not limited thereto and these tests may also be performed using the refrigerant used in the above-described cool-down operation (S204) instead of LNG in another example.

[00051] In this case, after performing the above-described cool-down operation (S204) and the pumping test and the loading arm test onshore, the above-described warm-up operation (S205) may be performed. Alternatively,

after performing the second secondary barrier tightening test (S207), the pumping test and the loading arm test may be performed onshore. In this case, onshore, the inside of the LNG cargo hold is filled with the refrigerant, and the pumping test is performed on the pump provided inside the LNG cargo hold, and then the test of offloading the refrigerant inside the LNG cargo hold to another LNG vessel using the loading arm may be performed. Therefore, the offshore structure including the FLNG facility may be subjected to the pumping test and the loading arm test onshore without moving the offshore structure to an offshore site.

[00052] FIG. 3 is a block diagram of a liquid nitrogen supply system according to an embodiment of the present disclosure.

[00053] Referring to FIG. 3, the liquid nitrogen supply system according to the embodiment of the present disclosure supplies onshore liquid nitrogen used for the operation of testing an LNG cargo hold 101 of an offshore structure 100 of FIG. 1 located onshore.

[00054] Such a liquid nitrogen supply system includes a tank lorry 110 configured to receive liquid nitrogen from a liquid nitrogen production facility 105 that produces liquid nitrogen, move to a buffer tank 120, and supply the liquid nitrogen to the buffer tank 120, the buffer tank 120 configured to supply liquid nitrogen to the LNG cargo hold 101, and a controller 130 configured to adjust an amount of liquid nitrogen injected into the LNG cargo hold 101 to maintain an internal temperature of the LNG cargo hold 101 within a predetermined temperature range for a preset time.

[00055] In addition, the liquid nitrogen supply system may further include a liquid nitrogen injection pipe 140 connecting the buffer tank 120 to the LNG cargo hold 101, a spray 150 configured to spray the liquid nitrogen supplied through the liquid nitrogen injection pipe 140 into the LNG cargo hold 101, a control valve 160 disposed in the liquid nitrogen injection pipe 140, and a temperature sensor 170 configured to measure a temperature inside the LNG cargo hold 101.

[00056] Also, the liquid nitrogen supply system may include at least one of a safety valve 193 a safety system 195 in the liquid nitrogen injection pipe 140 for emergency situations and abnormal conditions.

[00057] Hereinafter, each of the elements will be described in detail.

5 [00058] The liquid nitrogen production facility 105 may be manufactured by a gas specialized company. The liquid nitrogen produced in the liquid nitrogen production facility 105 may be transported to a place where the offshore structure 100 is located in a state of being stored in the tank lorry 110.

10 [00059] The buffer tank 120 may be provided in a movable trailer type and may stably supply the liquid nitrogen to the LNG cargo hold 101 of the offshore structure 100 upon receiving the liquid nitrogen from the tank lorry 110. The buffer tank 120, like the tank lorry 110, may be transported to an onshore place where the offshore structure 100 is located. Although not shown in the drawings, the buffer tank 120 may be provided with a cryogenic pump, an evaporator, a
15 mixer, or the like to discharge the liquid nitrogen toward the LNG cargo hold 101.

[00060] The controller 130 controls the degree of opening and closing of the control valve 160 based on temperature values measured by the temperature sensor 170 to adjust the amount of liquid nitrogen sprayed into the LNG cargo hold 101 by the spray 150. For example, the controller 130 may control the
20 degree of opening and closing of the control valve 160 to adjust the internal temperature of the LNG cargo hold 101 within a range of $-158^{\circ}\text{C}\pm 5^{\circ}\text{C}$. Accordingly, the internal temperature of the LNG cargo hold 101 may be maintained at about a temperature of LNG (at about -163°C), and the test
25 operation to test the LNG cargo hold using liquid nitrogen instead of LNG may be performed onshore. That is, because the liquid nitrogen is maintained at the temperature level of LNG, the same effects may be obtained as those obtained by testing the LNG cargo hold using LNG.

30 [00061] Specifically, in the cool-down operation for the inside of the LNG cargo hold 101, the temperature of the LNG cargo hold 101 gradually decreases by spraying liquid nitrogen having a temperature of about -195°C into the LNG

cargo hold 101 at room temperature. When liquid nitrogen is brought into contact with the LNG cargo hold 101 at room temperature, most of the liquid nitrogen is immediately vaporized to generate convection inside the LNG cargo hold 101. In this regard, the cool-down rate to lower the temperature of the LNG cargo hold 101 may be adjusted by controlling the amount of the liquid nitrogen being sprayed. When the internal temperature of the LNG cargo hold 101 is lowered too rapidly, the components of the LNG cargo hold 101 may be considerably affected thereby, and thus the spraying amount of the liquid nitrogen may be adjusted at a preset rate.

10 [00062] Immediately after the liquid nitrogen is sprayed onto inner walls of the LNG cargo hold 101 at room temperature, the temperature of the liquid nitrogen rises and the liquid nitrogen is changed to a gaseous state. When the cool-down operation is continuously performed in the LNG cargo hold 101, the temperature reaches about -158°C , and the spray 150 may stop spraying of the liquid nitrogen at this point. In this case, the controller 130 may control the spray 150 to stop spraying the liquid nitrogen by closing the control valve 160 based on the temperature values measured by the temperature sensor 170.

20 [00063] In addition, the controller 130 may control an internal temperature variation range of the LNG cargo hold 101 to be maintained at $-158^{\circ}\text{C}\pm 5^{\circ}\text{C}$ for 22 hours in accordance with preset cool-down conditions for the LNG cargo hold. That is, after the spraying of liquid nitrogen into the LNG cargo hold 101 is stopped, the internal temperature of the LNG cargo hold 101 gradually increases over time. Thus, the controller 130 may control the spray 150 to occasionally spray liquid nitrogen into the LNG cargo hold 101 in small amounts by opening the control valve 160 based on the temperature values measured by the temperature sensor 170 to keep the internal temperature variation range within $-158^{\circ}\text{C}\pm 5^{\circ}\text{C}$ for 22 hours in accordance with the preset cool-down conditions.

30 [00064] The liquid nitrogen injection pipe 140 is provided to supply liquid nitrogen supplied from the buffer tank 120 toward the LNG cargo hold 101 and withstand cryogenic liquified gas. The liquid nitrogen injection pipe 140 may be transported to the onshore site where the offshore structure 100 is located

5 together with the buffer tank 120. As described above, the tank lorry 110, the buffer tank 120, and the liquid nitrogen injection pipe 140 may be provided to be movable, the operation of testing the LNG cargo hold 101 of the offshore structure 100 may be performed at any onshore location, i.e., not only at the shipyard but also at any berthing location away therefrom.

[00065] The spray 150 may include a nozzle to spray liquid nitrogen supplied through the liquid nitrogen injection pipe 140 into the LNG cargo hold 101.

10 [00066] In addition, the control valve 160 may be located in the liquid nitrogen injection pipe 140 to adjust a flow of liquid nitrogen supplied to the LNG cargo hold 101.

[00067] The temperature sensor 170 measures the temperature inside the LNG cargo hold 101 changing as the liquid nitrogen is sprayed into the LNG cargo hold 101.

15 [00068] The safety valve 193 and the safety system 195 may protect the facility from abnormal conditions caused by an overpressure phenomenon of the supply facility (liquid nitrogen supply system) when the supply of liquid nitrogen is stopped or emergency situation.

20 [00069] At least one of the safety valve 193 and the safety system 195 may be located at one or more positions of a front end or a rear end of the control valve 160 of the liquid nitrogen injection pipe 140.

[00070] The safety valve 193 may include, for example, a pressure relief valve in preparation of a facility overpressure phenomenon and a pressure vacuum valve (PVV) in preparation of a low pressure (vacuum) phenomenon.

25 [00071] In addition, the safety system 195 may include at least one of an alarm for warning an abnormal situation and a device automatically starting and stopping the supply.

[00072] For example, the above-described facility overpressure phenomenon may occur in the pipe and the facility that supply liquid nitrogen when supply of

the liquid nitrogen to the LNG cargo hold (main vessel) is impossible while the liquid nitrogen is supplied to the LNG cargo hold (main vessel) using a transporting device such as a pump due to an emergency situation. Also, the overpressure phenomenon may be caused by a surge phenomenon occurring due to sudden valve manipulation or change in operation during a normal operation process. In addition, the overpressure phenomenon may be caused in a situation that the liquid nitrogen is out of the operating range of the supply pipe and the facility due to vaporization of the liquid nitrogen contained in the supply facility when supply to the LNG cargo hold (main vessel) is impossible for a long time.

[00073] In addition, the above-described low pressure (vacuum) phenomenon may be caused when liquid nitrogen needs to be supplied in an amount exceeding the available amount of liquid nitrogen that may be supplied from the liquid nitrogen supply facility to the main vessel or when a transport device is run in a state where the liquid nitrogen is insufficient in the liquid nitrogen supply facility.

[00074] In an embodiment of the present disclosure, the above-described overpressure phenomenon and low pressure (vacuum) phenomenon may be effectively prepared by the safety valve 193 and the safety system 195.

[00075] As described above, because liquid nitrogen, instead of LNG, may be injected into the LNG cargo hold 101 of the offshore structure 100 while maintaining the temperature of the liquid nitrogen at a temperature level of LNG by the liquid nitrogen supply system according to an embodiment of the present disclosure, the operation of testing the LNG cargo hold of the offshore structure 100 may be effectively performed onshore.

[00076] The embodiments of the present disclosure have been shown and described above with reference to the accompanying drawings. It will be understood by those of ordinary skill in the art that the present disclosure may be easily modified into other detailed forms without changing the technical principle or essential features of the present disclosure. However, the disclosed embodiments are illustrative and the scope of the present disclosure is not limited thereby.

【CLAIMS】

【Claim 1】

A method for testing a liquefied natural gas (LNG) cargo hold, the method comprising:

5 (a) performing a primary barrier global test on a secondary barrier of the LNG cargo hold after the LNG cargo hold of a floating liquefied natural gas (FLNG) facility is built;

 (b) performing a cool-down operation on the inside of the LNG cargo hold; and

10 (c) performing a secondary barrier tightening test on the secondary barrier of the LNG cargo hold,

 wherein the operations (a) to (c) are performed on the LNG cargo hold of the FLNG facility in a state where the FLNG facility is located onshore, and

 the operation (b) is performed using at least one refrigerant except for LNG.
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【Claim 2】

A method for testing a liquefied natural gas (LNG) cargo hold, the method comprising:

 (a) performing a primary barrier global test on a secondary barrier of the
20 LNG cargo hold after the LNG cargo hold of a vessel is built;

 (b) performing a pipe cold test on a pipe connected to the LNG cargo hold and performing loading or unloading of LNG;

 (c) performing a cool-down operation on the inside of the LNG cargo hold; and

25 (d) performing a secondary barrier tightening test on the secondary barrier of the LNG cargo hold,

 wherein the operations (a) to (d) are performed on the LNG cargo hold in a state where the vessel is located onshore, and

 the operations (b) and (c) are performed using liquid nitrogen.
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【Claim 3】

The method according to claim 1 or 2, wherein the performing of the cool-down operation comprises a process of controlling an internal temperature of the LNG cargo hold to be maintained at $-158^{\circ}\text{C}\pm 5^{\circ}\text{C}$ for a preset time by spraying liquid nitrogen into the LNG cargo hold at room temperature.

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【Claim 4】

The method according to claim 1 or 2, further comprising:

performing a pumping test on a pump provided in the LNG cargo hold by filling liquid nitrogen in the LNG cargo hold onshore after performing the cool-down operation, and

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performing a process of testing offloading of liquid nitrogen from the inside of the LNG cargo hold to another vessel using a loading arm.

【Claim 5】

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The method according to claim 1 or 2, further comprising:

performing a pumping test on a pump provided inside of the LNG cargo hold by filling LNG in the LNG cargo hold after performing the secondary barrier tightening test, and

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performing a process of testing offloading of LNG from the inside of the LNG cargo hold to another vessel using a loading arm,

wherein the FLNG facility is tested in a state of being located offshore and a vessel having navigational ability is tested in a state of being located at an onshore terminal.

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【Claim 6】

A method for testing a liquefied natural gas (LNG) cargo hold comprising:

(a) performing a primary barrier global test of an LNG cargo hold;

(b) performing a primary barrier global test on a secondary barrier of the LNG cargo hold;

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(c) performing a pipe cold test on a pipe connected to the LNG cargo hold;

(d) performing a cool-down operation on the inside of the LNG cargo hold;

(e) performing a warm-up operation to raise an internal temperature of the LNG cargo hold to room temperature;

(f) performing visual inspection on the inside of the LNG cargo hold after discharging a fluid contained in the LNG cargo hold and injecting dry air into the

5 LNG cargo hold; and

(g) performing a secondary barrier tightening test on the secondary barrier of the LNG cargo hold,

wherein the operations (a) to (g) are performed on the LNG cargo hold of an offshore structure in a state where the offshore structure including a vessel is located
10 onshore.

【Claim 7】

The method according to claim 6, wherein

the operations (b) and (g) are performed by a process comprising:

15 filling nitrogen gas in a lower insulation space of the second barrier and an upper inter barrier space of the second barrier with different pressures;

measuring pressure changes between the lower insulation space of the second barrier and the upper inter barrier space of the second barrier after a preset time; and

determining integrity of the secondary barrier based on the measured pressure
20 changes.

【Claim 8】

The method according to claim 6, wherein the operation (d) comprises a process of controlling the internal temperature of the LNG cargo hold to be
25 maintained at $-158^{\circ}\text{C}\pm 5^{\circ}\text{C}$ for a preset time by spraying a refrigerant into the LNG cargo hold.

【Claim 9】

The method according to claim 8, wherein

30 the primary barrier global test is performed by a process comprising applying an ammonia reactant to welded areas of a primary barrier, filling ammonia gas in a

space between the primary barrier and a secondary barrier, and determining integrity of the primary barrier based on discoloration of the ammonia reactant, and

the pipe cold test is performed by flowing the refrigerant to the pipe and measuring whether contraction and expansion displacement of the pipe is within an allowable range.

【Claim 10】

An offshore structure to which the method for testing the LNG cargo hold according to any one of claims 6 to 9 is applied.

【Claim 11】

A liquid nitrogen supply system of an offshore structure comprising:

a buffer tank configured to supply liquid nitrogen to an LNG cargo hold for an operation of testing the LNG cargo hold of an offshore structure located onshore; and

a controller configured to adjust an amount of liquid nitrogen sprayed into the LNG cargo hold to maintain an internal temperature of the LNG cargo hold within a predetermined temperature range for a preset time.

【Claim 12】

The liquid nitrogen supply system according to claim 11, further comprising a tank lorry configured to receive the liquid nitrogen from a liquid nitrogen production facility producing liquid nitrogen, move to a yard where the buffer tank is located, and supply the liquid nitrogen to the buffer tank.

【Claim 13】

The liquid nitrogen supply system according to claim 11, further comprising:

a liquid nitrogen injection pipe connecting the buffer tank to the LNG cargo hold;

a spray configured to cool down the LNG cargo hold by spraying the liquid nitrogen supplied through the liquid nitrogen injection pipe into the LNG cargo hold;

a control valve located in the liquid nitrogen injection pipe; and
a temperature sensor configured to measure an internal temperature of the
LNG cargo hold,

- 5 wherein the controller controls an amount of liquid nitrogen sprayed into the
LNG cargo hold by the spray by controlling a degree of opening and closing of the
control valve based on measured temperature values.

【Claim 14】

- 10 The liquid nitrogen supply system according to claim 13, wherein the
controller adjusts an amount of liquid nitrogen sprayed into the LNG cargo hold to
maintain an internal temperature of the LNG cargo hold at $-158^{\circ}\text{C}\pm 5^{\circ}\text{C}$.