DESCRIPTION

Title of Invention

TANK FACILITY AND FLOATING BODY

Technical Field

[0001]

The present disclosure relates to a tank facility and a floating structure.

Priority is claimed on Japanese Patent Application No. 2023-168977, filed on September 29, 2023, the content of which is incorporated herein by reference.

Background Art

[0002]

In a ship or the like including a tank that stores a liquefied gas, in a case where a pressure in the tank excessively increases, the pressure in the tank needs to be released to the outside of the tank. For example, PTL 1 discloses a configuration in which a safety valve that communicates the inside of the tank with the outside of the tank in a case where the pressure in the tank reaches a predetermined safety valve operating pressure is provided in a communication pipe that communicates with the outside of the tank.

Citation List

Patent Literature

[0003]

[PTL 1] Japanese Unexamined Patent Application Publication No. 2022-76210

Summary of Invention

Technical Problem

[0004]

Meanwhile, in a case where liquefied carbon dioxide is accommodated in the tank, carbon dioxide in the tank may be released to an atmosphere or the like outside the tank from the safety valve or the like. In this case, low-temperature carbon dioxide having a reduced pressure flows through the communication pipe, and in a case where the temperature of the communication pipe is sufficiently reduced, the carbon dioxide flowing through the communication pipe solidifies, and dry ice may be generated in the communication pipe. In a case where dry ice is generated in the communication pipe, the communication pipe may be clogged, or the safety valve may malfunction.

[0005]

The present disclosure has been made to solve the above-described problem, and an object thereof is to provide a tank facility and a floating structure in which generation of dry ice in a communication pipe is suppressed, and release of carbon dioxide to an outside of a tank can be favorably performed.

Solution to Problem

[0006]

In order to solve the above-described problem, a tank facility according to the present disclosure includes a tank, a communication pipe, a valve, and a heating unit. The tank is capable of storing liquefied carbon dioxide. The communication pipe is connected to the tank and communicates the inside of the tank with the outside of the tank. The valve is provided in the middle of the communication pipe and can open and close a flow passage in the communication pipe. The heating unit can heat, from outside, at least a downstream pipe portion of the communication pipe that is on a downstream side of the valve in a flow direction of carbon dioxide discharged from the

tank in a case where the valve is opened.

[0007]

A floating structure according to the present disclosure includes a floating main structure and the above-described tank facility provided in the floating main structure.

[0008]

The tank facility according to the present disclosure includes a tank, a communication pipe, a valve, and a pressure relief section. The tank is capable of storing liquefied carbon dioxide. The communication pipe is connected to the tank and communicates the inside of the tank with the outside of the tank. The valve is provided in the middle of the communication pipe and can open and close a flow passage in the communication pipe. The pressure relief section closes a distal end portion of the communication pipe and opens the inside of the communication pipe in a case where the pressure in the communication pipe is equal to or higher than a predetermined set pressure.

[0009]

The tank facility according to the present disclosure includes a plurality of tanks, a pipe system, a connection pipe, and a safety valve. The plurality of tanks can store liquefied carbon dioxide. The pipe system is connected to the plurality of tanks. One end of the connection pipe is connected to the pipe system, and the other end is connected to any one of the plurality of tanks. The safety valve is provided in the middle of the connection pipe. The safety valve operates in a case where the pressure in the connection pipe is equal to or higher than a predetermined safety valve operating pressure.

Advantageous Effects of Invention

[0010]

According to the tank facility and the floating structure of the present disclosure, the generation of dry ice in the communication pipe is suppressed, and the release of carbon dioxide to the outside of the tank can be favorably performed.

Brief Description of Drawings

[0011]

FIG. 1 is a side view of a floating structure including a tank facility according to a first embodiment of the present disclosure.

FIG. 2 is a diagram showing a configuration of the tank facility according to the first embodiment of the present disclosure.

FIG. 3 is a diagram showing a configuration of a tank facility according to a second embodiment of the present disclosure.

FIG. 4 is a diagram showing a configuration of a tank facility according to a third embodiment of the present disclosure.

FIG. 5 is a cross-sectional view taken along line A-A of FIG. 4.

FIG. 6 is a diagram showing a configuration of a tank facility according to a fourth embodiment of the present disclosure.

FIG. 7 is a diagram showing a configuration of a tank facility according to a fifth embodiment of the present disclosure.

Description of Embodiments

[0012]

<First Embodiment>

Hereinafter, a tank facility and a floating structure according to the embodiment of the present disclosure will be described with reference to FIGS. 1 to 7.

(Configuration of Ship)

As shown in FIG. 1, in the present embodiment, a ship 1 that is a floating

structure transports liquefied carbon dioxide. The ship 1 includes at least a hull 2 as a floating main structure and a tank facility 10A.

[0013]

(Configuration of Hull)

The hull 2 has a pair of hull sides 3A and 3B, a bottom 6, and an upper deck 5, which form an outer shell thereof. The hull sides 3A and 3B have a pair of side shell plates which respectively form the left and right hull sides. The bottom 6 includes a bottom shell plate that connects the hull sides 3A and 3B. The upper deck 5 shown in this embodiment is a continuous deck exposed to the outside. In the hull 2, a superstructure 7 having an accommodation space is formed on the upper deck 5 on a stern 2b side. The position of the superstructure 7 is merely an example, and may be disposed on a bow 2a side of the hull 2, for example. A cargo tank storage compartment (hold) 8 is formed in the hull 2.

[0014]

(Configuration of Tank Facility)

The tank facility 10A is provided in the cargo tank storage compartment 8. In the present embodiment, only one set of the tank facility 10A is provided, but two or more sets of the tank facility 10A may be provided.

[0015]

FIG. 2 is a diagram showing a configuration of the tank facility according to the first embodiment of the present disclosure.

As shown in FIG. 2, the tank facility 10A includes at least a tank 11, a communication pipe 15, a valve 20, and a heating unit 30A.

In the first embodiment, the tank 11 is disposed in the hull 2. The tank 11 can store liquefied carbon dioxide. The tank 11 includes a tank dome 11d that protrudes

upward in an up-down direction Dv above the upper deck 5. Here, the shape of the tank 11 is not limited to the shown shape. The tank 11 may have, for example, a horizontally extending cylindrical shape, a spherical shape, a rectangular shape, or the like.

[0016]

The communication pipe 15 communicates the inside of the tank 11 with the outside of the tank 11. One end 15a of the communication pipe 15 is connected to the tank dome 11d of the tank 11 above the upper deck 5. In the present embodiment, the other end 15b of the communication pipe 15 is connected to a vent post 18. The vent post 18 extends upward from the upper deck 5. The other end 15b of the communication pipe 15 is connected to a lower portion of the vent post 18. The vent post 18 allows carbon dioxide from the tank 11 to flow from below to upward and releases the carbon dioxide to the atmosphere in a case where the valve 20 described below is opened. The other end 15b of the communication pipe 15 may not be connected to the vent post 18.

[0017]

The valve 20 is provided in the middle of the communication pipe 15. The valve 20 is configured to open and close the flow passage in the communication pipe 15. The valve 20 is a so-called safety valve or a pressure relief valve. The valve 20 is in a closed state in a normal state and closes the flow passage in the communication pipe 15. A pressure in an upstream pipe portion 15p that communicates with the inside of the tank 11 acts on the valve 20 of a tank 11 side. The valve 20 is in an open state and opens the flow passage in the communication pipe 15 in a case where the pressure in the upstream pipe portion 15p reaches a predetermined pressure value. In a case where the valve 20 is in the open state, the carbon dioxide in the tank 11 is released to the

atmosphere through the communication pipe 15 and the vent post 18. Here, the carbon dioxide discharged from the tank 11 may be liquefied carbon dioxide or carbon dioxide gas generated by vaporization of the liquefied carbon dioxide in the tank 11.

[0018]

(Configuration of Heating Unit)

The heating unit 30A is configured to heat, from outside, at least a downstream pipe portion 15q of the communication pipe 15 on the other end 15b side with respect to the valve 20. The downstream pipe portion 15q is provided on a side closer to the vent post 18 than the valve 20.

[0019]

In the present embodiment, the heating unit 30A includes a water supply section 31 that supplies water to an outer peripheral surface of the downstream pipe portion 15q. The water supply section 31 includes, for example, a water supply pipe 311 and a plurality of nozzles 312. The water supply pipe 311 supplies water to be supplied to the outside of the downstream pipe portion 15q of the communication pipe 15 to the plurality of nozzles 312. The water supply pipe 311 in the present embodiment extends along the downstream pipe portion 15q. The water supply pipe 311 of the present embodiment is arranged at a predetermined interval with respect to the downstream pipe portion 15q and extends parallel to the downstream pipe portion 15q.

[0020]

Water is fed to the water supply pipe 311 from a water supply source. In the present embodiment, seawater is supplied to the water supply pipe 311 from a pump 315 that sucks water from the outside of the hull 2 as a water supply source. In the present embodiment, for example, the water supply pipe 311 is connected to a pipe 317 for a fire hydrant 316 provided on the upper deck 5. A plurality of the fire hydrants 316 are

disposed on the upper deck 5. The pipe 317 is provided to connect the pump 315 and the plurality of fire hydrants 316. An opening-closing valve 314 is provided in the middle of the water supply pipe 311. In a case where the opening-closing valve 314 is opened, the seawater is fed to the water supply pipe 311 from the pump 315 through the pipe 317.

[0021]

The seawater may be directly fed to the water supply pipe 311 from the pump 315 without passing through the pipe 317 for the fire hydrant 316. In addition, seawater or fresh water for other purposes stored in the hull 2 may be fed to the water supply pipe 311.

In addition, the water supplied by the water supply pipe 311 may be heated by a heat source such as a heater. In a case where the water to be supplied is heated, the temperature thereof may be adjusted based on the temperature, the flow rate, and the like of the carbon dioxide released through the communication pipe 15. In addition, the flow rate of the water supplied by the water supply pipe 311 may be adjusted based on the temperature, the flow rate, and the like of the carbon dioxide released through the communication pipe 15.

[0022]

The plurality of nozzles 312 are provided at intervals in an extending direction of the water supply pipe 311. Each of the plurality of nozzles 312 jets the water supplied through the water supply pipe 311 toward the outer peripheral surface of the downstream pipe portion 15q. The water jetted from the plurality of nozzles 312 comes into contact with the outer peripheral surface of the downstream pipe portion 15q of the communication pipe 15.

[0023]

Here, in a normal state, low-temperature carbon dioxide (liquefied carbon dioxide or carbon dioxide gas) is present in the upstream pipe portion 15p disposed on a side closer to the tank 11 than the valve 20 in the communication pipe 15 and the inside of the tank 11. Therefore, the tank 11 and the upstream pipe portion 15p of the communication pipe 15 are covered with an insulating material or the like. On the other hand, in a normal state, low-temperature carbon dioxide is not present in the inside of the downstream pipe portion 15q of the communication pipe 15. Therefore, the downstream pipe portion 15q is not covered with an insulating material or the like and is exposed to the atmosphere. Therefore, the water jetted from the plurality of nozzles 312 directly comes into contact with the outer peripheral surface of the downstream pipe portion 15q.

[0024]

The temperature of the downstream pipe portion 15q of the communication pipe 15 is near an atmospheric temperature (normal temperature) in a normal state. For example, in a case where the valve 20 is in the open state and the carbon dioxide in the tank 11 flows into the flow passage in the downstream pipe portion 15q, the temperature of the downstream pipe portion 15q is rapidly decreased. On the other hand, the heating unit 30A supplies water to the outer peripheral surface of the downstream pipe portion 15q by the water supply section 31, so that the downstream pipe portion 15q is heated from the outer peripheral side, and a decrease in the temperature of the downstream pipe portion 15q is suppressed.

[0025]

The supply of water in the water supply section 31 may be performed, for example, by an operator opening the opening-closing valve 314 and starting the pump 315. In addition, the supply of water in the water supply section 31 may be

automatically controlled by a control device (not shown) to control the operation of the opening-closing valve 314 and the pump 315, for example. In this case, the control device may open the opening-closing valve 314 and start the pump 315, for example, using the opening of the valve 20, the reaching of the pressure in the upstream pipe portion 15p of the communication pipe 15 to a reference value, or the like as a trigger.

[0026]

(Operations and Effects)

In the tank facility 10A and the ship 1 of the first embodiment, the heating unit 30A that can heat, from the outside, at least the downstream pipe portion 15q of the communication pipe 15 on the downstream side of the valve 20 in the flow direction of the carbon dioxide discharged from the tank 11 in a case where the valve 20 is opened is provided. In a case where the valve 20 provided in the communication pipe 15 is opened, the carbon dioxide is released from the tank 11 to the outside of the tank 11 through the communication pipe 15. Here, the carbon dioxide discharged from the tank 11 is liquefied carbon dioxide or carbon dioxide gas generated by vaporization of liquefied carbon dioxide in the tank 11, and is lower than the atmospheric temperature (normal temperature). Therefore, in the communication pipe 15, the downstream pipe portion 15q on the downstream side of the valve 20 is rapidly cooled by the carbon dioxide flowing therethrough. In this case, the heating unit 30A heats the downstream pipe portion 15q from the outside, so that a decrease in the temperature of the downstream pipe portion 15q is suppressed. Therefore, the generation of dry ice in the communication pipe 15 is suppressed, and the release of carbon dioxide to the outside of the tank 11 can be favorably performed.

[0027]

In addition, in the first embodiment, the heating unit 30A includes the water

supply section 31. As a result, the water supply section 31 supplies water having a temperature higher than the carbon dioxide flowing through the downstream pipe portion 15q to the outer peripheral surface of the downstream pipe portion 15q, so that a decrease in the temperature of the downstream pipe portion 15q is suppressed.

[0028]

In the first embodiment, the water is jetted from the plurality of nozzles 312 toward the outer peripheral surface of the downstream pipe portion 15q, but the supply form of the water to the downstream pipe portion 15q may be, for example, watering with a hose.

[0029]

In addition, in the first embodiment, the downstream pipe portion 15q is heated by supplying the water to the downstream pipe portion 15q of the communication pipe 15 by the water supply section 31, but the present disclosure is not limited thereto. The water supply section 31 may supply water not only to the downstream pipe portion 15q but also to the upstream pipe portion 15p. However, as described above, in a case where the upstream pipe portion 15p is covered with an insulating material or the like, it is necessary to consider damage to the insulating material due to the supply of water.

[0030]

<Second Embodiment>

Next, a second embodiment of the tank facility and the floating structure according to the present disclosure will be described. In the second embodiment that is described below, since only the configuration of the heating unit of the tank facility is different from that of the first embodiment, the same portions as those in the first embodiment are denoted by the same reference numerals, and overlapping description is omitted.

FIG. 3 is a diagram showing a configuration of a tank facility according to the second embodiment of the present disclosure.

As shown in FIG. 3, in a tank facility 10B provided in the ship 1 of the present embodiment, a heating unit 30B is configured to heat, from the outside, at least a downstream pipe portion 15q of the communication pipe 15 on the other end 15b side with respect to the valve 20.

[0031]

In the second embodiment, the heating unit 30B includes a heater section 33 provided along the outer peripheral surface of the downstream pipe portion 15q. The heater section 33 heats the downstream pipe portion 15q from the outside. As such a heater section 33, for example, so-called heat tracing using hot water or steam, an electric heater, or the like can be used.

The heater section 33 is provided to heat at least the outer peripheral surface of the downstream pipe portion 15q. The heater section 33 may be provided to heat the valve 20 and the upstream pipe portion 15p in addition to the downstream pipe portion 15q.

In the second embodiment, since the heater section 33 is provided as the heating unit 30B, the downstream pipe portion 15q and the heater section 33 may be covered with an insulating material or the like.

[0032]

(Operations and Effects)

In the tank facility 10B and the ship 1 of the second embodiment, a decrease in the temperature of the downstream pipe portion 15q is suppressed by heating the downstream pipe portion 15q from the outside by the heating unit 30B, as in the first embodiment. Therefore, the generation of dry ice in the communication pipe 15 is

suppressed, and the release of carbon dioxide to the outside of the tank 11 can be favorably performed.

[0033]

In addition, in the second embodiment, the heating unit 30B includes the heater section 33. As a result, the outer peripheral surface of the downstream pipe portion 15q is heated by the heater section 33, so that a decrease in the temperature of the downstream pipe portion 15q is suppressed due to the flow of the carbon dioxide.

[0034]

<Third Embodiment>

Next, a third embodiment of the tank facility and the floating structure according to the present disclosure will be described. In the third embodiment that is described below, since only the configuration of the heating unit of the tank facility is different from that of the first and second embodiments, the same portions as those in the first and second embodiments are denoted by the same reference numerals, and overlapping description is omitted.

FIG. 4 is a diagram showing a configuration of a tank facility according to the third embodiment of the present disclosure.

As shown in FIG. 4, in tank facility 10C provided in the ship 1 of the third embodiment, the communication pipe 15 is not connected to the vent post 18 as in the first and second embodiments.

In the third embodiment, a distal end portion 15s of the communication pipe 15 is provided to be open toward the outside of the hull 2. As in the first embodiment, the heating unit 30A (see FIG. 2; not shown in FIG. 4) is provided in the communication pipe 15. In addition, the communication pipe 15 may include the heating unit 30B as in the second embodiment.

[0035]

A nozzle 40 is detachable from the distal end portion 15s of the communication pipe 15. The nozzle 40 is a jettison nozzle, and is mounted on the distal end portion 15s of the communication pipe 15 in a case of an emergency release of the carbon dioxide (for example, liquefied carbon dioxide) in the tank 11. By mounting the nozzle 40 on the distal end portion 15s of the communication pipe 15, the carbon dioxide released through the communication pipe 15 is jetted toward a remote place outside the hull 2, and the attachment of the low-temperature carbon dioxide to the ship 1 is suppressed.

[0036]

FIG. 5 is a cross-sectional view taken along line A-A of FIG. 4.

As shown in FIGS. 4 and 5, in the third embodiment, the nozzle 40 integrally includes a nozzle main body 41 and a plurality of fins 42. The nozzle main body 41 is detachably mounted on the distal end portion 15s of the communication pipe 15. The nozzle main body 41 has a tubular shape and includes a nozzle flow passage 41r through which the carbon dioxide jetted from the distal end portion 15s of the communication pipe 15 flows.

[0037]

As shown in FIG. 5, a plurality of the fins 42 are provided on the outer peripheral surface of the nozzle main body 41. The plurality of fins 42 are provided at intervals in a circumferential direction centered on the nozzle main body 41, for example. Each fin 42 extends from the outer peripheral surface of the nozzle main body 41 to protrude toward the radially outer side of the nozzle main body 41. The shape, the number, and the like of the fins 42 are not limited, and a configuration other than the shown configuration can be appropriately adopted.

[0038]

(Operations and Effects)

In the tank facility 10C and the ship 1 of the third embodiment, a decrease in the temperature of the downstream pipe portion 15q is suppressed by heating the downstream pipe portion 15q from the outside by the heating unit 30A, as in the first embodiment. Therefore, the generation of dry ice in the communication pipe 15 is suppressed, and the release of carbon dioxide to the outside of the tank 11 can be favorably performed.

[0039]

In addition, in the third embodiment, the nozzle 40 detachable from the distal end portion 15s of the communication pipe 15 includes the fins 42 on the outer peripheral surface of the nozzle main body 41. The carbon dioxide discharged from the tank 11 is released to the outside through the nozzle main body 41 provided at the distal end portion 15s through the communication pipe 15. In this case, the nozzle main body 41 is rapidly cooled by the flowing carbon dioxide. On the other hand, the fins 42 provided on the outer peripheral surface of the nozzle main body 41 can efficiently exchange heat with the atmosphere to heat the fins 42 and the nozzle main body 41, so that a decrease in the temperature of the fins 42 and the nozzle main body 41 is suppressed. Therefore, the generation of dry ice in the nozzle main body 41 is suppressed, and the release of carbon dioxide to the outside through the nozzle 40 can be favorably performed.

[0040]

<Fourth Embodiment>

Next, a fourth embodiment of the tank facility and the floating structure according to the present disclosure will be described. In the fourth embodiment that is

described below, since only the configuration of the heating unit of the tank facility is different from that of the first to third embodiments, the same portions as those in the first to third embodiments are denoted by the same reference numerals, and overlapping description is omitted.

FIG. 6 is a diagram showing a configuration of a tank facility according to the fourth embodiment of the present disclosure.

As shown in FIG. 6, in a tank facility 10D provided in the ship 1 of the fourth embodiment, the communication pipe 15 is not connected to the vent post 18.

As in the first embodiment, the communication pipe 15 may include the heating unit 30A (see FIG. 2). The communication pipe 15 may include the heating unit 30B (see FIG. 3) as in the second embodiment.

[0041]

In the fourth embodiment, a pressure relief section 50 is provided at the distal end portion 15s of the communication pipe 15. The pressure relief section 50 closes the distal end portion 15s of the communication pipe 15 and opens the inside of the communication pipe 15 in a case where the pressure in the communication pipe 15 is equal to or higher than a predetermined set pressure. As such a pressure relief section 50, for example, a rupture disk can be used. As the pressure relief section 50, for example, a safety valve may be used. In the fourth embodiment, the set pressure of the pressure relief section 50 is set to be equal to or higher than the triple point pressure of the carbon dioxide.

[0042]

(Operations and Effects)

In the tank facility 10D and the ship 1 of the fourth embodiment, the distal end portion 15s of the communication pipe 15 is closed by the pressure relief section 50.

As a result, in a case where the valve 20 provided in the communication pipe 15 is opened and the carbon dioxide from the tank 11 flows into the downstream pipe portion 15q on the downstream side of the valve 20 in the communication pipe 15, the downstream pipe portion 15q is initially closed by the pressure relief section 50. Therefore, the pressure in the downstream pipe portion 15q of the communication pipe 15 gradually increases. In a case where the pressure of the carbon dioxide in the communication pipe 15 is increased, the dry ice is less likely to be generated in the communication pipe 15. Even in a case where the dry ice is generated in the downstream pipe portion 15q immediately after the valve 20 is opened, the generated dry ice is vaporized or liquefied by the increase in the pressure in the downstream pipe portion 15q after that. Then, in a case where the pressure in the communication pipe 15 is equal to or higher than the set pressure, the pressure relief section 50 opens the inside of the communication pipe 15, so that the carbon dioxide can be released to the outside of the tank 11 in a state where the dry ice is less likely to be generated in the communication pipe 15.

[0043]

In addition, in the fourth embodiment, the set pressure of the pressure relief section 50 is set to be equal to or higher than the triple point pressure of the carbon dioxide. As a result, in a state immediately before the pressure relief section 50 is opened, the pressure of the carbon dioxide in the communication pipe 15 is equal to or higher than the triple point pressure. As a result, in a case where the pressure relief section 50 opens the inside of the communication pipe 15, the carbon dioxide can be released to the outside of the tank 11 in a state where the dry ice is not generated in the communication pipe 15.

[0044]

<Fifth Embodiment>

Next, a fifth embodiment of the tank facility and the floating structure according to the present disclosure will be described. In the fifth embodiment that is described below, since only the configuration of the heating unit of the tank facility is different from that of the first to fourth embodiments, the same portions as those in the first to fourth embodiments are denoted by the same reference numerals, and overlapping description is omitted.

(Configuration of Ship)

FIG. 7 is a diagram showing a configuration of a tank facility according to the fifth embodiment of the present disclosure.

As shown in FIG. 7, in the fifth embodiment, a ship 1 that is a floating structure includes a tank facility 10E.

[0045]

As shown in FIG. 7, the tank facility 10E includes a plurality of tanks 11, a pipe system 60, and a connection pipe 70.

In the fifth embodiment, for example, four tanks 11 are provided. Each of the plurality of tanks 11 includes the communication pipe 15 and the heating unit 30A or 30B having the configuration as shown in the first and second embodiments. In addition, each of the plurality of tanks 11 may include the nozzle 40 and the pressure relief section 50 as shown in the third and fourth embodiments.

[0046]

The pipe system 60 is connected to the plurality of tanks 11. The pipe system 60 is used for, for example, loading liquefied carbon dioxide into each tank 11, unloading liquefied carbon dioxide from each tank 11, and the like. The pipe system 60 includes, for example, a main pipe 61 extending from a pipe connecting portion (not

shown) to which a pipe from the outside of the ship is connectable, and a plurality of branch pipes 62 extending from the main pipe 61. Each of the plurality of branch pipes 62 is connected to the plurality of tanks 11. In addition, an opening-closing valve 61v is provided in the main pipe 61. An opening-closing valve 62v is provided in each of the plurality of branch pipes 62.

In a case of loading liquefied carbon dioxide into each tank 11 and unloading liquefied carbon dioxide from each tank 11, the pipe system 60 appropriately opens and closes the opening-closing valves 61v and 62v.

[0047]

One end 70a of the connection pipe 70 is connected to the pipe system 60. The other end 70b of the connection pipe 70 is connected to any one of the plurality of tanks 11. In the fifth embodiment, a case where one tank 11A is connected among the four tanks 11 is exemplified.

[0048]

A safety valve 75 is provided in the middle of the connection pipe 70. The safety valve 75 operates in a case where the pressure in the pipe system 60, more specifically, the pressure in the connection pipe 70 on a side close to the one end 70a communicating with the pipe system 60 is equal to or higher than a predetermined safety valve operating pressure. For example, in a case where the opening-closing valves 61v and 62v are closed and the pipe system 60 is closed, and the carbon dioxide present in the pipe system 60 is heated due to heat input from the outside to increase the temperature, the pressure in the pipe system 60 may be increased due to the expansion of the carbon dioxide. As a result, in a case where the safety valve 75 is opened, the carbon dioxide in the pipe system 60 flows into the tank 11A through the connection pipe 70. The tank 11A is subjected to pressure management such that liquefied carbon

dioxide can be stored in the tank 11A. That is, the tank 11A is subjected to pressure management such that the pressure is equal to or higher than the triple point pressure. Therefore, the carbon dioxide flowing into the tank 11A through the connection pipe 70 is equal to or higher than the triple point pressure, and the generation of the dry ice is suppressed.

[0049]

(Operations and Effects)

In the tank facility 10E and the ship 1 of the fifth embodiment, in a case where the pressure of the carbon dioxide in the pipe system 60 connected to the plurality of tanks 11 is increased, the pressure of the carbon dioxide acts on the safety valve 75 through the connection pipe 70 to which the one end 70a is connected to the pipe system 60. In a case where the pressure in the connection pipe 70 is equal to or higher than the safety valve operating pressure and the safety valve 75 is operated, the carbon dioxide from the pipe system 60 side flows into the tank 11 through the connection pipe 70 to which the other end 70b of the connection pipe 70 is connected. Since the tank 11 is subjected to pressure management such that liquefied carbon dioxide can be stored, the generation of the dry ice from the carbon dioxide in the connection pipe 70 can be suppressed.

[0050]

(Other Embodiments)

Above, the embodiments of the present disclosure have been described in detail with reference to the drawings, but the specific configuration is not limited to the embodiments, and includes design changes and the like within a scope not departing from the gist of the present disclosure.

In each of the above embodiments, the ship 1 is exemplified as the floating

structure, but the present disclosure is not limited thereto. The floating structure may be an offshore floating structure facility that does not include a propulsion mechanism.

[0051]

<Supplementary Note>

The tank facility 10A and the floating structure 1 according to each embodiment are understood as follows, for example.

[0052]

(1) The tank facility 10A according to the first aspect includes a tank 11 that is configured to store liquefied carbon dioxide; a communication pipe 15 that is connected to the tank 11 and that communicates an inside of the tank 11 with an outside of the tank 11; a valve 20 that is provided in a middle of the communication pipe 15 and that is provided to open and close a flow passage in the communication pipe 15; and a heating unit 30A that is configured to heat, from outside, at least a downstream pipe portion 15q of the communication pipe 15 on a downstream side of the valve 20 in a flow direction of carbon dioxide discharged from the tank 11 in a case where the valve 20 is opened.

[0053]

The carbon dioxide discharged from the tank 11 is liquefied carbon dioxide or carbon dioxide gas generated by vaporization of liquefied carbon dioxide in the tank 11, and is lower than the atmospheric temperature (normal temperature). Therefore, in the communication pipe 15, the downstream pipe portion 15q on the downstream side of the valve 20 is rapidly cooled by the carbon dioxide flowing therethrough. In this case, the heating unit 30A heats the downstream pipe portion 15q from the outside, so that a decrease in the temperature of the downstream pipe portion 15q is suppressed. Therefore, the generation of dry ice in the communication pipe 15 is suppressed, and the release of carbon dioxide to the outside of the tank 11 can be favorably performed.

[0054]

(2) The tank facility 10A according to the second aspect is the tank facility 10A according to (1), in which the heating unit 30A includes a water supply section 31 that supplies water to an outer peripheral surface of the downstream pipe portion 15q.

[0055]

As a result, the water supply section 31 can supply water having a temperature higher than the carbon dioxide flowing through the downstream pipe portion 15q to the outer peripheral surface of the downstream pipe portion 15q, and a decrease in the temperature of the downstream pipe portion 15q is suppressed.

[0056]

(3) The tank facility 10B according to the third aspect is the tank facility 10B according to (1), in which the heating unit 30B includes a heater section 33 that is provided along an outer peripheral surface of the downstream pipe portion 15q.

[0057]

As a result, the outer peripheral surface of the downstream pipe portion 15q can be heated by the heater section 33, and a decrease in the temperature of the downstream pipe portion 15q is suppressed due to the flow of the carbon dioxide.

[0058]

(4) The tank facility 10C according to the fourth aspect is the tank facility 10C according to any one of (1) to (3), further including a nozzle 40 that is detachable from a distal end portion 15s of the communication pipe 15, in which the nozzle 40 includes a nozzle main body 41 that includes a nozzle flow passage 41r through which carbon dioxide discharged from the distal end portion 15s of the communication pipe 15 flows, and a fin 42 that protrudes from an outer peripheral surface of the nozzle main body 41 toward a radially outer side of the nozzle main body 41.

[0059]

The nozzle main body 41 is rapidly cooled by the flowing carbon dioxide. Since the fins 42 provided on the outer peripheral surface of the nozzle main body 41 can efficiently exchange heat with the atmosphere to heat the fins 42 and the nozzle main body 41, a decrease in the temperature of the fins 42 and the nozzle main body 41 is suppressed. Therefore, the generation of dry ice in the nozzle main body 41 is suppressed, and the release of carbon dioxide to the outside through the nozzle 40 can be favorably performed.

[0060]

(5) The tank facility 10D according to the fifth aspect is the tank facility 10D according to (1), further including a pressure relief section 50 that closes a distal end portion 15s of the communication pipe 15 and opens an inside of the communication pipe 15 in a case where a pressure in the communication pipe 15 is equal to or higher than a predetermined set pressure.

[0061]

As a result, in a case where the valve 20 provided in the communication pipe 15 is opened and the carbon dioxide from the tank 11 flows into the downstream pipe portion 15q on the downstream side of the valve 20 in the communication pipe 15, the pressure in the downstream pipe portion 15q of the communication pipe 15 is increased. In a case where the pressure of the carbon dioxide in the communication pipe 15 is increased, the dry ice is less likely to be generated in the communication pipe 15. Therefore, in a case where the pressure in the communication pipe 15 is equal to or higher than the set pressure, the pressure relief section 50 opens the inside of the communication pipe 15, so that the carbon dioxide can be released to the outside of the tank 11 in a state where the dry ice is less likely to be generated in the communication

pipe 15.

[0062]

(6) The tank facility 10D according to the sixth aspect is the tank facility 10D according to (5), in which the set pressure is set to be equal to or higher than a triple point pressure of carbon dioxide.

[0063]

As a result, in a state immediately before the pressure relief section 50 is opened, the pressure of the carbon dioxide in the communication pipe 15 is equal to or higher than the triple point pressure. Therefore, in a case where the pressure relief section 50 opens the inside of the communication pipe 15, the carbon dioxide can be released to the outside of the tank 11 in a state where the dry ice is not generated in the communication pipe 15.

[0064]

(7) The tank facility 10E according to the seventh aspect is the tank facility 10E according to any one of (1) to (6), further including a plurality of the tanks 11; a pipe system 60 that is connected to the plurality of tanks 11; a connection pipe 70 that has one end 70a connected to the pipe system 60 and the other end 70b connected to any one of the plurality of tanks 11; and a safety valve 75 that is provided in a middle of the connection pipe 70 and that operates in a case where a pressure in the connection pipe 70 is equal to or higher than a predetermined safety valve operating pressure.

[0065]

As a result, in a case where the pressure of the carbon dioxide in the pipe system 60 connected to the plurality of tanks 11 is increased, the pressure of the carbon dioxide acts on the safety valve 75 through the connection pipe 70 to which the one end 70a is connected to the pipe system 60. In a case where the pressure in the connection pipe

70 is equal to or higher than the safety valve operating pressure and the safety valve 75 is operated, the carbon dioxide from the pipe system 60 side flows into the tank 11 through the connection pipe 70 to which the other end 70b of the connection pipe 70 is connected. Since the tank 11 is subjected to pressure management such that liquefied carbon dioxide can be stored, the generation of the dry ice from the carbon dioxide in the connection pipe 70 can be suppressed.

[0066]

(8) The floating structure 1 according to the eighth aspect includes a floating main structure 2; and the tank facility 10A according to any one of (1) to (7) provided in the floating main structure 2.

Examples of the floating structure 1 include a ship and an offshore floating structure facility. Examples of the floating main structure 2 include a floating main structure of a hull 2 or an offshore floating structure facility.

[0067]

As a result, it is possible to provide the floating structure 1 including the tank facility 10A in which the generation of dry ice in the communication pipe 15 is suppressed and the release of carbon dioxide to the outside of the tank 11 can be favorably performed.

[0068]

(9) The tank facility 10D according to the ninth aspect includes a tank 11 that is configured to store liquefied carbon dioxide; a communication pipe 15 that is connected to the tank 11 and that communicates an inside of the tank 11 with an outside of the tank 11; a valve 20 that is provided in a middle of the communication pipe 15 and that is provided to open and close a flow passage in the communication pipe 15; and a pressure relief section 50 that closes a distal end portion 15s of the communication pipe 15 and

opens an inside of the communication pipe 15 in a case where a pressure in the communication pipe 15 is equal to or higher than a predetermined set pressure.

[0069]

As a result, in a case where the valve 20 provided in the communication pipe 15 is opened and the carbon dioxide from the tank 11 flows into the communication pipe 15, the pressure in the communication pipe 15 is increased. In a case where the pressure of the carbon dioxide in the communication pipe 15 is increased, the dry ice is less likely to be generated in the communication pipe 15. In this way, in a case where the pressure in the communication pipe 15 is equal to or higher than the set pressure, the pressure relief section 50 opens the inside of the communication pipe 15, so that the carbon dioxide can be released to the outside of the tank 11 in a state where the dry ice is less likely to be generated in the communication pipe 15. Therefore, the generation of dry ice in the communication pipe 15 is suppressed, and the release of carbon dioxide to the outside of the tank 11 can be favorably performed.

[0070]

(10) The tank facility 10E according to the tenth aspect includes a plurality of tanks 11 that are configured to store liquefied carbon dioxide; a pipe system 60 that is connected to the plurality of tanks 11; a connection pipe 70 that has one end 70a connected to the pipe system 60 and the other end 70b connected to any one of the plurality of tanks 11; and a safety valve 75 that is provided in a middle of the connection pipe 70 and that operates in a case where a pressure in the connection pipe 70 is equal to or higher than a predetermined safety valve operating pressure.

[0071]

As a result, in a case where the pressure in the connection pipe 70 is equal to or higher than the safety valve operating pressure and the safety valve 75 is operated, the

carbon dioxide from the pipe system 60 side flows into the tank 11 through the connection pipe 70 to which the other end 70b of the connection pipe 70 is connected. Since the tank 11 is subjected to pressure management such that liquefied carbon dioxide can be stored, the generation of the dry ice from the carbon dioxide in the connection pipe 70 can be suppressed.

Industrial Applicability

[0072]

According to the tank facility and the floating structure of the present disclosure, the generation of dry ice in the communication pipe is suppressed, and the release of carbon dioxide to the outside of the tank can be favorably performed.

Reference Signs List

[0073]

1: Ship (floating structure)

2: Hull (floating main structure)

2a: Bow

2b: Stern

3A, 3B: Hull side

5: Upper deck

6: Bottom

7: Superstructure

8: Cargo tank storage compartment

10A to 10E: Tank facility

11, 11A: Tank

15: Communication pipe

15a: One end

15b: Other end

15p: Upstream pipe portion

15q: Downstream pipe portion

15s: Distal end portion

18: Vent post

20: Valve

30A, 30B: Heating unit

31: Water supply section

33: Heater section

40: Nozzle

41: Nozzle main body

41r: Nozzle flow passage

42: Fin

50: Pressure relief section

60: Pipe system

61: Main pipe

61v: Opening-closing valve

62: Branch pipe

62v: Opening-closing valve

70: Connection pipe

70a: One end

70b: Other end

75: Safety valve

311: Water supply pipe

312: Nozzle

314: Opening-closing valve

315: Pump

316: Fire hydrant

317: Pipe

Claims

[Claim 1]

A tank facility comprising:

a tank that is configured to store liquefied carbon dioxide;

a communication pipe that is connected to the tank and that communicates an inside of the tank with an outside of the tank;

a valve that is provided in a middle of the communication pipe and that is provided to open and close a flow passage in the communication pipe; and

a heating unit that is configured to heat, from outside, at least a downstream pipe portion of the communication pipe on a downstream side of the valve in a flow direction of carbon dioxide discharged from the tank in a case where the valve is opened.

[Claim 2]

The tank facility according to claim 1,

wherein the heating unit includes a water supply section that supplies water to an outer peripheral surface of the downstream pipe portion.

[Claim 3]

The tank facility according to claim 1,

wherein the heating unit includes a heater section that is provided along an outer peripheral surface of the downstream pipe portion.

[Claim 4]

The tank facility according to claim 2 or 3, further comprising:

a nozzle that is detachable from a distal end portion of the communication pipe,

wherein the nozzle includes

a nozzle main body that includes a nozzle flow passage through which carbon dioxide discharged from the distal end portion of the communication pipe flows, and

a fin that protrudes from an outer peripheral surface of the nozzle main body toward a radially outer side of the nozzle main body.

[Claim 5]

The tank facility according to claim 1, further comprising:

a pressure relief section that closes a distal end portion of the communication pipe and opens an inside of the communication pipe in a case where a pressure in the communication pipe is equal to or higher than a predetermined set pressure.

[Claim 6]

The tank facility according to claim 5,

wherein the set pressure is set to be equal to or higher than a triple point pressure of carbon dioxide.

[Claim 7]

The tank facility according to claim 1, further comprising:

a plurality of the tanks;

a pipe system that is connected to the plurality of tanks;

a connection pipe that has one end connected to the pipe system and the other end connected to any one of the plurality of tanks; and

a safety valve that is provided in a middle of the connection pipe and that operates in a case where a pressure in the connection pipe is equal to or higher than a predetermined safety valve operating pressure.

[Claim 8]

A floating structure comprising:

a floating main structure; and

the tank facility according to claim 1 provided in the floating main structure.

[Claim 9]

A tank facility comprising:

a tank that is configured to store liquefied carbon dioxide;

a communication pipe that is connected to the tank and that communicates an inside of the tank with an outside of the tank;

a valve that is provided in a middle of the communication pipe and that is provided to open and close a flow passage in the communication pipe; and

a pressure relief section that closes a distal end portion of the communication pipe and opens an inside of the communication pipe in a case where a pressure in the communication pipe is equal to or higher than a predetermined set pressure.

[Claim 10]

A tank facility comprising:

a plurality of tanks that are configured to store liquefied carbon dioxide;

a pipe system that is connected to the plurality of tanks;

a connection pipe that has one end connected to the pipe system and the other

end connected to any one of the plurality of tanks; and

a safety valve that is provided in a middle of the connection pipe and that operates in a case where a pressure in the connection pipe is equal to or higher than a predetermined safety valve operating pressure.