

Description

TEST METHOD FOR SOUNDNESS OF SECONDARY BARRIER IN LIQUEFIED GAS TANK

Technical Field

- [1] The present invention relates to a test method for soundness of a secondary barrier in a liquefied gas tank, the method being capable of estimating soundness of a secondary barrier in a liquefied gas tank of a ship in service.

[2]

Background Art

- [3] As a method that transports natural gas, which is attracting attention as a clean fuel, from a producing region to a consuming region, there are known the following methods: one that transports natural gas in a gas state through a pipeline; and another that transports natural gas in a liquid state by a ship.
- [4] To transport the natural gas through the pipeline, high-pressure gas needs to be treated for long-distance transportation, and continuous maintenance and repair for the pipeline are needed. Further, the installment of the pipeline is largely affected by geo-political problems.
- [5] Recently, in order to overcome the above problems, a method that transports natural gas by a ship is widely used. Particularly, with developments in technologies for storing extremely low-temperature objects and technologies for building large ships, a liquefied natural gas transport ship that can transport natural gas in a liquid state can be easily built. Accordingly, the transportation of natural gas by the ship is increasingly used.
- [6] Tanks for use in the liquefied natural gas transport ship are broadly classified into a membrane type and an independent type. Among the membrane type and the independent type, the membrane type is much more widely used in recent.
- [7] In case of the membrane type, particularly, the MARK 3 type, the tank is made of corrugated stainless steel to have a thickness of 1.2 mm. This forms a primary barrier that stores extremely low-temperature liquefied gas. If the primary barrier has a problem, liquefied natural gas would leak from the tank and cause damage to the hull. In order to prevent the above-described damage, a secondary barrier that insulates the low-temperature liquefied gas from the hull for a predetermined time is attached in an insulation space.
- [8] While the ship is being built, soundness estimation of the secondary barrier is made by a secondary barrier airtight test method. In the airtight test method, a first insulation space is maintained at an atmospheric pressure and the pressure of a secondary in-

sulation space is reduce to -530 mbar, and, then, a time until the reduced pressure returns to the atmospheric pressure is measured. The airtight test method uses the fact that pressure exchange is made due to porosity of the secondary barrier.

- [9] However, the above-described method can be only applied to the ship that is being built, i.e., it cannot be applied to a ship that is in service. Accordingly, there is a need for a method that can estimate soundness of a secondary barrier in a liquefied gas tank of a ship in service.

[10]

Disclosure of Invention

Technical Problem

- [11] In view of the above, the present invention provides a test method for soundness of a secondary barrier in a liquefied gas tank, the method being capable of estimating soundness of a secondary barrier in a liquefied gas tank of a ship in service.

[12]

Technical Solution

- [13] In accordance with an aspect of the present invention, there is provided a test method for soundness of a secondary barrier in a liquefied gas tank, the method including the steps of: (A) observing an integrated automation system; (B) performing a first differential pressure test when abnormality is observed through the observation in the step (A); and (C) performing, when a pressure in an insulation space and a pressure in an inter-barrier space are not equal to each other or pressure reversal occurs after the pressures become equal to each other as a result of the first differential pressure test in the step (B), a second differential pressure test.
- [14] Preferably, the test method further includes: (D) performing, when the pressure in the insulation space and the pressure in the inter-barrier space are equal to each other as a result of the second differential pressure test in the step (C), a third differential pressure test.
- [15] Preferably, the first differential pressure test includes: (a-1) checking control valves and pressure transmitters when the tank is in a steady state; (b-1) confirming whether or not leakage of a safety valve for the insulation space occurs; (c-1) changing a valve control mode from an automatic mode to a manual mode; (d-1) setting a differential pressure between the insulation space and the inter-barrier space; (e-1) closing the control valves, observing a change in pressure, and recording process variables; (f-1) determining whether or not the pressure in the insulation space and the pressure in the inter-barrier space are equal to each other; and (g-1) determining, when it is determined in the step (f-1) that the pressure in the insulation space and the pressure in the inter-barrier space are equal to each other, whether or not pressure reversal occurs

after the pressures become equal to each other.

- [16] Preferably, the first differential pressure test further includes: (h-1) changing, when it is determined in the step (g-1) that the pressure reversal occurs, the valve control mode from the manual mode to the automatic mode, checking the leak portion of the nitrogen pressurization system, and returning to the step (c-1).
- [17] Preferably, the second differential pressure test includes: (a-2) checking control valves and pressure transmitters when the tank is in a steady state; (b-2) confirming whether or not leakage of a safety valve for the insulation space occurs; (c-2) changing a valve control mode from an automatic mode to a manual mode; (d-2) setting a differential pressure between the insulation space and the inter-barrier space; (e-2) closing the control valves, closing manual valves disposed before and after the control valves, observing a change in pressure, and recording process variables; and (f-2) determining whether or not the pressure in the insulation space and the pressure in the inter-barrier space are equal to each other.
- [18] Preferably, the second differential pressure test further includes: (g-2) comparing, when it is determined in the step (f-2) that the pressures are not equal to each other, test results of the first differential pressure test and the second differential pressure test; and (h-2) changing, when it is determined in the step (g-2) that the test results are not equal to each other, the valve control mode from the manual mode to the automatic mode, checking the leak portion of the nitrogen pressurization system, and returning to the step (c-2).
- [19] Preferably, the third differential pressure test includes: (a-3) checking control valves and pressure transmitters when the tank is in a steady state; (b-3) confirming whether or not leakage of a safety valve for the insulation space occurs; (c-3) providing nameplates to parts of the nitrogen pressurization system; (d-3) changing a valve control mode from an automatic mode to a manual mode; (e-3) setting a differential pressure between the insulation space and the inter-barrier space; (f-3) closing the control valves, closing manual valves disposed before and after the control valves, observing a change in pressure, and recording process variables; and (g-3) determining whether or not the pressure in the insulation space and the pressure in the inter-barrier space are equal to each other.
- [20] Preferably, the third differential pressure test further includes: (h-3) determining, when it is determined in the step (g-3) that the pressures are equal to each other, whether or not pressure reversal occurs after the pressures become equal to each other; (i-3) setting, when it is determined in the step (h-3) that the pressure reversal does not occur, an equivalent pressure between the insulation space and the inter-barrier space; (j-3) closing the control valves, closing manual valves disposed before and after the control valves, opening the control valve for exhausting a gas from the insulation

space, observing a change in pressure, and recording process variables; (k-3) determining whether or not the pressure in the insulation space and the pressure in the inter-barrier space are equal to each other; (l-3) changing, when it is determined in the step (k-3) that the pressures are equal to each other, the valve control mode from the manual mode to the automatic mode; and (m-3) checking the leak portion of the nitrogen pressurization system and returning to the step (d-3).

[21] Preferably, the third differential pressure test further includes jumping to the step (l-3) when it is determined in the step (h-3) that the pressure reversal occurs.

[22] Preferably, the third differential pressure test further includes performing a secondary barrier airtight test when it is determined in the step (k-3) that the pressure in the insulation space and the pressure in the inter-barrier space are not equal to each other.

[23]

Advantageous Effects

[24] In accordance with the present invention, a test method for soundness of a secondary barrier in a liquefied gas tank, the method capable of estimating soundness of a secondary barrier in a liquefied gas tank of a ship in service, is provided.

[25]

Brief Description of the Drawings

[26] The objects and features of the present invention will become apparent from the following description of embodiments, given in conjunction with the accompanying drawings, in which:

[27] Fig. 1 illustrates a schematic block diagram of a liquefied gas tank to which a test method for soundness of a secondary barrier in accordance with an embodiment of the present invention is applied;

[28] Fig. 2 illustrates a flowchart of the test method for soundness of a secondary barrier in the liquefied gas tank of Fig. 1;

[29] Figs. 3 and 4 illustrate a flowchart of a first differential pressure test process in accordance with the embodiment of the present invention;

[30] Figs. 5 and 6 illustrate a flowchart of a second differential pressure test process in accordance with the embodiment of the present invention; and

[31] Figs. 7 and 8 illustrate a flowchart of a third differential pressure test process in accordance with the embodiment of the present invention.

[32]

Best Mode for Carrying Out the Invention

[33] Hereinafter, an embodiment of the present invention will be described in detail with reference to the accompanying drawings, which form a part hereof. The same reference numerals in the drawings represent the same parts.

- [34] Fig. 1 illustrates a schematic block diagram of a liquefied gas tank to which a test method for soundness of a secondary barrier in accordance with an embodiment of the present invention is applied.
- [35] Referring to Fig. 1, a liquefied gas tank 10 includes a primary barrier 100 and a secondary barrier 200. Due to the primary and secondary barrier 100 and 200, an inter-barrier space IBS and an insulation space IS are formed. The inter-barrier and insulation space IBS and IS are connected to a nitrogen pressurization system, which supplies nitrogen to the spaces IBS and IS, via nitrogen supply control valves 110 and 210. Further, the inter-barrier and insulation space IBS and IS are connected to nitrogen exhaust control valves 120 and 220 through which gases in the spaces IBS and IS are exhausted to the atmosphere. With this configuration, inner pressures of the spaces IBS and IS can be maintained. Manual valves 111, 112, 121, 122, 211, 212, 221 and 222 are disposed before and after the control valves 110, 120, 210 and 220. Inside the inter-barrier and insulation space IBS and IS, pressure transmitters (PT) 130 and 230 for measuring inner pressures of the spaces IBS and IS are provided. Further, at the insulation space IS, a safety valve 240 for the insulation space IS is provided.
- [36] Fig. 2 illustrates a flowchart of the test method for soundness of a secondary barrier in the liquefied gas tank of Fig. 1.
- [37] Referring to Fig. 2, to estimate soundness of the secondary barrier 200 in the liquefied gas tank 10, first, an integrated automation system is observed (step S100). Through this observation, it is determined whether or not abnormality is observed (step S110). If it is determined that the tank 10 is in a normal state, the step 100 is performed again. If it is determined that abnormality is observed, a first differential pressure test is performed (step S200). In the first differential pressure test, a differential pressure is set between the insulation space IS and the inter-barrier space IBS, and then a change in pressure is observed. If it is determined through the observation that the pressure in the insulation space IS and the pressure in the inter-barrier space IBS are equal to each other and pressure reversal occurs after the pressures become equal to each other, the leak portion of the nitrogen pressurization system is checked and then the first differential pressure test is performed repeatedly. If it is determined through the observation that the pressure in the insulation space IS and the pressure in the inter-barrier space IBS are not equal to each other or pressure reversal does not occur after the pressures become equal to each other, a second differential pressure test is performed (step S400).
- [38] In the second differential pressure test, a differential pressure is set between the insulation space IS and the inter-barrier space IBS, and then a change in pressure is observed. If it is determined through the observation that the pressure in the insulation space IS and the pressure in the inter-barrier space IBS are not equal to each other and

the first differential pressure test result and the second differential pressure test result are equal to each other, soundness of the secondary barrier 200 is confirmed. If it is determined through the observation that the pressure in the insulation space IS and the pressure in the inter-barrier space IBS are not equal to each other and the first differential pressure test result and the second differential pressure test result are not equal to each other, the leak portion of the nitrogen pressurization system within the barrier is checked and then the first differential pressure test is performed repeatedly. If it is determined through the observation that the pressure in the insulation space IS and the pressure in the inter-barrier space IBS are equal to each other, a third differential pressure test is performed (step S600).

[39] In the third differential pressure test, a differential pressure is set between the insulation space IS and the inter-barrier space IBS, and then a change in pressure is observed. If it is determined through the observation that the pressure in the insulation space IS and the pressure in the inter-barrier space IBS are not equal to each other, soundness of the secondary barrier 200 is confirmed. If it is determined through the observation that the pressure in the insulation space IS and the pressure in the inter-barrier space IBS are equal to each other and pressure reversal occurs after the pressures become equal to each other, the leak portion of the nitrogen pressurization system is checked and then the differential pressure test is performed repeatedly. If it is determined through the observation that pressure reversal does not occur after the pressures become equal to each other, an equivalent pressure is set between the insulation space IS and the inter-barrier space IBS, and then a change in pressure is observed. Through the equivalent pressure test, if it is determined that the pressure in the insulation space IS and the pressure in the inter-barrier space IBS are equal to each other, a secondary barrier airtight test is performed. If it is determined that the pressure in the insulation space IS and the pressure in the inter-barrier space IBS are not equal to each other, the leak portion of the nitrogen pressurization system is checked and then the differential pressure test is performed repeatedly.

[40] Figs. 3 and 4 illustrate a flowchart of a first differential pressure test process in accordance with the embodiment of the present invention.

[41] Referring to Figs. 3 and 4, in the first differential pressure test, it is first determined whether or not the tank 10 is in a steady state (step S201). If it is determined that the tank 10 is not in the steady state, it waits until the tank 10 reaches the steady state (step S202). If it is determined that the tank 10 is in the steady state, the control valves 110, 120, 210 and 220 and the pressure transmitters 130 and 230 are checked (step S203). Next, leakage of the safety valve 240 for the insulation space IS is confirmed (step S204), and a valve control mode is changed from an automatic mode to a manual mode (step S205). Next, a differential pressure is set between the insulation space IS and the

inter-barrier space IBS (step S206), and the control valves 110, 120, 210 and 220 are closed (step S207). Next, a change in pressure is observed, and process variables are recorded (step S208). Next, it is determined whether or not the pressure in the insulation space IS and the pressure in the inter-barrier space IBS are equal to each other (step S209). If it is determined in the step S209 that the pressures in both spaces IS and IBS are equal to each other, it is determined whether or not pressure reversal occurs after the pressures become equal to each other (step S210). When the pressure reversal does not occur, the second differential pressure test is performed (step S211).

Meanwhile, if it is determined in the step S209 that the pressures in both spaces IS and IBS are not equal to each other, the second differential pressure test is performed (the step S211).

[42] In the step S210, if it is determined that the pressure reversal occurs, the valve control mode is changed from the manual mode to the automatic mode (step S212). Next, the leak portion of the nitrogen pressurization system is checked (step S213). Subsequently, the process progresses to the step S205.

[43] Figs. 5 and 6 illustrate a flowchart of a second differential pressure test process in accordance with the embodiment of the present invention.

[44] Referring to Figs. 5 and 6, in the second differential pressure test, it is first determined whether or not the tank 10 is in the steady state (step S401). If the tank 10 is not in the steady state, it waits until the tank 10 reaches the steady state (step S402). If the tank 10 is in the steady state, the control valves 110, 120, 210 and 220 and the pressure transmitters 130 and 230 are checked (step S403). Next, leakage of the safety valve 240 for the insulation space IS is confirmed (step S404), and the valve control mode is changed from the automatic mode to the manual mode (step S405). Next, a differential pressure is set between the insulation space IS and the inter-barrier space IBS (step S406), and the control valves 110, 120, 210 and 220 are closed (Step S407). Next, the manual valves 111, 112, 121, 122, 211, 212, 221 and 222 before and after the control valves 110, 120, 210 and 220 are closed (step S408), and a change in pressure is observed and process variables are recorded (step S409). Next, it is determined whether or not the pressure in the insulation space IS and the pressure in the inter-barrier space IBS are equal to each other (step S410). When the pressures in both spaces IS and IBS are equal to each other, the third differential pressure test is performed (step S411). When the pressures in both spaces IS and IBS are not equal to each other, it is determined whether or not the first differential pressure test result and the second differential pressure test result are equal to each other (step S412). If the first and second differential pressure test results are equal to each other, soundness of the secondary barrier 200 is confirmed (step S413). Otherwise, the valve control mode is changed from the manual mode to the automatic mode (step S414). Next, the leak

portion of the nitrogen pressurization system is checked (step S415). Subsequently, the process progresses to the step S405.

[45] Figs. 7 and 8 illustrate a flowchart of a third differential pressure test process in accordance with the embodiment of the present invention.

[46] Referring to Figs. 7 and 8, in the third differential pressure test, it is first determined whether or not the tank 10 is in the steady state (step S601). If the tank 10 is not in the steady state, it waits until the tank 10 reaches the steady state (step S602). If the tank 10 is in the steady state, the control valves 110, 120, 210 and 220 and the pressure transmitters 130 and 230 are checked (step S603). Next, leakage of the safety valve 240 for the insulation space IS is confirmed (step S604), and nameplates are provided to parts of the nitrogen pressurization system (step S605). Next, the valve control mode is changed from the automatic mode to the manual mode (step S606), and a differential pressure is set between the insulation space IS and the inter-barrier space IBS (step S607). Next, the control valves 110, 120, 210 and 220 are closed (step S608), and the manual valves 111, 112, 121, 122, 211, 212, 221 and 222 before and after the control valves 110, 120, 210 and 220 are closed (step S609). Next, a change in pressure is observed and process variables are recorded (step S610). Next, it is determined whether or not the pressure in the insulation space IS and the pressure in the inter-barrier space IBS are equal to each other (step S611). If the pressures in both spaces IS and IBS are not equal to each other, soundness of the secondary barrier 200 is confirmed (step S612). When the pressures in both spaces IS and IBS are equal to each other, it is determined whether or not pressure reversal occurs (step S613). When the pressure reversal does not occur, an equivalent pressure is set between the insulation space IS and the inter-barrier space IBS (step S614). Next, the control valves 110, 120, 210 and 220 are closed (step S615), and the manual valves 111, 112, 121, 122, 211, 212, 221 and 222 before and after the control valves 110, 120, 210 and 220 are closed (step S616). Next, only the exhaust control valve 220 for the insulation space IS is opened (step S617), and a change in pressure is observed and process variables are recorded (step S618). Next, it is determined whether or not the pressure in the insulation space IS and the pressure in the inter-barrier space IBS are equal to each other (step S619). When the pressures in both spaces IS and IBS are not equal to each other, the secondary barrier 200 airtight test is performed (step S620). If the pressures in both spaces IS and IBS are equal to each other, the valve control mode is changed from the manual mode to the automatic mode (step S621).

[47] Meanwhile, in the step S613, if it is determined that the pressure reversal occurs, the process progresses to the step S621, and the valve control mode is changed from the manual mode to the automatic mode. After the step S621, the leak portion of the nitrogen pressurization system is checked (step S622).

- [48] In the test method for soundness of a secondary barrier 200 in a liquefied gas tank 10 according to the present invention, as those skilled in the art request, a step such as the step of checking the leak portion of the nitrogen pressurization system or all the steps may be repeatedly performed.
- [49] While the invention has been shown and described with respect to the embodiment, it will be understood by those skilled in the art that various changes and modification may be made without departing from the scope of the invention as defined in the following claims.

Claims

- [1] A test method for soundness of a secondary barrier in a liquefied gas tank, the method comprising the steps of:
- (A) observing an integrated automation system;
 - (B) performing a first differential pressure test when abnormality is observed through the observation in the step (A); and
 - (C) performing, when a pressure in an insulation space and a pressure in an inter-barrier space are not equal to each other or pressure reversal occurs after the pressures become equal to each other as a result of the first differential pressure test in the step (B), a second differential pressure test.
- [2] The test method of claim 1, further comprising:
- (D) performing, when the pressure in the insulation space and the pressure in the inter-barrier space are equal to each other as a result of the second differential pressure test in the step (C), a third differential pressure test.
- [3] The test method of claim 1, wherein the first differential pressure test includes:
- (a-1) checking control valves and pressure transmitters when the tank is in a steady state;
 - (b-1) confirming whether or not leakage of a safety valve for the insulation space occurs;
 - (c-1) changing a valve control mode from an automatic mode to a manual mode;
 - (d-1) setting a differential pressure between the insulation space and the inter-barrier space;
 - (e-1) closing the control valves, observing a change in pressure, and recording process variables;
 - (f-1) determining whether or not the pressure in the insulation space and the pressure in the inter-barrier space are equal to each other; and
 - (g-1) determining, when it is determined in the step (f-1) that the pressure in the insulation space and the pressure in the inter-barrier space are equal to each other, whether or not pressure reversal occurs after the pressures become equal to each other.
- [4] The test method of claim 3, wherein the first differential pressure test further includes:
- (h-1) changing, when it is determined in the step (g-1) that the pressure reversal occurs, the valve control mode from the manual mode to the automatic mode, checking the leak portion of the nitrogen pressurization system, and returning to the step (c-1).
- [5] The test method of claim 1, wherein the second differential pressure test

includes:

(a-2) checking control valves and pressure transmitters when the tank is in a steady state;

(b-2) confirming whether or not leakage of a safety valve for the insulation space occurs;

(c-2) changing a valve control mode from an automatic mode to a manual mode;

(d-2) setting a differential pressure between the insulation space and the inter-barrier space;

(e-2) closing the control valves, closing manual valves disposed before and after the control valves, observing a change in pressure, and recording process variables; and

(f-2) determining whether or not the pressure in the insulation space and the pressure in the inter-barrier space are equal to each other.

[6] The test method of claim 5, wherein the second differential pressure test further includes:

(g-2) comparing, when it is determined in the step (f-2) that the pressures are not equal to each other, test results of the first differential pressure test and the second differential pressure test; and

(h-2) changing, when it is determined in the step (g-2) that the test results are not equal to each other, the valve control mode from the manual mode to the automatic mode, checking the leak portion of the nitrogen pressurization system, and returning to the step (c-2).

[7] The test method of claim 2, wherein the third differential pressure test includes:

(a-3) checking control valves and pressure transmitters when the tank is in a steady state;

(b-3) confirming whether or not leakage of a safety valve for the insulation space occurs;

(c-3) providing nameplates to parts of the nitrogen pressurization system;

(d-3) changing a valve control mode from an automatic mode to a manual mode;

(e-3) setting a differential pressure between the insulation space and the inter-barrier space;

(f-3) closing the control valves, closing manual valves disposed before and after the control valves, observing a change in pressure, and recording process variables; and

(g-3) determining whether or not the pressure in the insulation space and the pressure in the inter-barrier space are equal to each other.

[8] The test method of claim 7, wherein the third differential pressure test further includes:

(h-3) determining, when it is determined in the step (g-3) that the pressures are equal to each other, whether or not pressure reversal occurs after the pressures become equal to each other;

(i-3) setting, when it is determined in the step (h-3) that the pressure reversal does not occur, an equivalent pressure between the insulation space and the inter-barrier space;

(j-3) closing the control valves, closing manual valves disposed before and after the control valves, opening the control valve for exhausting a gas from the insulation space, observing a change in pressure, and recording process variables;

(k-3) determining whether or not the pressure in the insulation space and the pressure in the inter-barrier space are equal to each other;

(l-3) changing, when it is determined in the step (k-3) that the pressures are equal to each other, the valve control mode from the manual mode to the automatic mode; and

(m-3) checking the leak portion of the nitrogen pressurization system and returning to the step (d-3).

[9] The test method of claim 8, wherein the third differential pressure test further includes jumping to the step (l-3) when it is determined in the step (h-3) that the pressure reversal occurs.

[10] The test method of claim 8, wherein the third differential pressure test further includes performing a secondary barrier airtight test when it is determined in the step (k-3) that the pressure in the insulation space and the pressure in the inter-barrier space are not equal to each other.