

[DESCRIPTION]

[Invention Title]

LIQUEFIED GAS STORAGE TANK AND SHIP COMPRISING SAME

[Technical Field]

5 **[0001]** The present invention relates to a liquefied gas storage tank and a vessel including the same.

[Background Art]

10 **[0002]** Recently, liquefied gases, such as liquefied natural gas (LNG) and liquefied petroleum gas (LPG), are widely used to replace gasoline or diesel according to the technology development.

15 **[0003]** In addition, a storage tank (so-called “cargo tank”) for storing LNG in a cryogenic liquid state is installed in vessels, such as LNG cargo vessels, LNG regasification vessels (RVs), LNG floating, production, storage, and offloading (FPSO) vessels, and LNG floating storage and regasification units (FSRUs), for transporting or storing the liquefied gases such as LNG at sea.

20 **[0004]** In addition, boil off gas (BOG) may be generated in the liquefied gas storage tank affected by external heat, and a key technology for designing the liquefied gas storage tank is for reducing a boil off rate (BOR), which is a rate of vaporization of BOG, through an insulation design. In addition, since the liquefied gas storage tank is exposed to various loads such as sloshing, it may be essential to secure a mechanical strength of an insulation panel.

[0005] Considering this point, allowable thicknesses of a primary insulation wall and a secondary insulation wall may be associated with a mechanical strength of the

liquefied gas storage tank. Therefore, studies are being actively conducted to maintain the mechanical strength of the secondary insulation wall while eliminating the low-temperature load of a secondary barrier.

[Technical Problem]

5 **[0006]** The present invention has been made in efforts to solve the above problems of the related art and is directed to providing a liquefied gas storage tank and a vessel including the same, in which a thickness of a primary insulation wall is formed identically or similarly to a secondary insulation wall in the entire thickness of an insulation wall, thereby reducing the low-temperature load and sloshing load of a
10 secondary barrier while maintaining a mechanical strength of the secondary insulation wall at a predetermined level.

[0007] In addition, the present invention is directed to providing a liquefied gas storage tank and a vessel including the same, in which a thickness of a primary insulation wall is formed identically or similarly to a secondary insulation wall in the
15 entire thickness of an insulation wall, thereby reducing the low-temperature load and sloshing load of a secondary barrier in a range in which brittle fracture of a hull does not occur.

[0008] In addition, the present invention is directed to providing a liquefied gas storage tank and a vessel including the same, in which a configuration of a secondary
20 barrier is improved, thereby increasing insulation performance.

[0009] In addition, the present invention is directed to providing a liquefied gas storage tank and a vessel including the same, in which a configuration of a fixing member for fixing a secondary insulation wall to a hull is improved, thereby not only increasing insulation performance but also reducing the number of processes.

[0010] In addition, the present invention is directed to providing a liquefied gas storage tank and a vessel including the same, in which a slit provided to cope with contraction and expansion of a primary insulation wall formed on a secondary barrier is optimized and a convection phenomenon caused through the slit and an amount of heat transferred into the secondary barrier is minimized, thereby enhancing the stability of the primary insulation wall and also reducing a low-temperature load of the secondary barrier.
[Technical Solution]

[0011] A liquefied gas storage tank according to one aspect of the present invention is the liquefied gas storage tank that stores cryogenic substances, which includes a primary barrier, a primary insulation wall, a secondary barrier, and a secondary insulation wall, wherein, in a state in which unit elements, each of which is formed by stacking the secondary insulation wall, the secondary barrier, and a fixed insulation wall that is a part of the primary insulation wall, are disposed adjacent to each other, the primary insulation wall includes a connection insulation wall provided in a spatial portion between the adjacent fixed insulation walls, a first slit formed between the fixed insulation wall and the connection insulation wall when the connection insulation wall is inserted and installed between the adjacent fixed insulation walls, a plurality of second slits formed in a longitudinal direction and a width direction of the fixed insulation wall, and a first insulating filler material filling the first slit.

[0012] The first insulating filler material may be formed to fully fill the first slit, formed to fill the first slit from an inlet of the first slit to a predetermined depth so that a space is formed in a lower portion of the first slit, or formed to fill an inside of

the first slit in multiple layers so that a plurality of spaces are formed inside the first slit.

[0013] When the first insulating filler material is formed to fill the inside of the first slit in multiple layers so that the plurality of spaces are formed inside the first slit, the first insulating filler material may include a first upper insulating filler material formed in an upper portion of the first slit, a first middle insulating filler material spaced a predetermined interval from the first upper insulating filler material and formed in a middle of the first slit, and a first lower insulating filler material spaced a predetermined interval from the first middle insulating filler material and formed in a lower portion of the first slit, each of the first upper insulating filler material, the first middle insulating filler material, and the first lower insulating filler material may be formed of the same insulating material or different insulating materials, and the insulating material may include glass wool, super lite, a soft foam material, or an aerogel blanket.

[0014] The first insulating filler material may fill the first slit in an insertion method using a jig after the connection insulation wall is inserted and installed between the adjacent fixed insulation walls, or fill the first slit by inserting and installing the connection insulation wall between the adjacent fixed insulation walls in a state of being bonded to both side surfaces of the connection insulation wall facing a side surface of the fixed insulation wall using an adhesive member.

[0015] The second slit may be filled with a second insulating filler material therein when formed to a depth similar to a thickness of the fixed insulation wall, and the second insulating filler material may be formed to fill the second slit from an inlet of the second slit to a predetermined depth so that a space is formed in a lower portion

of the second slit, or formed to fill an inside of the second slit in multiple layers so that a plurality of spaces are formed inside the second slit.

- [0016]** When the second insulating filler material is formed to fill the inside of the second slit in multiple layers so that the plurality of spaces are formed inside the second slit, the second insulating filler material may include a second upper insulating filler material formed in an upper portion of the second slit, a second middle insulating filler material spaced a predetermined interval from the second upper insulating filler material and formed in a middle of the second slit, and a second lower insulating filler material spaced a predetermined interval from the second middle insulating filler material and formed in a lower portion of the second slit, each of the second upper insulating filler material, the second middle insulating filler material, and the second lower insulating filler material may be formed of the same insulating material or different insulating materials, and the insulating material may include glass wool, super lite, a soft foam material, or an aerogel blanket.
- [0017]** The liquefied gas storage tank may include one or more third slits formed in a longitudinal direction of the connection insulation wall and positioned collinearly with the second slit formed in the longitudinal direction when the connection insulation wall is inserted and installed between the fixed insulation walls, the second slit and the third slit may be formed to a depth corresponding to about half of thicknesses of the fixed insulation wall and the connection insulation wall and may not be filled with an insulating filler material therein, the first insulating filler material is formed to be at least longer than a depth of each of the second slit and the third slit, and a heat convection path through the first slit, the second slit, and the third slit may be intermittently formed.

[0018] The primary insulation wall and the secondary insulation wall may have the same or similar thickness.

[0019] A liquefied gas storage tank according to another aspect of the present invention is the liquefied gas storage tank that stores cryogenic substances, which includes a primary barrier, a primary insulation wall, a secondary barrier, and a secondary insulation wall, wherein, in a state in which unit elements, each of which is formed by stacking the secondary insulation wall, the secondary barrier, and a fixed insulation wall that is a part of the primary insulation wall, are disposed adjacent to each other, the primary insulation wall may include a connection insulation wall provided in a spatial portion between the adjacent fixed insulation walls, first steps formed on front, rear, left, and right side surfaces of the connection insulation wall, second steps formed on front, rear, left, and right side surfaces of the fixed insulation wall, first slits formed by the first steps and the second steps between the connection insulation wall and the fixed insulation wall when the connection insulation wall is inserted and installed between the adjacent fixed insulation walls, and a first insulating filler material filling the first slits.

[0020] The first step may be formed so that front-rear and left-right widths of an upper portion of the connection insulation wall is smaller than front-rear and left-right widths of a lower portion of the connection insulation wall, the second step may be formed so that front-rear and left-right widths of an upper portion of the fixed insulation wall is smaller than front-rear and left-right widths of a lower portion of the fixed insulation wall, and the first insulating filler material may fill the first slit, which is a space provided between the upper portion of the connection insulation wall and the upper portion of the fixed insulation wall by installing the lower portion

of the connection insulation wall to be adjacent to the lower portion of the fixed insulation wall.

[0021] The liquefied gas storage tank may include a plurality of second slits formed in a longitudinal direction and a width direction of the fixed insulation wall, and one
5 or more third slits formed in a longitudinal direction of the connection insulation wall and positioned collinearly with the second slit formed in the longitudinal direction when the connection insulation wall is inserted and installed between the fixed insulation walls, the second slit and the third slit may be formed to a depth corresponding to about half of thicknesses of the fixed insulation wall and the
10 connection insulation wall and not filled with an insulating filler material therein, the first slit filled with the first insulating filler material may be formed to be at least longer than a depth of each of the second slit and the third slit, and a heat convection path through the first slit, the second slit, and the third slit may be intermittently formed.

15 **[0022]** The primary insulation wall and the secondary insulation wall may have the same or similar thickness.
[Advantageous Effects]

[0023] In a liquefied gas storage tank and a vessel including the same according to the present invention, a thickness of a primary insulation wall is formed to be the
20 same as or similar to that of a secondary insulation wall in the entire thickness of the primary insulation wall and the secondary insulation wall including a connection insulation wall, thereby not only maintaining a mechanical strength of the secondary insulation wall at a predetermined level but also reducing a low-temperature load and a sloshing load of a secondary barrier to prevent damage to the secondary barrier.

[0024] In addition, in the liquefied gas storage tank and the vessel including the same according to the present invention, the thickness of the primary insulation wall is formed to be the same as or similar to that of the secondary insulation wall in the entire thickness of the primary insulation wall and the secondary insulation wall including the connection insulation wall, thereby preventing brittle fracture of a hull and reducing the low-temperature load and the sloshing load of the secondary barrier.

[0025] In addition, the liquefied gas storage tank and the vessel including the same according to the present invention is provided with an auxiliary insulation plate on a lower surface of the connection insulation wall provided in a space between adjacent primary insulation walls constituting a unit element, thereby further increasing insulation performance at a connected portion between adjacent secondary insulation walls constituting a unit element.

[0026] In addition, in the liquefied gas storage tank and the vessel including the same according to the present invention, a configuration of the secondary barrier is improved, thereby increasing insulation performance.

[0027] In addition, in the liquefied gas storage tank and the vessel including the same according to the present invention, a non-adhesive elastic insulating material is applied between the secondary insulation wall and the hull as a leveling member of the secondary insulation wall, thereby leveling a deformed portion of the hull and increasing insulation performance of the tank even without using a conventional mastic and leveling wedge.

[0028] In addition, in the liquefied gas storage tank and the vessel including the same according to the present invention, a unit panel of the adjacent secondary insulation walls is fixed in a cleat structure method using a protrusion provided to

protrude outward from a lower portion of a side surface of the unit panel of the secondary insulation wall and a stud bolt fixed to the hull, thereby reducing the number of processes compared to a method of making a hole in the secondary insulation wall and fixing the unit panel with the stud bolt.

- 5 **[0029]** In addition, in the liquefied gas storage tank and the vessel including the same according to the present invention, a slit structure is improved and various insulating filler materials filling the slit are provided in order to optimize the slit provided to cope with contraction and expansion of the primary insulation wall formed on the secondary barrier and minimize a convection phenomenon generated
- 10 through the slit and an amount of heat transferred into the secondary barrier, thereby enhancing the stability of the primary insulation wall according to the formation of the slit and also reducing the low-temperature load of the secondary barrier to prevent damage to the primary insulation wall and the secondary insulation wall.
- [Description of Drawings]

- 15 **[0030]** FIG. 1 is a partial cross-sectional view showing a liquefied gas storage tank according to a first embodiment of the present invention.

[0031] FIG. 2 is a partial perspective view showing the liquefied gas storage tank according to the first embodiment of the present invention.

- [0032]** FIG. 3 is a view showing a primary barrier of the liquefied gas storage tank
- 20 according to the first embodiment of the present invention.

[0033] FIGS. 4A and 4B are views showing a tensile force of a secondary barrier depending on a change in thicknesses of a primary insulation wall and a secondary insulation wall.

[0034] FIGS. 5 to 8 are views showing results of the performance of a structural

analysis while varying the thicknesses of the primary insulation wall and the secondary insulation wall in a first case in order to derive the thicknesses of the primary insulation wall and the secondary insulation wall of the liquefied gas storage tank according to the first embodiment of the present invention.

5 **[0035]** FIGS. 9 to 12 are views showing results of the performance of a structural analysis while varying the thicknesses of the primary insulation wall and the secondary insulation wall in a second case in order to derive the thicknesses of the primary insulation wall and the secondary insulation wall of the liquefied gas storage tank according to the first embodiment of the present invention.

10 **[0036]** FIGS. 13 to 16 are views showing results of the performance of a structural analysis while varying the thicknesses of the primary insulation wall and the secondary insulation wall in a third case in order to derive the thicknesses of the primary insulation wall and the secondary insulation wall of the liquefied gas storage tank according to the first embodiment of the present invention.

15 **[0037]** FIGS. 17 to 20 are views showing results of the performance of a structural analysis while varying the thicknesses of the primary insulation wall and the secondary insulation wall in a fourth case in order to derive the thicknesses of the primary insulation wall and the secondary insulation wall of the liquefied gas storage tank according to the first embodiment of the present invention.

20 **[0038]** FIG. 21 is a graph showing a low-temperature stress of the secondary barrier and a probability of brittle fracture of a hull depending on the change in the thicknesses of the primary insulation wall and the secondary insulation wall.

[0039] FIGS. 22, 23, and 24 are views showing various configurations of the secondary barrier of the liquefied gas storage tank according to the first embodiment

of the present invention.

[0040] FIG. 25 is a partial cross-sectional view showing a right angle corner structure of the liquefied gas storage tank according to the first embodiment of the present invention.

5 **[0041]** FIG. 26 is a partial cross-sectional view showing an obtuse angle corner structure of the liquefied gas storage tank according to the first embodiment of the present invention.

[0042] FIG. 27 is a graph showing a thermal conductivity according to materials used for a primary insulating material and a secondary insulating material of the
10 liquefied gas storage tank according to the present invention.

[0043] FIG. 28 is a partial cross-sectional view showing a liquefied gas storage tank according to a second embodiment of the present invention.

[0044] FIG. 29 is a partial perspective view showing the liquefied gas storage tank according to the second embodiment of the present invention.

15 **[0045]** FIG. 30 is a partial cross-sectional view showing a liquefied gas storage tank according to a third embodiment of the present invention.

[0046] FIG. 31 is an enlarged view of a main part of the liquefied gas storage tank according to the third embodiment of the present invention.

[0047] FIG. 32 is a partial cross-sectional view showing a liquefied gas storage tank
20 according to a fourth embodiment of the present invention.

[0048] FIG. 33 is a view showing an insulating filler material for filling a first slit forming a gap between a connection insulation wall and a fixed insulation wall, which constitute a primary insulation wall, and a plurality of second slits provided in the fixed insulation wall.

[0049] FIG. 34 is a view showing an insulating filler material for filling the first slit forming the gap between the connection insulation wall and the fixed insulation wall, which constitute the primary insulation wall, and the plurality of second slits provided in the fixed insulation wall, according to another embodiment.

5 **[0050]** FIG. 35 is a view showing an insulating filler material for filling the first slit forming the gap between the connection insulation wall and the fixed insulation wall, which constitute the primary insulation wall, and the plurality of second slits provided in the fixed insulation wall, according to still another embodiment.

[0051] FIG. 36 is a partial cross-sectional view showing a liquefied gas storage tank
10 according to a fifth embodiment of the present invention.

[0052] FIG. 37 is a cross-sectional view of a connection insulation wall along line A-A' in FIG. 36.

[0053] FIG. 38 is a cross-sectional view of a unit element formed by stacking a secondary insulation wall, a secondary barrier, and a fixed insulation wall
15 constituting a primary insulation wall along line B-B' in FIG. 36.

[0054] FIGS. 39 and 40 are views showing an insulating filler material for filling a first slit forming a gap between the fixed insulation wall and a connection insulation wall, which constitute the primary insulation wall.

[0055] FIGS. 41 and 42 are views showing structural analysis results of the
20 liquefied gas storage tank according to the fifth embodiment of the present invention.

[0056] FIGS. 43 to 46 are views showing a comparison of convection paths and temperatures of secondary barriers that vary depending on a structure of the slit and whether the insulating filler material for filling the slit is applied thereto in the liquefied gas storage tank according to the fifth embodiment of the present invention

and a liquefied gas storage tank according to a comparative example.

[0057] FIG. 47 is a graph showing a comparison between the temperatures of the secondary barriers under the slits depending on whether the insulating filler material for filling the slit is present in the liquefied gas storage tank according to the fifth
5 embodiment of the present invention and the liquefied gas storage tank according to the comparative example.

[0058] FIG. 48 is a partial cross-sectional view showing a liquefied gas storage tank according to a sixth embodiment of the present invention.

[0059] FIG. 49 is a cross-sectional view of a connection insulation wall along line
10 A-A' in FIG. 48.

[0060] FIG. 50 is a cross-sectional view of a unit element formed by stacking a secondary insulation wall, a secondary barrier, and a fixed insulation wall constituting a primary insulation wall along line B-B' in FIG. 48.

[0061] FIG. 51 is an enlarged view showing a state in which an insulating filler
15 material fills a first slit forming a gap between a connection insulation wall and the fixed insulation wall, which constitute the primary insulation wall.

[0062] FIG. 52 is a perspective view showing a liquefied gas storage tank according to a seventh embodiment of the present invention.

[0063] FIGS. 53A to 53C are plane, side, and cross-sectional views of the unit
20 element in which the secondary insulation wall, the secondary barrier, and the fixed insulation wall constituting a primary insulation wall in FIG. 52 are stacked.

[0064] FIGS. 54A to 54C are plane, side, and cross-sectional views of the connection insulation wall constituting the primary insulation wall in FIG. 52.

[0065] FIGS. 55A to 55C are plane, side, and cross-sectional views of a connection

insulation wall according to another embodiment constituting the primary insulation wall in FIG. 52.

[0066] FIG. 56 is a rear perspective view of a connection insulation wall according to still another embodiment constituting the primary insulation wall in FIG. 52.

5 **[0067]** FIG. 57 is a cross-sectional view of a portion in which the fixed insulation wall and the connection insulation wall, which constitute the primary insulation wall, are alternately connected.

[0068] FIG. 58 is a cross-sectional view of a portion in which a plurality of connection insulation walls constituting the primary insulation wall are consecutively
10 connected.
[Modes of the Invention]

[0069] Objects, specific advantages and new features of the present invention will become more apparent from the following detailed description and exemplary embodiments associated with the accompanying drawings. In the specification, in
15 adding reference numerals to components of each drawing, it should be noted that the same components have the same numbers as possible even when the components are displayed on different drawings. In addition, in describing the present invention, when it is determined that a detailed description of related known technologies may unnecessarily obscure the subject matter of the present invention, the detailed
20 description thereof will be omitted.

[0070] In addition, it should be understood that the accompanying drawings are only for easy understanding of the embodiments disclosed in the specification, and the technical spirit disclosed in the specification is not limited by the accompanying drawings and includes all changes, equivalents, or substitutes included in the spirit

and technical scope of the present invention.

[0071] In addition, terms including ordinal numbers, such as first and second, may be used to describe various components, but the components are not limited by the terms. These terms are only used for the purpose of distinguishing one component
5 from another.

[0072] Hereinafter, in the specification, liquefied gas may be used as the meaning including all gaseous fuels that are generally stored in a liquid state, such as liquefied natural gas (LNG), liquefied petroleum gas (LPG), ethylene, and ammonia, and liquefied gas in the case of being not in the liquid state by heating or pressurizing
10 may also be expressed as liquefied gas for convenience. Likewise, this may also be applied to boil off gas (BOG). In addition, for convenience, the LNG may be used as the meaning including not only natural gas (NG) in a liquid state but also LNG in a supercritical state, and the BOG may be used as the meaning including not only a BOG in a gaseous state but also liquefied BOG.

[0073] Hereinafter, exemplary embodiments of the present invention will be described in detail with reference to the accompanying drawings.

[0074] FIG. 1 is a partial cross-sectional view showing a liquefied gas storage tank according to a first embodiment of the present invention, and FIG. 2 is a partial perspective view showing the liquefied gas storage tank according to the first
20 embodiment of the present invention. FIG. 3 is a view showing a primary barrier of the liquefied gas storage tank according to the first embodiment of the present invention.

[0075] As shown in FIGS. 1 and 2, a liquefied gas storage tank 1 according to the first embodiment of the present invention may be provided in a vessel to store

liquefied gas, such as LNG that is a cryogenic (in a range of about -160°C to -170°C) substance.

[0076] Although not shown, it should be noted that the vessel equipped with the liquefied gas storage tank 1 to be described below has a concept including offshore
5 structures that float at a certain point at sea and perform specific tasks in addition to commercial vessels that transport cargo from a departure to a destination. In addition, in the present invention, it should be noted that the liquefied gas storage tank 1 also includes any type of tank for storing liquefied gas.

[0077] The liquefied gas storage tank 1 may include a primary barrier 2 in contact
10 with the liquefied gas, a primary insulation wall 3 installed outside the primary barrier 2, a secondary barrier 4 installed outside the primary insulation wall 3, and a secondary insulation wall 5 disposed outside the secondary barrier 4. The liquefied gas storage tank 1 may be supported on a hull 7 by a mastic 6 installed between the secondary insulation wall 5 and the hull 7.

[0078] The liquefied gas storage tank 1 may require the optimization of thicknesses
15 of the primary insulation wall 3 and the secondary insulation wall 5 in order to optimize insulation performance and a storage capacity. For example, when polyurethane foam is used as main materials of the primary insulation wall 3 and the secondary insulation wall 5, the total thickness of the primary insulation wall 3 and
20 the secondary insulation wall 5 may be in a range of 250 mm to 500 mm. This will be described with reference to FIGS. 4 to 20.

[0079] In the above description, the liquefied gas storage tank 1 may include a planar and corner structure. For example, a horizontal wall in a front-rear direction, a floor between the horizontal walls, a vertical wall, and a ceiling of the liquefied gas

storage tank 1 may correspond to the planar structure. In addition, for example, a structure in which the horizontal wall, the floor, the vertical wall, and the ceiling of the liquefied gas storage tank 1 meet may correspond to the corner structure. Here, the corner structure may include an obtuse angle corner structure or a right angle corner structure. When the thickness of the primary insulation wall 3 or the secondary insulation wall 5 is changed, the obtuse angle corner structure or the right angle corner structure may be changed. This will be described with reference to FIGS. 25 and 26.

[0080] Referring to FIGS. 1 and 2, the primary barrier 2 may form an accommodation space for accommodating liquefied gas, which is a cryogenic substance, and may be made of a metal material. For example, the metal material may be stainless steel, but is not limited thereto. The primary barrier 2 together with the secondary barrier 4 can prevent the liquefied gas from leaking to the outside.

[0081] The primary barrier 2 may be fixedly coupled to an upper portion of the primary insulation wall 3 by anchor strips (not shown) and installed in direct contact with the liquefied gas, which is a cryogenic substance stored in the liquefied gas storage tank 1.

[0082] Referring to FIG. 3, the primary barrier 2 may be divided into a planar portion 21 in contact with an upper surface of the primary insulation wall 3, a curved portion 22 for mitigating a contraction or expansion stress depending on a temperature, and an interface 23 between the planar portion 21 and the curved portion 22. For example, the primary barrier 2 may be formed of a corrugation membrane sheet made of stainless steel having a thickness of 1.0 to 1.5 mm, and preferably, stainless steel having a thickness of 1.0 to 1.2 mm. In other words, the

primary barrier may be formed in a wrinkled shape.

[0083] The primary barrier 2 may be formed in the wrinkle shape having a first curvature radius R1 and a second curvature radius R2. In other words, the primary barrier 2 in the embodiment may be formed to have two types of curvature radii R1 and R2 including the first curvature radius R1 at the interface 23 between the planar portion 21 and the curved portion 22 and the second curvature radius R2 at the curved portion 22. For example, the first curvature radius R1 may be formed to be smaller than the second curvature radius R2. The primary barrier 2 having the curvature radii R1 and R2 may be easy for an inspection of welding because an upper portion thereof has a smooth curve and may flexibly respond to sloshing because a fluid hitting laterally flows directly therethrough.

[0084] In addition, the primary barrier 2 in the embodiment may be formed to have the same sizes of horizontal and vertical wrinkles in the entire region without distinction between large corrugation and small corrugation. In other words, since the sizes of horizontal and vertical wrinkles are the same in the entire primary barrier 2, the primary barrier may be easily manufactured.

[0085] Referring to FIG. 1, the primary insulation wall 3 may be designed to withstand an external impact or an impact caused by internal sloshing of the liquefied gas while blocking an influence of external heat and installed between the primary barrier 2 and the secondary barrier 4.

[0086] The primary insulation wall 3 may have a structure in which a primary plywood 31 and a primary insulating material 32 are sequentially stacked outward from the primary barrier 2 and correspond to a total of a thickness of the primary plywood 31 and a thickness of the primary insulating material 32. The primary

insulation wall 3 may be formed with a thickness of 160 mm to 250 mm.

[0087] The primary plywood 31 may be installed between the primary barrier 2 and the primary insulating material 32.

[0088] The primary plywood 31 may be formed with a thickness of 6.5 mm to 15
5 mm.

[0089] The primary insulating material 32 may be made of a material having excellent insulation performance and mechanical strength to withstand the external impact or the impact caused by the internal sloshing of the liquefied gas while blocking the influence of external heat.

10 **[0090]** The primary insulating material 32 may be made of polyurethane foam between the primary plywood 31 and the secondary barrier 4 and may correspond to a thickness of 150 mm to 240 mm.

[0091] Referring to FIG. 1, a unit element may be formed by stacking a portion of the primary insulation wall 3, the secondary barrier 4, and the secondary insulation
15 wall 5. Here, a portion of the primary insulation wall 3 constituting the unit element may be defined as a fixed insulation wall 3b, and the fixed insulation wall 3b may have a smaller width than the secondary insulation wall 5 included in the unit element. In addition, the fixed insulation wall 3b, the secondary barrier 4, and the secondary insulation wall 5 may be disposed in a fixed state in advance, but the
20 present invention is not limited thereto and may also be separately disposed in the liquefied gas storage tank 1. Therefore, a portion of the secondary barrier 4 may be exposed to both sides of the primary insulation wall 3. The unit elements may be disposed adjacent to each other, and in this case, a connection insulation wall 3a may be installed in a spatial portion between the adjacent primary insulation walls 3, that

is, a spatial portion in which the secondary barrier 4 is exposed.

[0092] The secondary barrier 4 may be divided into a main barrier 41 and an auxiliary barrier 42, and the main barrier 41 is installed above the secondary insulation wall 5 in the unit element, and the auxiliary barrier 42 is installed between the exposed main barrier 41 and the connection insulation wall 3a. In this case, the auxiliary barrier 42 is provided to interconnect the main barriers 41 provided in the adjacent unit elements. In other words, the unit elements disposed adjacent to each other may be finished by the auxiliary barrier 42 stacked on the main barrier 41 and the connection insulation wall 3a.

[0093] A stacked structure of a portion in which the connection insulation wall 3a is provided will be described with reference to FIG. 2. The connection insulation wall 3a may be provided in the form of stacking a connection plywood 31a and a connection insulating material 32a, which are the same as or similar to those described in the primary insulation wall 3 constituting the unit element, and in the specification, it should be noted that the primary insulation wall 3 may include the connection insulation wall 3a and the fixed insulation wall 3b.

[0094] FIG. 2 shows a cross-sectional structure along line A-A' in FIG. 1, and the connection insulation wall 3a may have a structure in which the connection plywood 31a and the connection insulating material 32a are stacked. A thickness of the connection insulation wall 3a may correspond to a total of a thickness of the connection plywood 31a and a thickness of the connection insulating material 32a.

[0095] The connection plywood 31a may be formed with a thickness of 6.5 mm to 15 mm.

[0096] The connection insulating material 32a may be made of polyurethane foam

between the connection plywood 31a and the auxiliary barrier 42 of the secondary barrier 4 and may correspond to a thickness of 150 mm to 240 mm.

[0097] As described above, the primary insulating material 32 of the primary insulation wall 3 and the connection insulating material 32a of the connection insulation wall 3a may have the same thickness. However, since the connection insulating material 32a of the connection insulation wall 3a has the auxiliary barrier 42 additionally stacked thereon in addition to the main barrier 41 of the secondary barrier 4, the connection insulating material 32a of the connection insulation wall 3a may have a smaller thickness than the primary insulating material 32 as much as the thickness of the auxiliary barrier 42.

[0098] When the unit elements are disposed adjacent to each other, the connection insulation wall 3a is installed to serve to block the influence of external heat while sealing the spatial portion generated between the adjacent secondary insulation walls 5 together with the auxiliary barrier 42.

[0099] However, since the connection insulation wall 3a has a structure inserted and installed between the adjacent fixed insulation walls 3b constituting the unit element, the connection insulation wall 3a is inevitably vulnerable to protect the secondary barrier 4 under the connection insulation wall 3a from a cryogenic temperature. Therefore, a problem highly likely occurs in the secondary barrier 4 under the connection insulation wall 3a in which the main barrier 41 and the auxiliary barrier 42 overlap. Therefore, hereinafter, the connection insulation wall 3a will be mainly described.

[00100] The secondary barrier 4 may be installed between the primary insulation wall 3 including the insulation wall 3a and the secondary insulation wall 5

and may prevent the liquefied gas from leaking to the outside together with the primary barrier 2.

[00101] The secondary barrier 4 under the fixed insulation wall 3b may include the main barrier 41 as a single barrier, and the secondary barrier 4 under the connection insulation wall 3a may include the main barrier 41 connecting the unit elements and the auxiliary barrier 42 provided on the secondary insulation wall 5 constituting the unit element.

[00102] The main barrier 41 may be provided on the secondary insulation wall 5 constituting the unit element and formed with a thickness of 0.6 mm to 1.0 mm, and the auxiliary barrier 42 may be stacked on the adjacent main barriers 41, thereby achieving airtightness.

[00103] The auxiliary barrier 42 may be formed with a thickness of 0.6 mm to 1.0 mm as a component connecting the unit elements and stacked on the main barrier 41.

[00104] Meanwhile, referring to FIGS. 1 and 2, the secondary insulation wall 5 may be designed to withstand the external impact or the impact caused by the internal sloshing of the liquefied gas while blocking the influence of external heat together with the fixed insulation wall 3b and the connection insulation wall 3a. In addition, the secondary insulation wall 5 may be installed between the secondary barrier 4 and the hull 7 and may include a secondary insulating material 51 and a secondary plywood 52.

[00105] The secondary insulation wall 5 may have a structure in which the secondary insulating material 51 and the secondary plywood 52 are sequentially stacked outward from the secondary barrier 4 and may be formed so that a total of a

thickness of the secondary insulating material 51 and a thickness and the secondary plywood 52 is in a range of 150 mm to 240 mm.

[00106] The secondary insulating material 51 may be made of a material having excellent insulation performance and mechanical strength to withstand the external impact or the impact caused by the internal sloshing of the liquefied gas while blocking the influence of external heat.

[00107] The secondary insulating material 51 may be made of polyurethane foam between the secondary barrier 4 and the secondary plywood 52 and formed with a thickness of 140 mm to 230 mm.

[00108] The secondary plywood 52 may be installed between the secondary insulating material 51 and the hull 7. For example, the secondary insulating material 51 may also be installed in contact with the secondary plywood 52. The secondary plywood 52 may be formed with a thickness of 6.5 mm to 25 mm.

[00109] As described above, the liquefied gas storage tank 1 according to the embodiment may be formed so that the primary insulation wall 3 has a thickness of 66% to 166% of the secondary insulation wall 5 and the connection insulation wall 3a included in the primary insulation wall 3 has a thickness of 67% to 167% of the secondary insulation wall 5 so that the connection insulation wall 3a has a thickness that is the same as or similar to that of the secondary insulation wall 5. In connection with this configuration, the connection insulating material 32a of the connection insulation wall 3a may be formed to have a thickness of 90% to 110% of the secondary insulating material 51 so that the connection insulating material 32a of the connection insulation wall 3a has a thickness that is the same as or similar to that of the secondary insulating material 51. In the embodiment, in the case of including

the connection insulation wall 3a, the fixed insulation wall 3b constituting the unit element is not described in detail, but it should be noted that in the relationship with the secondary insulation wall 5, the fixed insulation wall 3b is also the same as or similar to the connection insulation wall 3a.

5 **[00110]** When the connection insulation wall 3a and the secondary insulation wall 5 or the connection insulating material 32a of the connection insulation wall 3a and the secondary insulating material 51 are formed at such a thickness ratio, an upper limit value of stress of the secondary barrier 4 at low temperature may correspond to 50 MPa or less under the connection insulation wall 3a. In addition,
10 specifically, a stress value of the secondary barrier 4 at low temperature may be in a range of 40 MPa to 50 MPa under the connection insulation wall 3a. The value was obtained according to results of structural analysis to be described below.

[00111] In the embodiment, the connection insulation wall 3a and the secondary insulation wall 5 or the connection insulating material 32a of the primary
15 insulation wall 3 and the secondary insulating material 51 are formed to have the thicknesses that are the same or similar, and this will be described with reference to FIGS. 4 to 20.

[00112] FIGS. 4A and 4B show a tensile force of the secondary barrier 4 under the connection insulation wall 3a depending on a change in the thicknesses of
20 the connection insulation wall 3a included in the primary insulation wall 3 and the secondary insulation wall 5. In FIGS. 4A and 4B, it is assumed that the total thickness of the connection insulation wall 3a, the secondary barrier 4, and the secondary insulation wall 5 is the same.

[00113] Meanwhile, there is a difference in amounts of contraction of the

secondary barrier 4 and the secondary insulation wall 5 depending on a temperature at which the secondary barrier 4 and the secondary insulation wall 5 are exposed, and the secondary barrier 4 and the secondary insulation wall 5 may be more affected by the cooling or heating of the cryogenic liquefied gas as the thickness of the connection insulation wall 3a is smaller. In addition, in this case, there is a problem that a risk of damage to the secondary barrier 4 increases because the temperatures of the secondary barrier 4 and the secondary insulation wall 5 are reduced and the amounts of contraction thereof are increased and thus the stress at low temperature increases. In particular, this problem may mainly occur in the auxiliary barrier 42 interconnecting the main barriers 41 provided in the adjacent unit elements under the connection insulation wall 3a by bonding or the like. Both ends of the auxiliary barrier 42 under the connection insulation wall 3a are connected to the main barrier 41 of each unit element, and this is because, as the secondary insulation wall 5 of the unit element contracts, the both ends of the auxiliary barrier 42 may be deformed by moving away from or being close to each other.

[00114] FIG. 4A shows a case in which the connection insulation wall 3a is formed to be relatively thinner than the secondary insulation wall 5 so that a height of the secondary barrier 4 is positioned upward from a center of the total thickness with respect to a thickness direction. In this case, as the thickness of the secondary insulation wall 5 is largely secured to reduce the mechanical stress applied to the secondary barrier 4 when the hull is structurally deformed due to a motion with six degrees of freedom of the hull 7, the thickness of the secondary insulation wall 5 may have a relatively greater thickness than the connection insulation wall 3a.

[00115] FIG. 4B shows a case in which the connection insulation wall 3a and

the secondary insulation wall 5 are formed to have similar thicknesses so that the height of the secondary barrier 4 is positioned in a central region of the total thickness with respect to the thickness direction. Here, the central region may correspond to a range of 40% to 60% of the total thickness. In this case, compared to FIG. 4A, the amounts of contraction are reduced, and thus the stress at low temperature will be reduced. In addition, compared to FIG. 4A, the risk of damage to the secondary barrier will be relatively reduced.

[00116] In the present invention, the liquefied gas storage tank 1 is derived to reduce the low-temperature load and sloshing load of the secondary barrier 4 while maintaining the mechanical strength of the secondary insulation wall 5 at the predetermined level, which will be understood by the following description with reference to FIGS. 5 to 20.

[00117] FIGS. 5 to 20 are views showing results of the performance of a structural analysis while varying the thicknesses of the connection insulation wall 3a and the secondary insulation wall 5 in each of a first case (see FIGS. 5 to 8), a second case (see FIGS. 9 to 12), a third case (see FIGS. 13 to 16), and a fourth case (see FIGS. 17 to 20) in order to derive the thicknesses of the primary insulation wall 3 including the connection insulation wall 3a and the secondary insulation wall 5 of the liquefied gas storage tank 1 according to the embodiment. In the embodiment, the thickness of the connection insulation wall 3a is mainly described, but it should be noted that the thickness of the primary insulation wall 3 is also the same as or similar to that of the connection insulation wall 3a.

[00118] In performing the structural analysis on each case, analysis conditions are as follows.

- [00119]** First, the total thickness of the connection insulation wall 3a and the secondary insulation wall 5 in the first to fourth cases, which are analytical models, was identically formed with 400 mm.
- [00120]** Second, only a position of the secondary barrier 4 was changed by
5 varying the thickness of each of the connection insulation wall 3a and the secondary insulation wall 5.
- [00121]** Third, considering the same linear temperature distribution condition, a temperature at the position of the primary barrier 2 was set to -163 °C, which is a temperature of the liquefied gas, and a temperature at the position of the
10 hull 7 was set to 20 °C, which is room temperature.
- [00122]** Fourth, a minimum value and a maximum value of the stress value were fixed, and a difference in stress is indicated by colors, for example, red indicated the greatest stress value, and as the color went to blue, this indicated a smaller stress value.
- [00123]** Fifth, the thickness ratio was a ratio of the thickness of the
15 connection insulation wall 3a to the total thickness (400 mm).
- [00124]** The structural analyses of the first to fourth cases, which are analysis models, were performed under the analysis conditions.
- [00125]** FIGS. 5 to 8 are views showing results of the performance of the
20 structural analysis while varying the thicknesses of the connection insulation wall 3a and the secondary insulation wall 5 in the first case in order to derive the thicknesses of the connection insulation wall 3a included in the primary insulation wall 3 and the secondary insulation wall 5 of the liquefied gas storage tank 1 according to the first embodiment of the present invention.

[00126] As shown in FIG. 5, the first case is a case in which the thickness of the connection insulation wall 3a is 100 mm and the thickness of the secondary insulation wall 5 is 300 mm. In other words, in the first case, a ratio of the thickness of the connection insulation wall 3a to the total thickness (400 mm) of the connection insulation wall 3a and the secondary insulation wall 5 is 0.25, and the secondary barrier 4 is positioned close to the primary barrier 2, which is positioned at the top, from the center of the total thickness of the connection insulation wall 3a and the secondary insulation wall 5.

[00127] In the first case, as shown in FIGS. 6 to 8, as a result of the structural analysis, in a state in which the unit elements were disposed adjacent to each other, the secondary barrier 4 corresponding to a space between the adjacent secondary insulation walls 5 appeared in red-based color, and a stress value thereof was calculated as 70.12 MPa.

[00128] The reason why stress is generated in the secondary barrier 4 in the first case can be seen through FIG. 4. In other words, this is because, as the thickness of the connection insulation wall 3a is smaller, the secondary barrier 4 is more affected by the cooling or heating of the liquefied gas.

[00129] FIGS. 9 to 12 are views showing results of the performance of the structural analysis while varying the thicknesses of the connection insulation wall 3a and the secondary insulation wall 5 in the second case in order to derive the thicknesses of the connection insulation wall 3a included in the primary insulation wall 3 and the secondary insulation wall 5 of the liquefied gas storage tank according to the first embodiment of the present invention.

[00130] As shown in FIG. 9, the second case was a case in which the

thickness of the connection insulation wall 3a was 160 mm and the thickness of the secondary insulation wall 5 was 240 mm. In other words, in the second case, the ratio of the thickness of the connection insulation wall 3a to the total thickness (400 mm) of the connection insulation wall 3a and the secondary insulation wall 5 was 0.4, and the secondary barrier 4 was positioned to be slightly tilted to the primary barrier 2 from the center of the total thickness of the connection insulation wall 3a and the secondary insulation wall 5.

[00131] In the second case, as shown in FIGS. 10 to 12, as a result of the structural analysis, in a state in which the unit elements were disposed adjacent to each other, the secondary barrier 4 corresponding to the space between the adjacent secondary insulation walls 5 appeared in yellow-based color, and a stress value thereof was calculated as 55.09 MPa.

[00132] FIGS. 13 to 16 are views showing results of the performance of the structural analysis while varying the thicknesses of the connection insulation wall 3a and the secondary insulation wall 5 in the third case in order to derive the thicknesses of the connection insulation wall 3a included in the primary insulation wall 3 and the secondary insulation wall 5 of the liquefied gas storage tank according to the first embodiment of the present invention.

[00133] As shown in FIG. 13, the third case was a case in which the connection insulation wall 3a and the secondary insulation wall 5 were formed to have the thicknesses that are the same or similar. In other words, in the third case, the ratio of the thickness of the connection insulation wall 3a to the total thickness (400 mm) of the connection insulation wall 3a and the secondary insulation wall 5 was about 0.5, and the secondary barrier 4 was positioned adjacent to the center of

the total thickness of the connection insulation wall 3a and the secondary insulation wall 5.

[00134] In the third case, as shown in FIGS. 14 to 16, as a result of the structural analysis, in a state in which the unit elements were disposed adjacent to each other, the secondary barrier 4 corresponding to the space between the adjacent secondary insulation walls 5 appeared in bright sky blue-based color, and a stress value thereof was calculated as 47.63 MPa.

[00135] FIGS. 17 to 20 are views showing results of the performance of the structural analysis while varying the thicknesses of the connection insulation wall 3a and the secondary insulation wall 5 in the fourth case in order to derive the thicknesses of the connection insulation wall 3a included in the primary insulation wall 3 and the secondary insulation wall 5 of the liquefied gas storage tank according to the first embodiment of the present invention.

[00136] As shown in FIG. 17, the fourth case is a case in which the thickness of the connection insulation wall 3a was 240 mm, and the thickness of the secondary insulation wall 5 was 160 mm. In other words, in the fourth case, the ratio of the thickness of the connection insulation wall 3a to the total thickness (400 mm) of the connection insulation wall 3a and the secondary insulation wall 5 was about 0.6, and the secondary barrier 4 was positioned downward from the center of the total thickness of the connection insulation wall 3a and the secondary insulation wall 5.

[00137] In the fourth case, as shown in FIGS. 18 to 20, as a result of the structural analysis, in a state in which the unit elements were disposed adjacent to each other, the secondary barrier 4 corresponding to the space between the adjacent secondary insulation walls 5 appeared in sky blue-based color, and a stress value was

calculated as 41.21 MPa.

[00138] As described above, as a result of the structural analysis of each of the first to fourth cases, it can be seen that the low-temperatures stress due to heat contraction tends to be reduced in the secondary barrier 4 under the connection
5 insulation wall 3a as the secondary barrier 4 moves away from the primary barrier 2. This will be described with reference to FIG. 21.

[00139] FIG. 21 is a graph showing the relationship between a low-temperature stress of the secondary barrier and a probability of brittle fracture of a hull depending on the change in the thicknesses of the primary insulation wall and
10 the secondary insulation wall.

[00140] As shown in the graph shown in FIG. 21, in addition to the first case to the fourth case, it can be predicted that the stress value due to the heat contraction at low temperature is more reduced in the secondary barrier 4 under the connection insulation wall 3a as the secondary barrier 4 further moves away from the primary
15 barrier 2. In other words, it can be seen that since the secondary barrier 4 under the connection insulation wall 3a has a relatively higher temperature than when the secondary barrier 4 is closer to the primary barrier 2 as the secondary barrier 4 moves away from the primary barrier 2, the contraction is reduced and thus the stress is reduced. In the embodiment, the secondary barrier 4 under the connection
20 insulation wall 3a is mainly described, but it will be apparent that the stress is also reduced in the secondary barrier 4 under the fixed insulation wall 3b constituting the unit element as the secondary barrier 4 moves away from the primary barrier 2. The secondary barrier 4 under the connection insulation wall 3a is in a state in which the main barrier 41 and the auxiliary barrier 42 are stacked, and the secondary barrier

4 under the primary insulation wall 3 is formed of only the main barrier 41.

[00141] In the liquefied gas storage tank 1 in the embodiment derived as described above, as the thickness of the connection insulation wall 3a from the total thickness of the connection insulation wall 3a and the secondary insulation wall 5 increases, the temperature received by the secondary barrier 4 is increased (influence by the cooling or the heating from the cryogenic liquefied gas is reduced). Therefore, it is possible to reduce the contraction of the secondary barrier 4 itself caused by the cooling or the heating and reduce the stress caused by the cooling or the heating, thereby preventing damage to the secondary barrier 4 caused by the cooling or the heating. It goes without saying that this principle is also applied to the secondary barrier 4 under the primary insulation wall 3 defined as including the connection insulation wall 3a.

[00142] In addition, as the thicknesses of the connection insulation wall 3a and the fixed insulation wall 3b increase (the thickness of the secondary insulation wall 5 is relatively reduced), a sloshing load and a hydrodynamic load transmitted to the secondary barrier 4 may be reduced, and the stress due to sloshing may be reduced, thereby preventing the damage to the secondary barrier 4 due to the sloshing. In addition, as the thickness of the secondary insulation wall 5 is smaller (the thickness of the primary insulation wall 3 is relatively larger), it may be easier to level the secondary barrier 4.

[00143] In addition, the thickness of the secondary insulation wall 5 may be relatively reduced as the thicknesses of the connection insulation wall 3a and the fixed insulation wall 3b increase, a contraction caused by the cooling or the heating of the secondary insulation wall 5 may also be reduced as the secondary insulation

wall 5 relatively moves away from the primary barrier 2, and the tensile force of the secondary barrier 4 may be reduced as the contraction of the secondary insulation wall 5 is reduced, thereby preventing the damage to the secondary barrier 4 due to the contraction of the secondary insulation wall 5.

5 **[00144]** Considering the low-temperature stress of the secondary barrier 4, in the present invention, the connection insulation wall 3a may be disposed to correspond to 40% or more of the total thickness of the connection insulation wall 3a and the secondary insulation wall 5. Preferably, in the liquefied gas storage tank 1 according to the present invention, the connection insulation wall 3a may be disposed
10 in the ranges in the second case to the fourth case, that is, disposed to correspond to a range of 40% to 60% of the total thickness of the connection insulation wall 3a and the secondary insulation wall 5. More preferably, in the liquefied gas storage tank 1 according to the present invention, the connection insulation wall 3a may be disposed in the range in the third case, that is, disposed to correspond to a range of 47% to
15 53% of the total thickness of the connection insulation wall 3a and the secondary insulation wall 5.

20 **[00145]** However, when the thicknesses of the connection insulation wall 3a and the primary insulation wall 3 are increased, since the thickness of the secondary insulation wall 5 is relatively reduced, the secondary insulation wall 5 is inevitably vulnerable to the mechanical stress applied when the hull 7 is structurally deformed by the motion with six degrees of freedom of the hull 7, and thus a level of the mechanical stress transmitted to the secondary barrier 4 through the secondary insulation wall 5 is inevitably increased.

25 **[00146]** In addition, in a state in which the liquefied gas is loaded, an

emergency condition, such as breakage of the primary barrier 2, may occur. In this case, since the primary barrier 2 can no longer prevent the leakage of the liquefied gas, the liquefied gas may be in contact with the secondary barrier 4. In addition, when the secondary barrier 4 is in contact with the cryogenic liquefied gas, the temperature of the hull may be reduced, thereby increasing the probability of brittle fracture. In addition, as the temperature is reduced, a material strength of the hull increases but a brittle problem may occur, thereby increasing the probability of brittle fracture. Here, the brittle fracture may correspond to sudden fracture that occurs with almost no plastic deformation and may also be understood as brittle crack.

10 **[00147]** In this regard, referring to FIG. 21, in the emergency condition, the secondary barrier 4 in contact with the cryogenic liquefied gas may be closer to the hull as the corresponding case moves from the first case to the fourth case, thereby increasing the probability of brittle fracture. In other words, in FIG. 21, the probability of brittle fracture of the hull further increases as the corresponding case

15 moves from the first case to the fourth case, that is, as the thickness of the connection insulation wall is greater than the thickness of the secondary insulation wall 5. In addition, when the thickness of the connection insulation wall 3a in the fourth case further increases, the probability of brittle fracture is close to 1, and the hull may crack or destruct.

20 **[00148]** Therefore, an insulation system of the liquefied gas storage tank 1 needs to be disposed in consideration of not only the above-described low-temperature stress but also the risk of crack or destruction of the hull. In the present invention, the second case to the fourth case in which the secondary barrier 4 is positioned in the central region of the total thickness of the connection insulation

wall 3a and the secondary insulation wall 5 may be appropriate considering all aspects of the low-temperature stress and the crack of the hull. Preferably, the third case can be considered appropriate considering the mechanical aspects of the low-temperature stress and the crack of the hull.

5 **[00149]** Therefore, in the present invention, the second case to the fourth case in which the thicknesses of the connection insulation wall 3a and the primary insulation wall 3 may be sufficiently secured, thereby reducing the low-temperature stress of the secondary barrier 4 and the thickness of the secondary barrier 4 may be appropriately provided to have an interval between the hull 7 and the secondary
10 barrier 4, thereby reducing the load on the structural stress transmitted from the hull 7 by the secondary barrier 4 can be considered appropriate embodiments. In addition, the third case among the second case to the fourth case will correspond to a preferred embodiment considering all aspects of the low-temperature stress and the mechanical strength.

15 **[00150]** Meanwhile, the secondary barrier 4 may be made of any of various materials, and this will be described with reference to FIGS. 22 to 24.

[00151] FIGS. 22, 23, and 24 are views showing various configurations of the secondary barrier of the liquefied gas storage tank according to the first embodiment of the present invention.

20 **[00152]** As shown in FIG. 22, the secondary barrier 4 may be made of a first material having a three-layer structure of stacked glass cloth (GC)/aluminum foil (AF)/glass-aramid cloth (GAC).

[00153] The GAC may be obtained by applying an aramid material to glass cloth and manufactured by mixing one line of aramid per two lines of glass fibers.

- [00154]** The first material may be applied to the auxiliary barrier 42 of the secondary barrier 4 and is not limited thereto, and it goes without saying that the first material may also be applied to the main barrier 41 of the secondary barrier 4.
- [00155]** As shown in FIG. 23, the secondary barrier 4 may be made of a
5 second material having a five-layer structure of stacked GC/AF/GC/AF/GC.
- [00156]** The second material may be applied to the main barrier 41 of the secondary barrier 4 and is not limited thereto, and it goes without saying that the second material may also be applied to the auxiliary barrier 42 of the secondary barrier 4.
- 10 **[00157]** As shown in FIG. 24, the secondary barrier 4 may use inorganic basalt cloth extracted from basalt and may be made of a third material having a three-layer structure of stacked basalt cloth (BC)/AF/BC.
- [00158]** The third material may be applied to the main barrier 41 of the secondary barrier 4 and is not limited thereto, and it goes without saying that the
15 third material may also be applied to the auxiliary barrier 42 of the secondary barrier 4.
- [00159]** As described in FIGS. 22 to 24, the secondary barrier 4 in the embodiment may be made of various materials having a multilayer structure of stacked first material/AF/ second material. In this case, at least one of the first
20 material and the second material may be GC, GAC, BC, or GC/AF/GC.
- [00160]** In addition, it goes without saying that various materials applied to the secondary barrier 4 may be applied to the main barrier 41 and the auxiliary barrier 42 of the secondary barrier 4 in various combinations.
- [00161]** FIG. 25 is a partial cross-sectional view showing a right angle

corner structure of the liquefied gas storage tank according to the first embodiment of the present invention, and FIG. 26 is a partial cross-sectional view showing an obtuse angle corner structure of the liquefied gas storage tank according to the first embodiment of the present invention.

5 **[00162]** In FIGS. 5 to 20, it can be seen that when the thickness of the connection insulation wall 3a or the primary insulation wall 3 and the thickness of the secondary insulation wall 5 is formed in the same or similar range, a more stable insulation system is secured. For example, the same or similar range may indicate a case in which the secondary barrier 4 is positioned in a range of 40% to 60% of the
10 total thickness of the connection insulation wall 3a or the primary insulation wall 3 and the secondary insulation wall 5. This configuration may also be applied to the right angle corner structure of the liquefied gas storage tank 1 shown in FIG. 25 and the obtuse angle corner structure of the liquefied gas storage tank 1 shown in FIG. 26 in the same manner.

15 **[00163]** However, in the right angle corner structure and the obtuse angle corner structure of the liquefied gas storage tank 1, the secondary barrier 4 is inevitably formed in a curved shape, and when formed in the curve shape, the secondary barrier 4 is vulnerable to a load caused by the nearby environment compared to a linear portion, and in the embodiment, it is possible to mitigate the
20 stress caused by the load. In addition, in the embodiment, the deformation of the hull may be easily absorbed.

[00164] Referring to FIG. 25, in the right angle corner structure, as the thickness of the primary insulation wall 3 becomes greater than in the first and second cases, the curvature radius of the secondary barrier 4 corresponds to 25% or

more, for example, 25% to 50% of the thickness of the primary insulation wall 3.

[00165] In addition, in the right angle corner structure, as the thickness of the primary insulation wall 3 becomes greater than in the first and second cases, the secondary barrier 4 moves toward the hull 7 compared to the existing thin primary
5 insulation wall. In this case, the curvature radius increases, and as the curvature radius increases, a length L1 of a portion in which the secondary barrier 4 is not attached to the secondary insulation wall 5 also increases. This means that the flexibility of the secondary barrier 4 increases in the right angle corner structure, and thus the secondary barrier 4 in the right angle corner structure easily absorbs the
10 deformation of nearby portions, for example, the deformation of the hull, and the low-temperature stress is also reduced in the secondary barrier 4. For example, the length L1 of the non-adhesive portion may be in a range of 100 mm to 200 mm.

[00166] Referring to FIG. 26, in the obtuse angle corner structure, as the thickness of the primary insulation wall 3 becomes greater than in the first and
15 second cases, the curvature radius of the secondary barrier 4 corresponds to 15% or more, for example, 15% to 35% of the thickness of the primary insulation wall 3.

[00167] In addition, in the obtuse angle corner structure, as the thickness of the primary insulation wall 3 becomes greater than in the first and second cases, the secondary barrier 4 moves toward the hull 7 compared to the existing thin primary
20 insulation wall, thereby increasing the curvature radius. In this case, as the curvature radius of the secondary barrier 4 increases, a length L2 of a portion in which the secondary barrier is not attached to the secondary insulation wall 5 also increases. This means that the flexibility of the secondary barrier 4 increases in the obtuse angle corner structure, and thus the secondary barrier 4 in the obtuse angle

corner structure easily absorbs the deformation of nearby portions, for example, the deformation of the hull, and the low-temperature stress is also reduced in the secondary barrier 4. For example, the length L2 of the non-adhesive portion may be in a range of 50 mm to 90 mm.

- 5 **[00168]** As described above, the low-temperature stress applied to the existing secondary barrier compared to the right angle corner structure and the obtuse angle corner structure of the primary insulation wall formed in a relatively smaller thickness may be reduced in the secondary barriers 4 in the right angle corner structure and the obtuse angle corner structure according to the present invention.
- 10 In addition, since the non-adhesive portion increases, the deformation of the hull is easily absorbed as well.

[00169] FIG. 27 is a graph showing a thermal conductivity according to materials used for a primary insulating material and a secondary insulating material of the liquefied gas storage tank.

- 15 **[00170]** In the liquefied gas storage tank 1 according to the embodiment of the present invention, each of the connection insulation wall 3a, the primary insulating materials 32 and 32a of the primary insulation wall 3, and the secondary insulating material 51 of the secondary insulation wall 5 has been described as being made of polyurethane foam having the same material, but may selectively use
- 20 polyurethane foam having different materials in some cases.

[00171] Specifically, reinforced polyurethane foam (RPUF) is manufactured by mixing polyol, isocyanate, and a blowing agent, and HFC-245fa or CO₂ may be used as the blowing agent. HFC-245fa may be relatively more expensive than CO₂.

[00172] In the embodiment, the primary insulating material 32 and 32a are

made of the RPUF that uses the blowing agent CO₂, and the secondary insulating material 51 is made of the RPUF that uses the blowing agent HFC-245fa.

[00173] Describing thermal conductivity characteristics of the blowing agent HFC-245fa and the blowing agent CO₂ with reference to the graph in FIG. 27, the
5 blowing agent HFC-245fa has a smaller thermal conductivity value than the blowing agent CO₂ at room temperature, but shows a value that is the same as or similar to that of the blowing agent CO₂ as the temperature is reduced to the cryogenic temperature.

[00174] In other words, the thermal conductivity values of the blowing agent
10 HFC-245fa and the blowing agent CO₂ show the same value or similar values at a temperature below -80 °C, and the blowing agent HFC-245fa shows a lower value than the blowing agent CO₂ at a temperature greater than or equal to -80 °C.

[00175] Therefore, in the embodiment, the relatively expensive blowing agent HFC-245fa is not used for the primary insulating material 32 and 32a and the
15 secondary insulating material 51, and considering the economic aspect, the primary insulating material 32 and 32a may be formed of the reinforced polyurethane foam that uses the blowing agent CO₂, and the secondary insulating material 51 may be formed of the reinforced polyurethane foam that uses the blowing agent HFC-245fa.

[00176] FIG. 28 is a partial cross-sectional view showing a liquefied gas
20 storage tank according to a second embodiment of the present invention, and FIG. 29 is a partial perspective view showing the liquefied gas storage tank according to the second embodiment of the present invention.

[00177] As shown in FIGS. 28 and 29, the liquefied gas storage tank 1 according to the second embodiment of the present invention may include a primary

barrier 2 in contact with liquefied gas therein, a primary insulation wall 3 and a connection insulation wall 3a installed outside the primary barrier 2, a secondary barrier 4 installed outside the primary insulation wall 3 and the connection insulation wall 3a, and a secondary insulation wall 5 disposed outside the secondary barrier 4 and fixed to a hull 7, and since the configuration of the connection insulation wall 3a in the embodiment is different from that of the first embodiment and other configurations are the same as or similar to those of the first embodiment, only changed portions will be described below in order to avoid overlapping descriptions.

[00178] In the embodiment, the configuration of the connection insulation wall 3a may be different from that of the first embodiment.

[00179] Specifically, compared to the first embodiment, the connection insulation wall 3a may further include an auxiliary insulation plate 33.

[00180] In other words, the connection insulation wall 3a may have a structure in which a connection plywood 31a, a connection insulating material 32a, and the auxiliary insulation plate 33 are stacked.

[00181] The auxiliary insulation plate 33 may have a thickness of 5 mm to 10 mm and may be made of plywood, high-density polyurethane foam (HD PUF), fiber reinforced plastic (FRP), etc. to obtain the load distribution effect of the secondary barrier 4. Alternatively, the auxiliary insulation plate 33 may be formed of vacuum insulation panel (VIP), low-density polyurethane foam (LD PUF), etc. having excellent insulation characteristics to compensate for the insulation weakness of a portion in which the connection insulation wall 3a is formed.

[00182] The connection insulating material 32a of the connection insulation wall 3a and the primary insulating material 32 of a fixed insulation wall 3b

constituting a unit element may have the same thickness. However, since the connection insulation wall 3a has an auxiliary barrier 42 stacked thereunder in addition to a main barrier 41 of the secondary barrier 4 and also includes the auxiliary insulation plate 33, a thickness of the connection insulating material 32a of
5 the connection insulation wall 3a may be smaller than the primary insulating material 32 of the primary insulation wall 3 as much as a thickness of the auxiliary barrier 42 and a thickness of the auxiliary insulation plate 33.

[00183] It goes without saying that the auxiliary insulation plate 33 may be installed not only under the connection insulating material 32a of the connection
10 insulation wall 3a but also under the primary insulating material 32 of the primary insulation wall 3 constituting the unit element.

[00184] FIG. 30 is a partial cross-sectional view showing a liquefied gas storage tank according to a third embodiment of the present invention, and FIG. 31 is an enlarged view of a main part of the liquefied gas storage tank according to the
15 third embodiment of the present invention.

[00185] As shown in FIGS. 30 and 31, the liquefied gas storage tank 1 according to the third embodiment of the present invention may include a primary barrier 2 in contact with liquefied gas therein, a primary insulation wall 3 and a connection insulation wall 3a installed outside the primary barrier 2, a secondary
20 barrier 4 installed outside the primary insulation wall 3 and the connection insulation wall 3a, a secondary insulation wall 5 disposed outside the secondary barrier 4 and fixed to a hull 7, a leveling member 8 installed between the secondary insulation wall 5 and the hull 7, and a fixing member 9 for fixing the secondary insulation wall 5 to the hull 7, and since the embodiment is different from the first embodiment in that

the leveling member 8 and the fixing member 9 are formed and other configurations are the same as or similar to those of the first embodiment, the leveling member 8 and the fixing member 9, which are components different from those of the first embodiment, and only portions changed by the leveling member 8 and the fixing member 9 will be described below in order to avoid overlapping descriptions.

[00186] The leveling member 8 may be installed between the secondary insulation wall 5 and the hull 7.

[00187] The leveling member 8 may be a non-adhesive elastic insulating material capable of leveling a deformed portion of the hull 7, increasing the insulation performance of the tank, and supporting the secondary insulation wall 5 and may be made of expanded polystyrene (EPS), etc.

[00188] An upper surface of the leveling member 8 in close contact with the secondary insulation wall 5 by an elastic force may become flat, and a lower surface of the leveling member 8 in close contact with the hull 7 may have a curved surface to match the deformation of the hull 7. The hull 7 may be deformed, for example, upon welding between blocks of the hull 7.

[00189] In other words, the leveling member 8 may level the deformed portion of the hull even without using the existing mastic and leveling wedge. Here, it goes without saying that the leveling wedge may be selectively used.

[00190] In the embodiment, by applying the leveling member 8, unlike the existing mastic applied in various types according to a size of a gap, the leveling member 8 may be constructed in a single size and does not require a mastic curing time, thereby shortening a work time and may apply the insulating material, thereby increasing heat retention.

- [00191]** The fixing member 9 may have a cleat structure including protrusions 91 and a stud bolt 92 to fix the secondary insulation wall 5 to the hull 7.
- [00192]** The protrusions 91 may be provided to protrude outward from lower portions of both side surfaces of the unit panel of the secondary insulation wall 5 and
5 made of plywood.
- [00193]** The protrusion 91 may have one side surface fixedly installed over a side surface of a secondary plywood 52 of the secondary insulation wall 5 and a partial side surface of a secondary insulating material 51 from the secondary plywood 52 to a predetermined height and have a lower surface having the same
10 level as a lower surface of the secondary plywood 52.
- [00194]** Widths and thicknesses of the protrusions 91 may be sizes sufficient for inserting the stud bolt 92 between the protrusions 91 facing each other when a plurality of unit panels constituting the secondary insulation wall 5 are disposed.
- [00195]** The stud bolt 92 may be fixed to the hull 7.
- 15 **[00196]** The stud bolt 92 may fixedly installed to the hull 7 to match a space between the unit panels of the adjacent secondary insulation walls 5 when the plurality of unit panels constituting the secondary insulation wall 5 are disposed.
- [00197]** The stud bolt 92 may be provided on a side surface of each of the unit panels of the adjacent secondary insulation walls 5 and may fix the secondary
20 insulation wall 5 to the hull 7 by tightening the bolt in a state of being positioned between two protrusions 91 facing each other.
- [00198]** FIG. 32 is a partial cross-sectional view showing a liquefied gas storage tank according to a fourth embodiment of the present invention, FIG. 33 is a view showing an insulating filler material for filling a first slit forming a gap

between a connection insulation wall and a fixed insulation wall, which constitute a primary insulation wall, and a plurality of second slits provided in the fixed insulation wall, FIG. 34 is a view showing an insulating filler material for filling the first slit forming the gap between the connection insulation wall and the fixed insulation wall, which constitute the primary insulation wall, and the plurality of second slits provided in the fixed insulation wall according to another embodiment, and FIG. 35 is a view showing an insulating filler material for filling the first slit forming the gap between the connection insulation wall and the fixed insulation wall, which constitute the primary insulation wall, and the plurality of second slits provided in the fixed insulation wall according to still another embodiment.

[00199] As shown in FIGS. 32 to 35, the liquefied gas storage tank 1 according to the fourth embodiment of the present invention may include a primary barrier 2 in contact with liquefied gas therein, a primary insulation wall 3 installed outside the primary barrier 2 and including a connection insulation wall 3a and a fixed insulation wall 3b, a secondary barrier 4 installed outside the primary insulation wall 3, and a secondary insulation wall 5 disposed outside the secondary barrier 4 and fixed to a hull 7, and since the embodiment is different from the first embodiment in that a first slit SL1 forming a gap between the connection insulation wall 3a and the fixed insulation wall 3b is filled and a plurality of second slits SL2 are provided in the fixed insulation wall 3b and other configurations are the same as or similar to those of the first embodiment, changed portions will be mainly described below in order to avoid overlapping descriptions.

[00200] The primary insulation wall 3 and the secondary insulation wall 5 in the embodiment may have the same thickness or similar thicknesses as described

above.

[00201] The primary insulation wall 3 may include the connection insulation wall 3a and the fixed insulation wall 3b.

[00202] The connection insulation wall 3a may be inserted and installed
5 between the adjacent fixed insulation walls 3b to seal a spatial portion formed between the adjacent secondary insulation walls 5 when unit elements including the fixed insulation wall 3b are disposed adjacent to each other, and in this case, the gap may be formed between the connection insulation wall 3a and the fixed insulation wall 3b.

10 **[00203]** The first slit SL1 may be the gap formed between the connection insulation wall 3a and the fixed insulation wall 3b and formed to a depth corresponding to a thickness of the primary insulation wall 3.

[00204] In addition, in the embodiment, the plurality of second slits SL2 may be formed in the fixed insulation wall 3b at regular intervals to cope with contraction
15 and expansion of the fixed insulation wall 3b.

[00205] The second slit SL2 may be formed to a depth that is similar to the thickness of the fixed insulation wall 3b to maximally mitigate a contraction or expansion stress due to a temperature applied to the fixed insulation wall 3b. For example, when the thickness of the fixed insulation wall 3b is 200 mm, the depth of
20 the second slit SL2 may be in a range of 185 mm to 195 mm, but is not limited thereto.

[00206] The first slit SL1 and the second slit SL2 can mitigate the contraction or expansion stress due to the temperature, thereby preventing damage to the primary insulation wall 3, but may serve as a convection path to increase the low-

temperature load of the secondary barrier 4.

[00207] Therefore, in the embodiment, the first slit SL1 may be fully or partially filled with a first insulating filler material GW1, and the second slit SL2 may be partially filled with a second insulating filler material GW2, thereby
5 preventing damage due to contraction and expansion of the fixed insulation wall 3b and also reducing the low-temperature load of the secondary barrier 4, which will be described in detail below.

[00208] The first insulating filler material GW1 and the second insulating filler material GW2 may be inserted into and fill the first slit SL1 and the second slit
10 SL2 using a jig.

[00209] As shown in FIGS. 33 to 35, the first insulating filler material GW1 may be formed to fully fill the first slit SL1 (see FIG. 33), formed to fill the first slit SL1 from an inlet of the first slit SL1 to a predetermined depth so that a space is formed in a lower portion of the first slit SL1 (see FIG. 34), or formed to fill an
15 inside of the first slit SL1 in multiple layers so that a plurality of spaces are formed inside the first slit SL1 (see FIG. 35).

[00210] In addition, as shown in FIGS. 33 to 35, the second insulating filler material GW2 may be formed to fill the second slit SL2 from an inlet of the second slit SL2 to a predetermined depth so that a space is formed in a lower portion of the
20 second slit SL2 (see FIGS. 33 and 34) or formed to fill an inside of the second slit SL2 in multiple layers so that a plurality of spaces are formed inside the second slit SL2 (see FIG. 35).

[00211] In the above description, each of the first insulating filler material GW1 filling in the first slit SL1 and the second insulating filler material GW2 filling

the second slit SL2 may be formed to have a (+) tolerance to completely seal the space in a state of filling the spaces of the first slit SL1 and the second slit SL2, thereby absorbing contraction and expansion.

[00212] Referring to FIG. 33, the first insulating filler material GW1 may be formed to fully fill the first slit SL1, and the second insulating filler material GW2 may be formed to fill the second slit SL2 from the inlet of the second slit SL2 to the predetermined depth so that the space is formed in a lower portion of the second slit SL2.

[00213] The first insulating filler material GW1 and the second insulating filler material GW2 may be made of glass wool, but are not limited thereto.

[00214] In the above description, the first insulating filler material GW1 may be formed to fully fill the first slit SL1, thereby increasing the insulation performance of a connected portion between the connection insulation wall 3a and the fixed insulation wall 3b. The second insulating filler material GW2 may be formed so that the space is formed in a lower portion of the second slit SL2, thereby not only increasing the insulation performance of the fixed insulation wall 3b by the second insulating filler material GW2 but also absorbing the contraction and expansion of the fixed insulation wall 3b in the spatial portion of the second slit SL2.

[00215] Referring to FIG. 34, the first insulating filler material GW1 may be formed to fill the first slit SL1 from the inlet of the first slit SL1 to the predetermined depth so that the space is formed in a lower portion of the first slit SL1, and the second insulating filler material GW2 may be formed to fill the second slit SL2 from the inlet of the second slit SL2 to the predetermined depth so that the space is formed in a lower portion of the second slit SL2.

[00216] The first insulating filler material GW1 and the second insulating filler material GW2 may be made of glass wool, but are not limited thereto.

[00217] In the above description, the first insulating filler material GW1 may be formed so that the space is formed in a lower portion of the first slit SL1, thereby
5 not only increasing the insulation performance of the connected portion between the connection insulation wall 3a and the fixed insulation wall 3b by the first insulating filler material GW1 but also absorbing the contraction and expansion of the connection insulation wall 3a and the fixed insulation wall 3b in the spatial portion of the first slit SL1. The second insulating filler material GW2 may be formed so that
10 the space is formed in a lower portion of the second slit SL2, thereby not only increasing the insulation performance of the fixed insulation wall 3b by the second insulating filler material GW2 but also absorbing the contraction and expansion of the fixed insulation wall 3b in the spatial portion of the second slit SL2.

[00218] Referring to FIG. 35, the first insulating filler material GW1 may be
15 formed to fill the first slit SL1 in multiple layers so that the plurality of spaces are formed inside the first slit SL1, and the second insulating filler material GW2 may be formed to fill the second slit SL2 in multiple layers so that the plurality of spaces are formed inside the second slit SL2.

[00219] The first insulating filler material GW1 may include a first upper
20 insulating filler material GW1-1 formed on an upper portion of the first slit SL1, a first middle insulating filler material GW1-2 spaced a predetermined interval from the first upper insulating filler material GW1-1 and formed in the middle of the first slit SL1, and a first lower insulating filler material GW1-3 spaced a predetermined interval from the first middle insulating filler material GW1-2 and formed in a lower

portion of the first slit SL1.

[00220] Each of the first upper insulating filler material GW1-1, the first middle insulating filler material GW1-2, and the first lower insulating filler material GW1-3 may be formed of the same insulating material or different insulating materials, and in this case, as the insulating material, glass wool, super lite, a soft foam material, an aerogel blanket, etc. may be used.

[00221] The second insulating filler material GW2 may include a second upper insulating filler material GW2-1 formed on an upper portion of the second slit SL2, a second middle insulating filler material GW2-2 spaced a predetermined interval from the second upper insulating filler material GW2-1 and formed in the middle of the second slit SL2, and a second lower insulating filler material GW2-3 spaced a predetermined interval from the second middle insulating filler material GW2-2 and formed in a lower portion of the second slit SL2.

[00222] Each of the second upper insulating filler material GW2-1, the second middle insulating filler material GW2-2, and the second lower insulating filler material GW2-3 may be formed of the same insulating material or different insulating materials, and in this case, as the insulating material, glass wool, super lite, a soft foam material, an aerogel blanket, etc. may be used.

[00223] In the above description, the first insulating filler material GW1 may be formed in multiple layers so that the plurality of spaces are formed inside the first slit SL1, thereby not only increasing the insulation performance of the connected portion between the connection insulation wall 3a and the fixed insulation wall 3b by the multi-layered first insulating filler materials GW1-1, GW1-2, and GW1-3 but also absorbing the contraction and expansion of the connection insulation wall 3a

and the fixed insulation wall 3b in the plurality of spatial portions of the first slit SL1. The second insulating filler material GW2 may be formed so that the plurality of spaces are formed inside the second slit SL2, thereby not only increasing the insulation performance of the fixed insulation wall 3b by the multi-layered second
5 insulating filler materials GW2-1, GW2-2, and GW2-3 but also absorbing the contraction and expansion of the fixed insulation wall 3b in the plurality of spatial portions of the second slit SL2.

[00224] FIG. 36 is a partial cross-sectional view showing a liquefied gas storage tank according to a fifth embodiment of the present invention, FIG. 37 is a
10 cross-sectional view of a connection insulation wall along line A-A' in FIG. 36, FIG. 38 is a cross-sectional view of a unit element formed by stacking a secondary insulation wall, a secondary barrier, and a fixed insulation wall constituting a primary insulation wall along line B-B' in FIG. 36, FIGS. 39 and 40 are views showing an insulating filler material for filling a first slit forming a gap between the
15 fixed insulation wall and a connection insulation wall, which constitute the primary insulation wall, FIGS. 41 and 42 are views showing structural analysis results of the liquefied gas storage tank according to the fifth embodiment of the present invention, FIGS. 43 to 46 are views showing a comparison of convection paths and temperatures of secondary barriers that vary depending on a structure of the slit and
20 whether the insulating filler material is applied thereto in the liquefied gas storage tank according to the fifth embodiment of the present invention and a liquefied gas storage tank according to a comparative example, and FIG. 47 is a graph showing a comparison between the temperatures of the secondary barriers under the slits depending on whether the insulating filler material for filling the slit is present in the

liquefied gas storage tank according to the fifth embodiment of the present invention and the liquefied gas storage tank according to the comparative example.

[00225] As shown in FIGS. 36 to 40, the liquefied gas storage tank 1 according to the fifth embodiment of the present invention may include a primary barrier 2 in contact with liquefied gas therein, a primary insulation wall 3 installed
5 outside the primary barrier 2 and including a connection insulation wall 3a and a fixed insulation wall 3b, a secondary barrier 4 installed outside the primary insulation wall 3, and a secondary insulation wall 5 disposed outside the secondary barrier 4 and fixed to a hull 7, and since a first insulating filler material GW1 for filling a first
10 slit SL1 forming a gap between the connection insulation wall 3a and the fixed insulation wall 3b and a plurality of second slits SL2 provided in the fixed insulation wall 3b in the embodiment are different from those of the above-described fourth embodiment and other configurations are the same as or similar to those of the first embodiment, changed portions will be mainly described below in order to avoid
15 overlapping descriptions.

[00226] The primary insulation wall 3 and the secondary insulation wall 5 in the embodiment may have the same thickness or similar thicknesses as described above.

[00227] The primary insulation wall 3 may include the connection insulation
20 wall 3a and the fixed insulation wall 3b, and in this case, the connection insulation wall 3a may be inserted and installed between the adjacent fixed insulation walls 3b to seal a space formed between the adjacent secondary insulation walls 5 when unit elements including the fixed insulation wall 3b are disposed adjacent to each other. In this case, the gap may be formed between the connection insulation wall 3a and

the fixed insulation wall 3b.

[00228] The first slit SL1 may be a gap formed between the connection insulation wall 3a and the fixed insulation wall 3b and formed to a depth corresponding to a thickness of the primary insulation wall 3.

5 **[00229]** In addition, in the embodiment, the plurality of second slits SL2 may be formed in the fixed insulation wall 3b at regular intervals to cope with contraction and expansion of the fixed insulation wall 3b. One or more second slits SL2 may be formed not only in a longitudinal direction of the fixed insulation wall 3b but also as shown in FIG. 38, in a width direction of the fixed insulation wall 3b.

10 **[00230]** In addition, in the embodiment, one or more third slits SL3 may be formed in the connection insulation wall 3a to cope with contraction and expansion of the connection insulation wall 3a. The third slit SL3 is not formed in a relatively narrower width direction, and as shown in FIG. 37, one or more third slits SL3 may be formed in a relatively longer longitudinal direction. The third slit SL3 formed in
15 the longitudinal direction may be positioned collinearly with the second slit SL2 formed in the longitudinal direction when the connection insulation wall 3a is inserted between the fixed insulation walls 3b.

[00231] In the above description, the second slit SL2 may be formed to a depth corresponding to about half of the thickness of the fixed insulation wall 3b to
20 secure insulation performance while mitigating a contraction or expansion stress due to a temperature applied to the fixed insulation wall 3b, and the insulating filler material does not fill the inside of the second slit SL2. For example, when the thickness of the fixed insulation wall 3b is 200 mm, the second slit SL2 may have a depth of about 90 mm but is not limited thereto, and it goes without saying that the

second slit SL2 may be formed in a range of 100 mm to 50 mm. The third slit SL3 may be formed similarly or identically to the second slit SL2.

[00232] It can be seen that when the first slit SL1, the second slit SL2, and the third slit SL3 are not filled with any insulating filler material, as in the structural analysis results shown in FIG. 41, the insulation performance of the fixed insulation wall 3b and the connection insulation wall 3a around the first slit SL1 formed to a greater depth is smaller than that of the fixed insulation wall 3b in which the second slit SL2 is formed, which is formed to a smaller depth. This is because a convection phenomenon mainly occurs through the deeper first slit SL1.

[00233] Therefore, in the embodiment, it can be seen that by partially filling the first slit SL1 with the first insulating filler material GW1, as in the structural analysis results shown in FIG. 42, it can be seen that the first insulating filler material GW1 prevents the heat convection phenomenon, and thus the insulation performance of the fixed insulation wall 3b and the connection insulation wall 3a around the first slit SL1 formed to the greater depth is shown as being similar to the insulation performance of the fixed insulation wall 3b in which the second slit SL2 is formed, which is formed to the smaller depth. In other words, it can be seen that when the first insulating filler material GW1 fills the first slit SL1, a low-temperature transmission depth is flattened in all portions.

[00234] In the embodiment, the first insulating filler material GW1 filling the first slit SL1 needs to be formed to be at least longer than a depth of the second slit SL2 or the third slit SL3 formed to the depth corresponding to about half of the thickness of the fixed insulation wall 3b or the connection insulation wall 3a in order to reduce the heat convection phenomenon through the slit.

[00235] Specifically, since the heat convection phenomenon increases when a convection path formed in the spatial portion of the first slit SL1 partially filled with the first insulating filler material GW1 is connected to a convection path formed in the spatial portion of the second slit SL2 of the fixed insulation wall 3b and a
5 convection path formed in the spatial portion of the third slit SL3 of the connection insulation wall 3a, the path needs to be blocked by the first insulating filler material GW1 in order to prevent the heat convection phenomenon.

[00236] For example, when the depths of the second slit SL2 and the third slit SL3 are 90 mm, a connection path of 10 mm needs to be formed when the first
10 insulating filler material GW1 is formed to a length of 80 mm from the inlet of the first slit SL1, and thus the first insulating filler material GW1 needs to be formed in a length of at least 90 mm or more to block the connection path.

[00237] In addition, as shown in FIG. 40, the first insulating filler materials GW1 in the embodiment may be attached to both side surfaces of the connection
15 insulation wall 3a facing a side surface of the fixed insulation wall 3b using an adhesive member 10.

[00238] Conventionally, the connection insulation wall 3a is installed between the adjacent fixed insulation walls 3b and then the first insulating filler material GW1 is inserted and installed using the jig, but in the embodiment, the
20 connection insulation wall 3a in a state in which the first insulating filler materials GW1 are attached to both side surfaces thereof may be directly inserted and installed between the adjacent fixed insulation walls 3b, thereby reducing the number of installation processes. In this case, the first insulating filler material GW1 attached to the fixed insulation wall 3b may maintain a compressed state (reduced volume

state) before the connection insulation wall 3a is inserted and installed between the adjacent fixed insulation walls 3b and may be in an uncompressed state (increased volume state) after the installation, thereby completely blocking the first slit SL1.

[00239] In the above description, the first insulating filler material GW1 in the embodiment has been described as partially filling the first slit SL1, but it goes without saying that in a state in which the first insulating filler material GW1 is variously formed such as being formed identically or similarly to the first insulating filler material GW1 in the fourth embodiment described with reference to FIGS. 33 to 35, after the first insulating filler materials GW1 are attached to both side surfaces of the connection insulation wall 3a using the adhesive member 10, the connection insulation wall 3a may be inserted and installed between the adjacent fixed insulation walls 3b.

[00240] Hereinafter, referring to FIGS. 43 to 47, in the liquefied gas storage tank 1 according to the embodiment and a liquefied gas storage tank 1' according to a comparative example, a comparison of convection paths that vary depending on the structures of the slits formed in the connection insulation wall 3a and the fixed insulation wall 3b and whether the insulating filler material for filling the slits is applied and a temperature difference due to the convection paths will be described.

[00241] FIGS. 43A and 45 show the liquefied gas storage tank 1 according to the embodiment, and the connection insulation wall 3a and the fixed insulation wall 3b have the same configurations as described above. In the case of the right angle corner structure and the obtuse angle corner structure, those shown in FIGS. 25 and 26 are applied but the present invention is not limited thereto, and another right angle corner structure and obtuse angle corner structure may also be applied.

- [00242]** FIG. 43B shows the liquefied gas storage tank 1' according to the comparative example, and a first slit SL1' has the same depth as in the liquefied gas storage tank 1 according to the embodiment but the comparative example is different from the liquefied gas storage tank 1 according to the embodiment in that an first
- 5 insulating filler material GW1 does not fill the first slit SL1' and a second slit SL2' is formed to a depth that is similar to the thickness of the fixed insulation wall 3b, and other configurations may be the same as or similar to those of the embodiment.
- [00243]** FIG. 44A shows first, second, and third convection paths CP1, CP2, and CP3 in the liquefied gas storage tank 1 according to the embodiment.
- 10 **[00244]** The first convection path CP1 is a path corresponding to the first slit SL1, which is the gap formed between the connection insulation wall 3a and the fixed insulation wall 3b, and it can be seen that the path is formed only to a lower spatial portion of the first slit SL1 as a convection blocking path CP1' is formed by the first insulating filler material GW1 above the first slit SL1.
- 15 **[00245]** The second convection path CP2 is a path corresponding to the second slit SL2 formed to a depth corresponding to about half of the thickness of the fixed insulation wall 3b, and it can be seen that the path is formed to the spatial portion of the second slit SL2 but is blocked at the portion of the first insulating filler material GW1 filling the first slit SL1.
- 20 **[00246]** The third convection path CP3 is a path corresponding to the third slit SL3 formed to a depth corresponding to about half of the thickness of the connection insulation wall 3a, and it can be seen that the path is formed to the spatial portion of the third slit SL3 but is blocked at the portion of the first insulating filler material GW1 filling the first slit SL1.

[00247] FIG. 44B shows fourth, fifth, and sixth convection paths CP4, CP5, and CP6 in the liquefied gas storage tank 1' according to the comparative example.

[00248] The fourth convection path CP4 is a path corresponding to the first slit SL1', which is the gap formed between the connection insulation wall 3a and the fixed insulation wall 3b, and unlike the embodiment, it can be seen that the path is formed to the entire spatial portion of the first slit SL1' because an insulating filler material does not fill the first slit SL1'.

[00249] The fifth convection path CP5 is a path corresponding to the second slit SL2' formed to the depth similar to the thickness of the fixed insulation wall 3b, and it can be seen that the fifth convection path CP5 formed to the spatial portion of the second slit SL2' is connected to the fourth convection path CP4 formed to the spatial portion of the first slit SL1'.

[00250] The sixth convection path CP6 is a path corresponding to the third slit (not shown) formed to the depth similar to the thickness of the connection insulation wall 3a, and it can be seen that the sixth convection path CP6 formed to the spatial portion of the third slit is connected to the fourth convection path CP4 and the fifth convection path CP5.

[00251] As described above, in the liquefied gas storage tank 1 according to the embodiment, it can be seen that the first, second, and third convection paths CP1, CP2, and CP3 are mutually intermittent and convection regions are reduced, and in the liquefied gas storage tank 1' according to the comparative example, it can be seen that the fourth, fifth, and sixth convection paths CP4, CP5, and CP6 are continuous and convection regions are increased.

[00252] In addition, as shown in FIG. 44B, in the liquefied gas storage tank

1' according to the comparative example, since each of the fourth, fifth, and sixth convection paths CP4, CP5, and CP6 forms a convection space from the primary barrier 2 to the secondary barrier 4, the temperature in the primary barrier 2 directly affects the secondary barrier 4, and thus the temperature is significantly reduced in the secondary barrier 4. On the other hand, in the liquefied gas storage tank 1 according to the embodiment, each of the first, second, and third convection paths CP1, CP2, and CP3 can prevent the temperature of the primary barrier 2 from being conducted to the secondary barrier 4 by the first insulating filler material GW1, and thus the temperature is less reduced in the secondary barrier 4 of the liquefied gas storage tank 1 according to the embodiment than in the liquefied gas storage tank 1' according to the comparative example.

[00253] Due to a difference in the convection paths, a temperature difference also occurs in the secondary barrier 4 of each of the liquefied gas storage tank 1 according to the embodiment and the liquefied gas storage tank 1' according to the comparative example.

[00254] As shown in FIGS. 45 and 46, when the unit elements are disposed adjacent to each other, a temperature sensor TL is attached close to the secondary barrier 4 in the spatial portion formed between the adjacent secondary insulation walls 5.

[00255] As a result of measuring the temperature through the temperature sensor TL in a state in which the temperature of the primary barrier 2 was -196 °C and the temperature of the hull 7 was 10 °C, the temperature in the liquefied gas storage tank 1 according to the embodiment was -79.3 °C, and the temperature in the liquefied gas storage tank 1' according to the comparative example was -100.9 °C.

As described above, it can be seen that the result is due to the fact that the convection path of the liquefied gas storage tank 1 according to the embodiment is intermittent and the convection region is reduced compared to the liquefied gas storage tank 1' according to the comparative example.

5 **[00256]** FIG. 47 is a graph showing a comparison between the temperatures of the secondary barriers 4 under the first slits SL1 and SL1' when an insulating filler material does not fill the first slit SL1' in the liquefied gas storage tank 1' according to the comparative example compared to a case in which the first insulating filler material GW1 fills the first slit SL1 in the liquefied gas storage tank 1 according to
10 the embodiment.

[00257] In a state in which the temperature of the primary barrier 2 was -196 °C and the temperature of the hull 7 was 10 °C, when heights of the first slits SL1 and SL1' were 0.2 mm, the temperature of the secondary barrier 4 under the first slit SL1 filled with the first insulating filler material GW1 according to the
15 embodiment was about -90 °C (graph A), and the temperature of the secondary barrier 4 under the first slit SL1' not filled with an insulating filler material according to the comparative example was about -150 °C (graph B).

[00258] Therefore, it can be seen that the temperature is less reduced in the secondary barrier 4 of the liquefied gas storage tank 1 according to the embodiment
20 than in the liquefied gas storage tank 1' according to the comparative example.

[00259] FIG. 48 is a partial cross-sectional view showing a liquefied gas storage tank according to a sixth embodiment of the present invention, FIG. 49 is a cross-sectional view of a connection insulation wall along line A-A' in FIG. 48, FIG.
50 is a cross-sectional view of a unit element formed by stacking a secondary

insulation wall, a secondary barrier, and a fixed insulation wall constituting a primary insulation wall along line B-B' in FIG. 48, and FIG. 51 is an enlarged view showing a state in which an insulating filler material fills a first slit forming a gap between a connection insulation wall and the fixed insulation wall, which constitute
5 the primary insulation wall.

[00260] As shown in FIGS. 48 to 51, the liquefied gas storage tank 1 according to the sixth embodiment of the present invention may include a primary barrier 2 in contact with liquefied gas therein, a primary insulation wall 3 installed outside the primary barrier 2 and including a connection insulation wall 3a and a
10 fixed insulation wall 3b, a secondary barrier 4 installed outside the primary insulation wall 3, and a secondary insulation wall 5 disposed outside the secondary barrier 4 and fixed to a hull 7, and since the embodiment is different from the fifth embodiment in that steps ST1 and ST2 formed on side surfaces of each of the connection insulation wall 3a and the fixed insulation wall 3b are formed and other
15 configurations are the same as or similar to those of the first embodiment, changed portions will be mainly described below in order to avoid overlapping descriptions.

[00261] The primary insulation wall 3 and the secondary insulation wall 5 in the embodiment may have the same or similar thickness as described above.

[00262] The primary insulation wall 3 may include the connection insulation
20 wall 3a and the fixed insulation wall 3b, and in this case, the connection insulation wall 3a may be inserted and installed between the adjacent fixed insulation walls 3b to seal a space formed between the adjacent secondary insulation walls 5 when unit elements including the fixed insulation wall 3b are disposed adjacent to each other.

[00263] As shown in FIGS. 48 and 49, the connection insulation wall 3a may

be divided into an upper portion and a lower portion, and front-rear and left-right widths of the upper portion may be formed to be smaller than front-rear and left-right widths of the lower portion, and thus the positive-shaped first steps ST1 may be formed on the front, rear, left, and right side surfaces of the connection insulation wall 3a.

[00264] The upper portion and the lower portion of the connection insulation wall 3a may be divided with respect to a position of about half of the thickness of the connection insulation wall 3a but are not limited thereto, and may be determined depending on the depth of the third slit SL3 formed to the depth that is similar to the thickness of the connection insulation wall 3a, which will be understood by the following description. Here, one or more third slits SL3 may be formed in the longitudinal direction of the connection insulation wall 3a and positioned collinearly with the second slit SL2 formed in the longitudinal direction when the connection insulation wall 3a is inserted and installed between the fixed insulation walls 3b.

[00265] In addition, as shown in FIGS. 48 and 49, negative-shaped chamfers CH may be formed at bottom edges of the connection insulation wall 3a.

[00266] The chamfer CH serves to facilitate insertion when the connection insulation wall 3a is installed between the adjacent fixed insulation walls 3b.

[00267] As shown in FIGS. 48 and 50, the fixed insulation wall 3b may be divided into an upper portion and a lower portion, and front-rear and left-right widths of the upper portion may be formed to be smaller than front-rear and left-right widths of the lower portion, and thus the positive-shaped second steps ST2 may be formed on front, rear, left, and right side surfaces of the fixed insulation wall 3b.

[00268] The upper portion and the lower portion of the fixed insulation wall

3b may be divided with respect to a position of about half of the thickness of the fixed insulation wall 3b but are not limited thereto, and may be determined depending on the depth of the second slit SL2 formed to the depth that is similar to the thickness of the fixed insulation wall 3b, which will be understood by the following description.

[00269] In the above description, the first step ST1 and the second step ST2 may have the same or similar shapes, and when the connection insulation wall 3a is inserted and installed between the adjacent fixed insulation walls 3b, the first slit SL1 defining the space while facing each other and filled with the first insulating filler material GW1 between the connection insulation wall 3a and the fixed insulation wall 3b may be formed.

[00270] In other words, when the connection insulation wall 3a is divided into the upper portion and the lower portion, the first step PS1 may be formed to have the front-rear and left-right widths of the upper portion smaller than the front-rear and left-right widths of the lower portion, and when the fixed insulation wall 3b is divided into the upper portion and the lower portion, the second step PS2 may be formed to have the front-rear and left-right widths of the upper portion smaller than the front-rear and left-right widths of the lower portion, and in this case, the first insulating filler material GW1 may fill the first slit SL1, which is the space provided between the upper portion of the connection insulation wall 3a and the upper portion of the fixed insulation wall 3b by installing the lower portion of the connection insulation wall 3a to be adjacent to the lower portion of the fixed insulation wall 3b. The first insulating filler material GW1 filling the first slit SL1 may be formed to have a (+) tolerance to completely seal the space in a state of filling the space of the

first slip SL1, and thus the heat convection path is not generated in the first slit SL1 even upon contraction and expansion of the connection insulation wall 3a and the fixed insulation wall 3b.

[00271] For example, in order to insert the first insulating filler material GW1 having a thickness of 10 mm into the first slit SL1, the first slit SL1 has a minimum width of about 6 mm in consideration of the compressed state of the first insulating filler material GW1, and thus in the embodiment, a width between a side surface of the lower portion of the connection insulation wall 3a and a side surface of the lower portion of the fixed insulation wall 3b is installed to be 2 mm (generally, a distance between the connection insulation wall and the fixed insulation wall), a width of the first step ST1 provided on the connection insulation wall 3a may be formed to be 2 mm, and a width of the second step ST2 provided on the fixed insulation wall 3b may be formed to be 2mm. Since the thickness of the first insulating filler material GW1 filling the first slit SL1 may vary, it goes without saying that the width of each of the first step ST1 and the second step ST2 in the embodiment may also vary.

[00272] In the embodiment, depths of the first step ST1 and the second step ST2 forming the first slit SL1 are not specially limited when the second slit SL2 or the third slit SL3 formed to the depth corresponding to about half of the thickness of the fixed insulation wall 3b or the connection insulation wall 3a is not formed, but needs to be limited to prevent the heat convection phenomenon when the second slit SL2 or the third slit SL3 is formed.

[00273] In other words, as described above in the fifth embodiment, in order to prevent the heat convection phenomenon through the slit, when considering that

the first insulating filler material GW1 filling the first slit SL1 needs to be formed to be at least longer than a depth of the second slit SL2 or the third slit SL3, the depth of the first slit SL1 filled with the first insulating filler material GW1 in the embodiment needs to be formed to be greater than the depth of the second slit SL2 or
5 the third slit SL3.

[00274] For example, when the depths of the second slit SL2 and the third slit SL3 not filled with an insulating filler material are 90 mm, the depth of the first slit SL1 filled with the first insulating filler material GW1 needs to be formed to be 90 mm or more, for example, 105 mm.

10 **[00275]** FIG. 52 is a perspective view showing a liquefied gas storage tank according to a seventh embodiment of the present invention, FIGS. 53A to 53C are plane, side, and cross-sectional views of a unit element in which the secondary insulation wall, the secondary barrier, and the fixed insulation wall constituting the primary insulation wall in FIG. 52 are stacked, FIGS. 54A to 54C are plane, side, and
15 cross-sectional views of a connection insulation wall constituting the primary insulation wall in FIG. 52, FIGS. 55A to 55C are plane, side, and cross-sectional views of a connection insulation wall according to another embodiment constituting the primary insulation wall in FIG. 52, FIG. 56 is a rear perspective view of a connection insulation wall according to still another embodiment constituting the
20 primary insulation wall in FIG. 52, FIG. 57 is a cross-sectional view of a portion in which the fixed insulation wall and the connection insulation wall, which constitute the primary insulation wall, are alternately connected, and FIG. 58 is a cross-sectional view of a portion in which a plurality of connection insulation walls constituting the primary insulation wall are consecutively connected.

[00276] In the above description, FIG. 53C is a cross-sectional view of the connection insulation wall along line A-A' in FIG. 53A, FIG. 54C is a cross-sectional view of the connection insulation wall along line B-B' in FIG. 54A, and FIG. 55C is a cross-sectional view of the connection insulation wall along line C-C' in FIG. 55A.

[00277] As shown in FIGS. 52 to 58, the liquefied gas storage tank 1 according to the seventh embodiment of the present invention may include a primary barrier in contact with liquefied gas therein, a primary insulation wall 3 installed outside the primary barrier and composed of a connection insulation wall 3a and a fixed insulation wall 3b, a secondary barrier 4 installed outside the primary insulation wall 3, and a secondary insulation wall 5 disposed outside the secondary barrier 4 and fixed to a hull 7, and since the embodiment is different from the fifth embodiment in that steps PS1, PS2, PS3, and PS4 formed on side surfaces of each of the connection insulation wall 3a and the fixed insulation wall 3b are formed and the steps PS1, PS2, PS3, and PS4 are finished with insulation pads IP1 and IP2 and other configurations are the same as or similar to those of the first embodiment, changed portions will be mainly described below in order to avoid overlapping descriptions.

[00278] The primary insulation wall 3 and the secondary insulation wall 5 in the embodiment may have the same or similar thickness as described above.

[00279] The primary insulation wall 3 may include the connection insulation wall 3a and the fixed insulation wall 3b, and in this case, the connection insulation wall 3a may be inserted and installed between the adjacent fixed insulation walls 3b to seal a space formed between the adjacent secondary insulation walls 5 when unit elements including the fixed insulation wall 3b are disposed adjacent to each other.

Hereinafter, front, rear, left, and right side surfaces of the fixed insulation wall 3b are defined as side surfaces connected to front and rear side surfaces of the connection insulation wall 3a, and left and right side surfaces of the connection insulation wall 3a are defined as side surfaces connected to a left side surface or a right side surface
5 of another adjacent connection insulation wall 3a.

[00280] As shown in FIGS. 52 and 53A to 53C, the fixed insulation wall 3b may be divided into an upper portion and a lower portion. The upper portion and the lower portion of the fixed insulation wall 3b may be divided with respect to a position of about half of a thickness of the fixed insulation wall 3b, but are not
10 limited thereto.

[00281] The fixed insulation wall 3b may be formed to have front-rear and left-right widths of the upper portion smaller than front-rear and left-right widths of the lower portion, and thus the positive-shaped first steps PS1 may be formed on the front, rear, left, and right side surfaces of the fixed insulation wall 3b.

15 **[00282]** The first step PS1 may overlap front and rear side surfaces of the second step PS2, the third step PS3, or the fourth step PS4 formed on the connection insulation wall 3a to be described below on the front, rear, left, and right side surfaces of the fixed insulation wall 3b to form the first slits SL1 as shown in FIG. 57. The first insulation pad IP1 may be formed to be bonded on the first step PS1 of the
20 fixed insulation wall 3b, and the first insulation pad IP1 will be described below.

[00283] As shown in FIGS. 52, 54A to 54C, and 56A to 56C, the connection insulation wall 3a may be divided into an upper portion and a lower portion. The upper portion and the lower portion of the connection insulation wall 3a may be divided with respect to a position of about half of the thickness of the connection

insulation wall 3a, but are not limited thereto.

[00284] The connection insulation wall 3a is inserted and installed into a linear spatial portion formed between two adjacent fixed insulation walls 3b and as shown in FIGS. 54A to 54C, may be formed have a front-rear width of the upper
5 portion greater than a front-rear width of the lower portion and a left-right width of the upper portion smaller than a left-right width of the lower portion so that the second step PS2 may be formed on the front, rear, left, and right side surfaces thereof.

[00285] The second step PS2 may have a positive shape on the left and right side surfaces of the connection insulation wall 3a as shown in FIG. 54B and have a
10 negative shape on the front and rear side surfaces of the connection insulation wall 3a as shown in FIG. 54C.

[00286] When a plurality of other connection insulation walls are consecutively inserted and installed into the linear spatial portions formed between the two adjacent fixed insulation walls 3b, the second step PS2 having the positive
15 shape on the left and right side surfaces of the connection insulation wall 3a may overlap steps formed in the negative shape on side surfaces of the other connection insulation walls connected adjacent thereto to form a fourth slit SL4 as shown in FIG. 58. The second insulation pad IP2 may be formed on the second step PS2 having the positive shape on the left and right side surfaces of the connection insulation wall
20 3a, and the second insulation pad IP2 will be described below. Here, the other connection insulation walls may be the connection insulation wall 3a having the third steps PS3 having the negative shape on one side surface thereof as shown in FIG. 55B or the connection insulation wall 3a having the fourth steps PS4 having the negative shape in recesses of the front, rear, left, and right side surfaces thereof.

[00287] When the connection insulation wall 3a is inserted and installed between the two adjacent fixed insulation walls 3b, the second steps PS2 having the negative shape on the front and rear side surfaces of the connection insulation wall 3a may overlap the first steps PS1 having the positive shape on the front, rear, left, and right side surfaces of the fixed insulation wall 3b to form the first slits SL1 as shown in FIG. 57.

[00288] In addition, the connection insulation wall 3a is inserted and installed into the linear spatial portion formed between the two adjacent fixed insulation walls 3b and as shown in FIG. 55A to 55C, may have the front-rear width of the upper portion formed to be greater than the front-rear width of the lower portion and the left-right width of the upper portion formed to be the same as the left-right width of the lower portion and may be alternately formed on the left and right side surfaces to form the third steps PS3 on the front, rear, left, and right side surfaces of the connection insulation wall 3a.

[00289] As shown in FIG. 55B, the third step PS3 may have the negative shape on one side surface of the left and right side surfaces of the connection insulation wall 3a and the positive shape on the other side surface and have the negative shape on the front and rear side surfaces of the connection insulation wall 3a as shown in FIG. 54C.

[00290] When the plurality of other connection insulation walls are consecutively inserted and installed into the linear spatial portion formed between the two adjacent fixed insulation walls 3b, the third step PS3 having the negative shape on the left and right side surfaces of the connection insulation wall 3a may overlap steps formed in the positive shape on side surfaces of the other connection insulation

walls connected adjacent to each other to form the fourth slit SL4 as shown in FIG. 58. Here, the other connection insulation walls may be the connection insulation wall 3a having the second steps PS2 having the positive shape on the left and right side surfaces thereof as shown in FIG. 54B or the connection insulation wall 3a having the third step PS3 having the positive shape on one of the left and right side surfaces thereof as shown in FIG. 55B.

[00291] When the plurality of other connection insulation walls are consecutively inserted and installed into the linear spatial portion formed between the two adjacent fixed insulation walls 3b, the third step PS3 having the positive shape among the left and right side surfaces of the connection insulation wall 3a may overlap steps formed in the negative shape on side surfaces of the other connection insulation walls connected adjacent to each other to form the fourth slit SL4 as shown in FIG. 58. The second insulation pad IP2 may be formed on the third step PS3 having the positive shape among the left and right side surfaces of the connection insulation wall 3a, and the second insulation pad IP2 will be described below. Here, another connection insulation wall may be the connection insulation wall 3a having the third step PS3 having the negative shape on one side surface thereof as shown in FIG. 55B or the connection insulation wall 3a having the fourth steps PS4 having the negative shape in recesses of the front, rear, left, and right side surfaces thereof.

[00292] In addition, the connection insulation walls 3a are inserted and installed into spatial portions having a cross shape formed between the four adjacent fixed insulation walls 3b and as shown in FIG. 56, may be formed to have the front-rear and left-right widths of the upper portion greater than the front-rear and left-right

widths of the lower portion so that the fourth steps PS4 may be formed on the front, rear, left, and right side surfaces thereof.

[00293] The fourth step PS4 may have the negative shape at the protrusions of the front, rear, left, and right side surfaces of the connection insulation wall 3a and
5 in recesses of the front, rear, left, and right side surfaces thereof.

[00294] When the connection insulation walls 3a are inserted and installed into the spatial portions having the cross shape formed between the four adjacent fixed insulation walls 3b, the fourth step PS4 having the negative shape at the protrusions of the front, rear, left, and right side surfaces of the connection insulation
10 wall 3a may overlap the steps formed in the positive shape on the side surfaces of the other connection insulation walls installed in the linear spatial portion formed between the two adjacent fixed insulation walls 3b to form the fourth slit SL4 as shown in FIG. 58. Here, the other connection insulation walls may be the connection insulation wall 3a having the second steps PS2 having the positive shape
15 on the left and right side surfaces thereof as shown in FIG. 54B or the connection insulation wall 3a having the third steps PS3 having the positive shape on one of the left and right side surfaces thereof as shown in FIG. 55B.

[00295] When the connection insulation walls 3a are inserted and installed into the spatial portions having the cross shape formed between the four adjacent
20 fixed insulation walls 3b, the fourth steps PS4 having the negative shape in recesses of the front, rear, left, and right side surfaces of the connection insulation wall 3a may overlap the first steps PS1 having the positive shape on the front, rear, left, and right side surfaces of each of the four adjacent fixed insulation walls 3b to form the first slits SL1 as shown in FIG. 57.

[00296] As shown in FIG. 57, the first slit SL1 in the embodiment is the space formed between the fixed insulation wall 3b and the connection insulation wall 3a by overlapping between a first negative step formed on the side surface of the connection insulation wall 3a and a first positive step formed on the side surface of the fixed insulation wall 3b when the connection insulation wall 3a is inserted and installed between the adjacent fixed insulation walls 3b and has a bent shape. Here, the first positive step formed on the side surface of the fixed insulation wall 3b may be the first steps PS1 having the positive shape formed on the front, rear, left, and right side surfaces of the fixed insulation wall 3b, and the first negative step formed on the side surface of the connection insulation wall 3a may be the second steps PS2 or the third steps PS3 formed on the front and rear side surfaces of the connection insulation wall 3a or the fourth steps PS4 formed in the recesses of the front, rear, left, and right side surfaces of the connection insulation wall 3a.

[00297] Although the heat convection phenomenon is reduced in the first slit SL1 having the bent shape when compared to a slit having a linear shape, the heat convection phenomenon may occur through the space of the first slit SL1.

[00298] Therefore, in the embodiment, the first insulation pads IP1 are formed to be bonded on the first steps PS1 formed in the positive shape on the front, rear, left, and right side surfaces of the fixed insulation wall 3b in order to prevent the heat convection phenomenon.

[00299] The first insulation pad IP1 may be formed to be bonded on the first positive step formed on the side surface of the fixed insulation wall 3b facing the connection insulation wall 3a and compressed by the first negative step formed on the side surface of the connection insulation wall 3a facing the fixed insulation wall

3b in a state of not being bonded to the connection insulation wall 3a when the connection insulation wall 3a is installed between the adjacent fixed insulation walls 3b, thereby blocking the spatial portion of the first slit SL1.

[00300] The first insulation pad IP1 may be made of an insulating material such as glass wool, but is not limited thereto.

[00301] In addition, as shown in FIG. 58, the fourth slit SL4 in the embodiment is the space formed between the adjacent connection insulation walls 3a by overlapping between a second positive step formed on a side surface of any one connection insulation wall 3a of the adjacent connection insulation walls 3a and a second negative step formed on a side surface of the other connection insulation wall 3a and has a bent shape. Here, the second positive step formed on the side surface of any one connection insulation wall 3a may be the second steps PS2 or the third steps PS3 formed on at least any one of the left and right side surfaces of the connection insulation wall 3a, and the second negative step formed on the side surface of the other connection insulation wall 3a may be the third steps PS3 formed on at least any one of the left and right side surfaces of the connection insulation wall 3a or the fourth steps PS4 formed on the protrusions of the front, rear, left, and right side surfaces of the connection insulation wall 3a.

[00302] Although the heat convection phenomenon is more reduced in the fourth slit SL4 having the bent shape than the slit having the linear shape, the heat convection phenomenon may occur through the space of the fourth slit SL4.

[00303] Therefore, in the embodiment, in order to prevent the heat convection phenomenon, the second insulation pads IP2 are formed to be bonded on the second positive steps among the second positive steps or the second negative

steps formed on the left and right side surfaces of the adjacent connection insulation walls 3a.

[00304] The second insulation pad IP2 may be formed to be bonded on the second positive step formed on the side surface of any one of the adjacent connection insulation walls 3a and compressed by the second negative step formed on the side surface of the other connection insulation wall 3a among the adjacent connection insulation walls 3a when the adjacent connection insulation walls 3a are consecutively installed between the adjacent fixed insulation walls 3b, thereby blocking the spatial portion of the fourth slit SL4.

[00305] The second insulation pad IP2 may be made of an insulating material such as glass wool, but is not limited thereto.

[00306] In the embodiment, a width of each of the first, second, third, and fourth steps PS1, PS2, PS3, and PS4 may be the same or similar, for example, 30 mm, and is not limited thereto.

[00307] In addition, the width of each of the first and fourth slits SL1 and SL4 may be the same or similar, and for example, the width between the side surface of the upper portion of the connection insulation wall 3a and the side surface of the upper portion of the fixed insulation wall 3b may be 2 mm, and the width between the side surface of the lower portion of the connection insulation wall 3a and the side surface of the lower portion of the fixed insulation wall 3b may be 2 mm, but the present invention is not limited thereto.

[00308] In addition, a thickness and a width of each of the first and second insulation pads IP1 and IP2 may be the same or similar, and for example, the thickness may be 10 mm and the width may be 30 mm, but the present invention is

not limited thereto.

- [00309]** As described above, in the embodiment, by forming the thickness of the primary insulation wall 3 and 3a from the total thickness of the primary insulation wall 3 including the connection insulation wall 3a and the secondary insulation wall 5 identically or similarly to that of the secondary insulation wall 5, it is possible to not only maintain the mechanical strength of the secondary insulation wall 5 to the predetermined level but also reduce the low-temperature load and the sloshing load of the secondary barrier 4, thereby preventing the damage to the secondary barrier 4.
- 10 **[00310]** In addition, in the embodiment, by providing the auxiliary insulation plate 33 on the lower surface of the connection insulation wall 3a provided in the space between the adjacent primary insulation walls 3 constituting the unit element, it is possible to further increase the insulation performance of the connected portion between the adjacent secondary insulation walls 5 constituting the unit element.
- 15 **[00311]** In addition, in the embodiment, it is possible to improve the configuration of the secondary barrier 4, thereby increasing the insulation performance.
- [00312]** In addition, in the embodiment, by applying the non-adhesive elastic insulating material to the leveling member 8 of the secondary insulation wall 5 between the secondary insulation wall 5 and the hull 7, it is possible to level the deformed portion of the hull 7 even without using the existing mastic and leveling wedge, thereby increasing the insulation performance of the tank.
- 20 **[00313]** In addition, in the embodiment, by fixing the unit panels of the adjacent secondary insulation walls in the cleat structure method by the protrusions

91 provided to protrude outward from the lower side surface of the unit panel of the secondary insulation wall 5 and the stud bolt 92 fixed to the hull 7, it is possible to reduce the number of processes compared to the method of making the hole in the secondary insulation wall 5 and fixing the unit panel using the stud bolt.

5 **[00314]** In addition, in the embodiment, by improving the structure of the slit and providing various insulating filler materials for filling the slit in order to optimize the slit provided to cope with the contraction and expansion of the primary insulation wall 3 formed on the secondary barrier 4 and minimize the convection phenomenon caused through the slit and an amount of the heat transferred into the
10 secondary barrier 4, it is possible to enhance the stability of the primary insulation wall 3 due to the formation of the slit and also reduce the low-temperature load of the secondary barrier 4, thereby preventing the damage to the primary insulation wall 3 and the secondary barrier 4.

15 **[00315]** The present invention is not limited to the above-described embodiments and may include a combination of the embodiments or a combination of at least one of the embodiments and known technologies as another embodiment. For example, the embodiments of FIGS. 28 and 29 may be combined with the embodiments of FIGS. 4 to 27. In addition, the embodiment of FIGS. 30 and 31 may be, for example, combined with the insulation system of FIGS. 1 and 2 or the
20 insulation system of FIGS. 28 and 29. In addition, the embodiments of FIGS. 32 to 58 may be, for example, combined with the embodiments of FIGS. 1 to 31 are possible.

25 **[00316]** Although the present invention has been described above in detail through specific embodiments, this is to specifically describe the present invention,

the present invention is not limited thereto, and it will be apparent that modifications or improvements thereof are possible by those skilled in the art without departing from the technical spirit of the present invention.

[00317] All simple modifications or changes of the present invention fall within the scope of the present invention, and the specific scope of the present invention will be clarified by the appended claims.

[00318] [Description of reference numerals]

	1, 1': liquefied gas storage tank	2: primary barrier
	21: planar portion	22: curved portion
10	23: interface	3: primary insulation wall
	3b: fixed insulation wall	31: primary plywood
	32: primary insulating material	3a: connection insulation wall
	31a: connection plywood	32a: connection insulating material
	33: auxiliary insulation plate	4: secondary barrier
15	41: main barrier	42: auxiliary barrier
	GAC: glass-aramid cloth	AF: aluminum foil
	GC: glass cloth	BC: basalt cloth
	5: secondary insulation wall	51: secondary insulating material
	52: secondary plywood	6: mastic
20	7: hull	8: leveling member
	9: fixing member	91: protrusion
	92: stud bolt	10: adhesive member
	SL1, SL1': first slit	SL2, SL2': second slit
	SL3: third slit	SL4: fourth slit
25	GW1: first insulating filler material	

	GW1-1: first upper insulating filler material	
	GW1-2: first middle insulating filler material	
	GW1-3: first lower insulating filler material	
	GW2: second insulating filler material	
5	GW2-1: second upper insulating filler material	
	GW2-2: second middle insulating filler material	
	GW2-3: second lower insulating filler material	
	CP1: first convection path	CP1': convection blocking path
	CP2: second convection path	CP3: third convection path
10	CP4: fourth convection path	CP5: fifth convection path
	CP6: sixth convection path	TL: temperature sensor
	ST1: first step	ST2: second step
	CH: chamfer	IP1: first insulation pad
	IP2: second insulation pad	PS1: first step
15	PS2: second step	PS3: third step
	PS4: fourth step	

[CLAIMS]

[Claim 1]

A liquefied gas storage tank that stores cryogenic substances, comprising a primary barrier, a primary insulation wall, a secondary barrier, and a secondary
5 insulation wall,

wherein, in a state in which unit elements, each of which is formed by stacking the secondary insulation wall, the secondary barrier, and a fixed insulation wall that is a part of the primary insulation wall, are disposed adjacent to each other, the primary insulation wall includes a connection insulation wall provided in a
10 spatial portion between the adjacent fixed insulation walls,

a first slit formed between the fixed insulation wall and the connection insulation wall when the connection insulation wall is inserted and installed between the adjacent fixed insulation walls,

a plurality of second slits formed in a longitudinal direction and a width
15 direction of the fixed insulation wall, and

a first insulating filler material filling the first slit.

[Claim 2]

The liquefied gas storage tank of claim 1, wherein the first insulating filler material is formed to fully fill the first slit,

20 formed to fill the first slit from an inlet of the first slit to a predetermined depth so that a space is formed in a lower portion of the first slit, or

formed to fill an inside of the first slit in multiple layers so that a plurality of spaces are formed inside the first slit.

[Claim 3]

The liquefied gas storage tank of claim 2, wherein, when the first insulating filler material is formed to fill the inside of the first slit in multiple layers so that the plurality of spaces are formed inside the first slit, the first insulating filler material includes:

5 a first upper insulating filler material formed in an upper portion of the first slit;

 a first middle insulating filler material spaced a predetermined interval from the first upper insulating filler material and formed in a middle of the first slit; and

 a first lower insulating filler material spaced a predetermined interval from
10 the first middle insulating filler material and formed in a lower portion of the first slit,
 each of the first upper insulating filler material, the first middle insulating filler material, and the first lower insulating filler material is formed of the same insulating material or different insulating materials, and

 the insulating material includes glass wool, super lite, a soft foam material, or
15 an aerogel blanket.

[Claim 4]

The liquefied gas storage tank of claim 1, wherein the first insulating filler material fills the first slit in an insertion method using a jig after the connection insulation wall is inserted and installed between the adjacent fixed insulation walls,

20 or

 fills the first slit by inserting and installing the connection insulation wall between the adjacent fixed insulation walls in a state of being bonded to both side surfaces of the connection insulation wall facing a side surface of the fixed insulation wall using an adhesive member.

25 [Claim 5]

The liquefied gas storage tank of claim 1, wherein the second slit is filled with a second insulating filler material therein when formed to a depth similar to a thickness of the fixed insulation wall, and

the second insulating filler material is formed to fill the second slit from an
5 inlet of the second slit to a predetermined depth so that a space is formed in a lower portion of the second slit, or

formed to fill an inside of the second slit in multiple layers so that a plurality of spaces are formed inside the second slit.

[Claim 6]

10 The liquefied gas storage tank of claim 5, wherein, when the second insulating filler material is formed to fill the inside of the second slit in multiple layers so that the plurality of spaces are formed inside the second slit,

the second insulating filler material includes a second upper insulating filler material formed in an upper portion of the second slit,

15 a second middle insulating filler material spaced a predetermined interval from the second upper insulating filler material and formed in a middle of the second slit, and

a second lower insulating filler material spaced a predetermined interval from the second middle insulating filler material and formed in a lower portion of the
20 second slit,

each of the second upper insulating filler material, the second middle insulating filler material, and the second lower insulating filler material is formed of the same insulating material or different insulating materials, and

the insulating material includes glass wool, super lite, a soft foam material, or
25 an aerogel blanket.

[Claim 7]

The liquefied gas storage tank of claim 1, comprising one or more third slits formed in a longitudinal direction of the connection insulation wall and positioned collinearly with the second slit formed in the longitudinal direction when the connection insulation wall is inserted and installed between the fixed insulation walls,

wherein the second slit and the third slit are formed to a depth corresponding to about half of thicknesses of the fixed insulation wall and the connection insulation wall and are not filled with an insulating filler material therein,

the first insulating filler material is formed to be at least longer than a depth of each of the second slit and the third slit, and

a heat convection path through the first slit, the second slit, and the third slit is intermittently formed.

[Claim 8]

The liquefied gas storage tank of claim 1, wherein the primary insulation wall and the secondary insulation wall have the same or similar thickness.

[Claim 9]

A liquefied gas storage tank that stores cryogenic substances, comprising a primary barrier, a primary insulation wall, a secondary barrier, and a secondary insulation wall,

wherein, in a state in which unit elements, each of which is formed by stacking the secondary insulation wall, the secondary barrier, and a fixed insulation wall that is a part of the primary insulation wall, are disposed adjacent to each other, the primary insulation wall includes a connection insulation wall provided in a spatial portion between the adjacent fixed insulation walls,

first steps formed on front, rear, left, and right side surfaces of the connection insulation wall,

second steps formed on front, rear, left, and right side surfaces of the fixed insulation wall,

5 first slits formed by the first steps and the second steps between the connection insulation wall and the fixed insulation wall when the connection insulation wall is inserted and installed between the adjacent fixed insulation walls, and

a first insulating filler material filling the first slits.

10 [Claim 10]

The liquefied gas storage tank of claim 9, wherein the first step is formed so that front-rear and left-right widths of an upper portion of the connection insulation wall is smaller than front-rear and left-right widths of a lower portion of the connection insulation wall,

15 the second step is formed so that front-rear and left-right widths of an upper portion of the fixed insulation wall is smaller than front-rear and left-right widths of a lower portion of the fixed insulation wall, and

the first insulating filler material fills the first slit, which is a space provided between the upper portion of the connection insulation wall and the upper portion of
20 the fixed insulation wall by installing the lower portion of the connection insulation wall to be adjacent to the lower portion of the fixed insulation wall.

[Claim 11]

The liquefied gas storage tank of claim 10, comprising:

a plurality of second slits formed in a longitudinal direction and a width
25 direction of the fixed insulation wall; and

one or more third slits formed in a longitudinal direction of the connection insulation wall and positioned collinearly with the second slit formed in the longitudinal direction when the connection insulation wall is inserted and installed between the fixed insulation walls,

5 wherein the second slit and the third slit are formed to a depth corresponding to about half of thicknesses of the fixed insulation wall and the connection insulation wall and are not filled with an insulating filler material therein,

the first slit filled with the first insulating filler material is formed to be at least longer than a depth of each of the second slit and the third slit, and

10 a heat convection path through the first slit, the second slit, and the third slit is intermittently formed.

[Claim 12]

The liquefied gas storage tank of claim 9, wherein the primary insulation wall and the secondary insulation wall have the same or similar thickness.

15