Method for assembling a liquid dome

Technical field

The invention relates to the field of sealed and thermally insulating membrane-type tanks. In particular, the invention relates to the field of sealed and thermally insulating tanks for storing and/or transporting liquefied gas at low temperature, such as tanks for transporting liquefied petroleum gas (also known as LPG) at for example a temperature of between -50°C and 0°C, or for transporting liquefied natural gas (LNG) at around -162°C at atmospheric pressure. These tanks can installed on land or on a floating structure. In the case of a floating structure, the tank can be intended to transport liquefied gas or to hold liquefied gas used as fuel for the propulsion of the floating structure.

In one embodiment, the liquefied gas is LNG, namely a mixture with a high methane content stored at a temperature of around -162°C at atmospheric pressure. Other liquefied gases may also be envisioned, in particular ethane, propane, butane or ethylene. Liquefied gases can also be stored under pressure, for example at a relative pressure of between 2 and 20 bar, and in particular at a relative pressure of around 2 bar. The tank can be produced by various techniques, in particular in the form of an integrated membrane-type tank or a self-supporting tank.

Technological background

The document FR2785034 discloses a sealed and thermally insulating tank for storing liquefied natural gas, which is installed in the double hull of a ship.

The sealed and thermally insulating tank has walls that have a multilayer structure made up successively of a secondary thermally insulating barrier resting against the internal hull of the ship; a secondary sealing membrane resting against the secondary thermally insulating barrier; a primary thermally insulating barrier resting against the secondary sealing membrane; and a primary sealing membrane intended to be in contact with the liquefied gas contained in the tank.

The tank is equipped with a loading/offloading tower for loading the cargo into the tank before it is transported, and for offloading the cargo after it has been transported.

During the assembly of such a tank, the secondary and primary thermally insulating barriers and the secondary and primary sealing membranes are mounted in the double hull of the ship and anchored thereto. Subsequently, in a second step, the loading/offloading tower is mounted in the tank and fastened to the double hull of the ship.

However, the pipes of the loading/offloading tower have to pass through the tank wall and the double hull in order to make it possible to decant the liquid contained in the storage space of the tank out of the tank. For this purpose, an upper wall of the double hull has an opening that is left free for mounting the loading/offloading tower in the tank. Similarly, the upper tank wall anchored on the upper wall of the double hull has a passage in line with said opening. This passage in the upper tank wall is also left free for mounting the loading/offloading tower. Thus, during the installation of the loading/offloading tower in the tank, the pipes of the loading/offloading tower are arranged so as to have an end passing successively through the passage in the upper tank wall and the opening in the double hull.

In order to complete the assembly of the tank following the installation of the loading/offloading tower, a hull insert is installed on the double hull at the opening in order to obstruct said opening in the double hull. Orifices are provided in this hull insert for the passage of the pipes of the loading/offloading tower. A plurality of tank wall portions are then mounted on the hull insert in order to surround the pipes and ensure that the upper tank wall remains insulated and sealed.

The method for assembling such a tank is not entirely satisfactory, in particular because it is particularly time-consuming and complex.

Summary

An idea underlying the invention is to propose a method for assembling a sealed and thermally insulating tank that makes it possible to reduce the assembly time.

According to one embodiment, the invention provides a method for assembling a sealed and thermally insulating tank inside a bearing structure, said bearing structure having a plurality of walls that delimit an internal space and include an upper wall of the bearing structure that has an opening, the assembly method including the following steps of:

- installing a loading/offloading tower in the internal space through the opening, said loading/offloading tower having a plurality of pipes that each have an upper end protruding from the internal space, said loading/offloading tower having at least one retaining member;
- providing a closing block having a tank wall portion, said closing block having orifices;
- inserting the upper ends of the pipes into the corresponding orifices in the closing block;
- sliding the closing block along the pipes until the closing block rests against the retaining member in the internal space;
- providing a bearing structure insert having through-orifices;
- mounting the bearing structure insert on the bearing structure such that said bearing structure insert obstructs the opening in the upper wall of the bearing structure and the ends of the pipes of the loading/offloading tower pass through the through-orifices in said bearing structure insert;
- sliding the closing block along the pipes in the direction of the bearing structure insert; and
- fastening the closing block to the bearing structure insert.

Thus, such an assembly method makes it possible to considerably reduce the assembly time since the closing block can be preassembled and then inserted in one piece directly into the storage space of the tank.

Moreover, the presence of the through-orifices in the closing block and the protruding member makes it possible to keep said closing block in position in the storage space while the bearing structure insert is being mounted on the bearing

structure. Thus, the closing block can simply be raised in one piece by sliding along the pipes in the direction of the bearing structure insert in order to be fastened when the bearing structure insert is mounted on the bearing structure. Such a mounting method is therefore quick and easy to implement.

According to embodiments, such an assembly method may include one or more of the following features.

According to one embodiment, the method also includes the step of anchoring a plurality of tank walls on corresponding walls of the bearing structure so as to delimit a storage space for fluid in the tank, one of said tank walls being an upper tank wall anchored on the upper wall of the bearing structure, said upper tank wall having a passage in line with the opening in the upper wall of the bearing structure, said passage putting the storage space into communication with an external space of the bearing structure.

According to one embodiment, the pipes extend in the storage space of the tank.

According to one embodiment, the upper end of the pipes protrudes from the internal space of the bearing structure successively through the passage in the upper tank wall and the opening in the upper wall of the bearing structure.

According to one embodiment, at least one of said pipes has the retaining member, said retaining member protruding from said pipe into the storage space of the tank.

According to one embodiment, the method also includes a step of sealing the tank between the upper tank wall and the tank wall portion formed by the closing block.

According to one embodiment, each tank wall has a thermally insulating barrier and a sealing membrane, the sealing membrane being intended to be in contact with the fluid stored in the storage space of the tank and resting against said thermally insulating barrier.

According to one embodiment, the tank wall portion of the closing block has a thermally insulating barrier portion and a sealing membrane portion.

According to one embodiment, the method also includes the step of welding the pipes of the loading/offloading tower to the bearing structure insert.

According to one embodiment, the method also includes the step of welding the pipes of the loading/offloading tower to the closing block.

According to one embodiment, several pipes or each pipe of the loading/offloading tower has/have a protruding portion that protrudes into the storage space of the tank. Thus, the closing block rests on several protruding portions.

According to one embodiment, the protruding member(s) connect(s) two pipes of the loading/offloading tower together. Typically, such a protruding member can be a reinforcing rod of the loading/offloading tower.

According to one embodiment, the bearing structure insert has an internal surface facing an external face of the closing block, the method also including the step of interposing correcting strips between the external face of the closing block and the internal surface of the bearing structure insert, said correcting strips forming a planar support surface in the internal space of the bearing structure, the external face of the closing block being fastened to said planar support surface.

According to one embodiment, the closing block and the protruding member are configured such that an external surface of the closing block is spaced apart from the internal surface of the bearing structure insert by a distance greater than or equal to 1.5 m when said closing block rests in the storage space on the protruding member.

Such correcting strips make it possible to make up for planarity defects of the bearing structure insert and thus afford a planar support surface that allows stable and secure fastening of the closing block to the bearing structure insert.

According to one embodiment, the wall portion of the closing block has an end panel that forms the external face of the closing block, the correcting strips being stapled to said end panel.

According to one embodiment, the end panel is a plywood panel.

According to one embodiment, the method also includes marking the location of the correcting strips on the internal face of the bearing structure insert.

According to one embodiment, the method also includes the steps of:

- measuring the planarity of the internal surface of the bearing structure insert,
- dimensioning a thickness of the correcting strips depending on the measurement of the planarity of the internal surface of the bearing structure insert such that internal faces of said correcting strips on the opposite side from the bearing structure are arranged in one and the same plane to jointly form the planar support surface.

According to one embodiment, the correcting strips have a bead of resin, and the beads of resin are secured to the internal surface of the bearing structure insert.

According to one embodiment, the beads of resin are made of mastic.

According to one embodiment, the step of fastening the closing block to the bearing structure insert includes a step of squashing the beads of resin.

According to one embodiment, the beads of resin are deformed by compression while the closing block is being fastened to the bearing structure insert.

According to one embodiment, the beads of resin jointly form, in a squashed state resulting from the squashing step, the planar support surface.

According to one embodiment, the beads of resin have thickness dimensioned depending on the measurement of the planarity of the internal surface of the bearing structure insert.

According to one embodiment, the beads of resin are dimensioned so as to form the planar support surface.

According to one embodiment, the beads of resin are secured to the closing block, typically to the external face of the closing block, before the step of sliding said closing block in the direction of the bearing structure insert.

According to one embodiment, the correcting strips have a batten, and a respective bead of resin is secured to each batten.

According to one embodiment, the battens are plywood battens.

According to one embodiment, the battens have a thickness that is dimensioned depending on the measurement of the planarity of the internal surface of the bearing structure insert so as to form the planar support surface, and said battens are fastened to the external face of the closing block.

By virtue of these features, the planarity defects of the bearing structure insert are made up for by the battens such that it is not necessary to provide beads of resin of different sizes to fill the planarity defects of the bearing structure insert.

According to one embodiment, the beads of resin have a uniform thickness.

Such beads of resin having a uniform thickness are quick and easy to produce. Thus, the beads of resin can be produced one after another and be positioned directly on the battens, said beads of resin thus being manufactured quickly and easily. Moreover, such beads of resin of uniform thickness avoid errors associated with the positioning of a bead of resin of given thickness on the wrong batten.

The successive production of said beads of resin thus limits the installation time of the set of beads of resin and thus the time necessary between the installation of the first bead of resin and the installation of the last bead of resin, thereby limiting the period of time for which the first bead of resin is installed without being squashed between the closing block and the bearing structure insert. Therefore, the time for which the first bead of resin installed on a batten is subject to drying without being in its final position is reduced.

According to one embodiment, the method also includes fastening the correcting strips to the external face of the closing block.

According to one embodiment, the method also includes, before the sliding of the closing block in the direction of the bearing structure insert, fastening the correcting strips to the external face of the closing block, and then fastening the correcting strips against the internal surface of the bearing structure insert in order to fasten the closing block to the bearing structure insert.

According to one embodiment, the method also includes the step of applying the beads of resin to an external face of the battens, said external faces of the battens being opposite the bearing structure insert.

According to one embodiment, the battens are stapled to the external face of the closing block.

According to one embodiment, the staples for fastening the battens to the external face of the closing block are at a spacing of 200 mm.

According to one embodiment, the method also includes the step of applying the beads of resin to the internal face of the bearing structure insert before the closing block is slid in the direction of the bearing structure insert.

According to one embodiment, the correcting strips are fastened to the internal face of the bearing structure insert at the pre-assembly stage such that the assembly method includes the step of fastening the correcting strips to the bearing structure insert before the step of providing the bearing structure insert.

According to one embodiment, the step of fastening the closing block to the bearing structure insert includes a step of fastening the correcting strips to the external face of said closing block after the step of sliding the closing block in the direction of the bearing structure insert.

According to one embodiment, the method also includes the step of installing reference strips on the internal face of the bearing structure insert, said reference strips having an internal surface on the opposite side from the bearing structure insert and situated in one and the same plane, the correcting strips being dimensioned to form the support surface in said plane.

In other words, the reference strips are dimensioned so as to define a reference plane and the correcting strips are dimensioned so as to form the support surface in said reference plane such that the closing block is pressed against the correcting strips in said reference plane.

According to one embodiment, the reference strips are positioned on the bearing structure insert in a reference pattern.

According to one embodiment, the correcting strips are positioned on the bearing structure insert in a fastening pattern.

According to one embodiment, the fastening pattern and the reference pattern are configured such that the reference strips and the correcting strips are positioned on different portions of the bearing structure insert.

According to one embodiment, the method also includes the step of installing tie rods between the bearing structure insert and the closing block, said tie rods being actuated to slide the closing block in the direction of the bearing structure insert.

According to one embodiment, the closing block and the bearing structure insert have through-passages through which the tie rods pass.

According to one embodiment, a locknut is mounted on a first end of the tie rods, said first end of the tie rods passing through the bearing structure insert.

According to one embodiment, a nut is screwed onto a second end of the tie rods, said second end passing through the closing block.

According to one embodiment, the tie rods keep the closing block in position during a drying period of the beads of resin.

Such a tank can be assembled in an on-shore storage facility, for example for storing LNG, or in a floating in-shore or off-shore structure, in particular a methane carrier ship, a floating storage and regasification unit (FSRU), a floating production storage and offloading (FPSO) unit and the like. Such a tank can also act as a fuel reservoir in any type of ship.

Brief description of the figures

The invention will be understood better, and further aims, details, features and advantages thereof will become more clearly apparent from the following description of several particular embodiments of the invention, which are given only by way of nonlimiting illustration, with reference to the appended drawings.

- Figure 1 is a partial schematic view of a bearing structure intended to receive the walls of the sealed and thermally insulating tank;

- Figure 2 is a schematic view of the multilayer structure of the walls of the tank;

- Figure 3 is a schematic view illustrating a loading/offloading tower and partially illustrating the bearing structure inside which it is mounted;

- Figure 4 is a partial schematic view in longitudinal section of the sealed and thermally insulating tank in the course of assembly at the liquid dome and the loading/offloading tower, in which the hull insert has not yet been installed on the liquid dome;

- Figure 5 is a partial schematic view in longitudinal section of the sealed and thermally insulating tank in the course of assembly at the liquid dome and the loading/offloading tower, in which the closing block has not yet been anchored on the hull insert;

- Figure 6 is a partial schematic view in longitudinal section of the sealed and thermally insulating tank assembled at the liquid dome and the loading/offloading tower;

- Figure 7 is a partial schematic detail view of figure 5 illustrating the difference in planarity between the hull insert and the closing block;

- Figure 8 is a schematic detail view similar to figure 6 illustrating a first embodiment of the invention;

- Figure 9 is a partial schematic view of the closing block anchored on the hull insert according to the first embodiment of the invention;

- Figure 10 is a partial schematic view similar to figure 8 according to a second embodiment of the invention;

- Figure 11 is a partial schematic view similar to figure 8 according to a third embodiment of the invention;

- Figure 12 is a partial schematic view in longitudinal section of the sealed and thermally insulating tank illustrating lifting means of the closing block;

- Figure 13 is a cutaway schematic depiction of a tank of a methane carrier ship and of a terminal for loading of/offloading from this tank.

Detailed description of embodiments

With reference to figure 1, the rear part of a bearing structure 1 intended to receive the walls of a sealed and thermally insulating tank can be seen. The bearing structure 1 is formed by the double hull of a ship. The bearing structure 1 has a polyhedral overall shape. The bearing structure 1 has a front wall 2 and a rear wall 3, in this case having octagonal shapes. In figure 1, the front wall 2 is shown only partially in order to make it possible to see the internal space of the bearing structure 1. The front wall 2 and rear wall 3 are cofferdam walls of the ship and extend transversely to the longitudinal direction of the ship. The bearing structure 1 also has an upper wall 4, a lower wall 5 and side walls 6. The upper wall 4, the lower wall 5 and the side walls 6 extend in the longitudinal direction of the ship and connect the front wall 2 and rear wall 3.

Near the rear wall 3 of the bearing structure 1, the upper wall 4 has a space, of rectangular parallelepipedal shape, protruding upward, known as the liquid dome 7. The liquid dome 7 is defined by a front transverse wall 8 and a rear transverse wall 9 and by two side walls 10, which extend vertically and protrude upward. The liquid dome 7 delimits an opening 11 in the upper wall 4 for the passage of pipes for transferring liquid from or to the tank mounted in the bearing structure, as explained below.

The tank is a membrane-type tank having a multilayer structure. Thus, as shown schematically in figure 2, each wall of the tank has, successively from the outside to the inside, in the direction of the thickness of the wall, a secondary thermally insulating barrier 12 having insulating elements resting against the bearing structure 1, a secondary sealing membrane 13 anchored to the insulating elements of the secondary thermally insulating barrier 12, a primary thermally insulating barrier 14 having insulating elements resting against the secondary sealing membrane 13, and a primary sealing membrane 15 anchored to the insulating elements of the primary thermally insulating barrier 14 and intended to be in contact with the fluid contained in the tank. This multilayer structure of the tank is disposed on each of the walls 2, 3, 4, 5, 6 of the bearing structure 1. This multilayer structure is also present on the walls

8, 9, 10 of the liquid dome 7 and thus delimits a passage 16 in the tank wall in line with the opening 11 in the liquid dome 7.

By way of example, each wall of the tank may in particular be of the Mark III type, as described for example in FR2691520, of the NO96 type, as described for example in FR2877638, or of the Mark V type, as described for example in WO14057221.

During the assembly of the tank in the bearing structure 1, each wall of the tank is anchored on the respective wall of the bearing structure 1, proceeding from the outside to the inside of the tank, i.e.:

- anchoring the insulating elements of the secondary thermally insulating barrier 12 on the respective wall of the bearing structure 1;
- anchoring the secondary sealing membrane 13 on the insulating elements of the secondary thermally insulating barrier 12;
- anchoring the insulating elements of the primary thermally insulating barrier 14 on the insulating elements of the secondary thermally insulating barrier 12 or on the bearing structure 1 through the secondary sealing membrane 13; and then
- anchoring the primary sealing membrane 15 on the insulating elements of the primary thermally insulating barrier 14.

The anchoring of the tank walls on the bearing structure 1 is carried out so as to form the passage 16 in line with the opening 11 in the liquid dome 7. The passage 16 and the opening 11 are thus left free in order to allow the installation of a loading/offloading tower 17 in the tank. Such a loading/offloading tower 17, illustrated in figure 3, makes it possible notably to load the cargo into the tank and/or to offload the cargo from the tank.

The loading/offloading tower 17 has a tripod structure made up of three vertical masts 18. These vertical masts 18 extend over virtually the entire height of the storage space of the tank. Cross members 23 distributed over the entire height of the loading/offloading tower 17 connect the masts 18 together in order to ensure the rigidity and the integrity of the loading/offloading tower 17.

A base of the loading/offloading tower 17 cooperates with a support foot which is fastened to the lower wall 5 of the bearing structure 1 and which is intended

to keep the loading/offloading tower 17 in a vertical position. Such a support foot is described for example in the applications FR3035475 and WO2011157915.

An upper end 19 of the vertical masts 18 protrudes out of the bearing structure 1 through the passage 16 and the opening 11 in the liquid dome 7. One or more of said upper ends 19 are intended to be connected to a LNG transfer system.

Each of the vertical masts 18 is hollow and thus forms either a pipe for loading or offloading the fluid to or from the tank; or an emergency shaft for lowering an emergency pump and an offloading line if the other offloading pumps fail. In the embodiment shown in figure 3, two of the masts 18 form an offloading line for offloading from the tank and, to this end, are each associated with an offloading pump fastened at the lower end of the loading/offloading tower 17, while the third mast 18 forms an emergency shaft.

Figures 4 to 6 illustrate different assembly states of the tank during the process for closing the liquid dome 7. Specifically, in order to have preserve the insulating and sealing features of the tank, the passage 16 in the tank wall has to be obstructed while allowing the upper end 19 of the masts 18 to pass through. For this purpose, as illustrated in figure 3, a closing block 20 for the passage 16 is provided.

The closing block 20 has a thermally insulating barrier portion and a sealing membrane portion. The thermally insulating barrier portion of the closing block 20 may have an insulating lining made for example of polyurethane foam interposed between two rigid sheets made for example of plywood. For example, the thermally insulating barrier portion of the closing block has a structure similar to the structure of a constituent insulating element of one of the thermally insulating barriers 12, 14 of the walls of the tank. Similarly, the sealing membrane portion of the closing block may have a structure similar to the structure of the sealing membranes 13, 15 of the tank walls.

The closing block 20 has dimensions complementary to the dimensions of the passage 16. Furthermore, the closing block 20 has through-orifices 21. These through-orifices 21 have a shape complementary to the external shape of the masts 18 of the loading/offloading tower 17. These through-orifices 21 are arranged in the

closing block 20 at a location corresponding to the location of the masts 18 in the passage 16.

As illustrated in figure 3, the closing block 20 is inserted into the storage space of the tank by inserting the masts 18 of the loading/offloading tower 17 into the corresponding through-orifices 21 in the closing block 20 and then sliding the closing block 20 along the loading/offloading tower 17.

The masts 18 have a retaining member 22. Such a retaining member 22 protrudes from an external face of the mast 18 into the storage space of the tank. The closing block 20 is slid along the masts 18 until it comes to bear on the retaining members 22. These retaining members 22 make it possible to keep the closing block 20 in position during the other operations of closing the liquid dome 7.

In an embodiment that is not illustrated, the retaining members 22 are formed by cross members 23 that connect the masts 18 together situated. More particularly, the closing block 20 rests in the storage space of the tank bearing on the cross member(s) 23 situated closest to the upper wall 4 of the bearing structure 1. Thus, the loading/offloading towers 17 as used in current tanks do not need to be modified to implement the assembly method described herein.

As soon as the closing block 20 is in the storage space bearing on the retaining members 22, the opening 11 in the upper wall 4 of the bearing structure 1 can be obstructed. For this purpose, a hull insert 24 is moved onto the walls 8, 9, 10 of the liquid dome 7, this hull insert 24 forming a cover for the liquid dome 7. Thus, the hull insert 24 has dimensions greater than the dimensions of the opening 11 so as to be able to rest on the upper edge of the walls 8, 9, 10 of the liquid dome 7. The hull insert 24 can be made in numerous ways, for example with a structure and materials similar to the upper wall 4 of the bearing structure 1. The hull insert 24 is preferably fastened to said walls 8, 9, 10 of the liquid dome 7, for example by welding.

In a similar manner to the closing block 20, the hull insert 24 has orifices 25 for the upper end 19 of the masts 18 to pass through. Thus, the hull insert 24 is attached to the walls 8, 9, 10 of the liquid dome by inserting the ends 19 of the masts 18 into the corresponding orifices 25 in the hull insert 24. These ends 19 of the masts

18 are fastened, for example by welding, to the hull insert 24. In other words, the masts 18 can be suspended from the hull insert 24.

The hull insert 24 constitutes a fastening structure for the closing block 20 in order to finish the assembly of the tank by completing the insulation and sealing of the upper tank wall. When the hull insert 24 is installed and obstructs the opening 11 in the liquid dome 7, the closing block 20 can be raised against the hull insert 24. The closing block 20 is slid in one piece along the masts 18 in the direction of the hull insert 24. An external face 27 of the closing block 20 facing the hull insert 24 is then fastened to an internal face 26 of said hull insert 24. In order to complete the sealing of the tank, the masts 18 are fastened in a sealed manner, for example by welding, to the sealing membrane portions of the closing block 20. Similarly, the sealing membrane portions of the closing block 20 are welded in a sealed manner to the sealing membranes of the tank walls anchored on the walls 8, 9, 10 of the liquid dome 7.

The method for assembling the tank at the liquid dome described above with reference to figures 4 to 6 is quick and easy to implement. This is because the closing block 20 can be prefabricated and inserted into the storage space of the tank in one piece. Similarly, this one-piece closing block 20 can be easily raised against and fastened to the hull insert 24, the masts 18 making it possible to keep it in position in the storage space by virtue of the retaining members 22 and to guide it by sliding of the closing block 20.

However, the internal face 26 of the hull insert 24 to which the closing block 20 is fastened can have planarity defects. In figures 6 to 11, such planarity defects are deliberately shown in an exaggerated manner in order to make it easier to study the figures and the following description.

As illustrated in figure 6, when the closing block 20 is raised against the hull insert 24, the planarity defects of the internal face 26 of the hull insert 24 do not make it possible to provide a planar fastening surface for the external face 27 of the closing block 20. Such a planar fastening surface allows good cooperation with the external face 27 of the closing block 20 and therefore allows secure and reliable positioning and fastening of the closing block 20 on/to the hull insert 24.

In order to make up for the planarity defects of the internal face 26 of the hull insert 24, correcting strips 28 are interposed between the closing block 20 and the hull insert 24, that is to say between the external face 27 of the closing block 20 and the internal face 26 of the hull insert 24. These strips have the function of providing a planar fastening surface for the closing block. Thus, these correcting strips 28 have to have an internal face situated in one and the same reference plane 29 in order to jointly form the planar fastening surface of the closing block 20.

The correcting strips 28 have a bead of resin 30. Such beads of resin 30 are used for example in the manufacture of the strips used to make up for the planarity defects of the bearing structure 1 during the anchoring of the tank walls on the walls 2, 3, 4, 5, 6 of the bearing structure 1. These beads of resin 30 are made for example of mastic.

However, because the tanks walls have already been anchored on the walls 2, 3, 4, 5, 6 of the bearing structure 1, the machine that was used to manufacture the resin necessary for the strips for making up for the planarity defects of the walls 2, 3, 4, 5, 6 of the bearing structure 1 is no longer present in the internal space of the bearing structure 1. The resin for manufacturing the beads of resin 30 for the correcting strips 28 is thus manufactured outside the tank and introduced into the tank in order to make the beads of resin 30 and install them between the hull insert 24 and the closing block 20.

Manufacturing the resin outside the tank and the delivery thereof in order to manufacture the beads of resin 30 at the installation site thereof increases the installation time of said beads of resin 30. This increase in the installation time of the beads of resin 30 is disadvantageous since such beads of resin 30 have a maximum exposure time to ambient air before their characteristics deteriorate.

In order to manufacture and install the beads of resin 30 one after another and to limit their exposure time to ambient air, measurements of the planarity of the surface 26 are taken in order to establish a spacing pattern. This spacing pattern defines the distance 31 between the internal face 26 of the hull insert 24 and the reference plane 29 in line with the positions provided for each correcting strip 28. This

spacing pattern thus makes it possible to dimension the thickness of each correcting strip 28 depending on its position.

In order to make it easier to realize the spacing pattern, reference strips 32 (see figure 12) can be positioned on the internal face 26 of the hull insert 24. Such reference strips 3 are fastened for example to the internal surface 26 by double-sided adhesive tape, glue or any other fastening means. These reference strips 32 have an internal face situated in the reference plane 29 and are made for example of plywood or the like. These reference strips 32 are installed on the internal face 26 of the hull insert 24 at locations different than the positions provided for the correcting strips 28 in order not to interfere with the positioning of said correcting strips 28.

Figures 8 to 11 illustrate different embodiments of correcting strips 28 with regard to different modes of assembling the tank at the liquid dome 7.

According to a first variant illustrated in figures 8 and 9, the correcting strips 28 are produced with the aid of beads of resin 30 alone. The beads of resin 30 are dimensioned depending on the measurements of planarity of the surface 26 of the hull insert 24, that is to say on the spacing pattern. Thus, the beads of resin 30 have a thickness determined depending on their position on the internal face 26 of the hull insert 24 and on the distance 31 between said internal face 26 and the reference plane 29 at this position. Each bead of resin 30 is manufactured directly on the external face 27 of the closing block 20 with the dimensions determined according to the spacing pattern. The beads of resin 30 can thus be realized one after another on the external face 27 of the closing block 20.

Since the thickness of the beads of resin 30 is dimensioned depending on the spacing pattern, a distance 33 between said beads of resin 30 and the internal face 26 of the hull insert 24 is uniform, the differences in thickness of the beads of resin 30 making it possible to fill the planarity defects of the hull insert 24. Thus, when the closing block 20 is raised against the internal face 26 of the hull insert 24, the beads of resin 30 are pressed against said internal face 26 substantially at the same time in spite of the planarity defects of the internal face 26. These beads of resin 30 can be subjected to compression and uniform deformation during this raising of the closing block 20 against the hull insert 24, making it possible to secure the closing

block 20 against the hull insert 24 by adhesion. In this compressed state, the internal face of the beads of resin 30 is situated in the reference plane 29.

Figures 10 and 11 illustrate an embodiment variant of the correcting strips 28. In this variant, each correcting strip 28 has a bead of resin 30 associated with a batten 34. Such battens 34 are made for example of plywood. In this variant, the battens 34 are dimensioned depending on the spacing pattern in order to make up for the planarity defects of the internal surface 26 of the hull insert 24. The beads of resin 30 for their part have a uniform thickness.

Such beads of resin 30 of uniform thickness are quick to manufacture since it is not necessary to modify the tooling for manufacturing them in order to adjust the thickness of said beads of resin 30. Thus, said apparatus can manufacture a continuous bead of resin 30 of uniform thickness, which is cut progressively depending on the desired length of the beads of resin 30 to be associated with the battens 34 of the correcting strips 28. Such an apparatus is for example a resin pouch having an application orifice or a pneumatic or electric resin nozzle.

Figure 10 illustrates a first mode of assembling such correcting strips 28. In this first assembly mode, each correcting strip 28 is prefabricated by assembling the correctly dimensioned batten 34 and a corresponding bead of resin 30. Each prefabricated correcting strip 28 is then fastened to the external face 27 of the closing block 20 in the storage space of the tank. More particularly, the battens 34 are fastened to the external face 27 of the closing block 20 such that the beads of resin 30 are interposed between the battens 34 and the internal face 26 of the hull insert 24. The battens 34 are for example stapled to the external face 27 of the closing block 30. Because of the adapted dimensioning of the battens 34, the distance 33 between the beads of resin 30 and the internal face 26 of the hull insert 24 is uniform, in spite of the planarity defects of said internal face 26.

Once the correcting strips 28 have been fastened to the external face 27 of the closing block 20, the closing block 20 can be raised against the hull insert 24 as described above. The beads of resin 30 can be compressed and deformed uniformly between the battens 34 and the internal face 26 of the hull insert 24 and act as an adhesive for fastening the closing block 20 to the hull insert 24.

According to a variant of this first assembly mode, the battens 34 are not prefabricated but assembled directly in the storage space of the tank. First, the correctly dimensioned battens 34 are manufactured and fastened to the external face 27 of the closing block 20 resting in the storage space of the tank. The battens 34 are for example stapled to the external face 27 of the closing block, for example with a stapling spacing less than or equal to 20 cm. When the battens 34 have been correctly fastened to the closing block 20, the beads of resin 30 are manufactured on the external face 35 of the battens 34 or attached to said external faces 35 of the battens 34, that is to say to the face of the battens 34 opposite the internal face 26 of the hull insert 24.

This variant of the first assembly mode makes it possible to further reduce the period of time during which the beads of resin 30 are manufactured without the closing block 20 being raised against the hull insert 24. Specifically, the beads of resin 30 are manufactured one after another and positioned directly on the battens 34 already fastened to the closing block 20 such that the beads of resin do not remain in contact with the ambient air during the steps of fastening the battens 34 to the external face 27 of the closing block 20.

Figure 11 illustrates a second assembly mode, which differs from the other assembly modes in that the correcting strips 28 are not fastened to the closing block 20 but directly to the internal face 26 of the hull insert 24. Thus, the correcting strips 28 are prefabricated one after another and then fastened to the internal face 26 of the hull insert 24. The correcting strips 28 can also be compressed for example by means of a template in order to deform the beads of resin 30 and ensure that the internal face of the battens 34 is in the reference plane 29.

In order to make it easier to assemble the tank, the correcting strips 28 can advantageously be fastened to the hull insert 24 outside the tank. Thus, the hull insert 24 attached to the walls 8, 9, 10 of the liquid dome 7 already has the correcting strips 28 fastened to its internal face 26 such that the closing block 20 can be raised directly in the direction of the hull insert 24 as soon as the hull insert 24 is fastened to the walls 8, 9, 10 of the liquid dome 7. The closing block 20 is raised in the direction of the hull insert 24 until it comes into contact with the battens 34 of the correcting strips 28 fastened to the hull insert 24.

The prior fastening of the correcting strips 28 to the hull insert 24 can be realized with correcting strips 28 having battens 34 associated with beads of resin 30 or only having beads of resin 30 dimensioned according to the spacing pattern, as were described above with reference to figures 8 and 9.

Figure 12 illustrates a closing block 20 anchored on the hull insert 24. In this figure, tie rods 35 are installed between the hull insert 24 and the closing block 20. These tie rods 35 make it possible to raise the closing block 20 against the hull insert 24 when the latter is installed on the walls 8, 9, 10 of the liquid dome 7. Such tie rods 35 have a rod 36 passing through the hull insert 24 and the closing block 20. In an embodiment that is not illustrated, the tie rods 35 have a chain instead of the rod 36.

An upper end of said rod 36 bears a first locking member 37 arranged outside the internal space of the bearing structure 1. This first locking member 37 is for example a nut screwed onto the threaded upper end of the rod 36. This first locking member 37 is in abutment against an external face 38 of the hull insert 24, said external face 38 being on the opposite side from the internal face 26 against which the closing block 20 is fastened.

Similarly, a lower end of the rod 36 bears a second locking member 39 arranged against an internal face 40 of the closing block 20. This second locking member 39 is for example a locknut in abutment against said internal face 40 of the closing block 20. Such tie rods 35 make it possible to raise the closing block 20 from its rest position bearing against the retaining member 21 in the storage space of the tank to its positioned fastened to the hull insert 24, that is to say with the external face 27 of the closing block 20 situated in the reference plane 29. The sealing of the sealing membranes can also be completed when the closing block is in position against the hull insert 24 by sealing the tie rods 35 and said sealing membranes. Similarly, the first locking member 36 can be welded to the hull insert 24.

In another embodiment, the tie rods are used to keep the closing block 20 in position during the drying period of the beads of resin 30, for example about 24 hours, and are then replaced by suitable anchoring members for anchoring the closing block 20 on the hull insert 24.

Advantageously, the reference strips 32 installed on the internal face 26 of the hull insert 24 in order to define the reference plane 29 also make it possible to block the raising of the closing block 20. Specifically, the raising of the closing block 20 against the hull insert 24 presses the beads of resin 30 against the internal face 26 of the hull insert 24. However, the deformation of said beads of resin 30 does not make it possible to reliably block the raising of the closing block 20 when the external face 27 of said closing block 20 arrives in the reference plane 29. The reference strips 32 act as a stop, blocking the raising of the closing block 20 when the external face 27 of said closing block 20 reaches the reference plane 29.

The technique described above for assembling a sealed and thermally insulating tank can be used in different types of reservoirs, for example to form the sealed and thermally insulating tank of a LNG reservoir in an on-shore facility or in a floating structure such as a methane carrier ship or the like.

With reference to figure 13, a cutaway view of a methane carrier ship 70 shows a sealed and insulated tank 71 of prismatic overall shape mounted in the double hull 72 of the ship. The wall of the tank 71 has a primary sealed barrier intended to be in contact with the LNG contained in the tank, a secondary sealed barrier arranged between the primary sealed barrier and the double hull 72 of the ship, and two insulating barriers arranged between the primary sealed barrier and the secondary sealed barrier and between the secondary sealed barrier and the double hull 72, respectively.

In a manner known per se, loading/offloading pipelines 73 disposed on the upper deck of the ship can be connected, by means of appropriate connectors, to a maritime or port terminal in order to transfer a LNG cargo from or to the tank 71.

Figure 13 shows an example of a maritime terminal having a loading and offloading station 75, an underwater pipe 76 and an on-shore facility 77. The loading and offloading station 75 is a fixed off-shore facility having a mobile arm 74 and a tower 78 that supports the mobile arm 74. The mobile arm 74 bears a bundle of insulated flexible pipes 79 that can be connected to the loading/offloading pipelines 73. The orientable mobile arm 74 is adaptable to all sizes of methane carriers. A connecting pipe (not shown) extends inside the tower 78. The loading and offloading

station 75 allows the loading of and offloading from the methane carrier 70 from or to the on-shore facility 77. The latter has tanks for storing liquefied gas 80 and connecting pipes 81 connected by the underwater pipe 76 to the loading or offloading station 75. The underwater pipe 76 allows the transfer of the liquefied gas between the loading or offloading station 75 and the on-shore facility 77 over a long distance, for example 5 km, making it possible to keep the methane carrier ship 70 a long way from the coast during the loading and offloading operations.

In order to generate the pressure necessary for transferring the liquefied gas, use is made of pumps carried onboard the ship 70 and/or pumps with which the on-shore facility 77 is equipped and/or pumps with which the loading and offloading station 75 is equipped.

Although the invention has been described in connection with a number of particular embodiments, it is obvious that it is in no way limited thereto and that it encompasses all the technical equivalents of the means described and the combinations thereof where these fall within the scope of the invention.

The use of the verb “have”, “comprise” or “include” and the conjugated forms thereof does not rule out the presence of other elements or other steps than those set out in a claim. The use of the indefinite article “a” or “an” for an element or a step does not, unless mentioned otherwise, rule out the presence of a plurality of such elements or steps.

In the claims, any reference sign between parentheses should not be interpreted as limiting the claim.

CLAIMS

1. A method for assembling a sealed and thermally insulating tank inside a bearing structure (1), said bearing structure (1) having a plurality of walls (2, 3, 4, 5, 6) that delimit an internal space and include an upper wall (4) of the bearing structure (1) that has an opening (11), the assembly method including the following steps of:

- installing a loading/offloading tower (17) in the internal space through the opening (11), said loading/offloading tower (17) having a plurality of pipes (18) that each have an upper end (19) protruding from the internal space, said loading/offloading tower (17) having at least one retaining member (22, 23);
- providing a closing block (20) having a tank wall portion, said closing block (20) having orifices (21);
- inserting the upper ends (19) of the pipes (18) into the corresponding orifices (12) in the closing block (20);
- sliding the closing block (20) along the pipes (18) until the closing block (20) rests against the retaining member (22, 23) in the internal space;
- providing a bearing structure insert (24) having through-orifices (25);
- mounting the bearing structure insert (24) on the bearing structure such that said bearing structure insert (24) obstructs the opening (11) in the upper wall (4) of the bearing structure (1) and the ends (19) of the pipes (18) of the loading/offloading tower (17) pass through the through-orifices (25) in said bearing structure insert (24);
- sliding the closing block (20) along the pipes (18) in the direction of the bearing structure insert (24); and
- fastening the closing block (20) to the bearing structure insert (24).

2. The assembly method as claimed in claim 1, wherein the bearing structure insert (24) has an internal surface (26) facing an external face (27) of the closing block (20), the method also including the step of interposing correcting strips

(28) between the external face (27) of the closing block (20) and the internal surface (26) of the bearing structure insert (24), said correcting strips (28) forming a planar support surface in the internal space of the bearing structure (1), the external face (27) of the closing block (20) being fastened to said planar support surface.

3. The method as claimed in claim 2, also including the steps of:

- measuring the planarity of the internal surface (26) of the bearing structure insert (24),
- dimensioning a thickness of the correcting strips (28) depending on the measurement of the planarity of the internal surface (26) of the bearing structure insert (24) such that internal faces of said correcting strips on the opposite side from the bearing structure (24) are arranged in one and the same plane (29) to jointly form the planar support surface.

4. The assembly method as claimed in either of claims 2 and 3, wherein the correcting strips (28) have a bead of resin (30), and wherein the beads of resin (30) are secured to the internal surface (26) of the bearing structure insert (24).

5. The assembly method as claimed in claim 4, wherein the correcting strips (28) have a batten (34), and wherein a respective bead of resin (30) is secured to each batten (34).

6. The assembly method as claimed in claim 5, wherein the battens (34) have a thickness that is dimensioned depending on the measurement of the planarity of the internal surface (26) of the bearing structure insert (24) so as to form the planar support surface, and wherein said battens (34) are fastened to the external face (27) of the closing block (20).

7. The assembly method as claimed in claim 6, wherein the beads of resin (30) have a uniform thickness.

8. The assembly method as claimed in one of claims 5 to 7, also including, before the sliding of the closing block (20) in the direction of the bearing structure insert (24), fastening the correcting strips (28) to the external face (27) of the closing block (20), and then fastening the correcting strips (28) against the internal

surface (26) of the bearing structure insert (24) in order to fasten the closing block (20) to the bearing structure insert (24).

9. The assembly method as claimed in claim 8, also including the step of applying the beads of resin (30) to an external face of the battens (34), said external faces of the battens (34) being opposite the bearing structure insert (24).

10. The assembly method as claimed in one of claims 4 to 7, also including the step of applying the beads of resin (30) to the internal face (26) of the bearing structure insert (24) before the closing block (20) is slid in the direction of the bearing structure insert (24).

11. The assembly method as claimed in claims 4 to 10, also including the step of installing reference strips (32) on the internal face (26) of the bearing structure insert (24), said reference strips (32) having an internal surface on the opposite side from the bearing structure insert (24) and situated in one and the same plane, the correcting strips (28) being dimensioned to form the support surface in said plane.

12. The assembly method as claimed in one of claims 1 to 11, also including the step of installing tie rods (35) between the bearing structure insert (24) and the closing block (20), said tie rods (35) being actuated to slide the closing block (20) in the direction of the bearing structure insert (24).