

INERTING DEVICE FOR A LIQUEFIED GAS STORAGE TANK FOR A LIQUEFIED GAS CARRYING VESSEL

TECHNICAL FIELD

5 The invention relates to an inerting device for a liquefied gas storage tank for a liquefied gas carrying vessel, as well as a vessel comprising at least one such device. The invention can be applied, in particular, to the inerting of a membrane tank used for the storage of liquefied natural gas (LNG).

PRIOR ART

10 Prior art includes documents FR-A1-3 014 197 and FR-A1-2 317 159.

 A liquefied gas carrying vessel includes one or more sealed and thermally insulating tanks for the storage of liquefied natural gas. Each tank includes a tank wall having successively, in the thickness direction, from the inside toward the outside of the tank, a primary sealing membrane adapted to be in contact with
15 the liquefied natural gas, a primary thermally insulating barrier, a secondary sealing membrane, a secondary thermally insulating barrier and a supporting structure defining the general shape of the tank.

 The primary and secondary sealing membranes delimit there between a primary space which contains the primary insulating barrier and which is intended
20 to be filled with an inert gas, usually nitrogen. Inert gas also supplies the secondary space defined by the secondary sealing membrane.

 The supporting structure of the tank is formed on the one hand by sealed transverse partitions called "cofferdam" located on at least two opposite sides of the tank, and a tank bottom which extends under the tank and defines with it a
25 passage in which fluids such as condensation water or LNG can flow in the event of a leak. These fluids generally flow by gravity into a drainage box before being evacuated.

 The sealing membranes of such a tank may include leaks causing the liquefied natural gas to pass from the inside of the tank toward the primary and
30 secondary thermally insulating barriers. However, when a combustible gas is in the presence of a oxidizing gas and the concentration of the combustible gas is in a concentration range between its lower explosive limit (LEL) and its upper

explosive limit (UEL) and the oxidizing gas is in an appropriate concentration range, the combustible gas is likely to ignite and explode.

Inerting the primary and secondary spaces, i.e. placing them under inert atmosphere, allows to prevent accidents. Thus, combustible and oxidizing gases,
5 which could be present in thermally insulating barriers, are diluted in such a way that explosive conditions are not reached.

In the current technique, each of the primary and secondary spaces is connected to a nitrogen line that allows to supply nitrogen to the space but also evacuates nitrogen from it. It is therefore a bi-directional line that is connected to
10 a space at one or two fluid communication ports.

There are several tank technologies available. The tank can be completely "buried" and covered by the double deck of the vessel. In another configuration, the inner and outer shells of the tank protrude from the double deck of the vessel to form vapour and liquid domes in the form of two turrets or
15 chimneys adapted to pass cargo handling equipment to handle a liquid phase and a vapour phase of the liquefied gas contained in the tank.

With this last technology, it is easier to access the primary and secondary spaces at the domes and connect them to the nitrogen lines. This is not the case with the first technology in which nitrogen lines must cross the double bridge to
20 connect the spaces to be inerted. This problem is the same for the piloted safety valves that equip the tanks.

A tank is equipped with such valves to prevent overpressure in the primary and secondary spaces. In the first technology mentioned above, the valves must cross the double upper deck to be connected to the spaces.

25 In general, crossings of the double deck and the supporting structure of the tank should be avoided as they can facilitate leaks and result in significant additional costs for the design and construction of the tank.

This invention offers a simple, efficient and cost-effective upgrade that allows the inerting of a secondary space of any type of tank without a dedicated
30 crossing of its supporting structure.

SUMMARY OF THE INVENTION

The invention proposes an inerting device for a liquefied gas storage tank for a liquefied gas carrying vessel, comprising:

- a liquefied gas storage tank including, successively, from the inside to the outside of the tank, a primary sealing membrane intended to be in contact with the liquefied gas, a primary thermally insulating barrier, a secondary sealing membrane, a secondary thermally insulating barrier and a supporting structure defining the general shape of the tank, said primary and secondary sealing membranes defining therebetween a primary space containing said primary thermally insulating barrier, said primary thermally insulating barrier forming an inner shell around the tank, and said secondary sealing membrane and said supporting structure defining therebetween a secondary space containing said secondary thermally insulating barrier, said secondary thermally insulating barrier forming an outer shell around the liquefied gas storage tank, each of the primary and secondary spaces being intended to be filled with an inert gas, and said liquefied gas storage tank being disposed between two sealed partitions and above a tank bottom, said sealed partitions and said tank bottom being part of said supporting structure,
- a drainage box located under the liquefied gas storage tank, the drainage box being connected to a passage extending between the tank bottom and the outer shell so that fluids can flow by gravity from the tank bottom to the drainage box,
- means for supplying nitrogen to the primary and secondary spaces, and/or evacuating nitrogen from the primary and secondary spaces,
- characterized in that said drainage box is in fluid communication with said passage and said secondary space, and in that said means for supplying and/or evacuating said secondary space include a nitrogen line which is connected to said drainage box so that the nitrogen supplied by the nitrogen line to the secondary space and/or evacuated from the secondary space circulates through the drainage box.

The invention thus proposes to connect the nitrogen line to the secondary space via the drainage box. The drainage box is connected to the passage extending between the tank bottom and the outer shell to be able to collect the fluids that are likely to flow through this passage. The drainage box is also
5 connected to the secondary space to ensure fluid communication between the nitrogen line and the secondary space. The secondary space no longer needs to be equipped with ports dedicated to the connection with the nitrogen line, which

simplifies the design of the tank. The nitrogen line can have a dual function, namely to supply the secondary space with nitrogen for its inerting and also to supply nitrogen to the drainage box itself. This prevents accidental explosions in both the secondary space and the drainage box, which is likely to receive LNG in the event of a leak.

The nitrogen supply to the secondary space through the drainage box also facilitates the gas evacuation, such as methane, from the secondary space. This gas is then driven out of the secondary space by nitrogen which, because of its lightness compared to methane, will tend to drive the methane toward the top of the tank where there is usually a fluid communication port.

The device according to the invention may include one or more of the following characteristics, taken in isolation from each other or in combination with each other:

- said drainage box is connected to a nitrogen drainage and circulation duct that opens into said passage and said secondary space,

- the device further comprises at least one safety valve, preferably piloted, which is directly connected to said nitrogen line; this means that the safety valve or valves securing the secondary space can be mounted directly on the nitrogen line and no longer on the tank; there are therefore fewer tank crossings, which is advantageous for the reasons explained above; moreover, the displacement of the valve(s) on the nitrogen line has a clear advantage of reactivity compared to the prior technique, which will be explained in more detail in the following,

- said at least one safety valve includes a main line including a main gate and a pilot line including a pilot gate, at least one of said main and pilot lines being directly connected to said nitrogen line,

- the device includes two piloted safety valves, at least one of said main and pilot lines of each of these valve being directly connected to said nitrogen line,

- the main and pilot lines of the valve or of each valve are directly connected to said nitrogen line,

- the device further includes at least one safety valve, preferably piloted, which is directly connected to said secondary space; this safety valve provides additional safety by preventing an excessive pressure increase in the secondary space,

5 - at the upper end of the tank, the outer shell extends completely above the inner shell,

- alternatively, at the upper end of the tank, the inner and outer shells protrude on a double bridge covering the tank, to form domes.

This invention also concerns a liquefied gas carrying vessel including at
10 least one device as described above.

BRIEF DESCRIPTION OF THE DRAWINGS

The invention will be better understood and other details, specifications and advantages of the present invention will appear more clearly after reading the following description, provided by way of illustration and with reference to the
15 appended drawings, in which:

- Figure 1 is a very schematic view of an inerting device of a liquefied gas carrying tank,

- Figure 2 is a schematic view of a drainage box and a tank portion, and illustrates an embodiment of the invention,

20 - Figures 3 to 5 are very schematic views of others embodiments of the invention, for a type of tank,

- Figures 6 and 7 are very schematic views of others embodiments of the invention for another type of tank,

- Figure 8 is a schematic cross-sectional view of a pilot-type safety valve,
25 and

- Figures 9 and 10 are very schematic views of a tank equipped with a piloted safety valve.

DETAILED DESCRIPTION

With reference to Figure 1, a schematic representation has been made
30 of a tank 1 for the storage of liquefied gas. Each wall of the tank 1 includes a multilayer structure comprising, from the outside to the inside of the tank 1, a supporting structure 2 defining the general shape of the tank 1, a secondary

thermally insulating barrier 3 including insulating elements resting against the supporting structure 2, a secondary sealing membrane 4, a primary thermally insulating barrier 5 including insulating elements resting against the secondary sealing membrane 4 and a primary sealing membrane 6 intended to contact the liquefied combustible gas contained in the tank 1.

In the following description, the term "primary space" refers to the space containing the primary thermally insulating barrier 5, and "secondary space" refers to the space containing the secondary thermally insulating barrier 3. As shown in the drawing, the primary thermally insulating barrier forms an inner shell that is surrounded by the outer shell formed by the secondary thermally insulating barrier, and which is itself surrounded by the supporting structure 2.

The supporting structure 2 may in particular be a self-supporting metal sheet and/or be formed by the hull or double hull of a vessel.

The thermally insulating barriers 3, 5 include insulating solids and a gas phase. According to an embodiment, the thermally insulating barriers 3, 5 are made up of heat-insulating boxes, not shown. The boxes include a bottom panel and a cover panel, made for example in plywood, and a plurality of spacers interposed between the bottom and cover panels. Compartments for the accommodation of a heat-insulating lining are provided between the spacers. The heat-insulating lining can be made of any material with appropriate thermally insulating properties. For example, the heat-insulating lining is chosen from materials such as perlite, glass wool, polyurethane foam, polyethylene foam, polyvinyl chloride foam, aerogels or others.

Primary and secondary sealing membranes 4, 6 are gas and liquid tight. The supporting structure 2 is also tight. Therefore, for the purposes of this description and the claims, the term "sealed barrier" covers both the sealing membranes 4, 6 and the supporting structure 2. Thus, the secondary thermally insulating barrier 3 is arranged in a sealed space which is isolated from the ambient pressure, on the one hand, by a first sealed barrier consisting of the secondary sealing membrane 4, and on the other hand, by a second sealed barrier consisting of the supporting structure 2.

The liquefied gas includes a chemical body or mixture of chemical bodies that has been placed in a liquid phase at low temperature and that occurs in a vapour phase under normal temperature and pressure conditions. The liquefied gas 3 may in particular be a liquefied natural gas (LNG), i.e. a gas mixture including mainly methane and one or more other hydrocarbons, such as ethane, propane, n-butane, 1-butane, n-pentane, i-pentane and nitrogen in a small proportion. The liquefied natural gas is stored at atmospheric pressure at a temperature of approximately -162°C.

The liquefied gas can also be ethane or liquefied petroleum gas (LPG), i.e. a mixture of hydrocarbons from petroleum refining including mainly propane and n-butane. The combustible gas can also be ethylene.

In order to avoid that, due to leaks of liquefied natural gas through the sealing membranes 4, 6 and/or air through the supporting structure 2, a gas mixture is present in explosive proportions in the walls of tank 1, these are subjected to a process known to the person skilled in the art, and for example described in application WO-A1-2015/124536.

In the example shown, the inerting device targets specifically to inert the secondary space. The inerting device also includes inert gas injection equipment 11 to flush the thermally insulating barrier 3 with an inert gas. The injection equipment 11 includes a pressurized inert gas generator 12 connected to an inert gas supply duct 14 opening into the secondary space. The pressurized inert gas generator 12 is connected to the duct 14 by a gate 16 to regulate the flow rate and/or the pressure of the inert gas injection inside the thermally insulating barrier 3. The inert gas is preferably nitrogen and more precisely dinitrogen or a mixture including this gas.

The duct 14 can also be equipped with an optional additional pump 13 to inject inert gas from the inert gas generator 12.

The invention proposes an improvement to this technology consisting in supplying dinitrogen to the secondary space of the tank via the drainage box 20 of this tank (see Figure 2).

The drainage box 20 is located under the tank 1 and is connected to a passage 22 extending between the tank bottom 2a of the supporting structure 2

and the outer shell so that fluids can flow by gravity from the tank bottom to the drainage box. The box 20 is thus connected to an end of a first duct 24 whose opposite end opens to an upper surface of the tank bottom. The box 20 is also connected to an end of a second duct 26 for the evacuation of the harvested
5 fluids toward the outside of the box, this second duct can be equipped with a gate 28.

Reference 23 refers to a peripheral cord that is placed in the space and that guides the fluids to the drainage box 20. For example, the cord is made of polymerizable resin and can be continuously extended around the entire
10 periphery of the tank bottom 2a so that the fluids flowing on the peripheral walls of the supporting structure 2 are then conveyed to the drainage box. Alternatively, the cord could be made of metal profiles.

Reference 30 refers to the nitrogen line of the secondary space, i.e. the line that allows both the nitrogen supply to the secondary space and the nitrogen
15 evacuation from that space, i.e. otherwise the nitrogen circulation in the secondary space. This nitrogen line 30 is thus bi-directional and can therefore be considered as fulfilling the functions of ducts 8 and 14 in Figure 1.

The nitrogen line 30 opens here directly into the drainage box 20 and its connecting duct 24 to the passage 22 is also configured to be in fluid
20 communication with the secondary space. In practice, the end of the duct 24 located at the passage 22 can be extended and have a first orifice opening into the passage 22 and a second orifice opening into the secondary space. Alternatively, the secondary space could be in fluid communication with the passage 22 through at least one orifice provided in the outer shell and opening
25 into the secondary space.

Figures 3 to 7 illustrate others embodiments of the invention.

Figures 3 to 5 refer to a first type of tank known as "NO96" and figures 6 and 7 refer to a second type of tank known as "Mark".

The upper double deck 2b of the vessel of the supporting structure 2 of
30 a NO96 tank covers the entire tank, which is also isolated from other tanks or the rest of the vessel by transverse sealed partitions 2c called "cofferdam".

In the embodiment of Figure 3, the secondary space of the tank 1 is equipped with two piloted safety valves 32 to prevent overpressure in this space. Although not shown, the primary space of the tank 1 is also equipped with one or two piloted safety valves.

5 From a sizing point of view, it is clearly accepted by classes, shipyards and ship-owners that the main cause of overpressure in the secondary space of a tank is the malfunctioning of control gate 28 34 located on the nitrogen line 30. Another possible cause of overpressure is related to the heating phase of the spaces.

10 A problem with the prior technique is related to the distance between the overpressure source (nitrogen line 30) and the valves 32. The sudden appearance of a high nitrogen flow rate (malfunction of gate 34) could induce a certain latency, due to pressure drops, so that the valve has not yet detected the overpressure. In such a case, the valve would not open fast enough and a rapid
15 overpressure would occur in the secondary space near the nitrogen line.

To solve this problem, a solution is to place at least one of the two valves 32 directly on the nitrogen line 30 which is identified as the only source of overpressure. Preferably, the valve(s) are arranged between the gate 34 and the drain box 20. In the variant of Figure 4, a valve 32 is mounted on line 30 and the
20 other is mounted on the tank crossing the double bridge 2b. In the variant of Figure 4, the two valves 32 are mounted on line 30.

The upper double deck 2b of the vessel of the support structure 2 of a Mark tank is crossed by portions of the inner and outer tank shells that form domes 33a, 33b. The double bridge 2b is interrupted at two locations where the
25 tank forms a protruding structure in turret or chimney shape. The first turret is a liquid dome 33a which serves as a penetration point for various LNG handling equipment, such as a filling line, an emergency pumping line, unloading lines linked to unloading pumps, a spraying line, a supply line linked to a spraying pump, etc. The second turret is a vapour dome 33b which serves as a penetration
30 point for example for a vapour collecting duct. The operation of this equipment is also known.

In Figures 6 and 7, the tank can be equipped with a dedicated line for evacuating the inert gas contained in the secondary space (represented by a dotted arrow 35). This evacuation line could be connected to a degassing mast to evacuate the inert gas to the atmosphere. The line 30 of this tank would then
5 be an intake line and not a bi-directional one. A similar technology can be used to equip the tank of figures 3 to 5.

In this invention, safety valves 34 are piloted type, i.e. they include a main line 36 including a main gate and a pilot line 38 including a pilot gate (Figure 8). Typically, the main line 36 includes an inlet and an outlet between which is
10 located the main gate 36a. The inlet and the outlet of the main line are connected to a circulation duct of a fluid such as the nitrogen line 30.

The pilot line 38 includes an inlet and an outlet between which the pilot gate 38a is arranged. The pilot line inlet is connected to the above-mentioned duct and its outlet is connected to the main gate 36a.

15 The pilot gate 38a is operated by high pressure P1 and back pressure P2. The reference pressure P0 in the pilot gate 38a is equal to the atmospheric pressure.

The main gate 26a is an opening gate. The high pressure P1 is applied to the underside of a cone 42. The pressure P1 also passes through a piston rod
20 43 to an upper chamber 44 of the gate, which exerts pressure on the piston 45. The surface of the piston is larger than that of the gate seat, which, with the action of a spring, keeps the gate closed.

When pressure P1 reaches the set pressure of the pilot gate, the opening starts. Pressure P2 increases in the pilot line and in the lower chamber 46 of the
25 main gate. The pressure of the lower chamber is limited by the flow rate through the port 47. When the flow rate through the pilot gate exceeds the capacity of the orifice, the pressure in chamber 46 increases, causing the main gate to open. When the pressure P1 decreases, the pilot gate closes, and the pressure P2 is equalized by the port 47. The spring then closes the main gate.

30 As shown in Figures 9 and 10, when a safety valve 32 is mounted on line 30, its two main 36 and pilot 38 lines can be connected to line 30 (Figure 9) or only one of them (Figure 10). In the case of Figure 10, the main line 36 is

connected to line 30 while the pilot line 38 is connected to the secondary space. This avoids the effects of dynamic pressure, and only measures a static pressure of the volume.

5 The invention therefore makes it possible to simplify the design of a liquefied gas carrying tank by optimizing its inerting device and even the safety (valve) associated with this device.

CLAIMS

1. Inerting device for a liquefied gas storage tank for a liquefied gas carrying vessel, comprising:

- 5 - a liquefied gas storage tank (1) including, successively, from the inside to the outside of the tank, a primary sealing membrane (6) intended to be in contact with the liquefied gas, a primary thermally insulating barrier (5), a secondary sealing membrane (4), a secondary thermally insulating barrier (3) and a supporting structure (2) defining the general shape of the tank (1), said primary
 - 10 (6) and secondary (4) sealing membranes defining therebetween a primary space containing said primary thermally insulating barrier (5), said primary thermally insulating barrier (5) forming an inner shell around the tank (1), and said secondary sealing membrane (4) and said supporting structure (2) defining therebetween a secondary space containing said secondary thermally insulating
 - 15 barrier (3), said secondary thermally insulating barrier (3) forming an outer shell around the liquefied gas storage tank, each of the spaces being intended to be filled with an inert gas, and said liquefied gas storage tank (1) being disposed between two sealed partitions (2c) and above a tank bottom (2a), said sealed partitions and said tank bottom being part of said supporting structure,
 - 20 - a drainage box (20) located under the liquefied gas storage tank, the drainage box being connected to a passage (22) extending between the tank bottom and the outer shell so that fluids can flow by gravity from the tank bottom to the drainage box,
 - means for supplying nitrogen to the primary and secondary spaces,
 - 25 and/or evacuating nitrogen from the primary and secondary spaces,
- characterized in that said drainage box is in fluid communication with said passage and said secondary space, and in that said means for supplying and/or evacuating said secondary space include a nitrogen line (30) which is connected to said drainage box so that the nitrogen supplied by the nitrogen line to the

secondary space and/or evacuated from the secondary space circulates through the drainage box.

2. Inerting device according to claim 1, wherein said drainage box (20) is connected to a nitrogen drainage and circulation duct (24) that opens into said
5 passage (22) and said secondary space.

3. Inerting device according to claim 1 or 2, wherein it further comprises at least one safety valve (32), preferably piloted, which is directly connected to said nitrogen line (30).

5 4. Inerting device according to the preceding claim, wherein said at least one safety valve (32) includes a main line (36) including a main gate (36a) and a pilot line (38) including a pilot gate (38a), at least one of said main and pilot lines being directly connected to said nitrogen line (30).

10 5. Inerting device according to the preceding claim, wherein it includes two piloted safety valves (32), at least one of said main (36) and pilot (38) lines of each of these valves being directly connected to said nitrogen line (30).

6. Inerting device according to claim 4 or 5, wherein the main (36) and pilot (38) lines of the valve (32) or of each valve (32) are directly connected to said nitrogen line (30).

15 7. Inerting device according to any one of the preceding claims, in which it further includes at least one safety valve (32), preferably piloted, which is directly connected to said secondary space.

8. Inerting device according to one of the preceding claims, in which, at the upper end of the tank (1), the outer shell extends completely above the inner shell.

20 9. Inerting device according to one of claims 1 to 7, wherein, at the upper end of the tank (1), the inner and outer shells protrude on a double bridge covering the tank to form domes (33a, 33b).

10. Vessel for carrying liquefied gas, including at least one inerting device according to any one of the preceding claims.