

Description

Title of the invention: Vessel for transporting or using a cold fluid

Technical field

- 5 [1] The invention relates to the field of vessels for transporting a cold fluid. In particular, the invention relates to the field of vessels comprising sealed and thermally insulating tanks for transporting a liquefied gas, in particular LNG, and to the liquefied gas powered vessel, for example, powered by LNG.

Technological background

- 10 [2] Liquefied natural gas is stored in sealed and thermally insulating tanks in a two-phase vapour-liquid equilibrium state at cryogenic temperatures, in particular Liquefied Natural Gas (LNG) is stored at approximately -162°C at atmospheric pressure.
- [3] The tank can be produced using various techniques, in particular in the form of an integrated membrane cargo tank or a self-supporting tank. The thermal insulation barriers
15 of the liquefied natural gas storage tanks and the adjacent compartments are the source of a heat flow that tends to heat the content of the tanks, resulting in the evaporation of the liquefied natural gas. The gas resulting from the natural evaporation is generally used to feed a gas consuming component, in order to take full advantage of said gas. Thus, on an LNG tanker vessel, the evaporated gas is used to power the propulsion unit for propelling
20 the vessel. However, although this practice allows the gas resulting from the natural evaporation in the liquefied gas transport tanks to be optimized, it does not allow its quantity to be reduced.
- [4] Furthermore, the LNG contained in the tanks is often intended to be transported and not to be consumed by the vessel. Thus, the evaporation rate, commonly called the “*Boil-Off Rate*” (BOR) of the liquid contained in the tank is a major problem, particularly leading to
25 the loss of some of the cargo.
- [5] Several solutions are known for reducing the BOR or for recycling the gas evaporated in a tank containing LNG, in particular:
re-liquefaction devices via a heat exchanger for condensing the gas resulting from the
30 natural evaporation;
increasing the thickness of the insulation in the tank; or
using more thermally efficient materials.
However, these solutions are reaching saturation point and no longer allow a favourable

performance-cost ratio to be obtained. Moreover, modifying a tank intended to receive LNG is complicated and costly.

- 5 [6] The liquefied natural gas is also frequently placed on board in order to make up the fuel, or at least one of the fuels, for propelling all types of vessels, for example, LNG transport or LNG tanker vessels, oil tankers, but also container vessels. This is called an “LNG Fueled Ship” or LFS. In such vessels, at least one LNG tank is commonly located in the vicinity of a heat source, for example, an engine room.

Summary

- 10 [7] One idea behind the invention is to provide a vessel for which the temperature can be lowered in the internal space of a transverse cofferdam in order to reduce the heat flows between this internal space and an adjacent tank and therefore the evaporation rate in the tank containing cold liquid. One aim is to reduce, for example, the BOR by 5% or 6%.
- 15 [8] One idea behind the invention is to reduce the heat flows between any hollow spaces of the vessel adjacent to the LNG storage tanks and the external environment, in particular ballast water and atmospheric air, for example, reducing the heat flows passing through the periphery of the cofferdams.
- [9] Another idea behind the invention is to reduce the heat flows in the cofferdams located between a heat source and an LNG tank in order to protect said heat source and said LNG tank from changes of temperature.
- 20 [10] Another idea behind the invention is to manage the gaseous atmosphere in the cofferdams of a vessel.
- [11] Another idea behind the invention is to reduce the temperature in the cofferdams in order to reduce the BOR in the LNG storage tanks.
- 25 [12] Another idea behind the invention is to obtain an equilibrium temperature in the cofferdams, for example, -15 degrees Celsius (°C) or -25 °C, while maintaining its integrity.
- 30 [13] The reduction in temperature in the hollow spaces of the vessel, and in particular the cofferdams, leads to the risks of frost appearing in the internal space of the cofferdam, in particular on the walls or in the insulation. This risk is particularly due to the humidity present in the ambient atmosphere. This creation of frost involves risks of degrading the thermal performance capabilities of the insulation and risks of corroding the walls of the cofferdam.

[14] The invention thus proposes integrating a gas management installation in order to manage a gaseous atmosphere in a hollow space of the vessel, such as the cofferdams, in order to address the technical problems that have been described.

[15] Definitions:

5 [16] The term “fluid” includes liquids and gases.

[17] The term “cold” or “cryogenic” is defined as being a low temperature, for example, negative temperatures (in °C), such as - 50°C or - 162°C.

[18] The term “cofferdam” is defined as being a hollow separating space in a vessel adjacent to at least one tank, it also can be called “caisson” or “dry mesh”.

10 [19] The term “valve” denotes a valve or a valve gate.

[20] According to one embodiment, the invention provides a vessel for transporting a cold fluid, the vessel comprising:

15 a load-bearing structure comprising a hull extending in a longitudinal direction and at least one transverse cofferdam subdividing the hull into a plurality of segments, the one or each transverse cofferdam comprising a pair of transverse bulkheads defining an internal space of the transverse cofferdam and an upper wall closing said internal space;

at least one sealed and thermally insulating tank disposed in a segment of the hull adjacent to said transverse cofferdam;

20 a gas management installation for managing a gaseous atmosphere in the internal space of the transverse cofferdam, wherein the gas management installation comprises:

a dry air supply pipeline comprising a first end located outside the transverse cofferdam and connected to a dry air generator supplying dry air, and a second end emerging into the internal space of the transverse cofferdam;

an intake valve mounted on the dry air supply pipeline;

25 a gas discharge pipeline comprising a first end emerging into the internal space of the transverse cofferdam and a second end emerging outside the vessel;

a discharge valve mounted on the gas discharge pipeline, the discharge valve being configured to open when a relative pressure in the internal space rises above a first threshold value;

30 a pressure sensor configured to detect a relative pressure in the internal space of the transverse cofferdam;

a pressure regulator connected to the pressure sensor and to the intake valve, the pressure regulator being configured to:

open the intake valve when the relative pressure in the internal space drops below a second threshold value, the second threshold value being a positive value lower than the first threshold value.

[21] By virtue of these features, the pressure of the gaseous atmosphere in the internal space of the transverse cofferdam is regulated so as to remain higher than the ambient pressure, so that spontaneous entry of ambient air and moisture is prevented. These features particularly allow corrosion damage to the various elements located in the internal space of the transverse cofferdam to be prevented. Furthermore, the gas management installation allows the relative pressure to be maintained in a positive range ranging between the second threshold value and the first threshold value, despite the temperature variations in the internal space and the variations in the ambient pressure. By virtue of the first threshold value, it is possible to limit the pressure that will be exerted on the pair of transverse bulkheads and the upper wall of the transverse cofferdam.

[22] According to embodiments, such a vessel can comprise one or more of the following features.

[23] According to one embodiment, the pressure regulator is further configured to:
close the intake valve when the pressure in the internal space rises above a third threshold value ranging between the second threshold value and the first threshold value.

[24] By virtue of these hysteresis features, the operation of the intake valve is optimized and also avoids the intake valve opening or closing too many times, which could lead to premature wear of the equipment.

[25] According to one embodiment, a difference between the third threshold value and the second threshold value is less than 2 kPa (kilopascal) (20 mbarg).

[26] According to one embodiment, a difference between the third threshold value and the second threshold value ranges between 0.5 kPa and 1.5 kPa, for example, a difference of 1 kPa.

[27] According to one embodiment, the pressure regulator is further connected to the discharge valve, the pressure regulator is further configured to:
open the discharge valve when the pressure in the internal space rises above the first threshold value.

- [28] By virtue of these features, the programming and management of the opening and closing parameters of the intake valve and of the discharge valve of the gas management installation are facilitated and can be managed centrally.
- [29] According to one embodiment, the pressure regulator is further configured to:
 5 close the discharge valve when the pressure in the internal space drops below a fourth threshold value ranging between the first threshold value and the second threshold value.
- [30] By virtue of these hysteresis features, the operation of the discharge valve is optimized and also avoids the discharge valve opening or closing too many times, which could lead to premature wear of the equipment.
- 10 [31] According to one embodiment, a difference between the fourth threshold value and the first threshold value is less than 2 kPa (20 mbarg).
- [32] According to one embodiment, a difference between the fourth threshold value and the first threshold value ranges between 0.5 kPa and 1.5 kPa, for example, a difference of 1 kPa.
- 15 [33] According to another embodiment, the discharge valve is a mechanically opening and closing discharge valve configured to:
 open when a relative pressure in the internal space rises above the first threshold value.
- [34] According to one embodiment, the discharge valve is configured to:
 20 close when the pressure in the internal space of the transverse cofferdam drops below a fourth threshold value ranging between the first threshold value and the second threshold value.
- [35] According to one embodiment, the discharge valve is selected from a ball valve, a needle valve, a butterfly valve, a gate valve, a check valve, a non-return valve, a piston valve, a diaphragm valve, a high-speed vacuum pressure relief valve, a safety valve, a spring or flap safety valve.
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- [36] According to one embodiment, the second threshold value ranges between 1 kPa (10 mbarg) and 10 kPa (100 mbarg), preferably between 2 kPa (20 mbarg) and 5 kPa (50 mbarg).
- [37] According to one embodiment, the second threshold value is 2 kPa or 5 kPa.
- 30 [38] According to one embodiment, the first threshold value ranges between 12 kPa (120 mbarg) and 18 kPa (180 mbarg), preferably between 13 kPa (130 mbarg) and 15 kPa (150 mbarg).
- [39] According to one embodiment, the first threshold value is 14 kPa (140 mbarg).

- [40] According to one embodiment, the gas management installation further comprises a gas bleed valve, the gas bleed valve being mounted on the gas discharge pipeline, upstream of the discharge valve to allow a volume of gas to be drawn from the internal space of the transverse cofferdam.
- 5 [41] By virtue of these features, an amount of gas can be easily drawn from the internal space of the transverse cofferdam, i.e. without entering the internal space of the transverse cofferdam or without having to draw a gas sample from the second end of the discharge pipeline, which is not always easily accessible. Furthermore, this allows gas to be drawn without working on the discharge valve and thus without disrupting the operation thereof.
- 10 [42] According to one embodiment, the pair of transverse bulkheads is manufactured from a steel grade selected from D grade, E grade, DH grade and EH grade. A grade D and/or grade E steel grade is preferred.
- [43] According to one embodiment, the thickness of the pair of transverse bulkheads is greater than or equal to 10 mm, for example, the thickness ranges between 10 mm and
15 50 mm, preferably the thickness ranges between 15 mm and 20 mm.
- [44] According to one embodiment, the longitudinal walls of the cofferdam are manufactured from a steel grade selected from D grade, E grade, DH grade and/or EH grade. A grade D and/or grade E steel grade is preferred.
- [45] According to one embodiment, the thickness of the longitudinal walls of the cofferdam
20 is greater than or equal to 10 mm, for example, the thickness ranges between 10 mm and 50 mm, preferably the thickness ranges between 15 mm and 20 mm.
- [46] The specific features of the indicated steel grades are described in the International Gas Code.
- [47] By virtue of these features, temperatures below -15°C and/or -25°C can be achieved
25 in the internal space of the transverse cofferdam without damaging the pair of transverse bulkheads.
- [48] According to one embodiment, the transverse cofferdam comprises a thermal insulator.
- [49] By virtue of these features, the heat flows are reduced between the sealed and thermally insulating tank and the one or more heat sources located in the vicinity of said
30 vessel.
- [50] According to one embodiment, the thermal insulation is located on an outer surface of the cofferdam. According to one embodiment, the thermal insulation is located on an outer surface of the pair of transverse bulkheads.

- [51] According to one embodiment, the thermal insulation is located in the internal space of the transverse cofferdam, the thermal insulation preferably being attached on longitudinal walls of the transverse cofferdam including the upper wall and a portion of the internal hull.
- 5 [52] By virtue of these features, the gas management installation allows the thermal insulation to be maintained in a dry state. Thus, the thermal insulation is not damaged by moisture or waterlogged. The thermal properties of the thermal insulation are thus optimally maintained.
- 10 [53] According to one embodiment, when the transverse cofferdam is adjacent to a single tank, the thermal insulation further covers the bulkhead of the pair of bulkheads that is furthest from said tank.
- [54] According to one embodiment, the thermal insulation is a thermally insulating glass wool covered on an outer face by a thermally insulating metal foil or foam. Preferably, the thermal insulation is thermally insulating glass wool covered on an outer face by a metal
15 foil, for example, an aluminium layer. According to one embodiment, the thermally insulating foam is a polyurethane foam (PUF).
- [55] According to one embodiment, the density of the thermally insulating glass wool ranges between 20 kg/m^3 and 60 kg/m^3 , preferably the density is 22 kg/m^3 .
- 20 [56] According to one embodiment, the density of the thermally insulating foam ranges between 20 kg/m^3 and 80 kg/m^3 , preferably the density is 50 kg/m^3 .
- [57] By virtue of these features, the thermal losses are reduced and therefore the management of the gaseous atmosphere in the internal space of the transverse cofferdam is facilitated.
- 25 [58] According to one embodiment, the thickness of the thermally insulating glass wool ranges between 100 mm and 400 mm, preferably between 200 mm and 350 mm, for example, 200 mm.
- [59] According to one embodiment, the thickness of the thermally insulating foam ranges between 100 mm and 400 mm, preferably between 200 mm and 350 mm, for example, 200 mm.
- 30 [60] By virtue of these features, temperatures below -15°C and/or -25°C can be achieved in the internal space of the transverse cofferdam.
- [61] According to one embodiment, the dry air supply pipeline passes through the upper wall.

- [62] According to one embodiment, the second end of the dry air supply pipeline emerges in the vicinity of a bottom wall of the transverse cofferdam.
- [63] According to one embodiment, the gas discharge pipeline passes through the upper wall.
- 5 [64] According to one embodiment, the first end of the gas discharge pipeline is located in the vicinity of the upper wall.
- [65] By virtue of these features, the dry air supplied to the internal space of the transverse cofferdam allows the gas located in the internal space of the transverse cofferdam to be more efficiently discharged via the discharge pipeline.
- 10 [66] According to one embodiment, the dry air supply pipeline and the gas discharge pipeline are manufactured from steel or another material selected from: stainless, D grade, E grade, DH grade and/or EH grade steel.
- [67] According to one embodiment, a moisture content in the internal space of the transverse cofferdam is kept below 25%, for example, below 15%, and preferably below
- 15 5%. According to one embodiment, the moisture content in the internal space of the transverse cofferdam is close to 0%.
- [68] By virtue of these features, the creation of frost on the thermal insulation or on the walls of the cofferdam is limited. Consequently, the risks of degrading the thermal performance capabilities of the insulation or the risks of corroding the cofferdam walls are
- 20 greatly reduced.
- [69] According to one embodiment, the dry air has a dew point temperature of less than -15°C, preferably less than -20°C, for example, a temperature that is less than or equal to -45°C or, for example, between -20°C and -40°C or -25°C and -30°C.
- [70] According to one embodiment, the pressure sensor is a piezoresistive pressure sensor
- 25 measuring the gauge pressure (GP). According to one embodiment, the sensor is manufactured from corrosion resistant steel resistant to negative temperatures, for example, it is manufactured from SUS316L steel. According to one embodiment, the pressure sensor comprises a diaphragm.
- [71] According to one embodiment, the pressure regulator is electronic.
- 30 [72] According to one embodiment, the intake valve and/or the discharge valve are solenoid valves.
- [73] According to one embodiment, several intake valves are mounted in series or are branched on the dry air supply pipeline. These intake valves can be different.

[74] According to one embodiment, several discharge valves are mounted in series or are branched on the gas discharge pipeline. These discharge valves can be different.

[75] By virtue of these features, the gas management installation of the vessel is more adaptable to the vessel in which it is integrated. Furthermore, these features allow the safety and the ease of monitoring and maintaining the gas management installation of the vessel to be enhanced.

[76] According to one embodiment, the dry air generator is an appliance that dries atmospheric air by heating.

[77] According to one embodiment, the dry air generator is an appliance that provides dry air having a dew point temperature below -40°C , preferably at a dew point temperature of -45°C .

[78] According to one embodiment, the dry air generator supplies dry air into the internal space of the transverse cofferdam with a flow rate ranging between $10,000\text{ m}^3/\text{h}$ and $20,000\text{ m}^3/\text{h}$, for example, $15,000\text{ m}^3/\text{h}$, in order to fill the transverse cofferdam with dry air.

[79] According to one embodiment, the dry air generator supplies dry air into the internal space of the transverse cofferdam with a flow rate ranging between 50 and $500\text{ m}^3/\text{h}$ in order to manage the gaseous atmosphere in the internal space of the transverse cofferdam.

[80] According to one embodiment, the dry air generator that is used is a dry air generator already installed on the vessel. This reduces costs by dispensing with the provision of a dry air generator specific to the gas management installation in order to manage the gaseous atmosphere in the internal space of the transverse cofferdam.

[81] According to another embodiment, the gas management installation for managing a gaseous atmosphere in the internal space of the transverse cofferdam comprises:

a dry air supply pipeline comprising a first end located outside the transverse cofferdam and connected to a first dry air generator supplying dry air, and a second end emerging into the internal space of the transverse cofferdam, with a first intake valve being mounted on the dry air supply pipeline,

the dry air generator being configured to deliver a dry air flow rate greater than $10,000\text{ m}^3/\text{h}$, for example, between $10,000\text{ m}^3/\text{h}$ and $20,000\text{ m}^3/\text{h}$, into the internal space of the cofferdam;

a second dry air generator connected to the dry air supply pipeline branching off the first dry air generator, with a second intake valve being mounted between the second dry air generator and the dry air supply pipeline, the second dry air generator being configured

to deliver a dry air flow rate of less than 1,000 m³/h, for example, between 50 and 500 m³/h, into the internal space of the cofferdam.

[82] Advantageously, the first dry air generator, the dry air supply pipeline and the first intake valve are components that are normally present in an LNG tanker vessel. This embodiment is particularly advantageous in that it limits the additional components to be installed on the vessel.

[83] According to one embodiment, the dry air generator is connected to said pressure regulator and the pressure regulator is further configured to:

activate the emission of dry air from the dry air generator into the supply line when the relative pressure in the internal space drops below the second threshold value, or, in other words, when the intake valve is open.

[84] According to one embodiment, the invention also provides a transfer system for a cold liquid product, the system comprising the aforementioned vessel, insulated pipes arranged to connect the tank installed in the hull of the vessel to a floating or onshore storage installation, and a pump for feeding a flow of the cold liquid product through the insulated pipes from or to the floating or onshore storage installation to or from the tank of the vessel.

[85] According to one embodiment, the invention also provides a method for loading or offloading such a vessel, wherein a cold liquid product is routed through insulated pipes from or to a floating or onshore storage installation to or from the tank of the vessel.

[86] By virtue of these features, the BOR can be reduced by 2% to 6%, preferably by 5% to 6%.

[87] Some aspects of the invention are based on the idea of drying the internal space of the transverse cofferdam in order to allow the temperature to be reduced in the internal space of the transverse cofferdam without damaging the vessel.

[88] Such a gas management installation of a vessel can be integrated via piping and valves already present in the vessel, for example, already present in an LNG tanker vessel. Furthermore, additional management or safety valves can be integrated into the vessel.

Brief description of the figures

[89] The invention will be better understood, and further aims, details, features and advantages thereof will become more clearly apparent, throughout the following description of several particular embodiments of the invention, which are provided solely by way of a non-limiting illustration, with reference to the accompanying drawings.

- [90] [Fig. 1] Figure 1 is a diagram showing typical temperature variations in a cofferdam of a liquefied natural gas vessel during operation as a function of time. Figure 1 does not form part of the invention but is useful for understanding.
- [91] [Fig. 2] Figure 2 is a section view along a longitudinal axis of a liquefied natural gas transport vessel according to one embodiment.
- [92] [Fig. 3] Figure 3 is a perspective and section view of a transverse cofferdam that can be used in the vessel of figure 2 according to one embodiment.
- [93] [Fig. 4] Figure 4 is a section view of a transverse cofferdam that can be used in the vessel of figure 2 according to one embodiment comprising a thermal insulation.
- [94] [Fig. 5] Figure 5 is a schematic diagram showing a transverse cofferdam provided with a gas management installation for managing a gaseous atmosphere in the internal space of the transverse cofferdam that can be used in the vessel of figure 2 according to one embodiment.
- [95] [Fig. 6] Figure 6 is a schematic diagram showing a transverse cofferdam provided with a gas management installation for managing a gaseous atmosphere in the internal space of the transverse cofferdam that can be used in the vessel of figure 2 according to another embodiment.
- [96] [Fig. 7] Figure 7 is a cutaway schematic representation of an LNG tanker vessel according to one embodiment comprising a tank and a terminal for loading/offloading this tank.
- [97] [Fig. 8] Figure 8 shows a schematic section view in a transverse direction of an oil tanker.
- [98] [Fig. 9] Figure 9 is a section view of the stern of a vessel comprising a sealed and thermally insulating tank for storing a liquefied fuel gas, the tank being located aft of the bridge of the vessel in the longitudinal direction of the vessel.

Description of the embodiments

- [99] Figure 1 shows a diagram representing the temperature variations T ($^{\circ}\text{C}$) of a cofferdam as a function of time (t). Significant temperature variations are common when the vessel is sailing. Indeed, when the vessel comprises full LNG tanks, a step 1 involves emptying seawater from the ballast tanks of the vessel and the temperatures of the cofferdams adjacent to the cryogenic tanks significantly cool down due to the heat flow from the tank to the cofferdams. According to a step 2, when the vessel offloads or uses LNG, part of the tanks is therefore emptied and the ballast tanks are filled with seawater

in order to optimize navigation. Thus, the temperature of the cofferdams varies via heat transfer from the seawater in the ballast tanks to the cofferdams. In general, during step 2, the temperature in the cofferdam increases. The vessel thus completes cycles, repeating step 1 and step 2. Therefore, it is difficult to regulate the temperature in the cofferdams.

5 [100] Figure 2 shows a vessel 3 equipped with a liquefied natural gas storage and transport installation that comprises four sealed and thermally insulated tanks 4. Each tank 4 is associated with a degassing mast 5, which is provided on the deck 12 of the vessel 3 and which allows gas in the vapour phase to escape when there is excess pressure inside the associated tank 4. An engine compartment 6 is provided at the stern of the vessel 3, which
10 compartment typically comprises a mixed power supply steam turbine capable of operating either by combusting diesel fuel or by combusting evaporation gas originating from the tanks 4. The tanks 4 have a longitudinal dimension extending in the longitudinal direction of the vessel 3. Each tank 4 is bordered at each of its longitudinal ends by a pair of transverse bulkheads 7, 8 defining a sealed interstitial space, known by the term
15 “cofferdam” 9. The tanks 4 are thus separated from each other by a transverse cofferdam 9. It thus can be seen that the tanks 4 are each arranged inside a load-bearing structure, which is formed, on the one hand, by the double hull of the vessel 3 and, on the other hand, by one of the transverse bulkheads 7, 8 of each of the cofferdams 9 bordering the tank 4.

[101] The vessels according to the embodiments of the invention can comprise several types
20 of tank without being limited to a particular tank, for example, a membrane tank for storing liquefied gas. The vessel 4 has a multi-layer structure, not shown, comprising, from the outside to the inside, a secondary thermally insulating barrier comprising insulating elements resting against a load-bearing structure, a secondary sealing membrane resting against the secondary thermally insulating barrier, a primary thermally insulating barrier
25 comprising insulating elements 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 primary sealing membrane defines an internal space of the tank 4 for receiving the liquefied gas.

[102] The liquefied gas intended to be stored in the tanks in particular can be a liquefied
30 natural gas (LNG), i.e. a gaseous mixture mainly comprising methane as well as one or more other hydrocarbons. The liquefied gas also can be ethane or liquefied petroleum gas (LPG), i.e. a mixture of hydrocarbons resulting from oil refining, basically comprising propane and butane.

[103] Figure 3 shows a section and perspective view of a transverse cofferdam 19 according
35 to one embodiment in a double hull vessel comprising an external hull 10 and an internal

hull 15. The transverse cofferdam 19 comprises a pair of transverse bulkheads defining an internal space 13 of the transverse cofferdam 19. Only one of the two transverse bulkheads 17 is shown in this figure 3 in order to show the internal space 13 of the transverse cofferdam 19. The transverse cofferdam 19 further comprises an upper wall 37 closing said internal space 13. By way of an example, the upper wall 37 can be a wall parallel to the upper deck 12 of the vessel. A portion of the internal hull 15 located opposite the upper wall 37 defines the bottom of the internal space of the transverse cofferdam 19. The vessel further comprises a ballast tank 41 located outside the transverse cofferdam 19. The ballast tank 41 is formed by a bottom portion of the space located between the internal hull 15 and the external hull 10 of the vessel.

[104] The transverse cofferdam 19 further comprises a stiffening structure 14 that criss-crosses the internal space 13 in a non-sealed manner. The internal space 13 of the transverse cofferdam 19 can contain a heating system 16 for controlling the temperature of the transverse cofferdam 19. The heating device is formed by a twisted pipeline, through which glycol or another heated antifreeze solution circulates.

[105] Figure 4 shows an embodiment of a transverse cofferdam 19 further comprising a thermal insulation 40 located in the internal space 23 of the transverse cofferdam. The thermal insulation 40 is attached on the longitudinal walls of the transverse cofferdam 29 including the upper wall 37 and a portion of the internal hull 15. If the transverse cofferdam 19 is located between two tanks 4, only the two transverse bulkheads 17 are not covered with thermal insulation 40.

[106] Figure 5 shows the gas management installation of a vessel for managing a gaseous atmosphere in the internal space 23 of the transverse cofferdam 29 of the vessel according to one embodiment. The transverse cofferdam 29 comprises a pair of transverse bulkheads 107, 109 defining an internal space 23 of the transverse cofferdam and an upper wall 37 closing said internal space. Like figure 4, the transverse cofferdam 29 comprises a thermal insulation 40 located in the internal space 23 of the transverse cofferdam, with the thermal insulation 40 being attached on the longitudinal walls of the transverse cofferdam 29 including the upper wall 37 and a portion of the internal hull 15.

The gas management installation of the vessel comprises:
a dry air supply pipeline 30 passing through the upper wall 37 of the transverse cofferdam 29 and comprising a first end located outside the transverse cofferdam 29 and connected to a dry air generator 31 providing dry air, and a second end emerging into the internal space 23 of the transverse cofferdam 29, in the vicinity of the portion of the internal hull 15 that is located in the vicinity of the bottom of the cofferdam, i.e. located opposite the upper

wall 37.

The gas management installation of the vessel further comprises:

an intake valve 32 mounted on the dry air supply pipeline 30 and located outside the transverse cofferdam 29;

5 a gas discharge pipeline 33 passing through the upper wall 37 and comprising a first end emerging into the internal space 23 of the transverse cofferdam 29 and a second end emerging outside the vessel;

a discharge valve 34 located outside the transverse cofferdam 29 mounted on the gas discharge pipeline 33;

10 a pressure sensor 35 configured to detect a relative pressure in the internal space 23 of the transverse cofferdam 29;

a pressure regulator 36 located outside the transverse cofferdam 29 and connected to the pressure sensor 35, to the intake valve 32 and to the discharge valve 34.

[107] In this case, the pressure regulator 36 is configured to:

15 open the intake valve 32 when the relative pressure in the internal space 23 drops below a second threshold value, the second threshold value being a positive value, for example, approximately 5 kPa;

open the discharge valve 34 when the relative pressure in the internal space 23 rises above a first threshold value higher than the second threshold value, for example, approximately 15 kPa. Furthermore, the pressure regulator 36 can be configured to carry out one or more of these actions:

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close the intake valve 32 when the relative pressure in the internal space 23 rises above the first threshold value or, with a hysteresis, when it rises above a third threshold value ranging between the second threshold value and the first threshold value;

25 close the discharge valve 34 when the relative pressure in the internal space 23 drops below the second threshold value or, with a hysteresis, when it drops below a fourth threshold value ranging between the first threshold value and the second threshold value. Such a gas management installation can be integrated, for example, in order to regulate the gaseous atmosphere of the cofferdams 9 and 19 shown above.

30 [108] Figure 6 shows a gas management installation for managing a gaseous atmosphere in the internal space 23 of the transverse cofferdam 29 according to another embodiment. The pressure regulator 136 is connected to the pressure sensor 35 and to the intake valve 32 as before. This embodiment differs from figure 5 in that the discharge valve 134 is a mechanically opening and closing discharge valve 134, which is not connected to the pressure regulator 136 and which opens and closes autonomously as a function of the pressure present in the internal space 23. The mechanically opening and closing

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discharge valve 134 is configured to open when a relative pressure in the internal space 23 rises above the first threshold value and to close again when it falls below this value, optionally with a hysteresis. To this end, the mechanically opening and closing discharge valve 134 comprises, for example, a spring closing mechanism or a flap closing mechanism. This mechanically opening and closing discharge valve 134 fulfils a safety function, as it particularly prevents the damages that can be caused by excess pressure in the internal space 23 of the transverse cofferdam 29.

[109] The gas management installation further comprises a gas bleed valve 18. The gas bleed valve 18 is mounted on the gas discharge pipeline 33 outside the transverse cofferdam 29 and upstream of the mechanically opening and closing discharge valve 134. Thus, an amount of gas can be drawn from the internal space 23 of the transverse cofferdam 29 in order to analyze the gaseous atmosphere or the temperature of the internal space 23 of the transverse cofferdam 29. Thus, it is possible to regulate the gaseous atmosphere in the internal space 23 of the transverse cofferdam 29. The embodiments described via the figures are not limited to a particular type of transverse cofferdam, for example, the embodiment described in figure 6 can be applied in the cofferdam described in one of the preceding figures.

[110] The transverse cofferdam 29 comprises a thermal insulation 40 covering the internal surface of the longitudinal walls of the transverse cofferdam 29, including the upper wall 37 and the internal hull 15, over the entire periphery of the internal space 23, like in figure 5. In the embodiment shown in figure 6, the transverse cofferdam 29 further comprises a thermal insulation 140 on the internal surface of the transverse wall 107, located opposite the adjacent vessel 4. In this embodiment, the thermal insulation 40 limits the heat flows with ballast water and ambient air and the thermal insulation 140 further limits the heat flows with the compartments adjacent to the transverse bulkhead 107, limiting, for example, the heat flows with the engine compartment 6 or any other heat source with a temperature that is higher than the temperature of the vessel 4.

[111] The thermal insulation 40 or 140 can be a glass wool covered on an outer face with a vapour barrier, for example, a layer of aluminium. The glass wool can be attached by protruding spikes (not shown) having a first end welded to the walls of the transverse cofferdam 29 and which pass through the glass wool. In order to hold the glass wool in place, a locking means is added over the glass wool on a second end of the spikes, for example, a clamping clasp.

[112] With respect to figures 8 and 9, embodiments are described above in which the previously described gas management installation is installed in other types of vessels.

[113] For example, in an oil tanker 80, as illustrated as a section view in figure 8, the vessel 80 comprises a sealed and thermally insulating tank 4 positioned between two cargo tanks 42 filled with a cargo, for example, filled with oil.

[114] The oil has a higher temperature than the temperature of the LNG in the tank 4. The oil is also likely to be heated by a heating device in order to increase its viscosity so as to facilitate the loading or offloading thereof. For example, it can have a temperature of 60°C.

[115] Each cargo tank 42 is spaced apart from the sealed and thermally insulating tank 4 by a transverse cofferdam 39. The transverse cofferdam 39 is similar to the transverse cofferdam 29 shown above and comprises a thermal insulation on at least the internal surface of a transverse bulkhead, thus limiting the heat flows 43 with the adjacent compartments, i.e. limiting the heat flows between the tank 4 and the cargo tanks 42, in particular by limiting the transfer of heat from the cargo tanks 42 to the tank 4. In other words, the tank 4 is thermally insulated from the oil stored in the cargo tank 42 at a higher temperature than the liquefied gas stored in the tank 4. Similarly, the cargo tanks 42 are thermally insulated from the LNG in the tank 4.

[116] Similarly, the vessel 90 shown in figure 9 is an LNG powered vessel. The vessel 90 can be a container vessel or a bulk carrier. The bulk carrier is a vessel designed for transporting solid bulk products. Thus, in a manner per se known, the vessel 90 comprises, in front of its bridge 44 in a longitudinal direction X'-X of the vessel 90, one or more holds 45 for transporting a solid bulk product. The holds 45 are spaced apart in the longitudinal direction X'-X of the vessel 90 in a manner per se known. It should be noted that only one of these holds 45, namely the hold 45 closest to the bridge 44, is schematically shown in figure 9. The vessel 90 further comprises a sealed and thermally insulating tank 4 containing LNG that is intended to supply a propulsion system 46. The tank 4 is located aft of the bridge 6 in the longitudinal direction X'-X. The tank 4 is spaced apart from the heat sources, namely: the bridge, the propulsion system 46 and the hold 45, via a transverse cofferdam 49. The transverse cofferdam 49 particularly comprises thermal insulation and the gas management installation as described above. Thus, like the vessels described above, the heat flows between the heat sources and the tank 4 are significantly limited.

[117] The gas management installation described above enables a method to be carried out comprising the following steps:

- sending dry air into the internal space of the transverse cofferdam via a dry air generator that supplies a dry air supply pipeline when a relative pressure in the internal space of the cofferdam falls below 5 kPa, so that the cofferdam receives only dry air and not moist

ambient air;

- discharging the gas from the internal space of the transverse cofferdam to the space outside the transverse cofferdam via the discharge pipeline when the relative pressure increases above 14 kPa.

5 Thus, it is possible to lower the temperature of the internal space of the cofferdam to -15 degrees Celsius (°C) or -25 °C without damaging the vessel.

The values shown can be adapted as a function of the desired gas management.

10 [118] With reference to figure 7, a cutaway view of an LNG tanker vessel 70 shows a sealed and insulated tank 71 of generally prismatic shape mounted in the double hull 72 of the vessel. The wall of the tank 71 comprises 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 vessel and two insulating barriers respectively arranged between the primary sealed barrier and the secondary sealed barrier and between the secondary sealed barrier and the double hull 72.

15 [119] In a manner per se known, loading/offloading pipes 73 disposed on the upper deck of the vessel can be connected, by means of suitable connectors, to a maritime or harbour terminal for transferring an LNG cargo from or to the tank 71.

20 [120] Figure 7 shows an example of a maritime terminal comprising a loading and offloading station 75, a submarine pipeline 76 and an onshore installation 77. The loading and offloading station 75 is a fixed offshore installation comprising a movable arm 74 and a tower 78, which supports the movable arm 74. The movable arm 74 supports a bundle of insulated flexible tubes 79 that can be connected to the loading/offloading pipes 73. The orientable movable arm 74 adapts to all types of LNG tanker vessel gauges. A connecting pipeline, not shown, extends inside the tower 78. The loading and offloading station 75 allows the LNG tanker vessel 70 to be loaded and offloaded from or to the onshore installation 77. This installation comprises liquefied gas storage tanks 80 and connecting pipelines 81 connected by the submarine pipeline 76 to the loading and offloading station 75. The submarine pipeline 76 allows the liquefied gas to be transferred between the loading or offloading station 75 and the onshore installation 77 over a significant distance, 25 for example, 5 km, which allows the LNG tanker vessel 70 to be maintained a significant distance away from the coast during the loading and offloading operations.

30 [121] In order to generate the pressure required to transfer the liquefied gas, pumps on board the vessel 70 and/or pumps provided on the onshore installation 77 and/or pumps provided on the loading and offloading station 75 are implemented.

[122] Even though the invention has been described with reference to several particular embodiments, it is clear that it is by no means limited thereto and that it comprises all the technical equivalents of the means described, as well as their combinations, if they fall within the scope of the invention.

5 [123] The gas management installation for managing a gaseous atmosphere in the internal space of the transverse cofferdam can, for example, further comprise branch pipelines comprising a manual valve spanning, for example, the intake valve or the discharge valve, or even alarm systems (PAL, PAH, PALL, PAHH) linked to the pressure sensor, yet without departing from the scope of the invention.

10 [124] Some of the elements, in particular the components of the pressure regulator, can be produced in various forms, in a unitary or distributed manner, by means of hardware and/or software components. Hardware components that can be used are specific ASICs, FPGAs or microprocessors. Software components can be written in various programming languages, for example, C, C++, Java or VHDL. This list is not exhaustive.

15 [125] The use of the verbs “comprise” or “include” and their conjugated forms does not exclude the presence of elements or steps other than those described in a claim.

[126] In the claims, any reference sign between brackets must not be interpreted as being a limitation of the claim.

Claims

[Claim 1] Vessel (3, 70) for transporting a cold fluid, the vessel (3, 70) comprising:

- a load-bearing structure comprising a hull (110) extending in a longitudinal direction and at least one transverse cofferdam (9, 19, 29) subdividing the hull into a plurality of segments, the one or each transverse cofferdam (9, 19, 29) comprising a pair of transverse bulkheads (7, 8, 17, 107, 109) defining an internal space (13, 23) of the transverse cofferdam (9, 19, 29) and an upper wall (37) closing said internal space (13, 23);
- at least one sealed and thermally insulating tank (4, 71) disposed in a segment of the hull (110) adjacent to said transverse cofferdam (9, 19, 29);
- a gas management installation for managing a gaseous atmosphere in the internal space (13, 23) of the transverse cofferdam (9, 19, 29), wherein the gas management installation comprises:
 - a dry air supply pipeline (30) comprising a first end located outside the transverse cofferdam (9, 19, 29) and connected to a dry air generator (31) supplying dry air, and a second end emerging into the internal space (13, 23) of the transverse cofferdam (9, 19, 29);
 - an intake valve (32) mounted on the dry air supply pipeline (30);
 - a gas discharge pipeline (33) comprising a first end emerging into the internal space (13, 23) of the transverse cofferdam (9, 19, 29) and a second end emerging outside the vessel (3, 70);
 - a discharge valve (34, 134) mounted on the gas discharge pipeline (33), the discharge valve (34, 134) being configured to open when a relative pressure in the internal space (13, 23) rises above a first threshold value;
 - a pressure sensor (35) configured to detect a relative pressure in the internal space (13, 23) of the transverse cofferdam;
 - a pressure regulator (36, 136) connected to the pressure sensor (35) and to the intake valve (32), the pressure regulator (36, 136) being configured to:
 - open the intake valve (32) when the relative pressure in the internal space (13, 23) drops below a second threshold value, the second threshold value being a positive value lower than the first threshold value.

[Claim 2] Vessel according to Claim 1, wherein the pressure regulator (36, 136) is further configured to:

- close the intake valve (32) when the pressure in the internal space (13, 23) rises above a third threshold value ranging between the second threshold value and the first threshold value.

[Claim 3] Vessel according to Claim 2, wherein a difference between the third threshold value and the second threshold value is less than 2kPa (20 mbarg).

[Claim 4] Vessel according to any of Claims 1 to 3, wherein the pressure regulator (136) is further connected to the discharge valve (34, 134), the pressure regulator (136) is further

5 configured to:

open the discharge valve (34, 134) when the pressure in the internal space (13, 23) rises above the first threshold value.

[Claim 5] Vessel according to Claim 4, wherein the pressure regulator (36) is further configured to:

10 close the discharge valve (34) when the pressure in the internal space (13, 23) drops below a fourth threshold value ranging between the first threshold value and the second threshold value.

[Claim 6] Vessel according to Claim 5, wherein a difference between the fourth threshold value and the first threshold value is less than 2 kPa (20 mbarg).

15 [Claim 7] Vessel according to any of Claims 1 to 3, wherein the discharge valve (34, 134) is a mechanically opening and closing discharge valve (34, 134) configured to:

open when a relative pressure in the internal space (13, 23) rises above the first threshold value.

[Claim 8] Vessel according to any of Claims 1 to 7, wherein the second threshold value
20 ranges between 1 kPa (10 mbarg) and 10 kPa (100 mbarg), preferably between 2 kPa (20 mbarg) and 5 kPa (50 mbarg).

[Claim 9] Vessel according to any of Claims 1 to 8, wherein the first threshold value ranges between 12 kPa (120 mbarg) and 18 kPa (180 mbarg), preferably between 13 kPa (130 mbarg) and 15 kPa (150 mbarg).

25 [Claim 10] Vessel according to any of Claims 1 to 9, wherein the gas management installation further comprises a gas bleed valve (18), the gas bleed valve (18) being mounted on the gas discharge pipeline (33), upstream of the discharge valve (34, 134) to allow a volume of gas to be drawn from the internal space (13, 23) of the transverse cofferdam.

30 [Claim 11] Vessel according to any of Claims 1 to 10, wherein the pair of transverse bulkheads (7, 8, 17, 107, 109) is manufactured from a steel grade selected from D grade, E grade, DH grade and EH grade.

[Claim 12] Vessel according to any of Claims 1 to 11, wherein the transverse cofferdam (9, 19, 29) comprises a thermal insulation (40) located in the internal space (13, 23) of the
35 transverse cofferdam, the thermal insulation (40) preferably being attached on longitudinal

walls of the transverse cofferdam (9, 19, 29) including the upper wall (37) and a portion of the internal hull (15).

[Claim 13] Vessel according to any of Claims 1 to 12, wherein the transverse cofferdam (9, 19, 29) comprises a thermal insulator located on an outer surface of the cofferdam.

5 [Claim 14] Vessel according to Claim 12 or 13, wherein the thermal insulation (40) is a thermally insulating glass wool covered on an outer face by a metal foil.

[Claim 15] Transfer system for a cold liquid product, the system comprising the vessel (3, 70) according to any of Claims 1 to 14, insulated pipes (73, 79, 76, 81) arranged to connect the tank (4, 71) installed in the hull (110) of the vessel to a floating or onshore storage installation (77), and a pump for feeding a flow of the cold liquid product through the
10 insulated pipes from or to the floating or onshore storage installation to or from the tank of the vessel.

[Claim 16] Method for loading or offloading the vessel (3, 70) according to any of Claims 1 to 15, wherein a cold liquid product is routed through insulated pipes (73, 79, 76, 81)
15 from or to a floating or onshore storage installation (77) to or from the tank (4, 71) of the vessel (3, 70).