

Description

Title of the invention: Storage facility for a liquefied gas and/or a hazardous liquid

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[1] The invention relates to the field of storage installations for liquefied gas and/or hazardous liquid comprising in particular an independent sealed tank of type A, B or C according to the IGC Code. In the context of the present invention the definitions given for the independent tanks of type A, B and C according to the IGC code refer to the "International Code of the Construction and Equipment of Ships Carrying Liquefied Gases in Bulk", 2016 edition.

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[2] Accordingly, the invention relates in particular but not exclusively to the field of sealed tanks for the storage and/or the transport of liquefied gas at low temperature such as tanks for the transport of ammonia. These tanks can also be installed on land or on a floating structure.

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[3] In the prior art there is known the document FR2996556 that describes a liner, or internal coating, for a compressed natural gas (CNG) tank of polyamide type with at least one shock modifier representing 10% to 30% by weight, that shock modifier possibly consisting of a rubber. Also, the document US 20090203845 describes a reservoir for hydrogen including a polyamide and copolyamide liner including between 15% and 20% of a shock resistant agent.

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[4] Also known is the document US 20120080106 that describes a tank for a liquid fluid under pressure with a metal main wall and a liner made of polyethylene, of polyethylene-based copolymer or a C₃-C₈ block polyolefin.

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[5] Finally, the document DE 202010017414 describes a reservoir of cylindrical shape for gas including a liner consisting of a polyamide matrix,

functional additives, olefin and acrylic ester copolymers and shock absorbers.

[6] All these solutions undoubtedly constitute an improvement to the seal of a tank but they are highly imperfect at the level of their prime function consisting in preventing leaks from the storage space or penetration of a foreign body following a breakdown of the seal of the walls of the tank, whilst being complicated and costly to install in the tank.

[7] Indeed, the polymer liner often adheres badly to a metal wall and installing it is particularly difficult for achieving a result as to the improvement of the seal of the tank that is somewhat lacking in homogeneity on the different internal faces.

[8] Given this fact, the applicant has sought to remedy the shortcomings of such tanks and following various experiments and analyses discovered that it was desirable and particularly advantageous to dissociate the liner or internal coating from the wall of the tank.

[9] Moreover, in tanks of this type it is impossible to detect a seal defect, in particular to prevent the liquefied gas or the hazardous liquid from flowing into the structure of the installation.

[10] This being the case, the applicant has designed a system that is simple and highly effective to use and makes it possible to fix the liner in an optimum manner, given firstly its sealing function - hereinafter the term "liner" is replaced by the expression "coating layer" - and also to allow other very useful functions, in particular surveillance, control and alerts in the event of any loss of seal of the tank with a reliable, modular and relatively low cost system and before this loss of seal is reflected in a leak from the storage space that is critical for the structure of the installation, typically a ship, including in the situation where

the wall of the tank suffers damage because of a collision/impact or a road traffic accident.

[11] Accordingly, the present invention concerns a storage installation for a liquefied gas and/or a liquid, comprising:

- 5 - a sealed tank for storage of the liquefied gas and/or of the liquid, consisting in a metal tank having a wall having an internal face and an external face, the wall including a lower wall, an upper wall and a lateral wall connecting the lower wall and the upper wall, delimiting a space for storage of the liquefied gas and/or of the liquid, and
- 10 - a layer coating the internal surface of the wall of the tank made of a polymer material or of a mixture of polymer materials, the coating layer being deformable.
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[12] The invention is characterized in that the storage installation comprises an intermediate layer disposed between the coating layer and the wall of the tank, in that the coating layer is anchored and/or fixed in a discontinuous manner to the intermediate layer and/or in that the intermediate layer is anchored and/or fixed in a discontinuous manner to the wall, and in that said intermediate layer allows the circulation of gas in order:

- 20 - to press said intermediate layer and therefore the coating layer against the wall of the tank, and/or
- 25 - using a fluid detection device, to allow the detection of liquid or of gas coming from the storage space in the event of loss of seal of the coating layer and/or from the outside of said storage space in the event of loss of seal of the tank.
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[13] Thus the coating layer is not attached to the tank or to the reservoir so that said layer is not subjected to the same deformation as the tank in the event of an impact from the outside.

[14] Without this being exhaustive, this kind of coating layer/intermediate layer arrangement, combining the fact that the intermediate layer allows the circulation of gas for pressing on it and/or for the detection of a fluid coming from the tank or from the outside, offers the following properties and advantages:

- smoothing of the surface of the polymer coating layer in the tank,
- limitation of friction between the polymer coating layer and the internal surface of the tank wall,
- thanks to flushing using an inert gas such as nitrogen, inhibition of corrosion of the internal face of the tank,
- circulation of gas in the intermediate layer enabling surveillance of this space, that is to say easy analysis of any fluid circulating therein, in order to detect any leak coming from the storage space or from the outside of the tank.

[15] By the expression "loss of seal" is meant that there exists a leak of a fluid, either at the level of the coating layer (= loss of seal of the storage space) or at the level of at least one wall of the tank (= loss of seal of the tank), penetrating into the intermediate layer.

[16] By the expression "hazardous liquid" is meant an inflammable, toxic or corrosive/reactive liquid. Where "liquefied gases" are concerned, this expression is known *per se* and is defined in the IGC code in particular. It may refer for example to methane or ammonia, preferably ammonia as will emerge hereinafter.

[17] Accordingly, liquefied natural gas (LNG) for example is of course part of the definition of liquefied gases but may equally correspond to the definition of a hazardous liquid since it is in particular inflammable. Likewise, here ammonia is above all a "hazardous liquid" because it is toxic,

inflammable and corrosive, but is often found in such tanks in liquefied gas form. Finally, kerosene and diesel oil or fuel oil are defined here as "hazardous liquids" because of their toxicity, especially because of the risk of pollution of the aquifer.

[18] By the expression "circulation of gas" is meant that the intermediate layer is permeable to gases so that it is possible to cause any type of gas to circulate between any two spaced points of the intermediate layer, typically between a point situated on the upper wall and a point situated on the lower wall, provided a classic pump or a circulation pump is used between these two points, with slight pressurization or depressurization - typically of at least 5 mbarg (milli-barg) - imposed at said two points without any significant deformation of the intermediate layer.

[19] To be more precise, if only the material forming the intermediate layer is considered, there is therefore intrinsic permeability of the latter at least equal to:

- 100 mDarcy ($1 \text{ mDarcy} = 0.0987 \times 10^{-12} \text{m}^2$) in air and at ambient temperature (20°C) according to the standard ISO 8841 when the intermediate layer is essentially made up of glass fibers or of another type of fiber such as basalt, carbon, aramide or stainless steel fibers;

- 100 mDarcy in air and at ambient temperature (20°C) according to the standard ISO 7229 (2015) when the intermediate layer consists essentially of a plastic or rubber matrix impregnated with textile fibers;

- 100 mDarcy in air and at ambient temperature (20°C) according to the standard ISO 2782-1 (2016) when the intermediate layer consists essentially of a thermoplastic, of an elastomer or of rubber.

[20] It should be noted here that when the intermediate layer consists essentially of a plastic

or rubber matrix impregnated with textile fibers or consists essentially of a thermoplastic, an elastomer or rubber, it advantageously comprises channels or the like allowing the channelled circulation of gas.

[21] In its wider sense, the present invention is intended to apply whatever the shape and the dimensions of the tank. Thus it has simply been defined here that the tank includes an upper wall, a lower wall and lateral wall that has in particular a cylindrical or again a polyhedral shape in which there is not, respectively, really any plane lateral wall (just a single curved lateral wall) or to the contrary a plurality of lateral walls.

[22] Also, in its broadest sense, the coating layer may consist of any types of polymers or mixtures of polymers provided that they are compatible with their use, that is to say in particular chemically and physically compatible (no physical-chemical reaction or degradation) with the liquefied gas and/or the hazardous liquid contained in the tank.

[23] By way of non-limiting example the coating layer according to the invention may consist of polytetrafluoroethylene (PTFE), polyethylene, preferably high-density polyethylene, polyvinyl chloride (PVC), propylene, polyamide, preferably a nylon, polyphenylene sulfide (PPS), polyvinylidene fluoride (PVDF), neoprene, an ethylene propylene diene monomer (EPDM) and its co-laminates, fluoro-elastomer (FKM), for example Viton®, or perfluoro-elastomer (FFKM), for example Kalrez®, natural rubber and its derivatives, or a mixture of at least two of these polymers (multilayer or mixed matrix).

[24] By convention, the terms "external" and "internal" are used to define the relative position of one element with respect to another, with reference to the interior and to the exterior of the tank.

[25] Other advantageous features of the invention are succinctly described below:

[26] In order to press on the intermediate layer, the storage installation advantageously comprises a system for pressing the intermediate layer against the wall of the tank, said pressing on system comprising:

- a means for depressurizing the intermediate layer with an average depressurization of at least 5 mbarg; and/or
- a means for pressurizing the storage space of the tank with an average pressurization of at least 5 mbarg.

[27] In the context of the present invention the expressions "average depressurization" and "average pressurization" mean that:

- for the pressurization of the storage space, the average pressurization is that considering the pressures at the level of the various locations on the coating surface, said various locations being distributed at least over or against the lateral wall, the upper wall and lower wall of the tank;
- for the depressurization of the intermediate layer, the average depressurization is that considering the depressurization at the level of the various locations on the coating layer, said various locations being distributed at least over or against the lateral wall, the upper wall and the lower wall of the tank.

[28] The intermediate layer is advantageously:

- anchored to the wall of the tank by a mechanical and/or chemical means, and/or
- fixed chemically to the coating layer.

[29] By the expression "mechanical fixing" is meant that the fixing between the two elements concerned is made possible thanks to an element forming a physical connection with no recourse to electrical, magnetic, electromagnetic or again chemical energy (gluing or the like).

[30] The coating layer preferably has a thickness between 1 millimeter (mm) and 9 millimeters inclusive, preferably between 2 mm and 6 mm inclusive.

5 [31] In accordance with one particularly interesting aspect of the invention, the coating layer - the polymer or the mixture of polymers - advantageously has a glass transition temperature T_g less than the temperature of liquefaction of the
10 liquefied gas and/or of the hazardous liquid at atmospheric pressure.

[32] The coating layer preferably consists of an elastomer, preferably an EPDM. Of course, as previously indicated, this kind of preferred choice
15 for the coating layer is directly linked to the nature of the liquefied gas and/or of the hazardous liquid contained in the tank.

[33] For hydrocarbons such as diesel oil or kerosene a coating layer made of Kalrez® or of Viton® will
20 be preferred.

[34] The coating layer advantageously comprises reinforcing fibers, preferably glass fibers.

[35] By way of non-limiting preferred examples of reinforcing fibers there may equally be cited fibers
25 of basalt, carbon, aramide or stainless steel present in the polymer or the mixture (matrix) of polymers in mat, felt or textile form.

[36] The intermediate layer preferably has a thickness between 2 mm and 30 mm inclusive,
30 preferably between 4 mm and 10 mm inclusive.

[37] The average depressurization or pressurization, respectively of the intermediate layer and of the storage space, produced by means of the pressing on system is preferably at least 10
35 mbarg, preferably at least 15 mbarg.

[38] Note that the term "barg" here has its technical sense known to the person skilled in the art, namely that this measurement consists in a relative pressure measured with respect to an

ambient pressure, in other words is equal to the absolute pressure less atmospheric pressure or that of the storage space.

5 [39] In accordance with an advantageous embodiment of the invention the means for depressurization of the intermediate layer comprises at least one pump connected to at least one orifice in the wall of the tank in such a manner as to create the average depressurization.

10 [40] In this context the wall of the tank preferably includes a plurality of orifices distributed in the latter. In the context of the present invention by the term "distributed" is meant the fact that the orifices are present on the upper wall and the lower wall when there are only two orifices and also on the lateral wall when there are at least three orifices. Beyond three orifices the walls of the tank advantageously include a number of orifices proportional to their respective lengths.

20 [41] The installation advantageously comprises at least one corner connecting part fixed in sealed manner to the internal face at an intersection between the upper and/or lower walls and/or the lateral wall and the corner part, the edges of which are in contact with each of at least two adjacent walls, advantageously comprises a section profile of which at least one portion is circular.

25 [42] In the remainder of the description one embodiment of this connecting part will be described in relation to an appended figure.

30 [43] In accordance with one possibility offered by the invention the corner connecting part comprises at least one communication channel extending substantially perpendicularly to the axis of the connecting part for connecting the drainage layer present on each of the two adjacent walls and/or a flow channel extending substantially along the axis of the connecting part, in particular for the flow

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of the liquefied gas and/or a hazardous liquid contained in the tank.

5 [44] Apart from its anchoring and sealing functions, a connecting part of this kind is provided above all for the flow of the gas in the intermediate layer:
- during the pressing on phase, by the depressurization of the intermediate layer, but
10 equally - even if to a lesser degree - the depressurization of the storage space is undesirable, because the presence of bubbles or the like in the intermediate layer,
- during the exterior fluid detection phase (i.e. during detection of fluid coming from the storage
15 space or from the outside of the tank) in order for the gas to circulate perfectly between the various walls.

[45] According to a particular feature of the present invention the intermediate layer or drainage
20 layer has no thermal insulation function. This is why, if thermal insulation is necessary or desirable, it is an element separate from the intermediate/drainage layer, preferably situated outside the tank when the latter consists in a tank of type A, B or C according to the IGC code.

25 [46] In accordance with one possibility offered by the invention, the intermediate layer advantageously consists in a drainage layer intended to drain a liquid coming from the storage space of the tank or from the outside of the tank.

30 [47] The fluid detection device advantageously comprises a means able to trigger an alert if such a fluid is detected.

[48] Such an alert may be visual and/or audible in order for an operator to be able to take notice of
35 it as quickly as possible. This alert may equally and automatically command a system for making the tank and its surroundings safe, for example by commanding evacuation of the fluid contained in the

tank to a safe zone or the destruction of said content, for example by controlled combustion.

5 [49] In accordance with one embodiment of the invention the installation comprises on the lower wall of the tank a collection portion situated at the lowest point of the tank and the fluid detection device is able to analyse said collection portion to detect the presence of liquid (coming from the storage space or possibly from the outside of the
10 tank).

[50] By the expression "at the lowest point" is meant that the collecting portion is situated on the lower wall of the tank, advantageously at the lowest level in the direction of terrestrial gravitation
15 if this lower wall is not plane. It may be noted that in the case of independent tanks conventional "drip tray" type second barrier retention is conventionally provided, and is conventionally situated at the level of the hull of the ship, below the tank as such, and then forms this collecting
20 portion should a crack develop in the tank itself. This secondary retention, which is of reduced volume, has the main function of containing a leak of moderate flowrate to protect the structure of the ship from temperatures that could damage it and may
25 be associated with a pumping system intended to evacuate too great a leak.

[51] The installation advantageously comprises a circulation pump and an inert gas is advantageously
30 circulated by the circulation pump in the intermediate or drainage layer between at least one entry point and at least one exit point.

[52] In the context of the present invention the expression "inert gas" means a gas different from
35 the liquefied gas or from the hazardous liquid contained in the tank and not capable of reacting chemically with the latter, in particular generally with all other components. This inert gas typically consists of nitrogen or a rare gas such as argon.

[53] The fluid detection device advantageously detects the presence of gas and/or of liquid at the entry point or at the exit point. In accordance with one possibility offered by the invention said entry point is situated at the level of the lower wall of the tank and said exit point is situated at the level of upper wall of the tank.

[54] Nevertheless, the choice of the entry orifice and of the exit orifice of the circulating inert gas is guided by the ratio of the density d_{tank} of the component contained in the tank (when in gas form) to the density d_{inert} of the circulating inert gas, in order to benefit from a form of piston effect. Accordingly, and advantageously:

- if $d_{\text{tank}} > d_{\text{inert}}$: the point of entry or of injection of the inert gas is situated at the top of the tank, i.e. at the level of the upper wall of the tank, and the exit point of the inert gas is situated at the bottom, i.e. on the lower wall of the tank;
- if $d_{\text{tank}} < d_{\text{inert}}$: the point of entry or of injection of the inert gas is situated at the bottom of the tank, i.e. at the level of the lower wall of the tank, and the exit point of the inert gas is situated at the top, i.e. on the upper wall of the tank.

[55] By way of non-limiting example, if the tank contains ammonia and the inert gas consists of nitrogen then the point of entry or of injection of the inert gas is therefore situated at the bottom of the tank, i.e. on the lower wall of the latter, and the exit point at the top, i.e. on the upper wall of the tank.

[56] In accordance with one possibility offered by the invention the installation comprises at least one device for filtering the gas circulating in the drainage layer, making it possible in particular to separate particles coming from the liquefied gas and/or from the hazardous liquid.

[57] The two main benefits of providing this kind of device for separating the gases, in particular the inert gas and the gas coming from the tank or even from the outside, are:

- 5 - operating in a closed loop on the inert gas when there is no leak;
- if the gas coming from the tank or even from outside it is toxic, such filtration (also designated by the expression "open loop"
- 10 filtration) makes it possible to recover and to store it, above all on the assumption that the circulating gas is not circulating in a so-called closed loop.

[58] Of course, such filtering is not the only
15 solution if an open loop is available: the circulating gas may further be injected at the outlet into a burner. For a tank containing ammonia the vapor (exit gas) can also be rinsed with water and an ammonium solution therefore recovered that
20 is processed independently.

[59] The fluid detection device preferably consists in a mass spectrometer, an infrared spectrometer, an electrochemical cell and/or a katharometer.

[60] In the situation where the tank contains
25 ammonia the fluid detection device advantageously consists in an electrochemical cell, that is to say a battery in which the ammonia will feed the electrolyte of the cell. Capacitive sensors may equally be provided to measure the variation of the
30 dielectric constant of an open capacitor, or absorption spectroscopy or mass spectrometry may be used. Of course, the choice of the most suitable fluid detection device is a function above all of the nature of the fluid contained in the tank.

35 [61] The intermediate layer or the drainage layer advantageously consists of:

- a mat, a felt, a mesh or a woven textile of glass, basalt, polyethylene and/or polypropylene fibers and assemblies thereof; or

- an aggregate material based on resin and mineral granulates and/or polymers; or

- a composite material with a heatset matrix, preferably epoxy-based, or a thermoplastic matrix, preferably polyethylene, polypropylene and/or polyamide based, preferably reinforced with glass or basalt fibers or wood particles.

[62] Concerning the nature of the intermediate or drainage layer, for the detection of fluid a material is required that withstands the working pressure concerned - if depressurization is employed to press on it or circulation of gas or if the latter necessitates the application of local pressurization - and that still has a permeability that makes the circulation of gas possible. In one application it is therefore possible to envisage particle board panels, particles of wood coextruded with a thermoplastic matrix or fibrocement panels.

[63] Generally speaking, with non-plane geometries of the tank wall a "textile" approach is favoured - the mat, felt, mesh or a woven textile of fibers as well as an aggregate material based on resin and mineral granulates and/or polymers - in which the intermediate or drainage layer adapts to the walls of the tank. Without being limiting on the invention, with plane geometries all the solutions mentioned hereinabove are possible and appropriate.

[64] The means for pressurizing the storage space of the tank preferably comprises a compressor or a reservoir of gas under pressure connected to the storage space of the closed tank in such a manner as to deliver the pressurization by means of a neutral gas or of the liquefied gas intended for said tank.

[65] In the context of the present invention by the term "compressor" is meant any type of means able to deliver a gas pressurized relative to its inlet pressure and the expression "neutral gas" means any gas different in nature from the liquefied gas or

the hazardous liquid present in the storage space that is not capable of any chemical reaction or physical interaction with the coating layer and the intermediate layer, such as nitrogen for example.

5 [66] The liquefied gas and/or the hazardous liquid preferably consists in liquid ammonia. The present invention is in fact intended to apply in particular, but not exclusively, to tanks containing ammonia.

10 [67] The metal tank preferably consists in an independent tank of type A, B or C according to the definition given by the IGC code.

[68] Independent tanks are self-supporting tanks. They do not form part of the hull of the ship and
15 are not essential to the strength of the hull. There are three categories of independent tanks, namely tanks of type A, B or C.

[69] By way of example, a tank of type A is a tank the design of which is essentially based on the
20 conventional methods of analysis of the structure of ships conforming to recognised standards. If these tanks are essentially constructed with plane surfaces, the calculation vapor pressure P_0 must be less than 0.07 MPa (MegaPascal). If the temperature
25 of the cargo at atmospheric pressure is below -10°C a secondary barrier must be provided in the manner specified in section 4.5 of said IGC code. That barrier must be designed in accordance with the provisions of that IGC code.

30 [70] The invention also relates to a method for installation of a coating layer and of an intermediate/drainage layer in a tank of a storage installation for a liquefied gas and/or a hazardous liquid as claimed in any one of the preceding
35 claims, including the successive steps of:

- fixing an intermediate/drainage layer against the internal face of the wall of the tank,
- fixing a coating layer against the intermediate/drainage layer,

- preferably bringing the tank to working temperature,

- depressurizing the intermediate layer to an average depressurization of at least 5 mbarg, preferably of at least 10 mbarg, or pressurizing the storage space of the tank to a pressure of at least 5 mbarg, preferably of at least 10 mbarg.

[71] By the expression "bringing to working temperature" is meant that the coating layer is subjected to a temperature equal to or slightly greater than that of the liquefied gas or of the hazardous liquid intended to occupy the storage space. To be more precise, this working temperature is equal to the temperature T of the liquefied gas or of the hazardous liquid plus 20 degrees Celsius ($T + 20^{\circ}\text{C}$), preferably plus 10 degrees Celsius ($T + 10^{\circ}\text{C}$).

[72] The present invention also relates to a ship for the transport of a liquefied gas and/or of a hazardous liquid, the ship including a hull, an exterior deck and at least one internal deck and a storage installation as succinctly described hereinabove disposed in the hull, on the exterior deck or on the interior deck.

[73] Again, as mentioned above, the invention is intended to apply equally to a storage installation including a sealed tank that may consist of an overground terrestrial reservoir, a semi-underground or underground (ground-based storage (GBS)) reservoir or a maritime reservoir. These tanks or reservoirs may be installed on land or on a floating structure. In the case of a floating structure the tank may be intended for the transport of the liquefied gas or of a hazardous liquid or to receive liquids serving as fuel for the propulsion of the floating structure.

[74] The invention also concerns a transfer system for a cold liquid product, the system including a ship as described hereinabove, insulated pipes

arranged in such a manner as to connect the tank installed in the hull of the ship to a floating or terrestrial external storage installation and a pump for driving a flow of cold liquid product through the insulated pipes from or to the floating or terrestrial external storage installation to or from the tank of the ship.

[75] Finally, the invention concerns a method for loading or offloading a ship as defined hereinabove, in which a cold liquid product is fed through insulated pipes from or to a floating or terrestrial external storage installation to or from the tank of the ship.

[76] The invention will be better understood and other aims, details, features and advantages thereof will become more clearly apparent in the course of the following description with reference to the appended drawings of particular embodiments of the invention provided by way of illustrative and non-limiting example.

[77] [fig.1] Figure 1 is a schematic view of a storage installation in accordance with a first embodiment of the invention in which the pressing on system comprises a means for depressurizing the intermediate layer.

[78] [fig.2] Figure 2 illustrates schematically a storage installation in accordance with a second embodiment of the invention in which the pressing on system comprises a means for pressurizing the storage space of the tank.

[79] [fig.3] Figure 3 illustrates schematically a storage installation in accordance with one embodiment of the invention in which a device for detecting fluid at the level of the intermediate layer is installed and employed.

[80] [fig.4] Figure 4 illustrates schematically in section a corner part that may be used in a tank of the storage installation in accordance with the invention.

[81] [fig.5] Figure 5 illustrates schematically in section another corner part that may be used in a tank of the storage installation in accordance with the invention.

5 [82] [fig.6] Figure 6 is a schematic perspective view of a corner connecting part between the walls of a tank of a storage installation in accordance with the invention.

10 [83] [fig.7] Figure 7 is a schematic cutaway representation of a methane tanker ship storage installation and a terminal for loading/offloading that tank.

[84] Here the term "vertical" means extending in the direction of the terrestrial gravity field. Here
15 the term "horizontal" means extending in a direction perpendicular to the vertical direction.

[85] The present invention is illustrated hereinafter with reference to a ship. In fact it is in this type of structure in particular
20 accommodating a prior art storage installation that the applicant has been able to pinpoint dysfunction potentials and thus to solve them thanks to the present invention. Nevertheless, applying the features of the present invention to a structure of
25 a different kind, such as for example a terrestrial or maritime reservoir type structure, may be envisaged.

[86] Figure 1 illustrates an embodiment in which the system for pressing on the intermediate layer 5
30 comprises a pump 6 connected to a plurality of orifices 7 on the various lateral walls 8, upper wall 9 and lower wall 10 of a tank 71 of a storage installation 1 in accordance with the invention.

[87] Here there are fifteen orifices 7 distributed
35 in a balanced manner as a function of the dimensions of each of the walls 8, 9 and 10 so as produce equal depressurization throughout the intermediate or drainage layer 5. When the pump 6 is activated to depressurize the intermediate layer 5 this latter

layer 5 is pressed against the wall 8, 9 or 10 of the tank 71 entraining with it in its movement the coating layer 3.

5 [88] As indicated above the intermediate layer 5 may be attached to the supporting surface, in this instance the wall 8, 9 or 10 of the tank 71, by gluing or any sort of discrete anchorage. As an alternative, the intermediate layer 5 is attached to the coating layer 3 and lines the surfaces of the
10 walls 8, 9 and 10 that are not intended to accommodate joints or fixing zones.

[89] The sealed coating layer 3 consists of pieces of polymer material cloth joined together by welding, vulcanisation or gluing while the
15 intermediate layer 5 may consist, in addition to the features described above, of plates made of a material such as a thermoset composite material, preferably based on epoxy, or a thermoplastic composite material, preferably based on
20 polyethylene (PE), polypropylene (PP), polyamide (PA), optionally reinforced/charged with glass or basalt fibers, either monolithic or expanded and machined or shaped on at least one of their faces in such a manner as to create an array of channels
25 enabling the flow of gas in the latter.

[90] During the process of applying the coating layer 3 and the intermediate layer 5 it is advantageous, once the latter layers 3, 5 have been applied and fixed, to bring the tank to working
30 temperature. As indicated above this step of reaching the working temperature aims to stretch the coating layer 3, which has high elastic properties, in order for the latter layer 3, at the moment of depressurizing the intermediate layer 5, to be pressed against the latter layer 5 with the
35 smoothest surface, with no asperities or overlays, when the tank 71 is filled with the liquefied gas and/or the hazardous liquid.

[91] Of course, this working temperature is most often a temperature below zero if the tank contains a liquefied gas and this will lead to greater or lesser shrinkage of the coating layer 3. Thus the applicant has been able to determine that it is particularly advantageous, in particular in the case of liquefied gases, to reach a temperature equal to or slightly greater than that of the liquefied gas, that is to say up to 10°C above that average temperature of the liquefied gas (some variation of temperature may exist in a liquid of this kind between the upper and lower layers), or even up to 20°C above that temperature, as a function of the liquefied gas present in the tank 71. Nevertheless, reaching this working temperature is equally advantageous in the situation where the hazardous liquid contained in the tank is at a temperature greater than, close to or even slightly above 0°C.

[92] The elasticity properties of the coating layer 3 are also high and the latter layer 3 advantageously has elongation at rupture capacities between 100% and 300% inclusive. Apart from the aspects of its application in the tank 71, a coating layer 3 of this kind also makes it possible to improve the robustness of the tank 71 in the face of collision accidents, coming alongside or objects falling onto the tank 71. Thus in the event of a serious impact on the tank 71, the latter tank 71 is in fact liable to be torn locally, thereby losing its sealed container function. The coating layer 3 suffers substantially the same deformation but because of its elastic properties and because the anchorages/fixings between the coating layer 3/intermediate layer 5 combination and the walls 8, 9 and 10 of the tank 71 are advantageously discontinuous - in such a manner as to distribute any local deformation of the structure over large areas - or these anchoring/fixing zones are able, either mechanically and/or because of their

intrinsic properties, to absorb the mechanical forces or, to the contrary, have dimensions such as to yield to some degree before the coating layer can be damaged, the coating layer 3 retains its seal even under deformation leading to so-called open rupture of the tank 71.

[93] Also, the fact that the polymer or polymers forming the coating layer 3 has/have a glass transition temperature T_v less than the temperature of the liquefied gas in particular, but also of the hazardous liquid, is advantageous because this makes it possible to have a layer 3 that is sufficiently malleable and elastic on the one hand for its application in the tank and then when filling the tank but also for its resistance to any mechanical stress or force to which the tank 71 might be subjected.

[94] If a tank 71 containing ammonia is considered the boiling point of which at atmospheric pressure is minus thirty-four degrees Celsius (-34°C), it is therefore advantageous to choose a polymer or a mixture of polymers having a glass transition temperature - of at least one of the polymers in the case of a mixture - lower than that temperature. Apart from its qualities of elasticity and of elongation at rupture, an EPDM that has a T_v of around -55°C is typically a particularly interesting candidate for forming the coating layer 3 of a tank 71 of a storage installation 1 in accordance with the invention. In a situation of this kind reaching a working temperature of -34°C before or at the moment of depressurizing the intermediate layer 5 is particularly advantageous.

[95] As will emerge hereinafter in the context of pressurization of the storage space 4 of the tank 71, represented in particular in the appended figure 2, reaching the working temperature may coincide with the step of pressurization by injection of gas or droplets under pressure at a temperature

equivalent to or slightly higher than the temperature of the contents of the tank 71. Injection of ammonia vapor or gas under pressure into the tank 71 typically makes it possible to carry out at the same time the pressurization step and the step of reaching the working temperature, these two steps being intended to bring about optimum pressing on and an optimum disposition of the coating layer 3 in the tank 71. It is important to note that, as indicated above, the step of reaching the working temperature is a non-essential step even if it is required or advantageous.

[96] Figure 2 illustrates a variant in which the pressing on system of the storage installation 1 in accordance with the invention comprises a pressurization means 11 that may consist of a reservoir ideally containing a gas under pressure of identical nature to the liquefied gas and/or to the hazardous liquid or a compressor or the like connected to the storage space 4 of the tank 71.

[97] Accordingly, in this variant pressurization of the storage space 4 makes it possible, possibly with the step of reaching the working temperature as indicated above, to obtain the same or substantially the same result as in the context of the first embodiment represented in figure 1.

[98] Although described here in an independent manner with reference to the appended figures 1 and 2, it is entirely possible to combine the first and the second embodiments in order to obtain a pressing on system including a means 6 for depressurization of the intermediate layer 5 with a means 11 for pressurization of the storage space 4 of the tank 71.

[99] There has been represented in figure 3 a storage installation 1 in accordance with the invention with a device for detection of fluid coming from the storage space 4 or from the outside of the tank 71 in the situation where the latter

tank 71 has been damaged and has lost its seal at least locally.

[100] In this embodiment in which the storage installation 1 includes a fluid detection device the intermediate layer 5 may consist in a drainage layer even though a layer of this kind is particularly advantageous if the fluid detected consists essentially in a liquid - and is not in essentially gaseous form - and the tank has a collecting portion, not represented in the appended figures, as described above.

[101] Whether the intermediate layer 5 consists in a drainage layer or not, the intermediate chamber 5 must be permeable to gases. Accordingly, in the complete architecture shown in figure 3 the detection device comprises at least one means 21 for circulating inert gas in the intermediate/drainage layer 5 and one means 20 for analysing the circulating gas in order to allow the detection of a fluid liable to be that contained in the tank 71 and/or coming from the outside of the tank 71, such as air for example if the quantity of oxygen (O_2) detected is too great.

[102] Accordingly, here a detection device of this kind comprises a circulation pump 21 for circulating inert gas from a storage reservoir 22 of said inert gas to an inlet 23 and then an outlet 24 of the intermediate/drainage layer 5. The circulating gas coming from the intermediate/drainage layer 5 is then analysed by the analysis means 20 connected to a control means 25 able to manage/command said analysis means 20 in such a manner as to detect the presence of "foreign" fluid (that is to say fluid coming from the space 4 or from the outside of the tank 71), possibly in significant quantity - a quantity threshold may be predetermined to define if detection of a foreign component or body should prove positive or not - in order to trigger an alert and/or ancillary safety means for the storage

installation 1 or for the surrounding structure, a ship 70 or otherwise.

5 [103] In an embodiment of this kind the circulation pump 21 may serve as a pump for depressurizing the intermediate/drainage layer 5 in order to press on the latter for its installation and fixing in the tank 71. Accordingly, the embodiment illustrated in figure 3 enables both production of the pressing of the intermediate/drainage layer 5 against the walls 10 8, 9, 10 of the tank 71 and detection of any leak from the storage space 4 or of loss of seal of the tank 71 itself.

15 [104] Moreover, although the embodiments of figures 1 and 2, illustrating a system for pressing on the intermediate/drainage layer 5, and the embodiment from figure 3, illustrating a way of detecting fluid following a loss of seal of the storage space 4 and/or of the tank 71, are described independently, both these embodiments may be combined with one 20 another, advantageously two of these embodiments or the three embodiments taken together.

[105] As previously indicated, the analysis means 20 may consist in an electrochemical cell, an infrared spectrometer or a mass spectrometer. In the 25 situation where the tank 71 contains ammonia, this analysis means 20 advantageously consists of an electrochemical cell.

[106] Optionally the detection device 20, 21 may advantageously comprise a means 26 for cleaning, for 30 example rinsing and/or filtering, the gas circulating in the intermediate/drainage layer 5, which may direct some or all of said gases to a gas evacuation stack 27 conventionally present on a ship 70 for transporting liquefied gas and/or hazardous 35 liquid.

[107] On the assumption that the inert gas in circulation is used in a loop system, that is to say with recovery of said gas for its re-use in a plurality of circulation loops, the detection device

20, 21 may comprise a metering means 28 enabling delivery, with or without necessitating a top up coming from the storage reservoir 22, of a sufficient quantity of inert gas for (re)circulation of the inert gas in the intermediate/drainage layer 5. Additionally, represented in figure 3 are a certain number of valves 29 that enable management of the circulation of the inert gas without the number or positions thereof being exhaustive or precise.

[108] As much for the system for pressing on the intermediate/drainage layer 5 - illustrated by means of two embodiments in figures 1 and 2 - as for the system 20, 21 for detection of liquid or gas coming from the storage space 4 in the event of loss of the seal of the coating layer 3 and/or from the outside of said storage space 4 in the event of loss of seal of the tank - illustrated in accordance with one embodiment in figure 3 - in the broadest sense the essential features of the invention consist in the presence of an intermediate/drainage layer 5 and the fact that, because of its (high) permeability to gases, the latter layer 5 allows the circulation of gas for one and/or the other of the functions that are by virtue of this fact linked by a common principle.

[109] Figures 4 and 5 illustrate in schematic section corner parts 35, 36 that may be disposed and fixed between the walls 8, 9, 10 of the tank 71, for example between a lateral wall 8 and a lower wall 10 as shown in these two figures.

[110] These corner parts 35, 36 advantageously have on the internal face of the tank connecting radii between 50 and 1000 mm inclusive so that the coating layer 3 and the intermediate/drainage layer 5 are well supported against pressure forces in the corners.

[111] The corner parts 36 may consist of moulded or extruded polymer bars with over-moulded metal

inserts intended to be welded to the walls 8, 10 of the tank 71 and disposed in end profile. These anchor zones are then covered by the end of a middle second profile portion.

5 [112] In figure 6 a variant has been represented consisting in a corner connecting part 37 fixed between two adjacent walls 8, 10 of the tank 71. The corner connecting part 37 may consist of sectors of metal tubes the radius of which is the appropriate
10 radius of curvature given the angle between the two adjacent walls 8, 10, that of the edge of the corner of the tank 71 concerned. The tube sector may then be coated with a polymer liner fastened to the latter by vulcanisation or by gluing.

15 [113] Apart from anchoring the coating layer 3 and/or the intermediate/drainage layer 5 in the zones where the corner parts 35, 36 or corner connecting parts 37 are fixed, the coating layer 3 and/or the intermediate/drainage layer 5 for large
20 tanks is or are advantageously anchored in a discontinuous manner, that is to say locally, to the walls 8, 9 and 10 of the tank 71.

[114] This anchoring may be achieved for example by gluing the coating layer 3 and/or the
25 intermediate/drainage layer 5 to the walls 8, 9, 10 of the tank 71, continuously or otherwise. On the vertical walls 8 of the tank 71 the cloth forming the coating layer 3 and/or the intermediate/drainage layer 5 may for example feature substantially
30 continuous horizontal gluing zones from ten (10) to fifty (50) centimeters (cm) high and spaced from one another by two (2) to five (5) meters, for example.

[115] On the upper walls 9 and the lateral walls 8 more dense gluing, possibly in accordance with a
35 specific meshing, will make it possible to prevent the formation of excessive wells in the non-anchored zones. In those zones complete gluing can also be envisaged with the use of a coating layer 3 facing the intermediate/drainage layer 5. In this case the

material of the intermediate/drainage layer 5 is glued directly to the walls 8, 9, 10 of the tank 71.

[116] Figure 7 represents an example of a maritime terminal including a loading and offloading station 75, an underwater pipe 76 and a terrestrial installation 77 that cooperates with a storage installation in accordance with the invention, that is to say a tank 71 having its essential features as well as advantageously some or all of its additional features, preferably in the context of the first or the second embodiment described hereinabove. It may be noted in figure 7 that the tank 71 is installed at the level of the internal deck of a ship 70 but of course the same tank could be installed on the top deck or at the level of any other part of the hull of the ship 70.

[117] The tank may obviously be integrated in a conventional manner so that it is free to contract relative to the hull of the ship 70 and is not subject to the same elongation. In this case the tank 71 rests on a support surface integrated into the hull, possibly provided with a thermal bridge breaker, for example made of wood. A unique zone of the lower wall 10 of the tank 71 is guided in both directions and abutment shoes disposed on the hull, on the wall and on the ceiling serve as anti-flotation means, so that the tank remains attached to the ship 70 in the event of loss of buoyancy of the ship 70 itself. In this architecture the tank 71 is advantageously insulated on the outside, for example with a 50 to 150 millimeter (mm) layer of low-density foam coated with a fire retardant so as to limit the heat flow with the content of the tank 71.

[118] Integrated systems may be envisaged for liquefied gases the equilibrium temperature of which at quasi-atmospheric pressure is above -50°C in which the tank 71 forms part of the structure of the ship 70 or in other words in which a part of the

ship 70 serves as the tank 71. At these temperatures low-carbon steels in fact make it possible to guarantee that no loss of resilience is hazardous to the structure, apart from other particular thermal arrangements. In this case, external thermal insulation may also be envisaged.

[119] The loading and offloading station 75 is a fixed off-shore installation including a mobile arm 74 and tower 78 that supports the mobile arm 74. The mobile arm 74 carries a bundle of insulated flexible tubes 79 that can be connected to the loading/offloading pipes 73. The orientable mobile arm 74 adapts to all methane tanker loading gauges. A connecting pipe that is not shown extends inside the tower 78. The loading and offloading station 75 enables loading and offloading of the methane tanker 70 from or to the terrestrial installation 77. The latter includes liquefied gas storage tanks 80 and connecting pipes 81 connected via the underwater pipe 76 to the loading or offloading station 75. The underwater pipe 76 enables transfer of the liquefied gas between the loading or offloading station 75 and the terrestrial installation 77 over a great distance, for example 5 km, which enables the methane tanker ship 70 to remain at a great distance from the coast during loading and offloading operations.

[120] Pumps onboard the ship 70 and/or pumps equipping the terrestrial installation 77 and/or pumps equipping the loading and offloading station 75 are used to generate the pressure necessary to transfer the liquefied gas.

[121] Although the invention has been described in connection with a plurality of particular embodiments, it is obvious that it is in no way limited to them and that it encompasses all technical equivalents and combinations of the means described if the latter fall within the scope of the invention.

[122] The use of the verb "to include" or "to comprise" and conjugate forms thereof does not exclude the presence of elements or steps other than those stated in a claim.

5 [123] In the claims, any reference sign between parentheses should not be interpreted as a limitation of the claim.

CLAIMS

[Claim 1] A storage installation (1) for a liquefied gas and/or a liquid, comprising:

- 5 - a sealed tank (71) for storage of the liquefied gas and/or of the liquid, consisting in a metal tank (71) having a wall having an internal face and an external face, the wall including a lower wall (10), an upper wall (9) and a lateral wall (8) connecting the lower wall (10) and the upper wall (9), delimiting a space (4) for storage of the liquefied gas and/or the liquid, and
- 10 - a layer (3) coating the internal surface of the wall (8, 9, 10) of the tank (71) made of a polymer material or of a mixture of polymer materials, the coating layer (3) being deformable,
- 15 characterized in that the storage installation (1) comprises an intermediate layer (5) disposed between the coating layer (3) and the wall (8, 9, 10) of the tank (71), in that the coating layer (3) is anchored and/or fixed in a discontinuous manner to the intermediate layer (5) and/or in that the intermediate layer is anchored and/or fixed in a discontinuous manner to the wall (8, 9, 10), and in
- 20 that said intermediate layer (5) allows the circulation of gas in order:
- 25 - to press said intermediate layer (5) and therefore the coating layer (3) against the wall (8, 9, 10) of the tank (71), and/or
- 30 - using a fluid detection device (20, 21), to allow the detection of liquid or of gas coming from the storage space (4) in the event of loss of seal of the coating layer (3) and/or from the outside of said storage space (4) in the event of loss of
- 35 seal of the tank (71).

[Claim 2] The storage installation (1) as claimed in claim 1, in which, in order to press on the intermediate layer (5), the storage installation (1) comprises a system for pressing the intermediate

layer (5) against the wall (8, 9, 10) of the tank (71), said pressing on system comprising:

- a means (6) for depressurizing the intermediate layer (5) with an average depressurization of at least 5 mbarg; and/or
- a means (11) for pressurizing the storage space (4) of the tank (71) with an average pressurization of at least 5 mbarg.

[Claim 3] The storage installation (1) as claimed in claim 1 or 2, in which the intermediate layer (5):

- is anchored to the wall (8, 9, 10) of the tank (71) by a mechanical and/or chemical means, and/or
- is fixed chemically to the coating layer (3).

[Claim 4] The storage installation (1) as claimed in any one of the preceding claims, in which the coating layer (3) has a glass transition temperature T_v less than the temperature of liquefaction of the liquefied gas and/or of the hazardous liquid at atmospheric pressure.

[Claim 5] The storage installation (1) as claimed in any one of the preceding claims, in which the coating layer (3) consists of an elastomer, preferably of an EPDM.

[Claim 6] The storage installation (1) as claimed in at least any one of the preceding claims including claim 2, in which the means (6) for depressurization of the intermediate layer (5) comprises at least one pump (6, 21) connected to at least one orifice (7) in the wall (8, 9, 10) of the tank (71) in such a manner as to create the average depressurization.

[Claim 7] The storage installation (1) as claimed in any one of the preceding claims, in which the intermediate layer (5) consists in a drainage layer intended to drain a liquid coming from the storage space (4) of the tank (71) or from the outside of the tank (71).

[Claim 8] The storage installation (1) as claimed in any one of the preceding claims, in which the installation (1) comprises on the lower wall (10) of the tank (71) a collection portion situated at the lowest point of the tank (71) and the fluid detection device (20, 21) is able to analyse said collection portion to detect the presence of liquid.

[Claim 9] The storage installation (1) as claimed in any one of the preceding claims, in which the installation (1) comprises a circulation pump (21) and an inert gas is circulated by the circulation pump (21) in the intermediate or drainage layer (5) between at least one entry point (23) and at least one exit point (24).

[Claim 10] The storage installation (1) as claimed in any one of the preceding claims, in which the fluid detection device (20, 21) detects the presence of gas and/or of liquid at the entry point (23) or at the exit point (24).

[Claim 11] The storage installation (1) as claimed in at least one of the preceding claims, in which the fluid detection device (20, 21) consists in a mass spectrometer, an infrared spectrometer, an electrochemical cell and/or a katharometer.

[Claim 12] The storage installation (1) as claimed in any one of the preceding claims, in which the intermediate layer or the drainage layer (5) consists of:

- a mat, a felt, a mesh or a woven textile of glass, basalt, polyethylene and/or polypropylene fibers and assemblies thereof; or
- an aggregate material based on resin and mineral granulates and/or polymers; or
- a composite material with a heatset matrix, preferably epoxy-based, or a thermoplastic matrix, preferably polyethylene, polypropylene and/or polyamide based, preferably reinforced with glass or basalt fibers or wood particles.

[Claim 13] The storage installation (1) as claimed in any one of the preceding claims, in which the means (11) for pressurizing the storage space (4) of the tank (71) comprises a compressor or a reservoir of gas under pressure connected to the storage space (4) of the closed tank (71) in such a manner as to deliver the pressurization by means of a neutral gas or of the liquefied gas intended for said tank.

10 [Claim 14] The storage installation (1) as claimed in any one of the preceding claims, in which the liquefied gas and/or the hazardous liquid consists of liquid ammonia.

15 [Claim 15] The storage installation (1) as claimed in any one of the preceding claims, in which the metal tank (71) consists of an independent tank of type A, B or C according to the definition given by the IGC code.

20 [Claim 16] A method for installation of a coating layer (3) and an intermediate/drainage layer (5) in a tank (71) of a storage installation (1) for a liquefied gas and/or a hazardous liquid as claimed in any one of the preceding claims, including the successive steps of:

- 25 - fixing an intermediate/drainage layer (5) against the internal face of the wall (8, 9, 10) of the tank (71),
- fixing a coating layer (3) against the intermediate/drainage layer (5),
- 30 - preferably bringing the tank (71) to working temperature,
- depressurizing the intermediate layer (5) to an average depressurization of at least 5 mbarg, preferably of at least 10 mbarg, or pressurizing
- 35 the storage space (4) of the tank to a pressure of at least 5 mbarg, preferably of at least 10 mbarg.

[Claim 17] A ship (70) for the transport of a liquefied gas and/or of a hazardous liquid, the ship

(70) including a hull, an exterior deck and at least one internal deck and a storage installation (1) as claimed in any one of claims 1 to 15 disposed in the hull, on the exterior deck or on the interior deck.

5 [Claim 18] A transfer system for a cold liquid product, the system including a ship (70) as claimed in claim 17, insulated pipes (73, 79, 76, 81) arranged in such a manner as to connect the tank (71) installed in the hull of the ship to a floating
10 or terrestrial external storage installation (77) and a pump for driving a flow of cold liquid product through the insulated pipes from or to the floating or terrestrial external storage installation to or from the tank of the ship.

15 [Claim 19] A method for loading or offloading a ship (70) as claimed in claim 17, in which a cold liquid product is fed through insulated pipes (73, 79, 76, 81) from or to a floating or terrestrial external storage installation (77) to or from the tank of the
20 ship (71).