

SYSTEM AND DEVICE FOR DETERMINING THE VALUE OF A LOCAL DEFORMATION PARAMETER OF A LIQUID STORAGE TANK AND USE OF SAID DEVICE

TECHNICAL FIELD OF THE INVENTION

The present invention relates to a system for determining the value of at least one parameter of a liquid storage tank, a device for forming such a system and a use of said device. It applies, in particular, to the field of liquefied natural gas transport and storage, and more specifically to the fields of:

- measuring the volume of liquefied natural gas in a tank;
- modeling dynamic motion phenomena of liquefied natural gas in the tank; and
- measuring the integrity of liquefied natural gas tanks.

10 STATE OF THE ART

In the liquefied natural gas (also abbreviated to "LNG") volume measurement and billing field, the method for calculating the transfer of energy between two LNG reservoirs recommended in the "Custody Transfer Handbook" by GIIGNL (the "International Group of Liquefied Natural Gas Importers") is known. Here "reservoir" refers to a reservoir of a factory, ship, FLNG (for "Floating Liquefied Natural Gas"), FSRU (for "Floating Storage Regasification Unit"), FSU (for "Floating Storage Unit") or SRV (for "Shuttle and Regasification Vessel") type of floating structure, or methane terminal.

Here "transfer between two reservoirs" refers to the LNG's movement between two reservoirs amongst those indicated above.

In the field of modeling dynamic phenomena of sloshing, i.e. the movement of liquid in a reservoir; known observation experiments of sloshing have utilized impact sensors built into tank walls. These impact sensors have the drawback of needing to be built into the tank walls when they are manufactured.

In the field of measuring the integrity of the LNG tanks, known methods of measuring the aging of tanks are used when the tank is empty (technical shutdowns):

visual inspection, portable devices for measuring integrity (by measuring various physical magnitudes). These methods have the drawback of being able to be used only during technical shutdowns, which occur, for example, every four years for methane tankers. Between two technical shutdowns, there is no inspection means that makes it possible to detect a premature aging of reservoirs, or to anticipate on an urgent basis a technical shutdown.

In the field of measuring the volume in a reservoir, a calculation method is currently used in which the height of the LNG in the reservoir is read before and after the transfer in order to deduce the LNG volume transferred. This method is currently only used to read the LNG volume in the reservoir of a ship which receives LNG, or which delivers it, and is not used in either methane terminals or floating structures.

This reading is corrected with tables to take into account the deformation of the tanks caused by the liquid in the reservoir.

However, in the case of offshore transfers, the LNG reservoir is subject to the sloshing phenomenon, which makes the reading of the LNG height in the reservoir imprecise or impossible.

To overcome this problem, the LNG industry has developed alternative methods for the online assessment of the energy transferred. In these methods, a dynamic flow meter is, for example, positioned inside an LNG transfer line connecting two reservoirs. This method allows the mass flow of the transferred LNG to be measured, thereby making it possible to move away from a static reading of the height of the LNG in the tanks. However, this technology is permissible up to flow rates not exceeding 1,000 m³/h, whereas the LNG transfers can reach 10,000 m³/h. To reach this value, the number of flow meters need to be increased.

These flow meters have one major drawback: they require an established flow to operate under the best conditions, which entails very long lengths of pipelines upstream and downstream of the flow meter.

To date, no offshore project has adopted this solution.

These problems also exist in the broader field of fluid transport in a tank subjected to sloshing.

SUBJECT OF THE INVENTION

The present invention aims to remedy all or part of these drawbacks.

To this end, according to a first aspect, the present invention relates to a system for determining the value of at least one parameter of a liquid storage tank, such as a local deformation of the tank, for example, which comprises:

- a liquid storage tank; and
- 5 - a removable device for determining the value of at least one parameter of a liquid tank, which device comprises:
 - a means for attachment to the inside of the tank, for example to a mast positioned inside the tank and in the vicinity of an upper wall of said tank, said attachment means supporting:
 - 10 - a multidirectional laser emitter;
 - a receiver of the light emitted by the laser;
 - a photodetector converting the received light into an electric signal; and
 - a means for detecting a relief inside the tank as a function of signals converted by the photodetector;
 - 15 - a means for determining a topography of at least one wall of the tank as a function of at least one detected relief; and
 - a means for determining the value of each local deformation parameter as a function of the determined topography.

20 These provisions make it possible to evaluate the mechanical stresses to which the tank is subjected.

When the topography of the liquid's surface is determined, the device makes it possible to determine the volume of the liquid in the tank, and when the topography of a wall of the tank is determined, the device makes it possible to determine the deformation of tanks, in particular.

25 In addition, a single device can cover an entire tank and this system can capture dynamic phenomena, inaccessible with current technologies, due to high spatial resolution.

30 In some embodiments, the system that is the subject of this invention is configured to determine a deformation parameter of the tank representative of a cavity in a wall.

In some embodiments, the system that is the subject of this invention is configured to determine a deformation parameter of the tank representative of a cavity whose maximum dimension, along one axis, is less than one meter.

In some embodiments, the system that is the subject of this invention is configured to determine a deformation parameter of the tank representative of a cavity whose maximum dimension, along one axis, is less than ten centimeters.

5 In some embodiments, the system that is the subject of this invention is configured to determine a deformation parameter of the tank representative of a cavity whose maximum dimension, along one axis, is less than one centimeter.

In some embodiments, the system that is the subject of the present invention comprises:

- 10 - a counter of a number of critical deformations in the tank determined by the determination means, this counter being configured to count the presence of a critical deformation when a deformation value measured is greater than a predefined limit value; and
- an emitter of a warning when a number of critical deformations counted is greater than a defined number.

15 In some embodiments, the means for determining a topography is also configured to determine the topography of a surface of liquid in the tank, the determination means determining a value representative of a volume of liquid in the tank as a function of the topography determined.

20 These embodiments allow the volume of liquid in the tank to be determined reliably regardless of the sloshing phenomenon of the tank.

In some embodiments, the system that is the subject of the present invention comprises a means for calculating a mechanical property of the tank as a function of the topography determined.

These embodiments allow the tank's state of wear to be determined.

25 In some embodiments, at least:

- the emitter;
- the receiver; and
- the photodetector

30 are built into a housing that is sealed and/or has filling material configured to limit the risk of explosions.

These embodiments allow the system to be utilized for a tank in an ATEX ("ATmosphère EXplosive" or "explosive atmosphere") environment, as defined in the European Union's ATEX 95 standard, in an equivalent standard or in an environment where liquid movements are likely to damage the device.

In some embodiments, the system that is the subject of the present invention comprises:

- a thermally insulated housing for at least:
 - the emitter;
 - the receiver; and
 - the photodetector; and
- a means for heating the interior of the housing to a temperature corresponding to the minimum operating temperature of the emitter, receiver and photodetector.

These embodiments allow the system to be used in a cryogenic tank.

In some embodiments, the system that is the subject of the present invention comprises at least one additional sensor capturing a value of an internal or external parameter of the tank, the value of the parameter determined by the system being determined as a function of at least one additional parameter value captured.

This sensor is, for example, an inclinometer, gyroscope, accelerometer, pressure gauge or thermometer. This sensor is positioned in or on the tank, or in a ship transporting the tank.

These embodiments make it possible to increase the reliability of the determination carried out.

According to a second aspect, the present invention relates to a removable device for determining the value of at least one parameter of a liquid storage tank, such as sloshing of the liquid in the tank, a volume of liquid in the tank or a deformation of the tank, for example, to form a system that is the subject of the present invention, which comprises:

- a removable device for determining the value of at least one parameter of a liquid storage tank, which device comprises:
 - a means for attachment to the inside of the tank, for example to a mast positioned inside the tank and in the vicinity of an upper wall of said tank, said attachment means supporting:
 - a multidirectional laser emitter;
 - a receiver of the light emitted by the laser;
 - a photodetector converting the received light into an electric signal; and

- a means for detecting a relief inside the tank as a function of signals converted by the photodetector;
- a means for determining a topography of at least one wall of the tank as a function of at least one detected relief; and
- 5 - a means for determining the value of each local deformation parameter as a function of the determined topography.

As the particular aims, advantages and features of the device that is the subject of the present invention are similar to those of the system that is the subject of the present invention, they are not repeated here.

10 This device also allows already existing tanks to be retro-fitted.

According to a third aspect, the present invention relates to a use of the device, the subject of the present invention, for determining the value of a mechanical property of the tank.

As the particular aims, advantages and features of the use that is the subject of the present invention are similar to those of the device that is the subject of the present invention, they are not repeated here.

BRIEF DESCRIPTION OF THE FIGURES

Other advantages, aims and particular features of the invention will become apparent from the non-limiting description that follows of at least one particular embodiment of the system and device that are the subjects of the present invention, with reference to drawings included in an appendix, wherein:

- figure 1 represents, schematically, a particular embodiment of the system and device that are the subjects of the present invention;
- 25 - figure 2 represents, schematically, a two-dimensional topography example of a liquid surface produced by the system and device that are the subjects of the present invention;
- figure 3 represents, schematically, a two-dimensional topography example of a tank wall produced by the system and device that are the subjects of the present invention; and
- 30 - figure 4 represents, schematically, a two-dimensional topography example of a tank wall produced by the system and device that are the subjects of the present invention.

DESCRIPTION OF EXAMPLES OF REALIZATION OF THE INVENTION

The present description is given in a non-limiting way, each characteristic of an embodiment being able to be combined with any other characteristic of any other embodiment in an advantageous way.

5 It is now noted that the figures are not to scale.

It is noted that the present invention preferably relates to LNG storage tanks, the term "liquid" therefore being interpreted as the liquid phase of the stored LNG.

The term "local deformation" refers to a deformation of a wall one of whose largest dimension is at least one order of magnitude smaller than the largest
10 dimension of the tank. For example, a local deformation can be a crack, cavity, bump, or other. It is noted that in this case an "order of magnitude" is defined as a power of ten.

This local deformation can also be synonymous with "localized deformation".

Figure 1, which is not to scale, shows a schematic view of an embodiment of
15 the system 100 that is the subject of the present invention. The system 100 for determining the value of at least one parameter of a liquid storage tank, such as a local deformation of the tank, for example, is characterized in that it comprises:

- a liquid storage tank 115; and
 - a means 125 for attachment to the inside of the tank, for example to a
20 mast positioned inside the tank and in the vicinity of an upper wall 130 of said tank, said attachment means supporting:
 - a multidirectional laser emitter 110;
 - a receiver 135 of the light emitted by the laser;
 - a photodetector 140 converting the received light into an electric
25 signal; and
 - a means 145 for detecting a relief inside the tank as a function of signals converted by the photodetector;
 - a means 146 for determining a topography of at least one wall of the tank as a function of at least one detected relief; and
 - a means 150 for determining the value of each local deformation parameter as
30 a function of the determined topography.

The tank 115 is, for example, a tank of a factory, ship or methane terminal. This tank 115 can thus be mounted on a ship known as a "methane tanker".

This tank 115 is, for example:

- a tank of a methane tanker,
 - a floating liquefied natural gas tank,
 - a tank of a floating storage and regasification plant,
 - a tank of a floating storage plant, or
- 5 - a tank of a gas fueling shuttle vessel.

The tank 115 can be at atmospheric pressure or pressurized to above atmospheric pressure, for example to at least one bar above atmospheric pressure. In some variants, the tank 115 is an LNG storage tank 115 and comprises a support mast 105.

10 The support mast 105 is, for example, a tripod mast, each leg of which comprises an attachment means 125. In some variants, this mast 105 comprises a single leg.

The attachment means 125 is, for example, a screw thread to receive a screw, or a flat surface to receive an adhesive material.

15 The mast 105 is positioned in an upper portion of the height in the tank 115. Here, "height" refers to the axis defined by the direction of the Earth's gravitational force, in the opposite direction to the Earth's gravitational force, once the tank 115 is filled with LNG. For example, the mast 105 is positioned against a wall facing the liquid phase of the liquefied natural gas contained in the tank 115, this liquid phase

20 positioning itself, gravitationally, in a lower portion of the tank 115. When the tank 115 is full, the liquid phase completely fills the tank 115. As the tank 115 is emptied, the upper portion of the tank is filled with a gas phase, coming from the evaporation of the LNG, called "boil-off gas".

The longitudinal dimension of the mast 105, which forms the height of said

25 mast 105 once positioned in the tank 115, is chosen such that the lowest point of the device 120 is positioned above the surface of the liquid, preferably at a height of the tank representing 98% of the total height of the storage volume of the tank 115. In some variants, the emitter 110, receiver 135 and photodetector 140 are positioned at this height, regardless of the height of the mast 105.

30 The emitter 110 is, for example, a laser source that is multidirectional, by means of a diffraction optical system, a set of movable mirrors, or by using a mounted source mobile in rotation and oriented such that the laser source can sweep the entire interior of the storage volume of the tank 115 except for a close portion

around the mast 105 and the portion of the upper wall 130 to which this mast 105 is attached.

The emitter 110 is preferably a pulsed laser source that emits wave trains (packets of light) of several microseconds. These wave trains take different light paths during which they are slowed and oriented onto a matrix. A lens enables the laser pulses to be distributed spatially.

The light used by this emitter 110 is, for example, in the infrared spectrum, with a wavelength value between 900 nanometers and 930 nanometers.

Preferably, this emitter 110 is configured to have a spatial resolution of one centimeter on activation. Spatial resolution of the order of one centimeter is sufficient for determining a local deformation of the tank, whereas spatial resolution of the order of 10 centimeters is sufficient for observing the sloshing, measuring the level of liquid, and determining an overall deformation value for the tanks. This emitter 110 preferably also has a temporal resolution of one second. This frequency is suitable for the typical time constants of the sloshing or expansion phenomena of the tanks observed.

The emission strength of the emitter 110 is chosen such that the reception strength of the light emitted, reflected, at a distance of one hundred meters, for example, and then received at the receiver 135 allows the light to be detected by the photodetector 140.

To measure a relief, a time-of-flight measurement is taken of the light traveling from the emitter to a point of the surface in question and then reflected to the receiver 135. The time window in which the signal is received also gives an indication of the direction, each delay line having a defined emission and reception window.

The receiver 135 is chosen to be very sensitive in order to detect weakly reflective materials.

The receiver 135 is, for example, a light-collecting type of optical system, for example a telescope. This receiver 135 allows beams of light emitted, and then reflected in a diffuse way by a surface in the tank 115, to be collected in a consistent way for sending to the photodetector 140.

The photodetector 140 is an electronic circuit configured to emit an electric signal representative of the detection of a light signal. This photodetector 140 is, for example, a photodiode.

Therefore, as can be seen:

- the emitter 110 emits a plurality of beams towards a wall of the tank 115 or towards the liquid stored in the tank 115;
- each beam is reflected by the wall of the tank 115 or by the surface of the liquid;
- 5 - the reflected beams are received by the receiver 135 and then by the photodetector 140;
- the distance from the wall of the tank or from the gas-liquid phase interface is deduced as a function of the time lag between the time a beam is emitted and the time the corresponding reflected beam is received.

10 This operation matches to the operation of a standard lidar.

 This lidar can be a mass-produced mobile lidar or a so-called "solid state" lidar, which emits in all directions of the space thanks to a delay-line photonic system and a suitable lens.

 The simultaneous emission of a plurality of beams makes it possible to
15 produce a topography of the reflective surface targeted by the emitter 110. Each beam being independently and spatially identified, as a function of an emission angle relative to a reference angle for example, this allows the position of the reflection points of the emitted beams to be established spatially.

 The means 145 for detecting a relief is, for example, an electronic calculation
20 circuit configured to associate a beam emission angle to each electric signal produced by the photodetector 140 so as to determine, in combination with the measured distance, the presence and height of a relief.

 As a function of each relief detected, the determination means 146 produces a
25 topography of the surface targeted by the emitter 110, which surface corresponds, for example, to:

- the surface of the liquid in the tank 115 and/or
- a wall of the tank 115.

 The means 150 for determining the value of each parameter is, for example, an electronic calculation circuit configured to determine:

- 30 -
- a volume of LNG in the tank 115,
 - a topography of the surface of the liquid in the tank 115 and/or
 - a mechanical property of the tank 115 or of a wall of said tank, such as a deformation value of a wall of the tank, for example.

In some preferred embodiments, the system 100 that is the subject of this invention is configured to determine a deformation parameter of the tank representative of a cavity in a wall. Such a cavity is, for example, a crack. Figure 3 shows an example of such a cavity.

5 This determination is performed, for example, by the determination means 150.

In some embodiments, the system 100 that is the subject of this invention is configured to determine a deformation parameter of the tank representative of a cavity whose maximum dimension, along one axis, is less than one meter.

10 In some embodiments, the system 100 that is the subject of this invention is configured to determine a deformation parameter of the tank representative of a cavity whose maximum dimension, along one axis, is less than ten centimeters.

In some embodiments, the system 100 that is the subject of this invention is configured to determine a deformation parameter of the tank representative of a
15 cavity whose maximum dimension, along one axis, is less than one centimeter.

In some embodiments, the system 100 that is the subject of the present invention comprises:

- a counter 155 of a number of critical deformations in the tank 115 determined by the determination means 150, this counter being configured to count the
20 presence of a critical deformation when a deformation value measured is greater than a predefined limit value; and
- an emitter 160 of a warning when a number of critical deformations counted is greater than a defined number.

The emitter 160 is, for example:

- 25 - an antenna configured to emit a wireless signal to a piece of third-party equipment;
- a wired link connected to a piece of third-party equipment;
- a loudspeaker or an emitter of light signals.

With respect to calculating the volume of liquid in the tank 115, this volume
30 can be determined by operating the lidar when the tank is empty so as to determine the total volume of the tank 115. Once the tank 115 is at least partially filled, activating the lidar allows the topography of the surface of the liquid in the tank 115 to be determined. Depending on the position of this interface, relative to the initial

topography determined, the volume of liquid can be calculated based on the dimensions determined for the volume occupied by this liquid phase.

The wear of tanks 115 leads, in particular, to deformation of the walls of this tank 115 relative to an initial state, this wear being generated by the thermal contraction or expansion of the material making up the wall, or by the hydrostatic pressure generated by the height of liquid in the tank 115.

With respect to calculating a mechanical property of the tank 115, the determination of a local or overall topography of a wall of the tank 115 means the presence of a local or overall deformation of this tank 115 can be determined.

Observing these deformations requires a spatial resolution of the determined topography of the order of a centimeter or less. Other mechanical properties of the wall, such as the elasticity of this wall, can be deduced from the deformation of the wall at a larger scale, in particular thanks to a spatial resolution of the order of ten or so centimeters. These calculations allow a user to be informed about the aging of the wall.

In some variants, this calculation can be performed by periodically activating the lidar so as to determine, as a function of the topography, the presence of a sloshing condition in the tank 115. This sloshing condition is characterized by a frequency of sloshing motions in the tank 115, the pressure or velocity fields of the liquid at the location of the wall that are generated by the liquid wave in the tank.

In some variants, the system 100 comprises a counter of a number of critical deformations in the tank 115, this counter being configured to count the presence of a critical deformation when a deformation value measured in one location of the tank is greater than a predefined limit value. When the number of critical deformations is greater than a predefined number, the counter emits a warning.

In some variants, the system 100 comprises a counter of the sloshing phenomenon's occurrence frequency during a defined period of time. The counter is configured to emit a warning when the sloshing frequency is greater than a defined frequency. This warning can take the form of a steering recommendation for the ship containing the tank 115.

In some variants, the system 100 that is the subject of the present invention comprises an emitter of a signal representative of a determined deformation value or a warning when the determined deformation value is greater than a predefined limit value.

Figure 2 shows a two-dimensional schematic topography, formed from plots 205 acquired by utilizing the system 100 that is the subject of the present invention, of the interface between the liquid phase and the gas phase of the LNG in a tank.

5 This topography makes it possible to identify the presence of a wave peak 210 and a wave trough 215 in this liquid phase.

The wave's movement from one side of the tank to the other makes it possible to determine the presence of a sloshing phenomenon.

Depending on the height of the wave peak 210, and this wave peak's movement speed, compared to topographies acquired successively, for example, the severity of the wave's impact against a wall of the tank can be determined.

This movement speed also allows a sloshing frequency to be determined.

Figure 3 shows a two-dimensional schematic topography 300, formed from plots 305 acquired by utilizing the system 100 that is the subject of the present invention, of a wall 310 in a tank.

15 This topography makes it possible to identify the presence of a local deformation 315 in the wall 310.

Figure 4 shows a two-dimensional schematic topography 400, formed from plots 405 acquired by utilizing the system 100 that is the subject of the present invention, of a wall 410 in a tank.

20 This topography makes it possible to identify the presence of an overall deformation of the wall 410.

Here, "mechanical property" refers to the elasticity of a wall of the tank 115 for example.

25 The detection means 140 and the determination means 150 are positioned close to the tank 115 or remote from this tank 115. In some variants, the link between the photodetector 140 and the detection means 140 comprises a wireless portion utilizing antennas to emit and receive signals representative of electrical signals produced by the photodetector 140.

30 In some embodiments, the detection means 140 and the determination means 150 are located in the area of an electronic calculation circuit of a ship transporting the tank 115. This electronic calculation circuit is, for example, a control unit in the control room of the ship comprising the system 100. In some variants, this electronic calculation circuit is remote from the ship or the tank.

In some preferred embodiments, such as that shown in figure 1, at least:

- the emitter 110;
- the receiver 135; and
- the photodetector 140

are built into a housing 165 that is sealed and/or has filling material configured to limit the risk of explosions.

The use of filling material allows the housing 165 to be positioned in an ATEX zone 0 area.

The housing 165 also comprises a transparent portion for the light emitted by the emitter 110 and received by the receiver 135.

The interference caused by this transparent portion, in the range of light frequencies utilized by the emitter 110 and the receiver 135, must be minimized through the selection of a type of material and thickness of material, and through the positioning of the emitter 110 and receiver 135 in relation to this transparent portion. Alternatively, or in a complementary manner, this interference can be corrected by applying a signal processing algorithm to the electrical signals produced by the photodetector 140.

The material forming the housing 165 is selected to withstand the thermal expansion stresses specific to storing LNG in a tank.

The housing 165 is, for example, made of:

- aluminum, with a window made of cemented borosilicate;
- stainless steel, as defined by the American Iron and Steel Institute standard AISI 316L, with a window made of cemented borosilicate; or
- stainless steel, as defined by the AISI 316L standard, with a window made of fused borosilicate.

In some preferred embodiments, such as that shown in figure 1, the system that is the subject of the present invention comprises:

- a thermally insulated housing 165 for at least:
 - the emitter 110;
 - the receiver 135; and
 - the photodetector 140; and
- a means 170 for heating the interior of the housing to a temperature corresponding to the minimum operating temperature of the emitter, receiver and photodetector.

The material forming the housing 165 is selected to thermally insulate the interior of the housing 165 at the operating conditions of the tank 115. The gas phase temperature of the LNG is of the order of -130°C . Preferably, the material selected allows the interior of the housing 165 to have a temperature higher than -40°C , the

5 minimum operating temperature of standard emitters 110, receivers 135 and photodetectors 140. Preferably, the material selected allows the interior of the housing to have a temperature higher than 20°C .

The heating means 170 is, for example, a heater element powered by an electrical current.

10 The power of this heating means 170 is determined according to the operating conditions of the tank 115 and the material of the housing 165 selected.

For example, if the housing 165 comprises a window made of Plexiglas (registered trademark) two centimeters thick with thermal conductivity of 0.19 W/m.K , and the temperature inside the housing 165 must be 20°C for a gas phase

15 temperature of the LNG of -130°C , then the thermal flow between the interior and exterior of the housing 165 is estimated to be approximately 10 W . The heating means 170 can therefore be configured to heat the interior of the housing 165 by 10W , the transformation by Joule effect of the utilization of the lidar being able to be subtracted from this heating.

20 The housing 165 is connected to the detection means 145 by an electrical cable, the material forming this electrical cable and the positioning of this cable being selected to reduce the loss of heat in the tank 115.

The electrical cable is, for example, made of nanotube- or graphene-filled polymer. Alternatively, a cable made of iron or steel can be used.

25 The weight of the housing 165 and the elements inside is preferably less than five kilograms. The volume of this housing 165 and the elements inside is preferably less than ten liters.

In some preferred embodiments, such as that shown in figure 1, the system 100 comprises at least one additional sensor 175 capturing a value of an internal or

30 external parameter of the tank, the value of the parameter determined by the system being determined as a function of at least one additional parameter value captured.

This sensor 175 is, for example, an inclinometer, inertial measurement unit, gyroscope, accelerometer, pressure gauge or thermometer. This sensor 175 is positioned in or on the tank 115, or in a ship transporting the tank 115.

The system 100 can also comprise a plurality of sensors 175 of a single type or different types.

Figure 1 also shows, independently, a particular embodiment of the device 120 for determining the value of at least one parameter of a liquid storage tank 130 to

5 form a system 100 as described with reference to figure 1, which device comprises:

- a means 125 for attachment to the inside of the tank, for example to a mast positioned inside the tank and in the vicinity of an upper wall 130 of said tank, said attachment means supporting:
 - a multidirectional laser emitter 110;
 - 10 - a receiver 135 of the light emitted by the laser;
 - a photodetector 140 converting the received light into an electric signal; and
- a means 145 for detecting a relief inside the tank as a function of signals converted by the photodetector;
- 15 - a means (146) for determining a topography of at least one wall of the tank as a function of at least one detected relief; and
- a means (150) for determining the value of each local deformation parameter as a function of the determined topography.

CLAIMS

1. System (100) for determining the value of at least one parameter of a liquid storage tank, such as a local deformation of the tank, for example, characterized in that it comprises:

- a liquid storage tank (115); and

5 - a removable device (120) for determining the value of at least one parameter of a liquid tank, which device comprises:

- a means (125) for attachment to the inside of the tank, for example to a mast positioned inside the tank and in the vicinity of an upper wall (130) of said tank, said attachment means supporting:

10 - a multidirectional laser emitter (110);
- a receiver (135) of the light emitted by the laser;
- a photodetector (140) converting the received light into an electric signal; and

15 - a means (145) for detecting a relief inside the tank as a function of signals converted by the photodetector;

- a means (146) for determining a topography of at least one wall of the tank as a function of at least one detected relief; and

- a means (150) for determining the value of each local deformation parameter as a function of the determined topography.

20

2. System (100) according to claim 1, configured to determine a deformation parameter of the tank representative of a cavity in a wall.

25 3. System (100) according to claim 2, configured to determine a deformation parameter of the tank representative of a cavity whose maximum dimension, along one axis, is less than one meter.

30 4. System (100) according to claim 3, configured to determine a deformation parameter of the tank representative of a cavity whose maximum dimension, along one axis, is less than ten centimeters.

5. System (100) according to claim 4, configured to determine a deformation parameter of the tank representative of a cavity whose maximum dimension, along one axis, is less than one centimeter.

- 5 6. System (100) according to one of claims 1 to 5, which comprises:
- a counter (155) of a number of critical deformations in the tank (115) determined by the determination means (150), this counter being configured to count the presence of a critical deformation when a deformation value measured is greater than a predefined limit value; and
 - 10 - an emitter (160) of a warning when a number of critical deformations counted is greater than a defined number.

7. System (100) according to one of claims 1 to 6, wherein the means (146) for determining a topography is also configured to determine the topography of a surface
 15 of liquid in the tank, the determination means (150) determining a value representative of a volume of liquid in the tank as a function of the topography determined.

8. System (100) according to one of claims 1 to 7, wherein at least:
- 20 - the emitter (110);
 - the receiver (135); and
 - the photodetector (140)
- are built into a housing (165) that is sealed and/or has filling material configured to limit the risk of explosions.

25

9. System (100) according to one of claims 1 to 8, which comprises:
- a thermally insulated housing (165) for at least:
 - the emitter (110);
 - the receiver (135); and
 - 30 - the photodetector (140); and
 - a means (170) for heating the interior of the housing to a temperature corresponding to the minimum operating temperature of the emitter, receiver and photodetector.

10. System (100) according to one of claims 1 to 9, which comprises at least one additional sensor (175) capturing a value of an internal or external parameter of the tank, the value of the parameter determined by the system being determined as a function of at least one additional parameter value captured.

5

11. Removable device (120) for determining the value of at least one parameter of a liquid tank (130) to form a system (100) according to one of claims 1 to 10, which comprises:

- a means (125) for attachment to the inside of the tank, for example to a mast positioned inside the tank and in the vicinity of an upper wall (130) of said tank, said attachment means supporting:
 - a multidirectional laser emitter (110);
 - a receiver (135) of the light emitted by the laser;
 - a photodetector (140) converting the received light into an electric signal; and
- a means (145) for detecting a relief inside the tank as a function of signals converted by the photodetector;
- a means (146) for determining a topography of at least one wall of the tank as a function of at least one detected relief; and
- a means (150) for determining the value of each local deformation parameter as a function of the determined topography.

10

15

20

12. Use of the device according to claim 11 for determining the value of a mechanical property of the tank.