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(54) METHOD OF DETECTING GAS IN GAS LEAKAGE RISK AREA AROUND GAS STORAGE SYSTEM

VERFAHREN ZUR ERKENNUNG VON GAS IN EINEM GASLECKAGE-RISIKOBEREICH RUND UM
EIN GASSPEICHERUNGSSYSTEM

MÉTHODE DE DÉTECTION DE GAZ AUTOUR DE SYSTÈMES DE STOCKAGE DE GAZ

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Description

Technical Field

[0001] The present invention relates to flammable gas detection for released gas in a hazardous area of gas carriers, and more particularly it concerns devices and methods of detecting and ventilating leaked flammable gases in hazardous area of a gas carrier. They can immediately detect the leakage of flammable gas in enclosed spaces in gas carriers or onshore or offshore facilities where boil-off gas (BOG) is compressed to be used as fuel or to be re-liquefied, or in any other places of hazardous area where have potential gas leakages to eliminate the possibility of gas explosion.

Background Art

[0002] In general, the places where have the likelihood that the explosive gas in atmosphere is present are classified as hazardous area in gas carriers. The traditional gas detection system samples the gases at a number of sampling heads around cargo tanks and enclosed spaces of the hazardous area by the procedure regulated in IGC Code (International code for the construction and equipment of ships carrying liquefied gases in bulk). The sampled gases are analyzed with a gas analyzer, which is located in a safe area (an accommodation side) according to a predefined sequence.

[0003] Specifically, LNG (liquefied natural gas) carriers, or LPG (liquefied petroleum gas) carriers, or onshore and offshore facilities using boil-off gas generated by atmospheric heat sources have an auxiliary equipment such as cargo compressors or re-liquefaction systems so that boil-off gas is compressed to be used as fuel for propulsion or power generation, or is re-liquefied to be stored as cargo.

[0004] The cargo compressors or the re-liquefaction systems are installed in a separate enclosed space for the protection and the separation thereof. Gas in the enclosed space is periodically sampled, and analyzed to measure the concentration of the flammable gas contained therein in order to eliminate the possibility of an explosion. That is to say, in an enclosed space such as a cargo compressor room, a valve room and a pump room, gas is periodically sampled and the concentration of the flammable gas contained therein is measured.

[0005] XP-000729280, US 2006/254340, US 2004/063394 and US 2003/0010918 represent relevant prior art in the technical field of gas monitoring systems.

Disclosure of Invention

Technical Problem

[0006] Conventional gas detection system constituted with a flammable gas analyzer and sampling scheme and it sequentially samples and analyses the sampled gases

come from a number of sampling ports in the hazardous area and enclosed spaces of a gas carrier. For analyzing all the sampling head locations including response time, approximately 30 minutes to complete the whole sequences will be taken and this means that the gas release to start right after the previous sampling turn will be continued during maximum 30 minutes and will be detected on the next turn. (In the IGC Code, it is stipulated that the gas detection equipment should be capable of sampling and analyzing for each sampling head location sequentially at intervals not exceeding 30 minutes, except that in the case of gas detection for the ventilation hoods and gas ducts sampling should be continuous).

[0007] Also, maximum length of pipeline for gas sampling from an analyzer to sampling head locations in the hazardous area is more than 260m, and up to 140 seconds are required for the sampled gas to reach the analyzer. This means, if flammable gas leaks right after the first sampling sequence, there are lots of possibilities to occur explosion due to the gas cloud comes from the released gas during at least 140 seconds by the second sampling sequence. Fig 4 shows the typical arrangement for installation of gas sampling pipeline.

[0008] Further, in the case of cargo compressor room as an enclosed space, two gas sampling pipes are installed therein and are connected to a gas detection equipment via tubes. In this regard, since the gas detection equipment is installed in an accommodation zone which is separate from the cargo compressor room as a separately enclosed space, by the distance of about 50-100 m, about 30 to 60 seconds are required for sampled gas to reach the gas detection equipment through the gas sampling pipes.

[0009] This time that is necessary to detect the leakage of gas does not cause any problem in the case of a conventional gas carrier, where gas pressure compressed by cargo compressor is less than 2 barg because the leakage of gas would be discharged by mechanical ventilation. Nevertheless, in the case of LNG carriers, which are equipped with medium speed dual-fuel diesel engines, or a re-liquefaction system, or dual-fuel gas turbines, or slow speed dual-fuel diesel engines, etc., boil-off gas should be compressed up to 6 barg, 8 barg, 40 barg and 250 barg respectively. If flammable gas leaks in these systems during about 30 to 60 seconds are required to detect leaking gas with the conventional art, a considerable amount of flammable gas can be dispersed and accumulated in the enclosed spaces. Consequently, extremely dangerous situation can be occurred.

[0010] Moreover, in the conventional gas sampling method, it is difficult to properly analyze the entire enclosed space because only the gas around the sampling head locations is sampled. In addition, since it is difficult to be aware of whether the analysis result obtained by analyzing a sampled gas using the analyzer contains errors or not, correction must be frequently performed by an operator. While the correction work is performing, the detection of leaking gas in the hazardous area cannot be

conducted.

[0011] Accordingly, an object of the present invention is to provide a method of detecting leaking gas in a hazardous area of a gas carrier, in which direct sensing type detectors are installed in the enclosed spaces and the hazardous area of a gas carrier so that leaking gas can be detected in real time.

[0012] Another object of the present invention is to provide a method of detecting leaking gas in a hazardous area of a gas carrier, in which an LOS (line of sight) type infrared gas detector is installed as a direct sensing type detector, so that the leakage of gas can be immediately detected over a wide area.

[0013] Another object of the present invention is to provide a method of detecting leaking gas in a hazardous area of a gas carrier, in which at least two direct sensing type detectors are installed in the same area, so that malfunction of the detectors can be monitored.

[0014] Still another object of the present invention is to provide a method of detecting leaking gas in a hazardous area of a gas carrier, which can immediately detect and forcibly ventilate leaking gas in the enclosed space, such as a cargo compressor room, a valve room and a pump room, of an LNG carrier or onshore or offshore facilities having steam turbines, or medium speed dual-fuel diesel engines, or a re-liquefaction system, or dual-fuel gas turbines, or slow speed dual-fuel diesel engine, etc. installed therein and operating at a high operating pressure.

[0015] A still further object of the present invention is to provide a method of detecting leaking gas in a hazardous area of a gas carrier, in which at least one exhaust fan is operated at the time of the detection of leaking gas in a enclosed space to forcibly ventilate the enclosed space, so that the dispersion of flammable gas and the possibility of an explosion can be prevented.

Technical Solution

[0016] In order to achieve the above objects, according to the present invention, there is provided a device for detecting in real time leaked flammable gases in a hazardous area according to claim 1 and a method using such a device according to claim 10.

[0017] Therefore, in the present invention, by installing at least one direct sensing type gas detector in the hazardous area and the enclosed spaces of a gas carrier, leaking gas can be immediately detected and confirmed.

[0018] Also, in the present invention, by installing an LOS (line of sight) type infrared gas detector, the leakage of gas can be immediately detected and confirmed over a wide area.

[0019] Further, in the present invention, by operating at least one exhaust fan in association with a gas detection system, a hazardous area and an enclosed space can be immediately and forcibly ventilated.

[0020] Moreover, in the present invention, by immediately ventilating an enclosed space, such as a cargo com-

pressor room, a valve room or a motor room, the likelihood of an explosion due to the leakage of flammable gas can be decreased.

[0021] Furthermore, by applying the present invention to an LNG carrier equipped with medium speed dual-fuel diesel engines for electric propulsion, dual-fuel gas turbines for electric propulsion, a re-liquefaction system, or direct drive slow speed dual-fuel diesel engines, etc. and operating at a high operating pressure ranging from 6 barg to 250 barg, it is possible to prevent the amount of gas leaking due to the high operating pressure from reaching an explosion threshold.

[0022] In addition, in the present invention, in the case of a enclosed space such as a cargo compressor room, a valve room or a motor room, leaking gas can be immediately detected and confirmed by the direct sensing type gas detector, and by operating two exhaust fans in association with the gas detection system, the enclosed space can be immediately and forcibly ventilated, whereby the possibility of an explosion due to the leakage of flammable gas can be prevented.

Brief Description of the Drawings

[0023]

FIG. 1 is a flow chart illustrating a method of detecting leaking gas in a hazardous area of a gas carrier according to the present invention;

FIG. 2 is a view illustrating an application example of the present invention;

FIG. 3 is a view illustrating the installed state of an LOS (line of sight) type gas detector according to the present invention;

FIG. 4 is a view illustrating a configuration of gas sampling tubes for a conventional gas detection system;

FIG. 5 is a flow chart illustrating a procedure for detecting leaking gas in a enclosed space according to the present invention; and

FIG. 6 is a view illustrating the state in which a gas detector according to the present invention is installed in an enclosed space.

<Description of Reference Numerals for Main Parts in Drawings>

[0024]

20: forced exhaust fan 40: air outlet

50: air inlet

100: receiver 110: transmitter

120: infrared gas sensing line

130: LOS (line of sight) type gas detector

140: point type gas detector (thermally insulated secondary space)

150: point type gas detector (thermally insulated primary space)

210: passage 220: thermal insulation layer
 230: LNG tank
 300: safe zone (accommodation side)
 310: bulkhead
 320: hazardous area 330: motor room
 340: cargo compressor room
 350: enclosed space
 360: void in LNG tank (cofferdam)
 400: gas detection and control system

Mode for the Invention

[0025] FIG. 1 is a flow chart illustrating a method of detecting leaking gas in a hazardous area of a gas carrier according to the present invention, FIG. 2 is a view illustrating an application example of the present invention, and FIG. 3 is a view illustrating the installed state of an LOS (line of sight) type gas detector according to the present invention. In the present invention, in a gas carrier and onshore and offshore facilities for using boil-off gas, at least two direct sensing type gas detectors 130, 140 and 150 are installed in an enclosed space, such as a cargo compressor room, a valve room and a pump room, defined to protect and separate apparatuses for handling compressed boil-off gas (BOG) of liquefied natural gas and liquefied petroleum gas generated due to heat transfer from the outside to thereby use the compressed boil-off gas as fuel for a propulsion engine or a power generation apparatus or for re-liquefying the boil-off gas, and in a hazardous area including these provisions, so that the leakage of gas into the hazardous area can be immediately detected.

[0026] The method of detecting leaking gas in a hazardous area of a gas carrier according to the present invention includes the steps of sensing amounts of leaking gas using direct sensing type gas detectors (S100), comparing the amounts of leaking gas detected by the gas detectors with an alarm issuance limit, and issuing an alarm and operating a forced exhaust fan when the amount of leaking gas detected by at least one gas detector exceeds the alarm issuance limit (S200), and actuating an emergency stop system when the amounts of leaking gas detected by at least two detectors exceed an emergency stop limit (S300).

[0027] The method further includes the step of re-sensing amounts of leaking gas in a hazardous area in which forced ventilation is implemented using the forced exhaust fan, using the gas detectors (S400), and sequentially stopping issuance of the alarm and operation of the forced exhaust fan when the re-detected amounts of leaking gas do not exceed a reference value (S500).

[0028] In the sensing step S100, the amounts of leaking gas are detected by the gas detectors 130, 140 and 150 which are installed in the hazardous area and an enclosed space 350, such as a cargo compressor room 330, a valve room, a pump room and a motor room 340. At this time, at least two electric gas detectors 140 and 150 (having an Ex-D class based on IEC, International

Electro-technical Commission) or LOS (line of sight) type detectors 130, which are direct sensing type detectors approved by the IGC Code (International code for the construction and equipment of ships carrying liquefied gases in bulk) and are explosion-proof, are installed.

[0029] Referring to FIG. 3, the LOS (line of sight) type detector 130 comprises a transmission section 110 capable of transmitting an infrared signal and a reception section 100 capable of receiving the infrared signal transmitted from the transmission section 110. If flammable gas reaches an infrared gas sensing line 120 between the transmission section 110 and the reception section 100, a change in the infrared sensitivity of the reception section 100 is detected, and thereby, the leakage of gas is detected.

[0030] In the warning alarm issuing step S200, the amounts of leaking gas detected by the gas detectors 130, 140 and 150 are compared with a preset reference value, that is, the alarm issuance limit, set to correspond to about 30% of the lower explosion limit of flammable gas, so as to eliminate the likelihood of an explosion. When the amount of leaking gas detected by at least one of the gas detectors 130, 140 and 150 exceeds the reference value, a warning alarm is issued.

[0031] Since the alarm issuance limit corresponds to about 30% of the lower explosion limit of the flammable gas, when converting the alarm issuance limit into a concentration of the flammable gas in the atmosphere, the alarm issuance limit corresponds to 1.5 vol% of methane, which is a concentration at which an explosion does not actually occur. However, when methane, which is the main constituent of the cargo of an LNG carrier, is contained in the atmosphere in an amount of about 5-15 vol%, an explosion may occur. Therefore, considering that the present invention applies to an LNG carrier operating at a high pressure of 6 barg to 250 barg, if the leakage of gas occurs, the flammable gas can immediately exceed the lower explosion limit and reach a concentration at which an explosion can easily occur. Thus, in order to prevent this situation from occurring, it is preferred that the reference value for the issuance of a warning alarm be set to correspond to about 30% of the lower explosion limit of the leaking gas.

[0032] In the emergency stopping step S300, the emergency stop limit, corresponding to about 60% of the lower explosion limit of the leaking gas, is compared with the amounts of leaking gas. When the amounts of leaking gas exceed the emergency stop limit, the travel of the ship is stopped. That is to say, when the leaking gas is detected by amounts exceeding about 60% of the lower explosion limit of the flammable gas, the emergency stop system is actuated to stop the travel of the ship so as to prevent the amounts of leaking gas from reaching an explosion threshold.

[0033] In this way, in the present invention, when the detected amount of leaking gas exceeds the alarm issuance limit, a warning alarm is issued to warn of the corresponding situation, and at the same time, a ventilation

system, such as the forced exhaust fan, etc. is operated. Also, when the detected amounts of the leaking gas exceed the emergency stop limit, the emergency stop system is actuated so that the travel of the ship is stopped.

[0034] Since the ventilation system such as the forced exhaust fan, etc. is a conventional provision which is installed in the hazardous area and the enclosed space of a gas carrier, the detailed description thereof will be omitted herein.

[0035] In the case of operating the ventilation system as described above, as ventilation of the hazardous area and the enclosed space occurs, the amounts of leaking gas in the hazardous area and the enclosed space abruptly decrease to less than 30% of the lower explosion limit of the flammable gas.

[0036] Further, when the forced exhaust fan is used as the ventilation system, the forced exhaust fan has capacity sufficient to ventilate a volume corresponding to 30 times the volume of the enclosed space per hour, and is configured such that exhausted gas is not re-introduced into the enclosed space. The capacity of the forced exhaust fan is determined in conformity with the fan capacity prescribed in the IGC Code.

[0037] As described above, in the present invention, in order to detect the leakage of gas in the hazardous area or the enclosed space, at least two electric gas detectors 140 and 150 (having an Ex-D design based on IEC) and at least two LOS (line of sight) type detectors 130, which are direct sensing type detectors and are explosion-proof, are installed together or independently in the same area. Hence, if one gas detector detects the leakage of gas, a warning alarm is issued depending upon the detected amount of the leaking gas, and only when at least two gas detectors simultaneously detect leaking gas exceeding the emergency stop limit, corresponding to 60% of the lower explosion threshold of the flammable gas, is the emergency stop system actuated.

[0038] In the gas re-sensing step S400, amounts of leaking gas are re-detected in the hazardous area and the enclosed space in which a warning alarm is issued and the emergency stop system is actuated. In this step, the amounts of leaking gas in the hazardous area 320 and the enclosed space 350 in which the ventilation is being conducted through the operation of the ventilation system are rapidly re-detected using at least two direct sensing type gas detectors 130, 140 and 150.

[0039] In the fan stopping step S500, the re-detected amounts of leaking gas are compared with the reference value. When the re-detected amounts are less than the reference value, the actuation of the emergency stop system or the issuance of the warning alarm is stopped.

[0040] The amounts of the leaking gas detected by the gas detectors are transmitted to a control system 400 as electrical signals. Also, these transmitted amounts of the leaking gas are converted through the internal operation of the control system 400 into commands for enabling the issuance of the alarm or the actuation of the emergency stop system.

[0041] As described above, in the hazardous area and the enclosed space, the leaking gas can be detected through the sensing step, the warning alarm issuing step, the emergency stopping step, the gas re-sensing step and the fan stopping step, and by operating the ventilation system, the probability of an explosion can be eliminated.

[0042] In the case of the enclosed space 350, such as the cargo compressor room 330, the valve room, the pump room and the motor room 340, since the amounts of leaking gas can abruptly increase, by which the probability of an explosion increases due to the characteristic of the enclosed space 350, it is preferred that the forced exhaust fan be installed as the ventilation system so that, when gas leakage is detected by the gas detectors, quick ventilation of the leaking gas by the forced fan is implemented, unlike the hazardous area.

[0043] In other words, at least two direct sensing type detectors are installed in the enclosed space of a gas carrier or similar onshore or offshore facilities equipped with a dual-fuel diesel engine, a gas turbine engine, reliquefaction apparatus, etc., and at least two forced exhaust fans operating in cooperation with the detectors are also installed to implement ventilation.

[0044] The method of detecting the leakage of gas and implementing ventilation in the enclosed space as described above will be described in further detail with reference to the attached drawings.

[0045] FIG. 5 is a flow chart illustrating a method for independently detecting leaking gas in an enclosed space according to the present invention, and FIG. 6 is a view illustrating the state in which a gas detector according to the present invention is installed in an enclosed space. At least two electric gas detectors 140 or 150 (having an Ex-D design based on IEC), which are explosion-proof, are installed in an enclosed space. Also, two forced exhaust fans 20 operating in cooperation with the direct sensing type gas detectors 140 or 150 are installed at one side of the enclosed space 350 to communicate with air outlets 40. By this configuration, leaking gas is detected through a direct sensing method, and through this, the two forced exhaust fans 20 are operated to immediately implement ventilation of the enclosed space 350.

[0046] In the present invention, the method comprises the steps of sensing flammable gas leaking into an enclosed space using gas detectors (S100a), comparing the amounts of flammable gas detected by the gas detectors with a preset reference value (S200a), issuing a warning alarm and simultaneously operating the two forced exhaust fans installed in the enclosed space to forcibly implement ventilation when the detected amount of leaking gas exceeds the reference value (S300a), re-sensing gas in the enclosed space using the gas detectors while forced ventilation is implemented by the two forced exhaust fans (S400a), and stopping the issuance of the alarm and the operation of the forced exhaust fans when the re-detected amounts of leaking gas do not exceed a reference value (S500a), so that the leaking gas in the enclosed space can be immediately detected and

the enclosed space can be forcibly ventilated.

[0047] In the sensing step S100a, the amounts of leaking gas are detected using the direct sensing type gas detectors installed in the enclosed space, such as a cargo compressor room, a valve room and a pump room. At this time, at least two gas detectors having an Ex-D design based on IEC, which are direct sensing type detectors approved by the IGC Code (International code for the construction and equipment of ships carrying liquefied gases in bulk), are installed.

[0048] In the comparing step S200a, the amounts of leaking gas detected by the gas detectors are compared with the preset reference value. The reference value is preset as an alarm issuance limit in a hazardous area, that is, a limit corresponding to about 30% of the lower explosion limit of flammable gas.

[0049] In the forced insulation step S300a, when the amount of leaking gas detected by the gas detectors is the same as or exceeds the preset reference value, apparatuses having increased probability of explosion are urgently stopped. Namely, when the detected amount of leaking gas exceeds the alarm issuance limit, an alarm is issued to warn of the emergency, and at the same time, the two forced exhaust fans installed in the enclosed space are operated. If the two forced exhaust fans are operated, since the enclosed space can be immediately ventilated, the amount of leaking gas in the enclosed space abruptly decreases below the alarm issuance limit. Between the two forced exhaust fans, one forced exhaust fan is always operated, and when the detected amount of the leaking gas exceeds the preset reference value, the remaining forced exhaust fan is forcibly operated to immediately ventilate the enclosed space.

[0050] The forced exhaust fan has a capacity to ventilate a volume corresponding to 30 times the volume of the enclosed space per hour, and is configured such that exhausted gas is not re-introduced into the enclosed space. The capacity of the forced exhaust fan is determined in conformity with the fan capacity prescribed in the IGC Code.

[0051] Also, in the enclosed space 350, in addition to the two forced exhaust fans 20, a separate exhaust fan may be installed as an auxiliary fan.

[0052] In the gas re-sensing step S400a, the amounts of leaking gas in the enclosed space 350 are re-detected while forced ventilation is implemented. That is to say, the amounts of leaking gas are immediately re-detected by the direct sensing type gas detectors in the enclosed space for which the ventilation is being implemented by the simultaneous operation of the two forced exhaust fans.

[0053] In the fan stopping step S500a, the re-detected amounts of leaking gas are compared with a reference value. When the re-detected amounts of leaking gas are less than the reference value, the operation of the forced exhaust fans is stopped.

[0054] In the case of the enclosed space as described above, it is preferred that the direct sensing type gas

detectors and the two forced exhaust fans be operated in cooperation with each other to sense the leaking gas before the amounts of leaking gas in the enclosed space reach the emergency stop limit and to forcibly ventilate the leaking gas to thereby eliminate the possibility of an explosion.

[0055] Although a preferred embodiment of the present invention has been described for illustrative purposes, those skilled in the art will appreciate that various modifications, additions and substitutions are possible, without departing from the scope and spirit of the invention as disclosed in the accompanying claims.

Claims

1. A device for detecting in real time leaked flammable gases in an hazardous area (320) including a separate enclosed space (350) of a gas storage system having a safe zone (300) separated by a bulkhead (310) from the hazardous area (320), said gas storage system using boil-off gas generated by atmospheric heat sources and having an auxiliary equipment installed in the separate enclosed space so that boil-off gas is compressed to be used as fuel or to be re-liquefied to be stored as cargo, said device comprises:

- at least two direct sensing type gas detectors (130, 140, 150) installed in the hazardous area (320) of the gas storage system, and configured to measure concentration of flammable gas released, and
- a gas detection and control system (400) installed in the safe zone (300) of the gas storage system, and configured to compare the concentration of flammable gas detected by the gas detectors (130, 140, 150) with an alarm issuance limit, to issue an alarm and to operate an exhaust fan (20, 40) if the concentration of flammable gas detected by at least one gas detector exceeds the alarm issuance limit; and to actuate an emergency shutdown system when the concentrations of flammable gas detected by at least two detectors exceed a limit for emergency shutdown.

2. The device according to claim 1, wherein the gas detectors (130, 140, 150) comprise electric gas detectors or LOS type infrared gas detectors, which are a direct sensing type and are explosion-proof (Ex-D class).

3. The device according to claim 2, wherein each of the LOS type gas detectors comprises a transmission section (110) capable of transmitting infrared signals and a reception section (100) capable of receiving the infrared signals transmitted from the transmis-

sion section (110), such that, when flammable gas reaches an area (120) between the transmission section (110) and the reception section (100), a change in infrared sensitivity of the reception section is sensed, and thereby, leakage of gas is detected.

4. The device according to anyone of claims 1-3, wherein the gas storage system is a carrier, an on-shore or an offshore facility.

5. The device according to any one of claims 1-4, wherein the auxiliary equipment is a cargo compressor or a re-liquefaction system.

6. The device according to any one of claims 1-5, wherein the enclosed space is a cargo compressor room, a valve room, a motor room or a pump room.

7. The device according to claim 4, wherein the carrier is a LNG carrier equipped with medium speed dual-fuel diesel engines, or a re-liquefaction system, or dual-fuel gas turbines, or slow speed dual-fuel diesel engines, with the boil-off gas compressed up to 6 barg, 8 barg, 40 barg and 250 barg respectively.

8. The device according to any one of claims 7, further comprising at least one exhaust fan (20) installed in the enclosed space to forcibly ventilate the enclosed space, for preventing the dispersion of flammable gas and the possibility of an explosion.

9. The device according to claim 7, wherein at least two direct sensing type gas detectors are installed in the enclosed space and at least two forced exhaust fans (20) operating in cooperation with the gas detectors installed to implement ventilation.

10. A method of detecting leaking gas in a hazardous area of a gas carrier using the device according to anyone of claims 1-9, wherein the method comprising the steps of:

- measuring (S100) the concentration of flammable gas released using direct sensing type gas detectors;
- comparing (S200) the concentration of flammable gas detected by the gas detectors with an alarm issuance limit, and issuing an alarm and operating an exhaust fan if the concentration of flammable gas detected by at least one gas detector exceeds the alarm issuance limit; and
- actuating (S300) an emergency shutdown system when the concentrations of flammable gas detected by at least two detectors exceed a limit for emergency shutdown.

11. The method according to claim 10, further compris-

ing the steps of: remeasuring (S400) the concentration of the flammable gas in a hazardous area where forced ventilation is implemented by the exhaust fan, using the gas detectors; and sequentially stopping (S500) issuance of the alarm and operation of the exhaust fans if the re-measured concentrations of the flammable gas do not exceed a limit to be issued.

12. The method according to claim 10, comprising the steps of: sensing (S100a) flammable gas released into an enclosed space using gas detectors; comparing (S200a) concentrations of flammable gas detected by the gas detectors with a preset reference value; issuing (S300a) a warning alarm and simultaneously operating two exhaust fans installed in an enclosed space to forcibly implement ventilation when the measured concentration of flammable gas released exceeds the preset reference value; remeasuring (S400a) gas in the enclosed space using the gas detectors while forced ventilation is implemented using the two forced exhaust fans; and stopping (S500a) issuance of the alarm and operation of the two exhaust fans when the re-measured concentrations of flammable gas do not exceed a reference value.

13. The method according to any one of claims 10-12, wherein the alarm issuance limit is set to correspond to about 30% of the lower explosion limit of leaking gas.

14. The method according to any one of claims 10-13, wherein the emergency stop limit corresponds to about 60% of the lower explosion limit of the leaking gas.

15. The method according to any one of claims 10-14, wherein the alarm issuance limit corresponds to 1.5 vol% of methane.

Patentansprüche

1. Eine Vorrichtung zur Ermittlung, in Echtzeit, von Leckage von entflammbarem Gas in einem Risikobereich (320), der eine separaten eingeschlossenen Raum (350) eines Gasspeicherungssystems umfasst, das eine Sicherheitszone (300) aufweist, die durch ein Schott (310) vom Risikobereich (320) getrennt ist, wobei das Gasspeicherungssystem ein, durch atmosphärische Wärmequellen erzeugtes Abdampfgas verwendet, und wobei eine Hilfseinrichtung im separaten eingeschlossenen Raum angebracht ist, so dass das Abdampfgas verdichtet wird um als Brennstoff verwendet zu werden, oder um, als Fracht gelagert, wiederverflüssigt zu werden, wobei die Vorrichtung Folgendes umfasst:

- mindestens zwei Gasdetektoren vom Direkterfassungstyp (130, 140, 150), die im Risikobereich (320) des Gasspeicherungssystems angebracht und zur Messung der Konzentration von freigesetztem entflammbarem Gas ausgebildet sind; und
- ein Gasdetektions- und Regelungssystem (400), das in der Sicherheitszone (300) des Gasspeicherungssystems angebracht und ausgebildet ist, um die von den Gasdetektoren (130, 140, 150) ermittelte Konzentration von entflammbarem Gas mit einer Alarmabgabengrenze zu vergleichen, um einen Alarm abzugeben und einen Abluftventilator (20, 40) zu betätigen wenn die, vom mindestens einen Gasdetektor ermittelte Konzentration von entflammbarem Gas die Alarmabgabengrenze überschreitet; und ein Notabschaltungssystem zu betätigen wenn die, durch mindestens zwei Gasdetektoren ermittelten Konzentrationen von entflammbarem Gas eine Notabschaltungsgrenze überschreiten.
2. Die Vorrichtung nach Anspruch 1, wobei die Gasdetektoren (130, 140, 150) elektrische Gasdetektoren oder Infrarot-Gasdetektoren vom LOS-Typ umfassen, die vom Direkterfassungstyp und explosionsssicher (Ex-D-Klasse) sind.
3. Die Vorrichtung nach Anspruch 2, wobei jeder der Gasdetektoren vom LOS-Typ einen Übertragungsabschnitt (110) umfasst, der in der Lage ist Infrarotsignale zu übertragen, und einen Empfangsabschnitt (100) der in der Lage ist, die vom Übertragungsabschnitt (110) übertragenen Infrarotsignale zu empfangen, so dass, wenn entflammbares Gas einen, zwischen dem Übertragungsabschnitt (110) und dem Empfangsabschnitt (100) liegenden Bereich (120) erreicht, eine Veränderung der Infrarotempfindlichkeit des Empfangsabschnitts erfasst und somit Gasleckage ermittelt wird.
4. Die Vorrichtung nach einem der Ansprüche 1 bis 3, wobei das Gasspeicherungssystem ein Träger, eine Onshore- oder eine Offshore-Anlage ist.
5. Die Vorrichtung nach einem der Ansprüche 1 bis 4, wobei die Hilfseinrichtung ein Frachtverdichter oder ein Wiederverflüssigungssystem ist.
6. Die Vorrichtung nach einem der Ansprüche 1 bis 5, wobei der eingeschlossene Raum eine Frachtverdichtungskammer, eine Ventilkammer, eine Motorenkammer oder eine Pumpenkammer ist.
7. Die Vorrichtung nach Anspruch 4, wobei der Träger ein LNG-Träger ist, der mit mittelschnell laufenden Zweistoff-Dieselmotoren, oder einem Wiederverflüssigungssystem, oder Zweistoff-Gasturbinen, oder langsam laufenden Zweistoff-Dieselmotoren ausgerüstet ist, wobei das Abdampfgas jeweils bis zu 6 bar Überdruck, 8 bar Überdruck, 40 bar Überdruck und 250 bar Überdruck verdichtet ist.
8. Die Vorrichtung nach Anspruch 7, die ferner mindestens einen, im eingeschlossenen Raum angebrachten Abluftventilator (20) umfasst, der zwangsläufig den eingeschlossenen Raum belüftet um die Dispersion von entflammbarem Gas und eine mögliche Explosion zu verhindern.
9. Die Vorrichtung nach Anspruch 7, wobei mindestens zwei Gasdetektoren vom Direkterfassungstyp im eingeschlossenen Raum angebracht sind, und mindestens zwei Zwangs-Abluftventilatoren (20) mit den angebrachten Gasdetektoren zusammenwirken um eine Belüftung durchzuführen.
10. Ein Verfahren zur Ermittlung einer Gasleckage in einem Risikobereich eines Gasträgers, unter Benutzung der Vorrichtung nach einem der Ansprüche 1 bis 9, wobei das Verfahren folgende Schritte umfasst:
- das Messen (S100) der Konzentration von freigesetztem entflammbarem Gas mithilfe von Gasdetektoren vom Direkterfassungstyp;
 - das Vergleichen (S200) der, durch die Gasdetektoren mit einer Alarmabgabengrenze ermittelte Konzentration von entflammbarem Gas, und das Abgeben eines Alarms und das Betätigen eines Abluftventilators wenn die, durch mindestens einen Gasdetektor ermittelte Konzentration von entflammbarem Gas die Alarmabgabengrenze überschreitet; und
 - das Betätigen (S300) eines Notabschaltungssystems wenn die, durch mindestens zwei Gasdetektoren ermittelten Konzentrationen von entflammbarem Gas eine Notabschaltungsgrenze überschreiten.
11. Das Verfahren nach Anspruch 10, das ferner folgende Schritte umfasst:
- das erneute Messen (S400) der Konzentration von entflammbarem Gas in einem Risikobereich, in welchem, mittels der Gasdetektors, eine Zwangsbelüftung durch den Abluftventilator durchgeführt wird; und
 - das sequenzielle Anhalten (S500) der Alarmabgabe und der Betätigung der Abluftventilatoren wenn die neu gemessenen Konzentrationen von entflammbarem Gas eine festzulegende Grenze nicht überschreiten.
12. Das Verfahren nach Anspruch 10, das folgende

Schritte umfasst:

- das Erfassen (S100a), mittels Gasdetektoren, von, in einen eingeschlossenen Raum freigesetztem entflammbar Gas; 5
 - das Vergleichen (S200a) der, durch die Gasdetektoren ermittelten Konzentrationen von entflammbar Gas mit einem vorgegebenen Referenzwert; 10
 - das Abgeben (S300a) eines Warnalarms und das gleichzeitige Betätigen zweier Abluftventilatoren, die in einem eingeschlossenen Raum angebracht sind, um zwangsläufig eine Belüftung durchzuführen wenn die gemessene Konzentration von freigesetztem entflammbar Gas den vorgegebenen Referenzwert überschreitet; 15
 - das erneute Messen (S400a), mittels der Gasdetektoren von Gas im eingeschlossenen Raum während, mittels der beiden Zwangs-Abluftventilatoren eine Zwangsbelüftung durchgeführt wird; und 20
 - das Einstellen (S500a) der Alarmabgabe und der Betätigung der beiden Abluftventilatoren wenn die neu gemessenen Konzentrationen von entflammbar Gas einen vorgegebenen Referenzwert nicht überschreiten. 25
13. Das Verfahren nach einem der Ansprüche 10 bis 12, wobei die Grenze der Alarmabgabe so festgelegt ist, dass sie ungefähr 30% der unteren Explosionsgrenze der Gasleckage entspricht. 30
14. Das Verfahren nach einem der Ansprüche 10 bis 13, wobei die Notabschaltungsgrenze ungefähr 60% der unteren Explosionsgrenze der Gasleckage entspricht. 35
15. Das Verfahren nach einem der Ansprüche 10 bis 14, wobei die die Alarmabgabengrenze 1,5 Vol.-% Methan entspricht. 40

Revendications

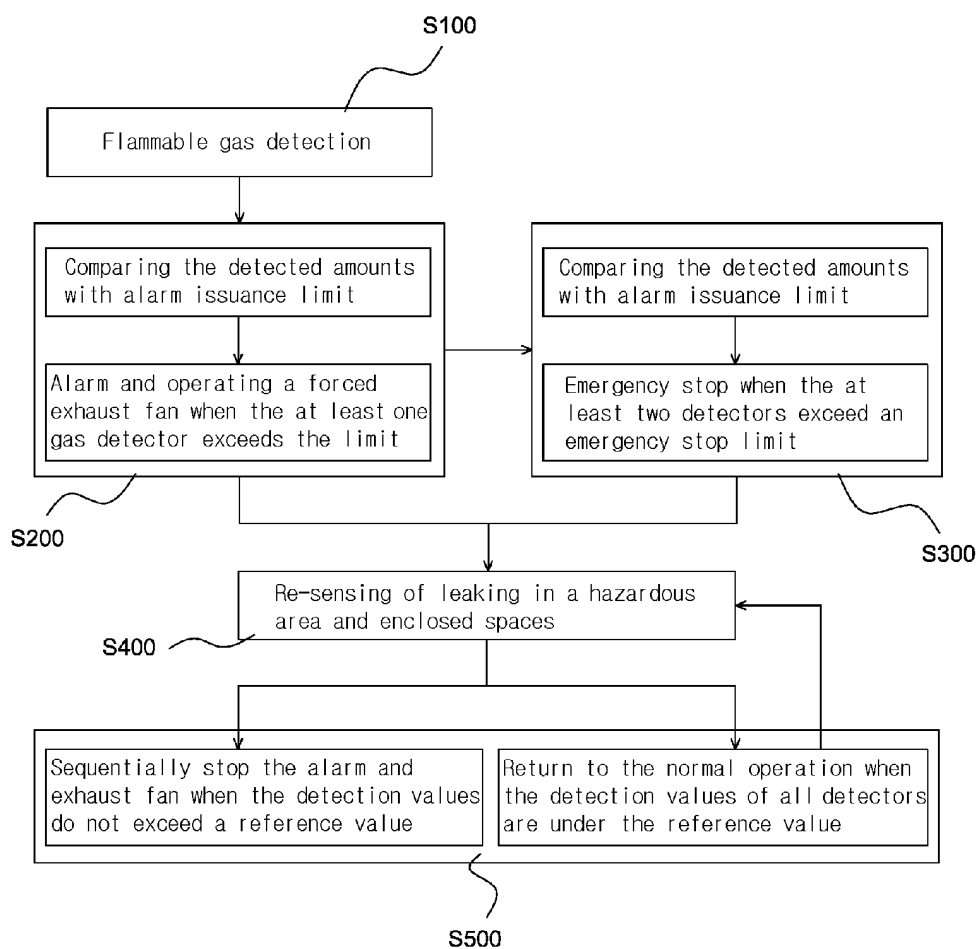
1. Dispositif pour détecter en temps réel des gaz inflammables qui fuient dans une zone dangereuse (320) comprenant un espace fermé séparé dans (350) d'un système de stockage de gaz ayant une zone de sécurité (300) séparée par une cloison (310) de la zone dangereuse (320), ledit système de stockage de gaz utilisant un gaz d'évaporation généré par des sources de chaleur atmosphériques et ayant un équipement auxiliaire installé dans l'espace fermé séparé de sorte que le gaz d'évaporation soit comprimé pour être utilisé comme combustible ou pour être reliquéfié de nouveau pour être stocké comme cargaison, 50

ledit dispositif comprenant :

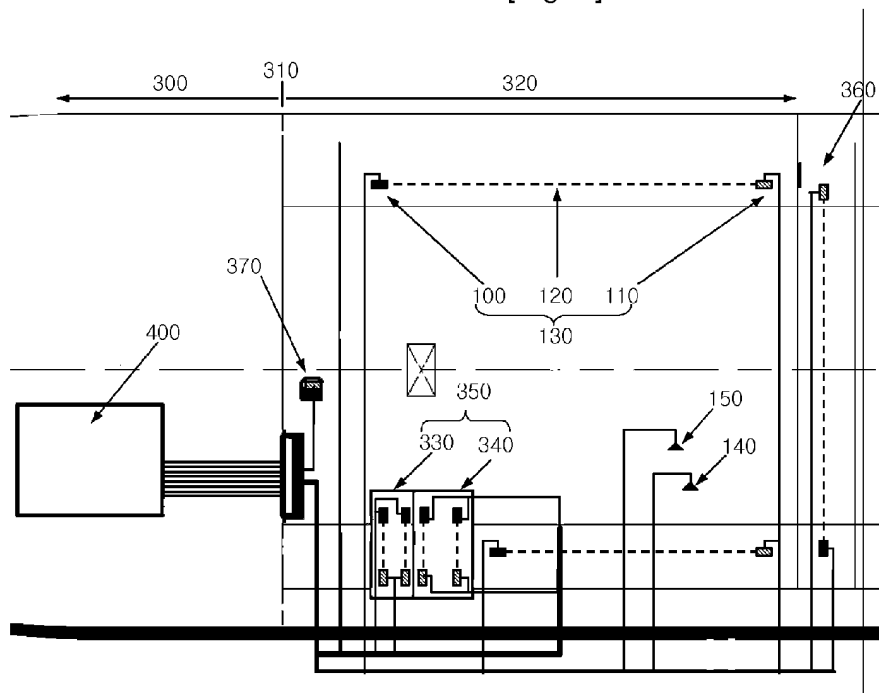
- au moins deux détecteurs de gaz à détection directe (130, 140, 150) installés dans la zone dangereuse (320) du système de stockage de gaz, et configurés pour mesurer la concentration de gaz inflammable libéré, et
 - un système de détection et de commande de gaz (400) installé dans la zone de sécurité (300) du système de stockage de gaz, et configuré pour comparer la concentration de gaz inflammable détectée par les détecteurs de gaz (130, 140, 150) avec une limite d'émission d'alarme, pour émettre une alarme et pour faire fonctionner un ventilateur d'évacuation (20, 40) si la concentration de gaz inflammable détectée par au moins un détecteur de gaz dépasse la limite d'émission d'alarme; et pour actionner un système d'arrêt d'urgence lorsque les concentrations de gaz inflammable détectées par au moins deux détecteurs dépassent une limite d'arrêt d'urgence.
2. Dispositif selon la revendication 1, dans lequel les détecteurs de gaz (130, 140, 150) comprennent des détecteurs de gaz électriques ou des détecteurs de gaz infrarouges de type LOS (ligne de mire), à détection directe et antidéflagrants (classe Ex-D).
3. Dispositif selon la revendication 2, dans lequel chacun des détecteurs de gaz de type LOS comprend une section de transmission (110) capable de transmettre des signaux infrarouges et une section de réception (100) capable de recevoir les signaux infrarouges transmis depuis la section de transmission (110) de sorte que, lorsque le gaz inflammable atteint une zone (120) entre la section de transmission (110) et la section de réception (100), un changement de sensibilité infrarouge de la section de réception est détecté, et ainsi une fuite de gaz est détectée.
4. Dispositif selon l'une quelconque des revendications 1 à 3, dans lequel le système de stockage de gaz est un transporteur, une installation terrestre ou en mer. 45
5. Dispositif selon l'une quelconque des revendications 1 à 4, dans lequel l'équipement auxiliaire est un compresseur de cargaison ou un système de re-liquéfaction.
6. Dispositif selon l'une quelconque des revendications 1 à 5, dans lequel l'espace fermé est une salle de compresseur de chargement, une salle des vannes, une salle des machines ou une salle des pompes. 55
7. Dispositif selon la revendication 4, dans lequel le

- transporteur est un méthanier équipé de moteurs diesel bicarburant à vitesse moyenne, ou d'un système de re-liquéfaction, ou de turbines à gaz bicarburant, ou de moteurs diesel bicarburant à vitesse lente, dans lequel le gaz d'évaporation est comprimé jusqu'à 6 Bar gauge, 8 Bar gauge, 40 Bar gauge et 250 Bar gauge respectivement.
8. Dispositif selon la revendication 7, comprenant en outre au moins un ventilateur d'évacuation (20) installé dans l'espace fermé pour ventiler à force l'espace fermé, pour empêcher la dispersion de gaz inflammable et la possibilité d'une explosion.
 9. Dispositif selon la revendication 7, dans lequel au moins deux détecteurs de gaz du type à détection directe sont installés dans l'espace fermé et au moins deux ventilateurs d'extraction forcée (20) fonctionnant en coopération avec les détecteurs de gaz installés pour réaliser la ventilation.
 10. Procédé de détection de fuites de gaz dans une zone dangereuse d'un transporteur de gaz en utilisant le dispositif selon l'une quelconque des revendications 1 à 9, dans lequel le procédé comprend les étapes consistant à :
 - mesurer (S100) la concentration de gaz inflammable libéré en utilisant des détecteurs de gaz à détection directe ;
 - comparer (S200) la concentration de gaz inflammable détectée par les détecteurs de gaz avec une limite d'émission d'alarme et émettre une alarme et actionner un ventilateur d'évacuation si la concentration de gaz inflammable détectée par au moins un détecteur de gaz dépasse la limite d'émission d'alarme; et
 - actionner (S300) un système d'arrêt d'urgence lorsque les concentrations de gaz inflammables détectées par au moins deux détecteurs dépassent une limite d'arrêt d'urgence.
 11. Procédé selon la revendication 10, comprenant en outre les étapes consistant à: mesurer de nouveau (S400) la concentration du gaz inflammable dans une zone dangereuse où une ventilation forcée est mise en oeuvre par le ventilateur d'évacuation, en utilisant les détecteurs de gaz ; et arrêter séquentiellement (S500) l'émission de l'alarme et le fonctionnement des ventilateurs d'extraction dans le cas où les concentrations mesurées de nouveau du gaz inflammable ne dépassent pas une limite à émettre.
 12. Procédé selon la revendication 10, comprenant les étapes consistant à: détecter (S100a) un gaz inflammable libéré dans un espace fermé en utilisant des détecteurs de gaz; comparer (S200a) les concentra-
- tions de gaz inflammable détectées par les détecteurs de gaz avec une valeur de référence prédéfinie; émettre (S300A) une alarme d'avertissement et actionner simultanément deux ventilateurs d'évacuation installés dans un espace fermé pour mettre en oeuvre de façon forcée la ventilation lorsque la concentration mesurée de gaz inflammable libéré dépasse la valeur de référence prédéfinie ; mesurer de nouveau (S400a) le gaz dans l'espace fermé en utilisant les détecteurs de gaz tandis que la ventilation forcée est mise en oeuvre en utilisant les deux ventilateurs d'évacuation forcée ; et arrêter (S500a) l'émission de l'alarme et le fonctionnement des deux ventilateurs d'extraction lorsque les concentrations mesurées de nouveau de gaz inflammable ne dépassent pas une valeur de référence.
13. Procédé selon l'une quelconque des revendications 10 à 12, dans lequel la limite d'émission d'alarme est fixée pour correspondre à environ 30% de la limite inférieure d'explosion de gaz qui fuit.
 14. Procédé selon l'une quelconque des revendications 10 à 13, dans lequel la limite d'arrêt d'urgence correspond à environ 60% de la limite d'explosion inférieure du gaz qui fuit.
 15. Procédé selon l'une quelconque des revendications 10 à 14, dans lequel la limite d'émission d'alarme correspond à 1,5% en volume de méthane.

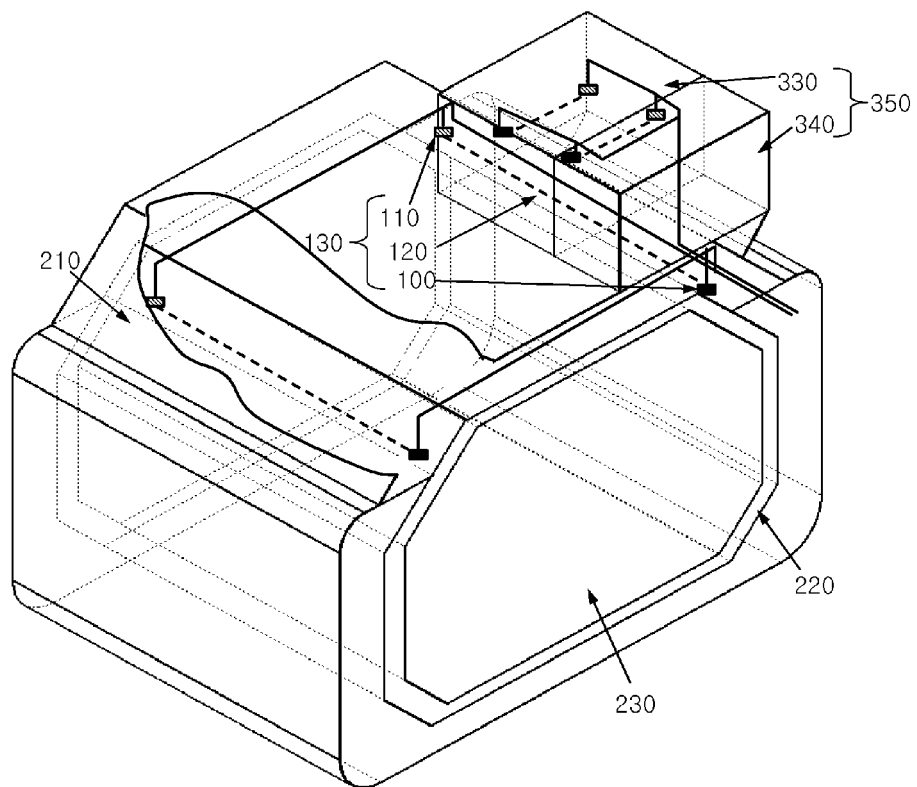
[Fig. 1]

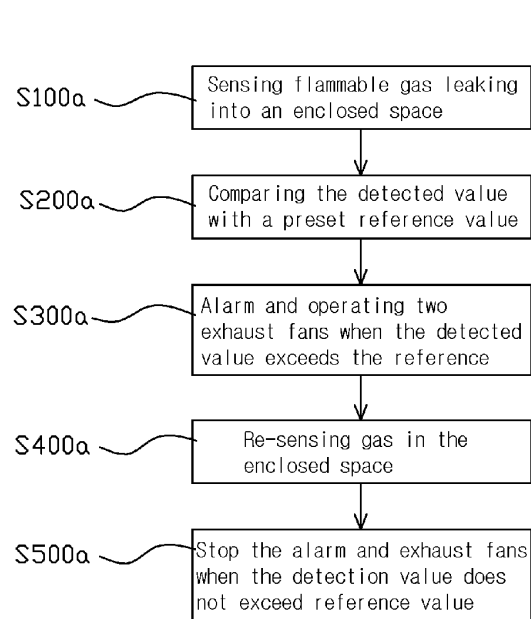
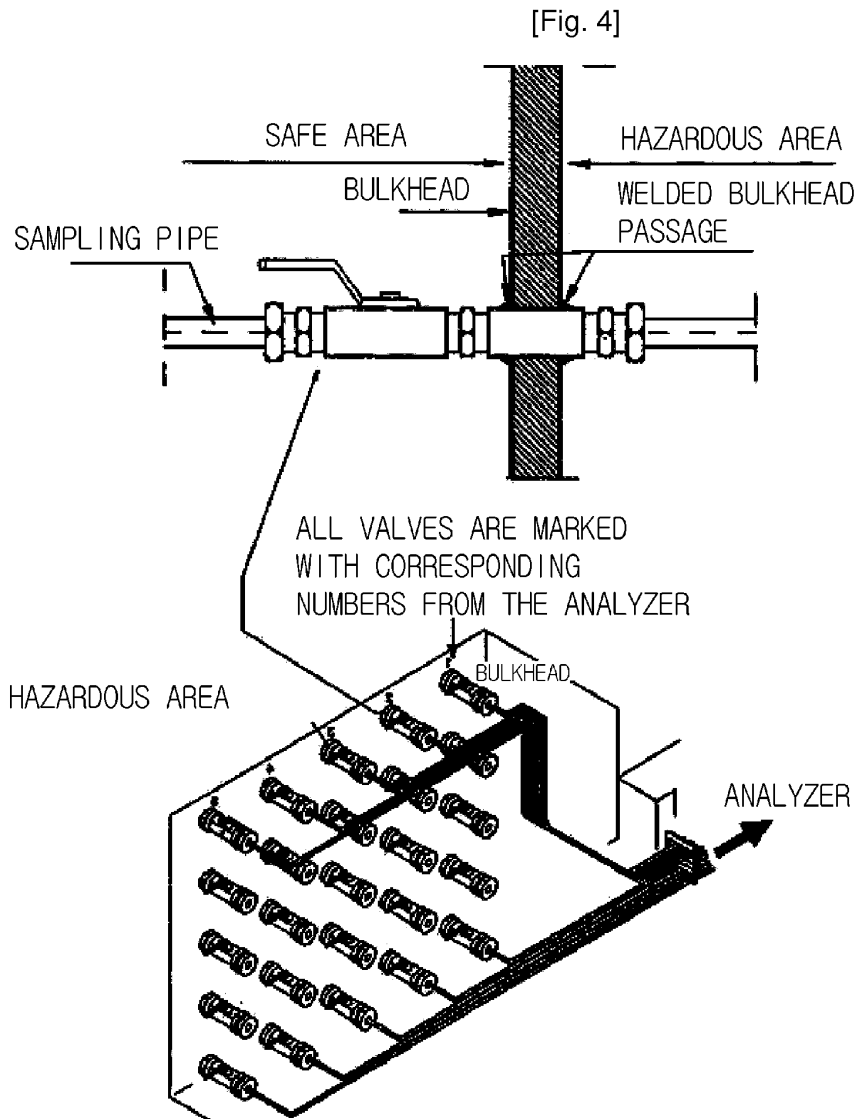


[Fig. 2]

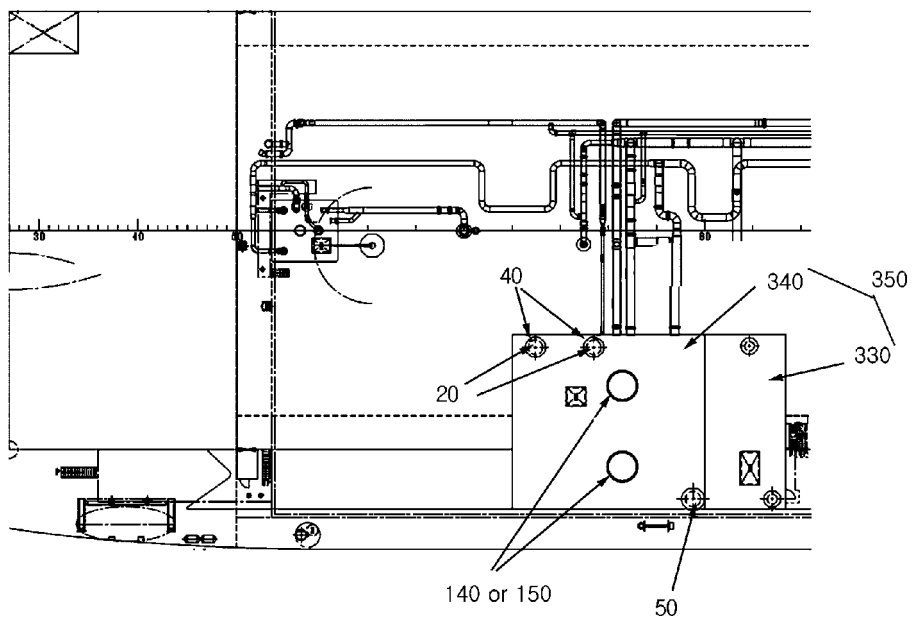


[Fig. 3]





[Fig. 6]



REFERENCES CITED IN THE DESCRIPTION

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