

TITLE: PROBE WITH NO MOVING PARTS FOR A TANK**CROSS REFERENCE TO RELATED APPLICATIONS**

- [0001] The present application claims priority to and the benefit of co-pending US Patent Application Serial No.: 15/041,821 filed on February 11, 2016, entitled “PROBE WITH NO MOVING PARTS FOR USE IN A TANK”, issued as US Patent No. 9,476,743 on October 25, 2016 and co-pending US Patent Application Serial No.: 15/041,847 filed on February 11, 2016, entitled “MARINE PROBE WITH NO MOVING PARTS FOR A MARINE TANK”, issued as US Patent No. 9,347,848 on May 24, 2016. These references are hereby incorporated in their entirety.

FIELD

- [0002] The present embodiments generally relate to a probe for measuring fluids in one or more stationary tanks or tanks on a marine floating vessel.

BACKGROUND

- [0001] A need exists for a highly sensitive monitoring probe that is easy to manufacture, easy to install and incorporates the use of synchronized sensing devices for increase accuracy in measurements and can accommodate pitch, heave and yaw motions.
- [0002] The present embodiments meet these needs.

BRIEF DESCRIPTION OF THE DRAWINGS

- [0003] The detailed description will be better understood in conjunction with the accompanying drawings as follows:

- [0004] Figure 1 shows a probe for use in a tank according to one or more embodiments.
- [0005] Figure 2 shows a detail of the sensor housing in partial cross section according to one or more embodiments.
- [0006] Figure 3 is a detailed view of a channel of the sensor housing according to one or more embodiments.
- [0007] Figure 4 shows a probe with an outer surface in a stepped configuration according to one or more embodiments.
- [0008] Figures 5A and 5B depict a probe processor and a probe data storage according to one or more embodiments.
- [0009] Figure 6 depicts a remote data storage according to one or more embodiments.
- [00010] The present embodiments are detailed below with reference to the listed Figures.

DETAILED DESCRIPTION OF THE EMBODIMENTS

- [00011] Before explaining the present apparatus and system in detail, it is to be understood that the apparatus and system are not limited to the particular embodiments and that it can be practiced or carried out in various ways.
- [00012] The embodiments relate to a
- [00013] probe with no moving parts for use in one or more tanks mounted stationarily, or on a floating vessel, such as ships, barges and offshore floating platforms
- [00014] In embodiments, the probe can be connected with other probes and be operable from a remote control processor connected through a network.
- [00015] The probe can have a plurality of pressure transducers and a plurality of temperature

sensors electrically connected to a probe processor.

- [00016] The probe controls the temperature and pressure transducers to produce bidirectional signals and calculates at least one physical property of fluid in the tank while performing adaptive measurement for dynamic and static synchronized and non-synchronized measurement.
- [00017] The probe additionally identifies temperature sensors and pressure transducers not covered by the fluid in the tank.
- [00018] The probe can calibrate pressure transducers in a vapor space of the tank when the pressure transducers are no longer in the fluid and can use values from an inclinometer transferring the bidirectional signals to a client device via a network to provide accurate interpretations of pressure measurements.
- [00019] The present embodiments can have the benefit of being both a leak detection and an emission monitoring apparatus that can detect leaks and monitor emissions from tanks, and then perform a comparison of measured emission to stored requirements of environmental laws and regulations which can be stored in a data storage connected to the processor. The probe can automatically provide a notification via a network to a client device when the comparison fails to comply with the stored requirements of environmental laws and regulations.
- [00020] Some embodiments are for a marine probe that can utilize multiple temperature sensors and multiple pressure transducers for performing hydrostatic tank measurements and provide increased accuracy and consistency with regard to measurement values.
- [00021] Specific structural and functional details disclosed herein are not to be interpreted as limiting, but merely as a basis of the claims and as a representative basis for teaching persons having ordinary skill in the art to variously employ the present embodiments.
- [00022] The term “fluid” as used herein can include liquids, gasses with or without

particulates and combinations thereof. Vapor pressure can be used in the conventional manner and can be included within the scope of the term “gas” for this application. Fluids include hydrocarbons, water, gasoline, oil, pharmaceuticals, alcohols, esters, inert gasses and vapors.

- [00023] The term “fluid temperature” as used herein can refer to an average fluid temperature or a multipoint spot temperature of the fluid.
- [00024] The term “inclinometer” as used herein can refer to an instrument for measuring angles of a floating object with respect to gravity. The inclinometer can measure after draft, forward draft, list, trim, or pitch and roll.
- [00025] The term “pressure transducer” as used herein can refer to a device that measures pressure of the fluid.
- [00026] The term “processor” as use herein can be a laptop, a cellular phone or smart phone, a desktop computer, a server on a network, an additional measuring device that does different measuring and can connect to the plurality of temperature sensors and plurality of pressure transducers, and combinations thereof. The processor can be in wired or wireless communication with the temperature sensors and pressure transducers.
- [00027] The term “data storage” refers to a non-transitory computer readable medium, such as a hard disk drive, solid state drive, flash drive, tape drive, and the like. The term “non-transitory computer readable medium” excludes any transitory signals but includes any non-transitory data storage circuitry, e.g., buffers, cache, and queues, within transceivers of transitory signals.
- [00028] The term “simultaneously” as used herein can mean the temperature sensors and pressure transducers can collect measured data at the same time or within a few milliseconds of each other, such as a period ranging from zero to one hundred milliseconds.

- [00029] The term “temperature sensor” as used herein can refer to either one temperature sensor, or a pair of temperature sensors for detecting a temperature of a fluid in a tank.
- [00030] The term “tank” as used herein can refer to a wide variety of tanks, and containers that hold fluids including separators, storage tanks, container trucks, and vats. For example, the tank can include a tank containing as much as ten barrels of oil, or as much as 1,000,000 barrels of oil. The tank can be structured with or without floating roofs. The tank can have any shape, including circular shapes, square shapes or other similar shapes. Tanks of any volume made from various materials are contemplated.
- [00031] The probe of the invention can occupy less space than other methods known in the art.
- [00032] The probe of the invention can provide the benefit of continuous measurements, while providing a comparison of measured values with preset limits, such as environmental standards.
- [00033] The probe of the invention can provide enhanced accuracy and consistent measurement over existing detection and monitoring apparatus.
- [00034] The probe of the invention can identify many physical characteristics that can be measured using the temperature sensors and pressure transducers for the gas, or liquid, with or without particulate matter.
- [00035] Use of the present probe of the invention can prevent hazardous environmental emissions, and avoid other potentially dangerous or detrimental fluid conditions through continuous monitoring.
- [00036] The comparison of measurements with preset limits by the probe as described herein, can allow remediation to be taken when fluid conditions reach unacceptable levels, such as extreme pressures and temperatures, the formation of vacuums, and the emissions of harmful amounts of hydrocarbons and other potentially harmful

chemicals, thereby preventing environmental contamination, explosions, loss of fluid, death and damage to equipment.

- [00037] For example, a calculated value, such as a mass of a fluid can range from a few tons to hundreds of thousands of tons of crude oil in a ship or barge. A calculated value, such as a fluid volume in a tank can range from tens of barrels to millions of barrels of liquid petroleum gas. Fluid densities can range from 0.5 g/cm^3 to 2 g/cm^3 or more for most petroleum products.
- [00038] Temperature of the fluid can range from -60 degrees Centigrade to 200 degrees Centigrade and can include vapor temperatures in addition to liquid temperature measurement. Impurity of the fluid can include a detection of water in oil on a percentage basis, for example a 5 percent impurity in West Texas crude oil.
- [00039] The probe can communicate via a network with a remote processor to use a computed mass of the fluid for balancing a floating vessel during loading, and unloading of the floating vessel; and for inventory control and custody transfer.
- [00040] In an embodiment, one or more of the pressure transducers can include a diaphragm. The diaphragm can be oriented horizontal to the bottom of the tank but can be at other orientations.
- [00041] In embodiments, one or more of the temperature sensors or pressure transducers can provide an analog signal to a probe processor. The analog signal can be digitized, such as by use of an analog-to-digital converter, and stored in fixed or removable data storage, transmitted to remote data storage or another processor, or combinations thereof.
- [00042] In embodiments, the probe can use temperature sensors and pressure transducers with a built-in processor and direct digital communications to probe processor. That is, each temperature sensors and pressure transducer can communicate with a probe processor which then can wirelessly communicate or make a wired connection to a network with a remote processor and remote data storage, such as a cloud processing

system.

- [00043] An example of the probe can use temperature sensors and pressure transducers in a long row, each temperature sensor and pressure transducer having a sequential number 1 to 10. In this embodiment, the temperature sensors numbering 1, 3, 5, 7, 9 can communicate with a processor "A" the temperature sensors with numbers 2, 4, 6, 8, and 10 can communicate with a processor "B". This alternating measurement using multiple processors continuously can provide for the extreme high accuracy and reliability of measurement with this device.
- [00044] By connecting multiple probes of the probe processor together, the individual probe data can be compounded to create a virtual reading within one tank in case multiple probes are installed into the same tank.
- [00045] The synchronization of the pressure transducers can be established using a clock or timing device with the processor or internal to the processor, to synchronize pressure transducers, electronic switches and signals, analog-to-digital converters, and other equipment connected to the invention for increased accuracy.
- [00046] The probe processor can synchronously poll measurement data from the one or more temperature sensors and one or more pressure transducers to simultaneously and continuously calculate values, forming calculated values. For example, the fluid density can be difficult to measure in a moving fluid without using synchronized data.
- [00047] The probe processor can convert pressure and temperature sensor data to one or more values using computer instructions with models and other computations stored in memory of the associated data storage. The values can provide a reading or notification of a measurement or leak detection and related measurement, including unauthorized movement of fluid from the tank.
- [00048] The calculated values can be compared to one or more predetermined ranges of values for the fluid to identify whether the calculated values are within the

predetermined ranges. For example, a density of a specific crude oil can have a predetermined range from 0.85 g/cm^3 to 1.0 g/cm^3 and the present apparatus can constantly collect data and compare the collected data to that predetermined range. It can be contemplated that notification can be provided if the calculated values exceed a predetermined range. Use of automated responses, such as alarms, when the calculated values exceed a predetermined range, can also be contemplated.

- [00049] The calculated values can include a mass of the fluid, a fluid volume, an average temperature of the fluid, a multiple density strata of the fluid, an average density of the fluid, a level of the fluid, a fluid flow rate, an impurity content of the fluid, an entrained water content of the fluid, a free water content of the fluid, or combinations thereof.
- [00050] An embodiment of the invention can monitor and compare measurements for atmospheric or ambient pressures and temperatures to measure vapor pressures and vapor temperatures to provide data simultaneously with notifications and/or alarms. Examples of these types of data can include extreme pressures, extreme temperatures, formation of vacuums, high amounts of hydrocarbon emissions or other harmful chemical emissions, or combinations thereof. Immediate notifications and alarms can be produced to provide an alert of potentially harmful gasses, liquids, and vapors that are escaping into the atmosphere and surrounding area.
- [00051] The probe processor can communicate compared values to a data collector, which can include one or more data storage media in communication with the processor, including remote data storage media, removable data storage media, and fixed data storage media.
- [00052] In embodiments, the remote processor can communicate with one or more of the following: (1) a remote terminal unit, such as a Bristol Babcock RTU for tubular line monitoring, (2) a distributive control system, such as, a Honeywell DSC 3000, (3) a supervised control and data acquisition (SCADA) system, such as a Human Machine Interface system, (4) another computer, (5) another a tank or vessel gauge interface

unit, such as a 1515 ETGI provided by Gauging Systems, Inc., of Houston, Texas, and other similar devices.

- [00053] In embodiments, communication of compared values to the remote processor can be performed using a field wiring bus, a network, or combinations thereof. Useable networks can include the internet, a local area network, a radio network, a hard-wired network, a copper wire network, a cellular network, a satellite network, a fiber optic network, an infrared connection, a plain old telephone system (POTS), other wireless or wired networks, and combinations thereof.
- [00054] In an embodiment, temperature sensors and pressure transducers can each include a transmitter, such as a radio transceiver, a satellite transmitter, a cellular transceiver, an RS-485 wired transmitter, or other similar transmitters. The transmitter can communicate between the temperature sensors and pressure transducers and the remote processor. In embodiments, communication can be a wireless communication, such as an infrared, satellite, or cellular communication, a fiber optic communication, a cabled communication, or combinations thereof.
- [00055] In embodiments, a transmitter can be disposed in proximity to one or more tanks for transmitting data from the temperature sensors and pressure transducers within the one or more tanks to a remote processor.
- [00056] The invention can include a sensor housing for containing temperature sensors and pressure transducers. The sensor housing can be made from any durable material, including machined stainless steel, plastic, a metal alloy, such as HASTELLOY-C™, TEFLON™, aluminum, KYNAR™ composites, ceramic composites, and formed polymer blends, such as polyvinyl chloride (PVC).
- [00057] In an embodiment, the invention can include one or more channels. The channels can contain signaling wires to convey temperature sensor data to the probe processor. The channels can be smooth walled. The signaling wires can be multi-conductor wire, such as wire available from Belden, other types of wire, or similar communication

wiring, such as fiber optic wiring or cable.

- [00058] In one embodiment, the invention can be installed into or in proximity to a gauge well or gauge hatch of a large tank, such as an oil tank, on a floating vessel, so that uncertainties caused by comparison with manual gauging due to reference point movement or bottom movement of the tank are eliminated.
- [00059] By locating the invention with the gauge well of the tank, the invention can provide multiple measurements at the same single location where manual measurements are taken and greatly increase the verifiability of a monitoring function.
- [00060] With this alignment, the invention can measure automatically all the values that are measured manually from the gauge well so that comparisons can be made of many variables at the same time the manual samplings by the gauge well are occurring.
- [00061] Examples of samplings and measurement values can include: a fluid level, temperatures of the fluid, fluid density, and a percentage of water content in a hydrocarbon fluid.
- [00062] Tank samplings and measured values include: level and temperature of the fluid and fluid density. The alignment of the invention with the gauge well of the tank can allow the measured values from the invention to be compared and calculated with the manual gauge well samplings and readings and dramatically improves the verification ability and consistency of the measurement values.
- [00063] Turning now to the Figures, Figure 1 shows a probe for use in a tank according to one or more embodiments.
- [00064] In embodiments, the probe 1 can have no moving parts for use in the tank 8. The tank can have a floor 9 and at least one wall 10. In this embodiment, the tank is shown with a cylindrical wall.
- [00065] The probe 1 can be configured for continuous measurement of a fluid 2 while the

probe is immersed in that fluid. The fluid 2 can be a combination of liquid and vapor. The tank can have a vapor space 15 above the fluid in the tank.

- [00066] The probe 1 can have a processor housing 20 and a plurality of pressure transducers 22a-22i. In embodiments, each pressure transducer can have a diaphragm 24a-24i.
- [00067] Each pressure transducer can be configured for continuous pressure measurement through direct contact with the fluid 2 in the tank 8.
- [00068] The probe 1 can have a plurality of temperature sensors 30a-30i, wherein each of the temperature sensors can be contained in one of the pressure transducers 22a-22i or in one of the sensor housings 21a-21i.
- [00069] Each temperature sensor can be configured for continuous temperature measurement of the fluid 2 in the tank 8.
- [00070] The processor housing 20 can have a probe processor 40 that can be electrically connected to the plurality of pressure transducers and to the plurality of temperature sensors and electronically connected to a network 64 with bidirectional signal 60a-60d.
- [00071] A probe data storage 50 can also be in the processor housing 20. The probe data storage 50 can be in bidirectional communication with the probe processor 40.
- [00072] The term “data storage” refers to a non-transitory computer readable medium, such as a hard disk drive, solid state drive, flash drive, tape drive, and the like. The term “non-transitory computer readable medium” excludes any transitory signals but includes any non-transitory data storage circuitry, e.g., buffers, cache, and queues, within transceivers of transitory signals.
- [00073] The probe data storage 50 can be computer readable medium with computer instructions for instructing the probe processor to control the plurality of temperature sensors and the plurality of pressure transducers to produce a bidirectional signal 60a

to the network and to produce a bidirectional signal 60d to the plurality of temperature sensors and the plurality of pressure transducers.

- [00074] A temperature and pressure transducer 61 can be located in the vapor space 15 of the tank 8. In embodiments, more than one temperature and pressure transducer can be used.
- [00075] A plurality of conduits 19a-19j can be used for connecting the processor housing 20 with the sensor housings 21a-21i. The conduits can extend to a bottom of the probe. In embodiments, the bottom of the probe can be proximate or within inches, such as 1 inch to 30 inches of the floor 9 of the tank 8.
- [00076] A plurality of switches 66a-66d can be located in the tank 8. Each switch can detect liquid levels, compare detected liquid levels to a preset level in the switch, and then provide a notification signal to a client device 67, the probe processor 40 or both the client device and the probe processor when the liquid exceeds or fails to meet the preset level in the switch.
- [00077] An external sensor 63 can be disposed outside of the tank 8. The external sensor can be electrically connected to the probe processor 40.
- [00078] The external sensor 63 can be configured to measure ambient pressure and ambient temperature outside the tank.
- [00079] The external sensor 63 can provide signals to the probe processor 40. The probe processor can use computer to compare the ambient pressure and temperature measured outside the tank by the external sensor to measured pressure and temperature inside the tank measured by the plurality of pressure transducers and the plurality of temperature sensors for gas blanket monitoring and asset protection of the tank 8.
- [00080] The probe 1 is shown communicating using the bidirectional signals 60a and 60d with the network 64. Some of the bidirectional signals 60b can be further transmitted

to the network 64 to a client device 67 and commands and data can be transmitted from the client device 67 to the network 64 for transmission to the probe processor 40.

- [00081] A remote processor 71 can be in communication with the probe processor 40 through the network 64. The remote processor can be depicted in communication with bidirectional signals 60c to the network for communication with the probe processor.
- [00082] The remote processor 71 can be further communicating with a remote data storage 73.
- [00083] Various other sensors can be utilized to enhance safety, functionality, and performance while implementing the present invention. Sensors for application specific parameters can be included, utilized, and recorded. Persons having ordinary skill in the art can select such sensors on a case by case basis. For example, a compound containing sulfur detector 69 can be in communication with the probe processor 40 for detecting compounds containing sulfur. Although the compound containing sulfur detector 40 is shown to be proximate a bottom or the floor 9 of the tank8, the compound containing sulfur detector 69 can also be located in the vapor space 15.
- [00084] The compound containing sulfur detector can be in the fluid in the tank, in vapor space in the tank, or mounted external to the tank.
- [00085] The probe processor can compute compound containing sulfur concentration for protection of personnel or for estimation of quality of crude oil.
- [00086] Figure 2 shows a detail of the sensor housing 21 in partial cross section according to one or more embodiments.
- [00087] Output leads 73 are shown from the temperature and pressure transducer 61. The temperature and pressure transducer 61 can be disposed partially in the sensor housing 21. In embodiments, to operate the temperature and pressure transducer 61, a

portion of the temperature and pressure transducer can be external of the sensor housing.

- [00088] A channel 79 can be formed in the sensor housing 21. The channel 79 can have a plurality of inclined surfaces that can enable the fluid from the tank to contact the temperature and pressure transducer 61.
- [00089] Figure 3 is a detailed view of a channel of the sensor housing according to one or more embodiments.
- [00090] In this embodiment, the probe can have two inclined surfaces in the sensor housing 21, shown as a first surface 25 and a second surface 29 that can form the channel 79. Each inclined surface can have a slope from 2 degrees to 50 degrees.
- [00091] In embodiments, a plurality of inclined surfaces can be used on one side of the channel 79. The channel 79 can enable the fluid from the tank to contact a pressure transducer or a temperature sensor in the sensor housing or a combination pressure and sensor transducer in the sensor housing.
- [00092] In embodiments, one inclined surface can be formed on a side of the channel 79.
- [00093] Figure 4 shows a probe with an outer surface in a stepped configuration according to one or more embodiments.
- [00094] The probe 1 is shown with an outer surface 81 formed in a sequential stepped configuration as three segments, wherein each segment expands at least 10 percent in diameter sequentially from an adjacent segment.
- [00095] The probe 1 can have a tank movement measuring device 83 connected to a roof 99 of the tank 8 with the fluid 2 and the vapor space 15. The tank 8 can have at least one wall 10, shown here as a cylindrical tank, and a floor 9. The tank movement measuring device 83 can be mounted external of the tank 8.
- [00096] The tank movement measuring device 83 can be electronically connected to the probe

processor 40 in the processor housing 20 or the remote processor via the network. The tank movement measuring device can provide signals that can be stored in the remote processor data storage. The tank movement measuring device 83 can communicate with the probe processor 40 or a display for an operator. The tank movement measuring device can measure and display movement due to flexing of the floor 9 of the tank 8 or due to flexing of the roof 99 of the tank 8. The display can be a local display, a remote display, or combinations thereof.

- [00097] The tank movement measuring device 83 can measure when the probe has moved due to the flexing of the floor 9 of the tank 8 with the fluid 2 or flexing of the roof 99 of the tank with the vapor space 15 relative to the floor 9. The tank movement measuring device can transmit those measurements to the probe data storage 50 either wirelessly or in a wired communication for further notification to the display associated with the probe processor 40 or the remote processor via the network or the client device via the network.
- [00098] Figures 5A and 5B depict a probe processor and a probe data storage according to one or more embodiments.
- [00099] In embodiments, the probe processor 40 can have a temperature sensor simulation circuit 85 and a pressure transducer simulation circuit 87.
- [00100] The probe data storage 50 can be connected to the probe processor 40.
- [00101] The temperature sensor simulation circuit 85 can be for automatically calibrating the probe processor and can use a temperature reference value 234 for calibration. The temperature reference value 234 can be shown in the probe data storage 50.
- [00102] The pressure transducer simulation circuit 87 can be for automatically calibrating the probe processor. The pressure transducer simulation circuit can use a pressure reference value 235 for calibration. The pressure reference value 235 can be shown in the probe data storage 50.

- [000103] The probe data storage 50 can contain a tank capacity table 200, which can show capacities and/or volumes in a tank for various fluid levels as measured from a reference gauge point.
- [000104] The probe data storage can contain computer instructions 202 configured to instruct the probe processor to calculate at least one physical property for the fluid.
- [000105] The physical properties can be stored in the probe data storage and can include but are not limited to: a mass of the fluid 303, a volume of the fluid 304, a density strata of the fluid 306, an average density of the fluid 308, a level of the fluid 310, a fluid temperature 311, a fluid flow rate 312, a fluid pressure 313, an amount of impurity in the fluid 314, an entrained water content in the fluid 316, and a free water content in the fluid 318.
- [000106] The probe data storage can contain computer instructions 204 to instruct the probe processor to perform adaptive measurement for at least one of: synchronized measurement of the fluid in static operation, non-synchronized measurement of the fluid in static operation, non-synchronized measurement of the fluid in dynamic operation, and synchronized measurement of the fluid in dynamic operation.
- [000107] The probe data storage can contain computer instructions 208 configured to instruct the probe processor to identify which of the plurality of temperature sensors and the plurality of pressure transducers are not covered by a fluid by comparing signals from the plurality of temperature sensors and the plurality of pressure transducers to each other.
- [000108] The probe data storage can contain computer instructions 210 configured to instruct the probe processor to measure movement of the fluid in the tank.
- [000109] The probe data storage can contain computer instructions 212 configured to instruct the probe processor to calibrate pressure transducers of the tank when the pressure transducers are no longer in a fluid.

- [000110] The probe data storage can contain computer instructions 213 configured to instruct the probe processor to use inclinometer values to recalculate the location of each of the temperature sensors and each of pressure transducers in the fluid, and use the tank capacity table to determine accurate volume and mass of liquid and vapor of the fluid.
- [000111] The probe data storage can contain computer instructions 214 configured to instruct the probe processor to communicate with a client device via a network by using the bidirectional signals.
- [000112] The probe data storage can contain computer instructions 218 configured to instruct the probe processor to perform self-calibration.
- [000113] The probe data storage can contain computer instructions 220 configured to instruct the probe processor to perform self-diagnostics.
- [000114] The probe data storage can contain computer instructions 222 configured to instruct the probe processor to perform self-configuration.
- [000115] In embodiments, the probe data storage can have at least one computer instruction configured to instruct the probe processor to perform self-calibration, perform self-diagnostics, perform self-configuration, or various combinations thereof.
- [000116] The probe data storage can contain computer instructions 224 configured to instruct the probe processor to configure and reconfigure automatically online.
- [000117] The probe data storage can contain computer instructions 228 configured to instruct the probe processor to compare the ambient pressure and temperature to measured pressure and temperature inside the tank for gas blanket monitoring and asset protection of the tank.
- [000118] The probe data storage can contain computer instructions 230 configured to instruct the probe processor to use the plurality of pressure transducers and temperature

sensors internal to the tank, any temperature and pressure transducer located in a vapor space of the tank and the external sensor to calculate parameters necessary for emissions monitoring.

- [000119] The probe data storage can contain computer instructions 232 configured to instruct the probe processor to use the plurality of temperature sensors and/or the plurality of pressure transducers to calculate parameters necessary for leak detection and unauthorized movement of fluid into and out of the tank.
- [000120] The temperature sensor simulation circuit's temperature reference value 234 and the pressure transducer simulation circuit's pressure reference value 235 are shown in the probe data storage 50.
- [000121] The probe data storage can contain computer instructions 236 configured to instruct the probe processor to compute sulfur containing compound concentration for protection of personnel or for estimation of quality of crude oil as mentioned earlier.
- [000122] The probe data storage can contain computer instructions 322 configured for instruct the remote processor to use a computed mass of the fluid for balancing during loading and unloading of the floating vessel and for inventory control and custody transfer.
- [000123] Figure 6 depicts a remote data storage according to one or more embodiments.
- [000124] The remote data storage 73 can contain computer instructions 226 configured to instruct the remote processor to calculate snow or water accumulation on a roof of the tank using bidirectional signals from the probe processor.
- [000125] The remote data storage can contain computer instructions 430 configured to instruct the remote processor to calculate parameters necessary for emission monitoring.
- [000126] The remote data storage can contain computer instructions 432 configured to instruct the remote processor to calculate parameters necessary for leak detection and

unauthorized movement of fluid into or out of the tank.

- [000127] The remote data storage can contain computer instructions 434 configured to instruct the remote processor to calculate parameters necessary for overfill protection of the tank.
- [000128] The remote data storage can contain computer instructions 436 configured to instruct the remote processor to calculate tank overpressure or vacuum parameters in the tank.
- [000129] In embodiments, the processor housing can be weatherproof or explosion proof.
- [000130] In embodiments, at least one probe can be used. In embodiments, multiple or a plurality of probes can be used in one or more tanks of a floating vessel.
- [000131] In embodiments, multiple probe processors and probe data storages can be used.
- [000132] In an embodiment, a plurality of processor housings can be configured to prevent degradation in marine environments.
- [000133] In embodiments, the inclinometer can be mounted to a floating vessel and can provide measuring angles of the floating vessel relative to gravity for use by each probe processor.
- [000134] Each probe processor can electrically and bi-directionally connect to each of the plurality of pressure transducers, the plurality of temperature sensors and the inclinometer of a marine probe system.
- [000135] While these embodiments have been described with emphasis on the embodiments, it should be understood that within the scope of the appended claims, the embodiments might be practiced other than as specifically described herein.

CLAIMS

What is claimed is:

1. A probe with no moving parts for use in a tank, the tank having a floor and at least one wall, the probe configured for continuous measurement of a fluid while immersed in the fluid, wherein the probe comprises:
 - a. a processor housing;
 - b. a plurality of sensor housings connected to the processor housing;
 - c. a plurality of pressure transducers, each pressure transducer of the plurality of pressure transducers within a sensor housing of the plurality of sensor housings, each pressure transducer of the plurality of pressure transducers having a diaphragm, wherein the plurality of pressure transducers measure pressure through direct contact with the fluid in the tank;
 - d. a plurality of temperature sensors, each temperature sensor of the plurality of temperature sensors within a sensor housing of the plurality of sensor housings or contained in each pressure transducer of the plurality of pressure transducers, wherein each temperature sensor of the plurality of temperature sensors is configured for continuous temperature measurement of the fluid in the tank;
 - e. optionally, an inclinometer mounted to a floating vessel or within the processor housing for measuring angles of the floating vessel relative to gravity;
 - f. a probe processor in the processor housing, the probe processor electrically and bidirectionally connected to the plurality of pressure transducers, to the plurality of temperature sensors, the inclinometer and a network; and
 - g. a probe data storage in the processor housing, the probe data storage in communication with the probe processor, the probe data storage being a non-transitory computer readable medium with computer instructions for instructing the probe processor to control the plurality of temperature sensors and the plurality of pressure transducers to produce bidirectional signals to the network,

to the plurality of temperature sensors and to the plurality of pressure transducers, the probe data storage containing:

- (i) a tank capacity table;
- (ii) computer instructions instructing the probe processor to calculate at least one physical property for the fluid, the physical property selected from the group consisting of:
 - 1. a mass of the fluid;
 - 2. a volume of the fluid;
 - 3. a density strata of the fluid;
 - 4. an average density of the fluid;
 - 5. a level of the fluid;
 - 6. a fluid temperature;
 - 7. a fluid flow rate;
 - 8. a fluid pressure;
 - 9. an amount of impurity in the fluid;
 - 10. an entrained water content in the fluid; and
 - 11. a free water content in the fluid;
- (iii) computer instructions instructing the probe processor to: perform adaptive measurement for at least one of:
 - 1. a synchronized measurement of the fluid and a non-synchronized measurement of the fluid in static operation; or
 - 2. a synchronized measurement of the fluid and a non-synchronized

measurement of the fluid in dynamic operation;

- (iv) computer instructions instructing the probe processor to determine which of the plurality of temperature sensors and the plurality of pressure transducers are not covered by the fluid by comparing signals from the plurality of temperature sensors and the plurality of pressure transducers to each other;
 - (v) computer instructions instructing the probe processor to measure movement of the fluid in the tank;
 - (vi) computer instructions instructing the probe processor to calibrate pressure transducers of the tank when the pressure transducers are no longer in the fluid;
 - (vii) computer instructions instructing the probe processor to use inclinometer values when present to recalculate the location of each of the temperature sensors and each of the pressure transducers in the fluid, and use the tank capacity table to determine accurate volume and mass of liquid and vapor of the fluid; and
 - (viii) computer instructions instructing the probe processor to communicate with a client device via the network using the bidirectional signals.
2. The probe of claim 1, comprising at least one temperature sensor and pressure transducer located in a vapor space of the tank.
 3. The probe of claim 1, wherein an outer surface of the probe expands in a stepped configuration, increasing at least ten percent in diameter.
 4. The probe of claim 1, comprising a channel in the sensor housing to provide contact with the fluid from the tank to at least one temperature sensor of the plurality of temperature sensors and at least one of the plurality of pressure transducers.
 5. The probe of claim 1, comprising a plurality of switches in the tank that each provide a notification signal to the probe processor, the network, or both the probe processor and

the network when the liquid exceeds or fails to meet a preset level.

6. The probe of claim 1, comprising a tank movement measuring device connected to at least one of: the probe processor and a remote processor for displaying and measuring probe movement due to flexing of the floor of the tank or due to flexing of a roof of the tank.
7. The probe of claim 1, wherein the probe data storage comprises at least one of:
 - a. computer instructions instructing the probe processor to perform self-calibration;
 - b. computer instructions instructing the probe processor to perform self-diagnostics; and
 - c. computer instructions instructing the probe processor to perform self-configuration.
8. The probe of claim 1, wherein the probe data storage comprises computer instructions instructing the probe processor to configure and reconfigure online.
9. The probe of claim 4, comprising a plurality of inclined surfaces on at least one side of the channel, the plurality of inclined surfaces enabling fluid to contact with at least one pressure transducer of the plurality of pressure transducers and with at least one temperature sensor of the plurality of temperature sensors.
10. The probe of claim 1, comprising a temperature sensor simulation circuit in the probe processor with a temperature reference value in the probe data storage and a pressure transducer simulation circuit in the probe processor with a pressure reference value in the probe data storage, the temperature sensor simulation circuit and the pressure transducer simulation circuit for calibrating the probe processor.
11. The probe of claim 6, comprising the remote processor bidirectionally connected to the probe processor via the network, the remote processor further comprising a remote data storage, the remote data storage comprising at least one of:
 - a. computer instructions instructing the remote processor to calculate parameters

necessary for emissions monitoring;

- b. computer instructions instructing the remote processor to calculate parameters necessary for leak detection and unauthorized movement of fluid into or out of the tank;
 - c. computer instructions instructing the remote processor to calculate parameters necessary for overfill protection of the tank; and
 - d. computer instructions instructing the remote processor to calculate tank overpressure or vacuum parameters in the tank.
12. The probe of claim 2, comprising an external sensor outside of the tank and electrically connected to the probe processor, the external sensor configured to measure ambient pressure and ambient temperature outside the tank, the external sensor providing signals to the probe processor, the probe processor using computer instructions in the probe data storage, the computer instructions configured to instruct the probe processor to compare measured ambient pressure and temperature to measured pressure and temperature inside the tank for gas blanket monitoring and asset protection of the tank.
13. The probe of claim 12, comprising computer instructions in the probe data storage, the computer instructions instructing the probe processor to use the plurality of pressure transducers and the plurality of temperature sensors internal to the tank, any temperature sensors and any pressure transducers located in the vapor space of the tank and the external sensor to calculate parameters necessary for emissions monitoring.
14. The probe of claim 1, comprising computer instructions in the probe data storage instructing the probe processor to use the plurality of temperature sensors and the plurality of pressure transducers to calculate parameters necessary for leak detection and unauthorized movement of fluid into and out of the tank.
15. The probe of claim 1, further comprising at least one compound containing sulfur detector in communication with the probe processor for detecting compounds containing sulfur and computer instructions in the probe data storage instructing the probe processor to compute compounds containing sulfur concentration for protection of personnel or for

estimation of quality of crude oil, wherein the compound containing sulfur detector is in liquid in the tank, in vapor in the tank or mounted external to the tank.

16. The probe of claim 1, wherein the processor housing is weatherproof or explosion proof.
17. The probe of claim 1, comprising a plurality of conduits connecting the processor housing with the sensor housings and extending to a bottom of the probe.
18. The probe of claim 11, comprising computer instructions instructing the remote processor to use a computed mass of the fluid for balancing during loading and unloading of the floating vessel and for inventory control and custody transfer.
19. The probe of claim 1, wherein the processor housing is configured to prevent degradation in marine environments.