GAS BLANKETING SYSTEM FOR LOW-PRESSURE HYDROCARBON TANKS

(54) Title: GAS BLANKETING SYSTEM FOR LOW-PRESSURE HYDROCARBON TANKS

(57) Abstract: A hydrocarbon tank system environment corrosion inhibitor includes use of inert gas, preferably nitrogen, to blanket ullage. Blanket gas is provided via controller into coupling to access ullage. Blanket gas is provided upon fueling events to stabilize the pressure in the system and prevent entry of atmospheric air and water (vapor). A controlled system allows for monitoring of pressures in the tank and thereby identify pressure events and even leaks in system due to unusual events, or general loss of pressure.
— with amended claims (Art. 19(1))
Gas Blanketing System for Low-Pressure Hydrocarbon Tanks

Field of the Invention

The present invention relates to maintenance of gas blanketed hydrocarbon tank systems. The present invention more particularly relates to a system and method of blanketing gas over hydrocarbon fuel within a small underground storage tank to resist corrosion in the tank.

Background

Small and medium size (typically thought of as 50,000 and less gallon) underground storage tanks, both steel and fiberglass are normally used to store and dispense petroleum hydrocarbon products from a wide range of facilities. Some of the most common hydrocarbon products are diesel and gasoline. These tanks are often at retail gasoline stations.

There is a current and growing need to protect this infrastructure from degradation due to corrosion. While there is more than one corrosion issue concerning fuel tanks, it is clear that a broad range of acetobacter microbes are growing in the ullage (empty space) of underground storage tanks and one byproduct of this growth is acetic acid. There are several problems that this acid directly and indirectly cause including; small particles which interfere with fuel delivery by clogging filters and wearing sensitive meter vanes and gears, to destroying the structural integrity of tanks, sumps, impact valves, and other service station equipment. One solution, keeping the ullage dry and reducing or eliminating oxygen in this empty portion of a tank, will significantly reduce or stop the acidification. At present, there are no commercially available, permanently installed, environmental control systems using nitrogen or other inert gas to control the environment of the ullage in small and medium sized tanks in retail, buildings, and small commercial sites.

There are inert gas blanketing systems designed for refineries, bulk storage and transfer terminals. These large gasoline and diesel above and below ground, high and low pressure fuel storage tanks use inert gas blanketing systems.

There are at present no ullage (empty space atmosphere) environmental control systems using nitrogen or inert gas blanketing design principals for low pressure, small and medium size
storage tanks typically used and in service to store and dispense gasoline or Ultra Low Sulfur diesel fuels.

There are inert gas blanketing systems designed for refineries, bulk storage, airport terminals, and transfer terminals. The API 2000 protocols are found in refineries, pipeline terminals and airports worldwide and serve to prevent internal tank corrosion and as a safety blanket that reduces the possibility of explosion of the contained hydrocarbons.

It is therefore an object of the present invention to provide a gas blanketing system for small and medium sized storage tanks.

It is another object of the present invention to provide a controlled self-contained blanketeted system for producing and dispensing hydrocarbons.

It is another object of the present invention to provide a controlled self-contained blanketeted system which includes blanket gas generation, application and dispensation.

It is yet another object of the present invention to provide a system to generate and dispense a blanketing gas along with provision of blanketing gas in the ullage of a hydrocarbon tank.

It is yet another object of the present invention to provide a system to disburse a blanketing gas along with a volatile corrosion inhibitor into the ullage and/or interstice of a hydrocarbon tank.

It is therefore an object of the present invention to provide a method for coating various surfaces in a fuel storage and delivery system.

It is another object of the present invention to provide a system for proper dispersant of VCIs in a fuel system.

It is still yet another object of the present invention to measure and maintain system integrity in a pressure controlled blanket gas system.

It is as yet another object of the present invention to control and/or prevent unwanted release of hydrocarbon vapor from tanks.

It is still another object of the present invention to deter and/or prevent corrosion of tank walls.
Summary of Invention

The genesis of this invention and the proposed use at retail sites is the unusual corrosion (hereafter considered as aggressive corrosion) that has been documented in many instances over the last several years. Since the use of alcohols being added to gasoline products became more widespread, there has been a sensitivity to reduce water infiltration/ mixing with gasohol (also referred to as E-gas, representing the many blends of ethanol and gasoline being sold now or potentially available in the near future) as the alcohol will absorb the water as it enters the fuel distribution system. Several problems may develop as water enters the fuel system. One such problem can occur when the alcohol content reaches a water saturation level for the fuel at a specific temperature. If the temperature of the fuel drops (typically due to environmental reasons), the alcohol / water mix will separate and drop to the bottom of the tank. This process is referred to as phase separation. The fuel should not be sold at this point, as the alcohol is one component that supports the octane rating of the fuel and the octane rating is lowered if phase separation occurs. This new liquid, the phase separated fuel, is typically more corrosive than normal alcohol / gasoline fuel mix. This new liquid also has the alcohol and water to supply the nutrients needed to support rapid microbial growth. One byproduct of microbial growth is acetic acid, a corrosive fluid that is harmful to the fuel delivery equipment, vehicle fueling equipment and motor components.

Similarly, diesel fuel is now blended with biodiesel. Biofuels also absorb water. This water in biodiesel also supports rapid microbial growth, the acetic acid byproduct of the microbes, and the resulting aggressive corrosion.

The reduction of sulfur in fuels today is yet another factor in the acidification of the tank ullage and fuels, higher concentrations of sulfur inhibited the growth of bacteria in the fuels.

One action that brings water into the tanks storing fuel is the act of dispensing the fuel from the tank. As the fuel leaves the tank, a low(er) pressure area is established in the tank as fuel leaves and ambient air from the outside flows into the tank. This air vapor has moisture, the moisture condenses on the (inside) tank surfaces. The condensed water vapor provides a wetted surface on the exposed portion of the tank known as the ullage or headspace of the tank. The water and oxygen provide an ideal environment for bacteria to grow.
As more fuel leaves the tank more air is drawn into the tank. More air brings more water vapor and therefore more condensation is deposited on the exposed portion of the tank. At some point this water begins to drip from the top of the tank and run down the sides of the tank into the fuel thus encouraging and feeding the growth of bacteria in the fuel.

Another action that encourages condensation in a tank is one that is exposed to, or at least partially exposed to wide temperature changes such as aboveground storage tanks or tanks that are only partially buried and aboveground storage tanks that are encased in concrete. In these cases, the tank is heated during the warmer periods of the day and by exposure to the sun, the tanks are also exposed to a greater cooling effect during storms, rain, snow and at night. These events create large temperature differentials, therefore pressure differentials to expel vapor and ingest moisture.

Another action where water enters the tank system is when rain water percolates through the ground or when ground water covers the top of the tank. Water entry into the tank may occur through holes in the tank, bungs and fittings that allow equipment to be installed or to provide access for inspections, fueling, etc.

It would be beneficial to continuously monitor the tightness of the tank for potential leaks from the entry points described in the tank top.

As mentioned, one byproduct of the moisture and oxygen and the bacteria and the hydrocarbons is acetic acid, the headspace of the tank itself is acidified. This acidified vapor becomes pressurized (the whole headspace of the tank is pressurized) during the delivery of fuel into the tank. This pressure tries to return through intended venting methods but also is forced out through any opening available including threads, gasketed manways, any opening that is not effectively sealed to the pressure differential between the tank into the sump(s).

The initial test requirement stimulus for inert gas nitrogen blanketing is to prove or disprove a positive effect environmental control to prevent acidic atmosphere and its corrosive effects, on the design integrity of ULSD fuel storage tanks, their connected fittings and components.

One benefit mentioned when inerting of the headspace of a fuel storage tank is to reduce the chance of a flash fire, such as those that regularly occur in these tanks due to lightning strikes to the vents or other metallic connections to the headspace of the tank or from static discharge from
fueling or filling that be in communication with the head space of a tank, both of these are known and identified problems in this industry.

The initial test stimulus for inert gas blanketing is to prove or disprove an environmental control to prevent the acidic ullage atmosphere and its corrosive effects on the design integrity of fuel storage tanks, their connected fittings and components.

As more ORVR equipped vehicles fuel in regulated vapor recovery attainment regions, the Phase II vapor recovery systems are adversely impacted as the ORVR equipment does not return vapor from the vehicle as the previous generation of Phase II equipment was designed for. As the matrix of ORVR equipped vehicles increase, vapor recovery function to prevent the release of hydrocarbon has been affected and vapor recovery fail alarms have increased. This has caused great frustration for fueling station owners as downtime do to the alarms and test costs mandated by the alarms have greatly increased.

Efforts to control excess and fugitive hydrocarbon emissions through the existing vapor recovery systems may become less efficient depending on what ORVR Equipped Vehicle Fueling Matrix was used during the permitting, system design, and fuel site construction. Some fueling site operators are realizing fuel loss and excess emissions particularly due to tank empty space pressure fluctuations overwhelming existing vapor control equipment design parameters.

Another benefit to introducing Nitrogen only into the ullage is as it is lighter that most hydrocarbons, Nitrogen is vented first during any tank refueling. This reduces the amount of vaporized fuel lost to the tank owner. This economic value is greater the higher the volume of product sold or transferred each day.

This transfer of Nitrogen during refueling of the tank is also beneficial to public transportation as the return tanker truck is no longer filled just with explosive vapor, but reduced fuel vapor and reduced oxygen content providing a safer transport for the driver and the public.

Another benefit to introducing a pressurized inert gas into the ullage is to reduce the amount of fuel that vaporizes. Any pressure on the fuel reduces the amount vaporization that occurs, and will significantly reduce the vaporization of fuels that are currently kept in a lower pressure system and specifically those tank systems that have vacuum on the tank system.
Another benefit to introducing an inert gas into the ullage system is to reduce the oxygen content in the ullage. Oxygen being one of the components that many bacteria that produce acids need to reproduce.

A benefit to blanketing the tank top with nitrogen is that the nitrogen molecule is larger than some hydrocarbon molecules and other air molecules, as well as lighter than some, so that the nitrogen may not pass through some of the smallest openings in the tank top. If the nitrogen was not present, hydrocarbon molecules would pass through the same openings causing ground or air pollution.

Another aspect of the present invention is to provide the dry inert gas to the interstitial space of double wall tanks. The interstitial area is a place that moisture accumulates. Flowing dry inert gas can remove existing moisture and preventing the accumulation of new moisture. The ability to reduce or eliminate the oxygen content in the interstitial space of double wall tanks, to prevent or halt bacteria growth. This can be accomplished by periodic flushing, or via constant flow to draw or force other air molecules.

The effect of a successful application of these standards is to collect a sufficient amount of reliable and pertinent data to see if nitrogen blanketing of a storage tanks empty space with an inert gas will inhibit and or prevent the formation of acidic acid in some tanks holding, storing and dispensing fuel. We actually have data from two tanks to confirm this specific to N2 and several studies that specifically tie water, water vapor, fuel and oxygen to producing acids.

The reduction of rust particles in the tank fuel means the rust will no longer be picked up by the submersible pump, wearing pump components, pushing the rust into dispenser meters, reducing wear to meters and reducing the need to change clogged filters as often. Currently, as fuel is being delivered, the rust is moved by the fuel, the rust particles typically accumulate together due to the flow pattern repeating from the fuel drops. The rust particles provide a weighted area for bacteria to colonize and slime, making the colony better able to protect themselves from biocides.

Typically, retail tanks store routine and custom blends of diesel and biodiesel, gasoline and ethanol, and other commercial liquid hydrocarbon fuels. Additionally, these tanks are usually
50,000 gallon capacity or less, low pressure, and may be installed above or below ground. Benefits of inerting fuel tanks with nitrogen are well known in the prior art.

As such, the present invention includes:

1. Air compressor produces the pressurized air needed for the nitrogen generator.

2. The compressed air reserve tank reduces the need for the air compressor to run continuously, saving electricity, etc. Compressed air from the compressed air reserve tank is cooled and filtered prior to use with the nitrogen generator.

3. Nitrogen generator(s) functions to separate nitrogen under pressure from atmosphere. Compressed nitrogen generated by the nitrogen generator is on demand or continuous to maintain a volume of compressed nitrogen at a set and determined pressure in the nitrogen reserve storage tank.

4. The pressurized nitrogen reserve tank's primary function is to hold a sufficient volume of inert nitrogen gas to continuously blanket, at a determined pressure, the empty spaces of associated fuel storage tanks. The pressurized nitrogen reserve tank can also provide sufficient volumes of inert nitrogen gas to:
   
   A. Continuously inert associated fuel storage tank interstitial spaces via separate conduit, and potential additional venting of interstice.

   B. On a select or programmed schedule, leak test associated tank ullage or head space (C.A.R.B.TP-201, ST-27, ST-30, VMI-10).

   C. Provide an adequate volume of sufficiently pure nitrogen for scheduled and unscheduled third party testing of associated or unassociated fuel storage tanks (C.A.R.B TP-201, ST-27, ST-30, VMI-10)

   D. Provide adequate volumes at sufficient pressure to enable vending of nitrogen, e.g. allowing motorists to check and inflate tires with nitrogen (preferably providing at least 80 PSI).

5. Nitrogen vending. Vending of excess inert nitrogen gas provides additional site retail or equipment reimbursement revenue streams.
6. The NBS Controller is responsible for detecting fuel movement and adding nitrogen to replace the fuel. The controller is also responsible for head space or ullage testing if testing is desired or required at the site. The controller gives notification if there is a failure of the nitrogen generator to deliver nitrogen.

In addition to serving a blanketing gas protection agent in the ullage (and/or interstice of a tank), the present invention may also be used as a deployment of volatile corrosion inhibitor (VCI), such as via gas, fog, etc. into the ullage, interstice, and/or into the primary gasoline delivery lines of a retail station, or the like.

One common set of materials used to coat fuel (particularly hydrocarbon based) tanks includes ZERUST product provided by Northern Technologies International Corporation of Circle Pines, Minnesota. VCIs may be infused into a stable base material - like polyethylene (plastic) sheets. When deployed, VCIs are released from the base/delivery material and a molecular layer of VCI is deposited on the surface of the metal to be protected. VCIs act in one of the following ways - or a combination of these mechanisms depending on the application: 1. Barrier Film: Where the molecular layer prevents corrosive elements from reaching the metal. In some cases, this may also be in the form of a passivation film. 2. pH Altering: Where the VCI molecules alter the pH of the layer in contact with the metal and prevent corrosion 3. Scavenging: Where the VCI molecules react with the corrosive elements in the environment and convert them into neutral compounds.

VCI products prevent corrosion in several ways. By acting as a protective barrier from external dirt and abrasion, and also as a barrier to help block the diffusion of corrosive acid gas pollutants from outside the packaging material (such as sulfur dioxide or hydrogen sulfide) - thereby preventing contact of these corrosive gases with enclosed metal surfaces. By vapor corrosion inhibitors that passivate the electron flow between the anodic and cathodic areas on metal surfaces and interrupt the electro-chemical corrosion process. By adding water repulsion properties to the metal surface, which inhibit water from permeating the metal surface and providing the electrolyte for corrosion reactions. The vapor corrosion inhibitor portion of products is made of proprietary chemical formulations that are invisible, odorless, non-toxic, non-reactive, non-flammable and non-allergenic. These chemical formulations release a
corrosion inhibiting vapor that diffuses throughout an enclosure and settles on exposed metal surfaces to form a microscopic corrosion inhibiting layer.

This protective layer will remain on the surface of the metal as long as there is no significant, continuous exchange of air within the enclosure. Ideally, there should be less than one air exchange per day (for example, when an electrical cabinet or package is opened briefly and occasionally). Once the metal part is removed from the enclosure, the corrosion inhibiting layer is no longer kept in place by equilibrium with the VCI source, and it dissipates from metal surfaces (typically within about an hour) leaving the metal part clean, dry and corrosion-free.

VCIs can be water-based rust preventative compounds. They can be designed for use as foggable protection for the inside void spaces of tanks, packages and enclosures. It protects ferrous metals and is multimetal compatible.

VCI foggable aqueous-based rust preventative liquid protects ferrous metals via contact inhibitors. It can also be used as a pressurized spray. VCI molecules migrate to provide protection on even hard to reach areas within an enclosed space. The rust preventative forms a clear, thin, dry-to-touch coating and is safe for use on most painted surfaces, rubber seals, and plastics. It is compatible with other metals such as aluminum, copper, brass, and nickel alloys, etc.

However, there still exists a need to properly incorporate VCIs in fuel systems. The present invention utilizes a gas blanketing system to disperse a VCI onto surfaces in a fuel system. VCI can be disperses along with an inert or blanketing gas into a tank ullage to provide for coating of system surfaces. By integrating with a blanketing system, the tank and supply lines can be provided with a consistent amount of VCI. In a preferred embodiment, the VCIs will not be under any exceptional pressure and may be drawn during the fueling cycle, or interstice treatment, via Venturi effect. Alternatively, the VCIs may be introduced as needed at one or more particular time or interval. VCIs may be stored in a pressurized container and disbursed in a separate event to deliver a specific amount of VCI, in such a case, enough pressure and volume would be provided to cause the vent to open, thus coating the entire exposed tank and venting system (preventing rust form forming in the vent).
The system may include a VCI storage/source tied into the controller to open VCI source valves in conjunction with gas blanketing valves to provide for a carrier of VCI (e.g. in fog form) into storage tank. By utilizing the Venturi effect, a non-pressurized VCI source can be drawn into the supply line into the tank and mix properly with the blanketing gas to evenly coat the tank ullage and supply lines.

In the alternative, the VCI can be pressurize and introduced with the blanketing gas, or otherwise introduced alone or sprayed onto tank wall. The introduction and application of VCIs may comprise a separate event to deliver a predetermined level of VCI into the system. VCIs may also be sent as a pressurized spray to coat tank and cause the pressure relief system to open in the tank, and thereby force gases out of the ullage and the relief line. By coating the pressure relief line, it prevents rust on the upper portions of the fuel storage system and prevents rust from breaking off and falling back into the fuel.

VCIs also serve to coat and protect sulfur dioxide from diesel exhaust in a vehicle motor to prevent acid (i.e. sulfuric acid) from eating up vehicle tanks and motor system tubing. VCIs can be used on diesel exhaust fluid and used to line tanks on trucks.

The present invention includes a method to efficiently use a pressure system for more than one purpose; where the demands may have different pressure needs; where there are different priorities for the use of the pressure/ fluid. The system to produce this method can efficiently store and use pressure/ fluid; to use a pumping system to meet more than one demand at the same time.

The present invention includes a method to prioritize the resource (pressure/ fluid) to more than one demand given competing priorities; to reduce the number of pumping systems and components; to reduce utility costs by reducing the number of pumping systems by using a larger more efficient pump system; to reduce maintenance costs by reducing the number of pumping systems by using a larger more efficient pump system; and to reduce monitoring costs by reducing the number of pumping systems.

There are three critical points to the NBS system. First, the system should dry the air and remove water vapor from the ullage (interstice, etc.) The preferred system can inject dry air into the ullage as untreated air entering the ullage can cause the problems discussed above. The preferred
embodiment of the present invention includes provision of injected dry N2. If moisture is finding a way into the tank independent of the vent (gaskets, fittings not water vapor tight, manways or other loose porous means to enter the ullage) then water can still get into the ullage. Water, along with 02 and moisture, allow acetobacter bacteria to thrive. The concentration of N2 provided reduces or eliminates 02 to reduce bacterial growth. While dry air works, N2, or other inert gas is preferable.

Second, the present invention provides a means for inerting the ullage with an inert gas that will kill, arrest, or suspend the growth of the bacteria, thus preventing acidic liquid to be disbursed in vapor or deposited in the ullage, or joining with other water vapor and depositing moisture to the fuel in the UST / AST. N2 is preferable because it may be inexpensively generated on site.

Current solutions in the art include ships using exhaust to clear/blanket ullages. This is done to keep them safe, but this has a side effect of reducing moisture and killing bacteria. An alternative to the Nitrogen embodiment would be the use of pressurized inert gas containers or bottles, the inert gas when blown into the ullage lowers the 02 content.

**Detailed Description of the Present Invention**

The invention may be utilized by modifying prior systems, or by creation of the system in its most preferred form.

**EXISTING SYSTEM EQUIPMENT MODIFICATION**

Referring to Fig. 1, pressure/vacuum (p/v) control valve 1 is installed above ground, in the tanks vent pipe or pipes. The test tanks overall operating positive and or negative empty space pressure is now controlled to stay within the p/v control valve parameters.

A checked low pressure regulated control valve 4 is connected to the exposed tank vent pipe 2, below the tank vent p/v control valve 1. The inert gas line was connected to the checked, low pressure regulated control valve, or below, along the vent pipe (as shown). The other end of the inert gas line was connected to and fed from a sourced volume of compressed nitrogen.

Pressure regulator valve 4 is set to allow the flow of an inert nitrogen gas from delivery tube 5 to enter tank as fuel is dispensed. Fundamental dynamics being a valve sensing a lower pressure
connected to the headspace of a tank storing fuels and delivering nitrogen accordingly. Headspace control positive pressure set as low as 0.1 inch of water column being sufficient, as the tank discharges fuel and liquid level drops, the pressure drops and nitrogen is added. As the tank is (re)filled with the hydrocarbon fuel, the pressure rises, nitrogen exits through a preset vent p/v valve.

Retail gas stations are not equipped with blanket gas systems due to the irregular fuel dispensation throughout the day. A volume of nitrogen is the inert blanketing gas used to replace the air vapor that is normally pulled into the empty space of the tank when fuel is dispensed, or other physical events that occur that would reduce the pressure in the headspace of the tank and draw in ambient air with water vapor (i.e. humidity, rain, etc.).

For testing, the delivery pressure of the reserve volume was regulated at less than 5 PSI, connected to the low pressure regulated control valve attached to the tank vent riser. 5 PSI is not the absolute value, however the pressure must be high enough to allow sufficient volume to pass through the regulating orifice and the delivery tube 5 given the tube diameter and distance, to keep air vapor from entering the tank, offsetting the drawdown of fuel and or other physical attributes that might reduce the pressure in the tank. Another consideration is sizing the nitrogen delivery system to minimize the potential of over-pressurizing the tank 10. The test tank’s normal liquid output volume is one factor that allows us to determine the nitrogen source volume to meet blanketing tank requirements, the number of nozzles that dispense fuel is another. There are other factors that determine the source volume needs.

To test, a copper test strip probe inspected and or set on a predetermined schedule is used as a visualized control. Once tank test equipment is installed the test tanks are allowed to operate normally open to atmosphere for a period of time, say 30 to 90 days. Copper strip visual inspection are used to detect low or high PH values in the test tanks empty spaces. If copper test strips show acidic conditions, the indication of failure to significantly reduce or eliminate the acetobacter bacterial growth will be indicated. Test strip samples will be visually compared to previous test strip samples taken.

A p/v sensing transducer with a narrow sensing range, for example, between 10 inches water column positive and 10 inches water column negative is installed below the test tanks p/v control valve. The p/v sensing transducer signal is in communication with one or more devices that
could include one or more proportional valves, one or more non-proportional valves, an event
data logger, computational devices, control devices, algorithms, event parameters, response
parameters, alarm and notification potentials, communication devices and other devices not
noted here.

EXISTING SYSTEM MODIFICATION Alternative 2

A p/v control valve is installed on the tanks above ground riser vent pipe. The test tanks overall
operating positive and or negative empty space pressure is controlled by the p/v control valve
installed on the tanks vent riser.

A checked low pressure regulated control valve is connected below the tank vent p/v control
valve, to the tanks above ground vent riser and connected (inert gas being fed from) to a sourced
reserve volume of compressed nitrogen. The pressure regulator valve is set to allow the flow of
an inert nitrogen gas to enter tank as fuel is dispensed. Fundamental dynamics being a valve
sensing pressure below a valve connected to the headspace of a tank storing fuel and delivering
nitrogen accordingly. Headspace control positive pressure set as low as 0.1 inch of water column
being sufficient, as the tank discharges fuel and liquid level drops, the pressure drops and
nitrogen is added; as the tank is filled, the pressure rises, nitrogen exits through a preset vent p/v
valve.

A reserved volume of compressed nitrogen is the inert blanketing gas used to replace the
normally resident atmosphere in the empty space of the tank being tested. For testing the delivery
pressure of the reserve volume is regulated at less than 5 PSI connected to the low pressure
regulated control valve attached to the tank vent riser. The test tanks normal liquid output
volume determines the volume nitrogen source reserve to meet blanketing tank requirements.

A copper test strip probe inspected and or set on a predetermined schedule is used as a visualized
control. Once tank test equipment is installed the test tanks are allowed to operate normally open
to atmosphere for 30 - 90 days. Copper strip visual inspection may or may not confirm low PH
values in test tanks empty spaces. Assuming that copper test strips show acidic conditions or
anaerobic activity in the test tanks empty space the test strip samples will be visually compared
to test strip samples taken during the succeeding 30 - 90 day periods where the test tanks empty
spaces have been blanketed with nitrogen.
A p/v sensing transducer with a narrow sensing range, for example, between 10 inches water column positive and 10 inches water column negative, is installed below the test tanks p/v control valve. The p/v sensing transducer signal is in communication with one or more devices that could include one or more proportional valves, one or more non-proportional valves, an event data logger, computational devices, control devices, algorithms, event parameters, response parameters, alarm and notification potentials, communication devices and other devices not noted here.

The present invention may include a novel method for detecting leaks. A separate temperature and/or pressure gauge can be mounted or floated into the tank, or set somewhere along the venting system. Pressure readings can be taken from the tank space to determine when blanketing gas should be delivered into the system. On a normal operating daily cycle, temperatures will vary (as with seasons, etc.) and the system must be configured to distinguish changes in temperature/pressure based on environmental factors and operation factors. Multiple dispensations of gasoline may occur throughout the day. As each dispensation event occurs, if the pressure in the tank drops below a preset threshold, N2 will be release by act of the controller into the ullage. A p/v sensing transducer with a narrow sensing range, for example, of between 10 inches water column positive and 10 inches water column negative is installed below the test tanks p/v control valve. The p/v sensing transducer signal is in communication with one or more devices that could include one or more proportional valves, one or more non-proportional valves, an event data logger, computational devices, control devices, algorithms, event parameters, response parameters, alarm and notification potentials, communication devices and other devices not noted here. Data collected provides information that may be viewed in several formats, and such date may be analyzed, tested, compared and otherwise used to determine event that include leaks, leak rates, fuel delivery times and other events including pressure events and other seeming non related events such as theft. As fuel leaves the tank, one customer fueling, or even smaller leaks that would allow vapor pressure to leave the tank would trigger N2 to flow into the tank. Testing the ullage of the container for leaks, potential vapor losses (PVA) and water intrusion points can resolve issues of gaskets that slowly deteriorate, threaded connections that are not tightened or sealed correctly, caps not replaced, etc. We set a threshold below the level we wish to maintain at which we begin repressurizing. There are several methods we use to distinguish a fueling event vs a leak. These include the amount, the volume of the pressure drop.
This along with a statistical evaluation of our other gathered pressure data allow us to detect leaks, quantify leaks and separate them from fueling events.

When the test tank receives a bulk fuel delivery. It would be expected the p/v valve would open to relieve excess pressure. If other components are working correctly, such as the stage 1 vapor control system, the N2 or saturated hydrocarbon would flow out of the tank and into the transfer truck.

When the test tank dispenses fuel to a customer. As fuel leaves the tank,- one customer fueling, or even smaller leaks that would allow vapor pressure to leave the tank would trigger N2 to flow into the tank. We set a threshold below the level we wish to maintain at which we begin repressurizing. There are several methods we use to distinguish a fueling event vs. a leak. These include the amount, the volume of the pressure drop. This along with a statistical evaluation of our other gathered pressure data allow us to detect leaks, quantify leaks and separate them from fueling events.

The fuel storage tank has multiple cycles, such as when the tank receives a bulk fuel delivery or refill, or when the test tank dispenses fuel to a customer. At what points the p/v valve cracks venting nitrogen to atmosphere or triggers recharge ingestion of nitrogen as designed to inert or blanket test tanks empty space. Some tanks are under low-pressure, while others may be maintained at a different pressure depending on environmental conditions, use type of tank, etc. For instance, a leak can be detected when (aside from environmental factors) N2 is required to top off the ullage. Additionally, leaks are relatively constant over the usual time needed to evaluate "tightness", fuel sold changes by the number of customers fueling. This can also be used in conjunction with monitoring the volume of hydrocarbon product dispensed to determine the fueling system integrity.

Referring to Fig. 1, Nitrogen may be isolated in the present invention to act as an inert blanketing gas in ullage 11 of tank 10 above liquid fuel 12. Tank inner wall 13 must be kept clean and clear to ensure the tank systems. Interstice 15 is the section between outer wall 14 and tank wall 13. Air Compressor 20 feeds Nitrogen Generator 21. The Nitrogen generator may be any of the N2 generators known in the art to isolate Nitrogen gas for collection from a mixed gas. In certain occasions, stored Nitrogen may be substituted for a compressor and a Nitrogen generator. In certain occasions, stored Nitrogen may be substituted for a compressor and a Nitrogen generator.
In one embodiment, the N\textsubscript{2} serves a dual function of tank ullage protection and dispensation for use, e.g. at a tire fill. In such a case nitrogen is directed from the generator to a Dispenser reserve 22. The dispenser reserve may be along the line 50 to the main compressed N\textsubscript{2} reservoir 3 (as shown) or may be set apart to accept N\textsubscript{2} when pressure in dispensation reservoir is below some threshold. From dispensation, a vending machine 24 is provided behind a pressure regulator. A hose 25 may be supplied, such as for filling tires. Optionally, a regulator releasing pressure above 90 PSI or similar can be placed before N\textsubscript{2} compressed reserve to ensure the pressure in reserve is not too high or low.

The preferred embodiment of the N\textsubscript{2} main N\textsubscript{2} reserve is compressed, preferably above 90 PSI. Down from main reserve is a pressure regulator 7 which leads to a smart system controller 30. The system controller 30 provides for delivery of N\textsubscript{2} gas to the hydrocarbon tank 10. The system controller may also include function to monitor and measure the pressure in the tank. The N\textsubscript{2} tank delivery line and pressure monitoring line may be the same, or may run on separate lines (for quicker, more accurate and constant pressure monitoring). A primary valve 31 may be included along first conduit 32 to test and monitor the pressure in the tank, and a secondary 33 or additional valves, along secondary conduit 34 may be used to supply N\textsubscript{2} to keep up with delivery. Conduits 32 and 34 may be separated or joined, depending on the sophistication of the controller.

N\textsubscript{2} is provided to the tank through N\textsubscript{2} multi-port coupling 35 and forced into the ullage 11. The N\textsubscript{2} displaces air within the ullage and rests over the liquid (or solid) fuel. Although ullage may also include hydrocarbon vapor, N\textsubscript{2} does not readily mix with hydrocarbon vapor. N\textsubscript{2} is generally lighter than hydrocarbon vapor and thus remains at the top of the ullage 11 and up vent pipe 2. Gases displaced may exit via pressure release 1 at the top of tank outlet. Ullage vent 36 is an optional access point that can be permanently installed as a valve access point (for instance, in the N\textsubscript{2} multiport coupling, a multi-port (threaded for permanent / semi-permanent) etc.), in both size of ports. The availability of numerous access points in a coupling / block configuration as further shown in Fig. 5-8. This permanently installed access port allows manual gauges, sensors, data loggers easy available access, also samples can be gathered at this point to determine many things such as N\textsubscript{2}, O\textsubscript{2}, Relative Humidity, etc.
It is contemplated that Ns supplied into ullage will be a low pressure, for reasons of restricting turbulence and safety as UST's and AST's are (relatively) low pressure tanks. Keeping the nitrogen delivery pressure low is suggested to prevent overpressurization of the tank in the event of multiple or cascading failures of safeties (i.e. vents, etc.). There is absolutely no reason the line has to be low pressure, correctly functioning, the system is even faster responding to fuel demands and high volumes with high pressure, even in a low pressure tank. There will be high pressure applications where it will be desirable or even required to use high pressure. It may be preferable to include high pressure N2 in higher pressure tanks, for instance to prevent liquids from turning to a gas / vapor state. It is contemplated that in future tanks with upgraded safety equipment, a high pressure source of nitrogen may be included. When periodically clearing the interstice, for instance, a high pressure source of N2 may be preferred, and the controller, in such embodiments should be able to set predetermined N2 gas pressure when providing N2 to ullage vs. interstice, etc.

While in some future instances, the pressure / vacuum (p/v) valve may include a one-way check valve (only letting air out as pressure relief), present tank systems are not designed for high pressure (e.g. 5 psi recommended max. / burst pressure 7 - 8 psi.). Current tanks typical of retail systems must be able to vent in the event there is a vacuum, even of a relatively small amount, to avoid crumpling, or even implosion.

Manual Gauge 37 may be optionally be installed a mechanical psi / vacuum gauge as a temporary or permanent fixture in the system. This may be one embodiment of a pressure sensing item to provide information to the controller, and/or be read manually. Stick Pressure Correction Gauge 38 may optionally be included such as a drop tube installed in the UST or AST (underground or aboveground storage tank), and that drop tube may have a seal, that separates the ullage (empty space in tank) from atmospheric pressure, except through the fuel in a column (drop tube) or the atmosphere through the vent which may have a functioning p/v valve. To the extent that the p/v valve holds pressure above or below ambient air pressure, there may be a different fuel level in the drop tube versus the tank. Manual sticking in the drop tube can be reconciled with actual fuel inside the tank, outside of the drop tube, through the use of a gauge to read the pressure differential.
Separate conduit 250 may be used to clear interstice 15. Forced N2 may run along conduit 205 from controller 30 at same or different pressure as used in the blanketing system. Instead of running through coupler 35, interstice provided gas runs directly to interstice (as there is less issue with turbulence. Interstice may be separately vented (potentially with a one-way valve, at interstice vent 16, which may open for occasional, or constant, treatment.

VCI reserve or source 200 may be included in an embodiment of the system. VCI treatment may be managed by the controller. For instance, for ullage treatment, VCIs may be dispersed concurrently with N2 blanketing gas, either at once, always, or at set predetermined intervals of time or N2 blanketing. Additionally, a separate conduit 202 may serve to supply VCIs from a separate VCI source 201 into ullage (either along with N2 gas, or alone). This may be accomplished either from the same source 200, or additional source 201, to coat interstice.

When N2 is placed over the hydrocarbon fuel, the N2 provides pressure to resist incoming air and the associated water vapor. Hydrocarbon is dispensed via submersible pump below liquid level of tank. As pressure in the tank decreasing due to pumping, and the level of hydrocarbon fuel drops, the system controller activates release of N2 gas into ullage, rather than allow low pressure to remain, or in venting of atmospheric air and possible water vapor.

Referring to Figs. 5-8, N2 multi-port coupling / Nitrogen Connection Coupling is shown in detail. Coupling 400 may include multiple openings of different sizes available for any variety of uses. In this case holes 401 are drilled in each of sides 402. Holes 401 are preferably threaded to allow engagement with complimentary threaded conduits (or other items). Coupling as contemplated in the present invention replaces typical couplings of used in the art, as standard couplings are typically too thin to drill and thread to the industry standard for correct number of or depth of threads. Coupler may include six sides 402. The coupling 400 preferred provides specific installed height 404 in the vent. Height 404 may include the height to holes 404b from bottom 410 and to top 411 as space 404a. Coupler furthermore includes cavity or chamber 403 in bottom 410 that assists in the invention, and may be utilized to reduce turbulence of incoming nitrogen to prevent stirring vapors in the ullage. Cavity walls may be threaded for engagement with the tank system. Coupler may include rounded edge 405 with width 406, as shown in Fig. 8, are flat as shown in Fig. 7. Coupler has width 407.
One advantage of the system includes the system controller ability to test the pressure in the tank. As hydrocarbon is dispensed (e.g. at a fuel pump) the pressure in the tank drops, and N2 goes into replace. If there is a preset condition for pressure within the tank, one can monitor the level and amount of N2 sent to tank. See Figs 2-3. After each dispensation event, the system controller will stabilize and repressurize the tank with the N2 gas. When the N2 going into tank is above the amount required to replace the fuel, a leak, or other systematic issue) may be inferred. For instance, if the valves to send N2 open continuously, this may indicate a leak. The volume of dispensed fuel may also be monitored to determine the volume of replacement N2 (given known temperature and pressure). N2 dispensing may be monitored by weight.

As shown in Figs. 2 and 3, dispensation events over the course of the day demonstrate the working system. Dispensation in a retail fueling or gas station, typically involves opening a nozzle to dispense fuel (e.g. into a truck), and each station may have a single fuel tank tied to multiple nozzles (typically 1-6 nozzles). Fig. 2 demonstrates the fuel dispensations over the course of a day and effect on pressure. Fig. 3 provides a close up of fueling instances, whereby fuel dispensation takes approximately 1.5 to 4 minutes, and repressurization (which may start upon initial fuel dispensation, competes approximately 1 second after fuel finishes dispensing. As the pressure in the tank is measured with a precision monitoring system, the amount of N2 and the integrity of the system can be monitored. Keeping the tank pressure within approximately 2” water column pressure in the tank (1 psi = 26.5” water column, 1 atmosphere ~ 15 psi) the system controller can measure and detect minute pressure differences. Preferably the pressure is maintained between 1.9” and 2” of water column pressure reading.

As shown in Fig. 2, a 24-hour cycle is shown. Pressure 500 in the tank system is shown as the level of inches in the water column. Fueling from the tank system triggers the inert gas blanketing disbursement through vent opening events 501 (not all marked). The level of the inert as valve pending is indicated vertically from 100 - 260. Inert gas system valve is shown closed at 100 and fully open at 260. Typical events include fueling of one to four nozzles simultaneously. These relate to valve openings, at double nozzle dispensation event 502 and quadruple 504. Significant events show that the pressure in the system dropped below 1.9” at least four times during the day. These drops 505 indicate a partial failure of the blanketing system to completely compensate for fueling or other pressure drop events. Specifically, event 506 shows a significant
drop in the pressure of the system down to 1.6" causing a simultaneous opening of the inert gas valve 507 up to maximum of 260. It is presumed that either the inert gas was enough to overcome this event, or that the p/v vent opened to let in ambient air to restabilize pressure in system. Unusual event 510 indicates an exceptional rise in the pressure around 3:30. As yet, this appears to be a thermal/temperature event change causing the pressure to build.

As shown in Fig. 3, approximately a dozen fueling events occurred throughout the day. This represents a tight system. Particularly, stability events 610 like that around 4:00 demonstrate the stability of the pressure in system between 1.9" and 2". Fueling events 601 represent single or more fueling nozzles open in the system, causing the inert gas to repressurize/compensate. Event 602 likely shows a first fueling nozzle in use, followed by a second, whereby the first event ends and the second finishes up, a 1-2-1 nozzle opening event.

While the pressure changes on the level of 1/10" or 1/300 psi are currently performed, it is foreseen that more precision may be desirable for other thresholds and sensitivities. Current equipment is capable for greater precision. Additionally, the current algorithm used and the current statistical analysis methods allow for greater sensitivity if desirable. It is envisioned that system controllers may measure and monitor up to 1/1000" in water pressure.

The NBS system extends the quality of the fuel, which can be especially useful in backup generators that are not often filled/refilled. N2 displaces the 02 and H2O in the ullage air to prevent reaction with diesel and other fuels as mentioned above. N2 reduces the evaporation of the fuel, the degradation of the fuel, and prevents damage to the tank and tank equipment.

One additional feature of the present invention is the reduction in petroleum vapor intrusion (PVI). PVI occurs when hydrocarbons from storage tanks leaks into the ground via various holes, openings, or corrosions in the system. As N2 is the lightest material, N2 exists up and out first, including through holes within the tank itself, when ullage is exposed.

The present invention includes generated or provided pressurized source of inert vapor/gas. For example, bottles source of inert gas, combined with a p/v valve on the vent, and a pressure regulator set to release inert gas only between 2-4 inches water column. The p/v valve might hold 6 in. water pressure. When the fuel tank is used (e.g. heating oil, and generators that burn small amounts of fuel each month, and generators for short emergency use), inert gas may be
injected into the tank system. Rail cars and other mobile tanks / containers that transfer, carry, contain and load/unload explosive fuels or gasses may also be inerted via the present invention. When emptied, an automatic replacement with an inert gas reduces the potential of railcar explosions. High pressure supply of nitrogen, or other inert gas, can help contain the pressure in these systems to reduce vaporization of liquid fuels.

The present invention also includes a method for testing the system for pressure decay - and in turn test for leaks. Oftentimes, the tank is opened for testing and the system is not necessarily completely closed. The continuous use and repressurization of the tank ensures that tank pressure (and therefore leaks) are constantly checked for tight seal. One item that is of importance is to distinguish changes in temperature (i.e. daily high/low, hourly, seasonal, etc.) and atmospheric pressure. Given the exactitude of the pressure monitoring system, such items must be taken into account to determine if a drop in system pressure is simply due to temperature drop in tank ullage.

Following is a description of a method that may be used in a pressure delivery system, such as that shown in Fig. 4, that has a Primary function to vend N2 and a Secondary function to fill the tank. The use of this method is for situations where the Primary function of a deliver system is to maintain a minimum pressure / volume of a fluid (vaporous or liquid) for a specific function for example filling tires. While seemingly obvious once described, the industry has not used the method for control or configuration.

In this case we will use 100 psi as the minimum pressure needed or the Primary function. There is also a maximum pressure for the Primary Tank 100, for illustration we will say that is 135 psi. There is a Secondary use or need for the fluid. As long as the Primary pressure vessel 100 maintains the minimum pressure (100 psi), the fluid may be used or diverted from the Primary function to flow into a hose, line, or tank to use, control, direct or store the available excess fluid under pressure from the delivery source. In this example, the Secondary function 104 has a use or uses that could utilize the excess fluid / pressure, but does not require the same pressure as the Primary function. The Secondary use may use the excess pressure as it is delivered or it may be stored in a Secondary vessel or vessels.

For instance, the Primary system could require that there be a 5 gallon pressure vessel 101, that maintains at least 100 psi, to fill tires. If this tank falls to 100 PSI (monitored by a pressure
sensor), the compressor (part of Primary tank 100, along with compressor, nitrogen generator) moving air through a Nitrogen generator 100, shall be started to keep the Primary vessel 101 at or above 100 psi. This Primary vessel 101 has a valve as a pressure relief or solenoid valve that allows flow from the Nitrogen Generator along conduit 105 into the tank 101, and out to the tire filling equipment 106 but does not allow the fluid (Nitrogen) to the Secondary system 103 or purpose 104 unless it is determined that the primary source tank 101 is at or above the desired (100 psi) pressure.

The Secondary system may use the Nitrogen (or air, or liquid) that is in excess of the needs of the Primary system. The Secondary system could be used to deliver the excess full operating pressure or may be used to deliver to a need or purpose that is less than the full operating pressure of the Primary purpose. For example, the Nitrogen used for filling tires may also be desirable to use as a blanket on top of fuel or to prevent air from being sucked into the ullage or headspace of a UST('s) or AST('s). This delivery system responds to the pressure in the Primary Tank and the need of the secondary system. As long as pressure is above the minimum 100 psi pressure in the Primary tank, fluid is available to flow into the Secondary tank. As pressure reaches 100 psi in both the Primary and Secondary tank, pressure flows equally into the Primary and Secondary tanks. In this example, when pressure reaches 135 psi in the Primary tank, the flow is stopped.

For efficiency and cost effectiveness the control of the compressor or pump providing pressure to the described system is important. It is important to insure the runtime of equipment does not exceed manufacturer guidelines. The system as described, only responding to pressure, may call for the delivery system to run continuously. For equipment not rated for continuous use, this may lead to system failure due to premature equipment failure. A control system monitoring the run time of the pump /compressor can protect this equipment. The control should be such that the runtime is set to not exceed the equipment parameters or may be variable to be set for runtime to meet equipment that is changed out during the life of the system. Insuring the Primary system needs are met and insuring there is adequate off or quiet time to prevent compressor damage by restricting the secondary use from overriding the needed down or off time for the specific equipment providing pressure.
This type of control means there is special consideration given to insure that equipment run parameters are followed. A compressor that is equipped with pressure responsive controls only responds to the demand of pressure only. This type of setup can cause the equipment to run continuously. Certain compressors are not equipped to run continuously compressor type such as reciprocating, screw, scroll is made to insure the needed pressure / volume to fill the Primary function is then identified, then the compressor CFM at pressure desired is sized along with the appropriate storage tank size to insure the volume needed for the primary purpose never has the compressor run, for longer than specified by the manufacturer. Other efficiencies such as elevation, equipment and diurnal temperatures need to be included in CFM / pressure calculations. Additionally, the desired volume for the secondary use should be considered; is it important to meet 1-100 percent of the secondary volume required. The available run time to meet this need should be considered, then the volume and pressure sized as well as the required (pressure compensated) storage volume required.

The type of compressor (such as reciprocating, screw, scroll) and speed/volume of compressed air produced is determined by the compressor. For best practices, if the reciprocating compressor should only have a 50% duty cycle and a max run time of 15 minutes, the compressor should only be started when air is called for, or when pressure in one of the reserves is below a set low threshold, but not run for greater than the max run time. For example, the next compressor "start" is triggered when Nitrogen reserve falls below 100 psi. In another embodiment with two nitrogen reserves, or in an embodiment with a compressed air reserve (for use as compressed air) and at least one nitrogen reserve, a threshold may be set by each of both or all reserve tanks to trigger the compressor.

One aspect of the present invention includes a method to introduce Nitrogen from a high or top point in the system, in a controlled, non-turbulent manner. This allows the nitrogen to blanket the hydrocarbon and reduces mixing of Nitrogen and hydrocarbon.

The embodiments set forth in this application specification are for illustrative purposes alone, and should not be seen to limit the inventions as described and presently claimed. The terms Nitrogen and N2 typically refer to molecular nitrogen and nitrogen gas, respectively, however use in this specification may be interchangeable, or refer to nitrogen in a general sense.
I CLAIM:

1. An apparatus for protecting deterioration of a fuel storage tank, said apparatus comprising:
   (a) a Nitrogen gas generator supplying a source of N2 under pressure;
   (b) a source of compressed Nitrogen supplying N2 under pressure;
   (c) a conduit for interconnecting said source with the ullage of the fuel storage tank;
   (d) a valve for controlling flow of nitrogen through said conduit into the ullage;
   (e) a pressure vacuum valve controlling the pressure, negative or positive in a tank separate from ambient atmospheric pressure; and
   (f) a vent for exhausting the nitrogen from the ullage upon replenishing the storage tank with fuel.

2. The apparatus as set forth in Claim 1 further comprising an annular compartment about the storage tank, said conduit including a connection with said annular compartment to surround the storage tank with nitrogen.

3. The apparatus of Claim 1 further comprising a controller for controlling release of Nitrogen gas.

4. The apparatus of Claim 3 further comprising a monitor to test pressure within the tank and relay system to send information regarding the pressure in the tank to said controller.
5. The apparatus of Claim 3 further comprising a programmable system programmed to respond to drops in pressure in the tank and supply a determined amount of Nitrogen gas into the tank to stabilize pressure within the tank.

6. The apparatus of Claim 5 whereby the amount of N2 determined to be supplied by controller is determined by weight.

7. The apparatus of Claim 3, wherein said monitor further adapted to control nitrogen fill into said tank ullage to achieve a predetermined pressure in said tank.

8. The apparatus of Claim 1 further comprising a nitrogen dispensation hose for optional direct dispensation of nitrogen gas from system.

9. The apparatus of Claim 8 further comprising a secondary N2 reservoir to accept N2 from generator and supply N2 to said N2 dispensation hose.

10. The apparatus of Claim 1 further comprising a source for volatile corrosion inhibitors, whereby VCIs may be drawn to join with said nitrogen gas into said ullage.

11. The apparatus of Claim 1 further comprising a secondary conduit in fluid communication with said nitrogen source and an interstice of the tank, to allow nitrogen to flow into and/or through said interstice.

12. A method for controlling release of hydrocarbons from a fuel storage tank, said method comprising the steps of:

    filling the tank with fuel;
tapping the tank ullage with nitrogen gas from a nitrogen source;

monitoring the pressure within the tank;

topping off the tank with additional nitrogen when the pressure in the system drops below a predetermined threshold.

13. The method of Claim 12 further comprising the step of generating nitrogen to fill said nitrogen reserve.

14. The method of Claim 12 further comprising the step of dispensing nitrogen from reserve into nitrogen dispensation hose.

15. The method of Claim 12, whereby the step of monitoring detects the timing and proportion of the topping off events, and further including the step of detecting a leak.

16. An apparatus for protecting deterioration of a fuel storage tank, said apparatus comprising:

(a) a source of compressed inert gas under pressure;

(b) a conduit for interconnecting said source with the ullage of the fuel storage tank;

(c) a valve for controlling flow of the inert gas through said conduit into the ullage;

(d) a pressure vacuum valve controlling the pressure, negative or positive in a tank separate from ambient atmospheric pressure; and

(f) a vent for exhausting gases within the tank.
1. An apparatus for protecting deterioration of a fuel storage tank, said apparatus comprising:
   (a) a Nitrogen gas generator supplying a source of N2 under pressure;
   (b) a source of compressed Nitrogen supplying N2 under pressure;
   (c) a conduit for interconnecting said source with the ullage of the fuel storage tank;
   (d) a valve for controlling flow of nitrogen through said conduit into the ullage;
   (e) a pressure vacuum valve controlling the pressure, negative or positive, in a said fuel storage tank separate from ambient atmospheric pressure;
   (f) a vent for exhausting the nitrogen from the ullage upon replenishing the storage tank with fuel coupled with said pressure vacuum valve;

   wherein said fuel storage tank comprises a small or medium sized underground storage tank.

2. The apparatus as set forth in Claim 1 further comprising an annular compartment about said fuel storage tank, said conduit including a connection with said annular compartment to surround the fuel storage tank with nitrogen.
3. The apparatus of Claim 1 further comprising a controller for controlling release of Nitrogen gas.

4. The apparatus of Claim 3 further comprising a monitor to test a pressure within the fuel storage tank and relay system to send information regarding the pressure in the fuel storage tank to said controller.

5. The apparatus of Claim 3 further comprising a programmable system programmed to respond to drops in pressure in the tank and supply a determined amount of Nitrogen gas into the tank to stabilize pressure within the tank.

6. The apparatus of Claim 5 whereby the amount of N2 determined to be supplied by controller is determined by weight.

7. The apparatus of Claim 3, wherein said controller further adapted to control nitrogen fill into said tank ullage to achieve a predetermined pressure in said tank.

8. The apparatus of Claim 1 further comprising a nitrogen dispensation hose for optional direct dispensation of nitrogen gas from generator.
9. The apparatus of Claim 8 further comprising a secondary N2 reservoir to accept N2 from generator and supply N2 to said N2 dispensation hose.

10. The apparatus of Claim 1 further comprising a source for volatile corrosion inhibitors, whereby VCIs may be drawn to join with said nitrogen gas into said ullage.

11. The apparatus of Claim 1 further comprising a secondary conduit in fluid communication with said nitrogen source and an interstice of the tank, to allow nitrogen to flow into and/or through said interstice.

12. A method for controlling release of hydrocarbons from an underground fuel storage tank, said method comprising the steps of:
   - filling the tank with fuel;
   - topping the tank ullage with nitrogen gas from a nitrogen source;
   - monitoring the pressure within the tank;
   - topping off the tank with additional nitrogen when the pressure in the system drops below a predetermined threshold.

13. The method of Claim 12 further comprising the step of generating nitrogen to fill a nitrogen reserve.
14. The method of Claim 12 further comprising the step of dispensing nitrogen from reserve into a nitrogen dispensation hose.

15. The method of Claim 12, whereby the step of monitoring detects the timing and proportion of the topping off events, and further including the step of detecting a leak.

16. An apparatus for protecting deterioration of an underground fuel storage tank, said apparatus comprising:
   (a) a source of compressed inert gas under pressure;
   (b) a conduit for interconnecting said source with the ullage of the fuel storage tank;
   (c) a valve for controlling flow of the inert gas through said conduit into the ullage;
   (d) a pressure vacuum valve controlling the pressure, negative or positive, in a tank separate from ambient atmospheric pressure;
   (e) a vent for exhausting gases within the tank; and
   (f) a second conduit for interconnecting said source with an interstice surrounding the fuel storage tank.

17. The apparatus of Claim 1 wherein said Nitrogen gas generator comprises an air compressor.
18. The apparatus of Claim 17 further comprising a compressed air reserve tank coupled to said Nitrogen gas generator to supply said Nitrogen gas generator with compressed air.

19. The apparatus of Claim 1 wherein said storage tank is coupled to a fuel dispenser at a retail fueling station adapted to dispense fuel in a vehicle operating fuel tank.

20. The apparatus of Claim 1 further comprising a Nitrogen vending station coupled to said source.

21. The apparatus of Claim 1 further comprising a second conduit interconnecting said source with an interstice of said fuel storage tank.

22. The apparatus of Claim 10 wherein said source for volatile corrosion inhibitors is coupled to a venting system for said fuel storage tank adapted to allow VCI s to coat the interior surface of said vent.

23. The apparatus of Claim 10 wherein said source for volatile corrosion inhibitors is coupled to a venting system for said fuel storage tank adapted to allow VCI s to coat an interior surface of said vent.
24. The apparatus of Claim 10 wherein said source for volatile corrosion inhibitors is coupled to a fuel delivery system adapted to allow VCIs to coat an interior line of said fuel delivery system.

25. The apparatus of Claim 21 further comprising a source for volatile corrosion inhibitors coupled to said interstice.

26. The method of Claim 12 wherein said step of topping is conducted at a low pressure so as to minimize turbulence in said ullage.

27. The method of claim 26 wherein said low pressure is at or below 5 p.s.i.

28. The method of Claim 12 further comprising the step of testing the storage tank for pressure decay.

29. The method of Claim 12 wherein said step of monitoring is conducted with a p/v sensing transducer.

30. The method of claim 29 wherein said p/v sensing transducer uses a narrow sensing range between 10 inches of water column positive and 10 inches of water column negative.
31. The method of Claim 12 further comprising the step of injecting dry gas.

32. The method of claim 31 wherein said step of injecting forces dry gas into the storage tank ullage to dry the ullage space.

33. The method of claim 31 wherein said step of injecting forces dry air into the storage tank interstice to dry the interstice space.

34. The method of Claim 12 further comprising the step of probing the pH of the ullage of the storage tank.

35. The method of Claim 34 wherein said step of probing comprises the use of test strip containing copper.

36. The method of Claim 12 further comprising the step of coating the interior surfaces of the storage tank system with VCIs.

37. The method of Claim 12 further comprising the step of coating a fuel dispensing system coupled to said storage tank with VCIs.

38. A method of detecting leaks in an underground fuel storage tank comprising the steps of:
(a) pressurizing the ullage space of the storage tank to a predetermined pressure level;
(b) testing the pressure in the tank ullage space;
(c) dispensing fuel from the storage tank to drop the pressure within the storage tank;
(d) monitoring the amount of fuel dispensed in said step of dispensing;
(e) repressurizing the ullage space of the storage tank to said predetermined pressure level;
(f) determining the amount of gas required to repressurize the ullage space;
(g) calculating if the amount of gas required to pressurize the ullage space coincides with a predicted amount of gas based on the amount of fuel dispensed;
(h) alerting of a potential leak if the amount of gas determined to repressurize the ullage space exceeds the calculated amount.

39. The method of Claim 38 wherein said step of pressurizing and repressurizing are completed using a source of inert gas.
INTERNATIONAL SEARCH REPORT

International application No. PCT/US 16/34900

A. CLASSIFICATION OF SUBJECT MATTER

IPC(8) : F17C 3/02, 3/10, 3/12 (2016.01)
CPC : A62C 9/0018; B64D 37/32; F17C 3/02, 3/10, 3/12

According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)

IPC(8): F17C 3/02, 3/10, 3/12; B64D 37/32 (2016.01)
CPC: A62C 9/0018; B64D 37/32, 2700/62456; F17C 3/02, 3/10, 3/12; Y10S 220/901; Y10T 137/86228, 137/86196, 137/4824

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Electronic data base consulted during the international search (name of data base and, where practicable, search terms used)

PatSeer (US, EP, WO, JP, DE, GB, CN, FR, KR, ES, AU, IN, CA, INPADOC Data); Google, Google Scholar, ScienceDirect;

Keywords: fuel, gas, inert, nitrogen, blanket, corrosion, fire, insulation, tank, container, cryogenic

C. DOCUMENTS CONSIDERED TO BE RELEVANT

<table>
<thead>
<tr>
<th>Category*</th>
<th>Citation of document, with indication, where appropriate, of the relevant passages</th>
<th>Relevant to claim No.</th>
</tr>
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<tbody>
<tr>
<td>X</td>
<td>US 2,889,955 A (NUALTY, HW et al.) 09 June 1959; figure 1, column 1, lines 20-30, lines 50-72, column 2, lines 5-20, lines 25-40, lines 45-50, column 3, lines 20-30</td>
<td>16 1-14 1-3-10, 11-14</td>
</tr>
<tr>
<td>Y</td>
<td>US 5,979,481 A (AYRESMAN, L) 09 November 1999; column 1, lines 20-30, column 2, lines 10-15, column 5, lines 5-10, column 6, lines 35-45</td>
<td>12 15</td>
</tr>
<tr>
<td>Y</td>
<td>US 2002/084080 A1 (GOLNER, TM et al.) 04 July 2002; figure 1, paragraphs [0004], [0017], [0022], [0025]</td>
<td>1-14</td>
</tr>
<tr>
<td>Y</td>
<td>US 3,935,957 A (HASEGAWA, T) 03 February 1976; column 1, lines 30-35, column 2, lines 35-40</td>
<td>2</td>
</tr>
<tr>
<td>Y</td>
<td>CN 203408423 U (Beijing Taihejia Firefighting Equipment Co Ltd) 29 January 2014; paragraphs [0004], [0007], [0009]</td>
<td>4</td>
</tr>
<tr>
<td>Y</td>
<td>GB 826,965 A (General Electric) 27 January 1960; page 1, lines 50-55, lines 65-75</td>
<td>7</td>
</tr>
<tr>
<td>Y</td>
<td>US 6,152,192 A (KLOTZ, MF et al.) 28 November 2000; column 6, lines 1-5, column 6, lines 55-60, column 19, lines 15-20</td>
<td>5-6</td>
</tr>
<tr>
<td>Y</td>
<td>US 2007/138031 A1 (MIKSIC, BA) 21 June 2007; figure 1, paragraphs [0018], [0027]</td>
<td>10</td>
</tr>
<tr>
<td>Y</td>
<td>JPH 109493 A (Tokico Ltd.) 13 January 1998; paragraphs [0010], [0050]</td>
<td>15</td>
</tr>
</tbody>
</table>

Further documents are listed in the continuation of Box C. See patent family annex.

Date of the actual completion of the international search 05 August 2016 (05.08.2016)

Date of mailing of the international search report 02 SEP 2016

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PCT OGP: 571-272-7774

Form PCT/ISA/210 (second sheet) (January 2015)