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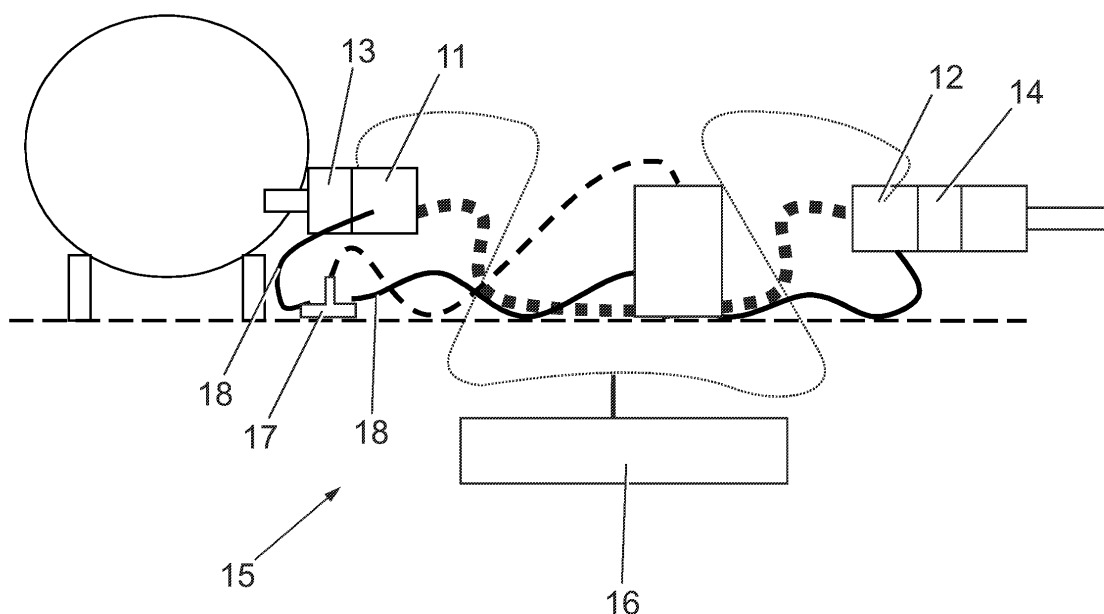
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(54) **Apparatus and method for testing vapor recovery systems**

(57) A test apparatus (15) locatable in a vapour recovery system (1) for recovering a volatile organic compound comprising a pressure sensor (16) arranged to measure a pressure or a pressure interval in the vapour recovery system (1). The pressure sensor (16) is arranged to perform the pressure measurement without

substantially affecting the flow rate pressures of fluid in the vapour recovery system (1). A method of pressure measurement in a vapour recovery system (1) and a method of risk assessment in a vapour recovery system explosive atmosphere are also disclosed.

To be accompanied when published by Figure 2 of the drawings.



*Fig. 2*

## Description

[0001] This invention relates to a stage 1B vapour recovery test apparatus, test method and risk assessment method.

[0002] Stage 1B vapour recovery or vapour balancing involves modifying a petrol storage vent system so that the vapours displaced during unloading are returned to the road tanker.

[0003] EU Directive 94/63/EC requires the introduction, installation, operation and monitoring of so called Stage 1B vapour recovery systems at petrol filling stations across the EU member states. This measure is designed to protect the air environment from the impact of harmful volatile organic compounds (VOCs) in petrol vapours.

[0004] The installation of Stage 1B vapour recovery systems at petrol filling stations may introduce additional safety hazards and associated safety risks. They may also exacerbate any existing problems to give rise to serious hazards. Hazards include increased potential for vapour leaks and petrol spills and risks include increased potential for fires and explosions. Until recently, there has been no particular statutory obligation to identify, note and report these safety hazards or to assess the associated risks.

[0005] EU Directive 99/92/EC requires the preparation of an Explosion Protection Document (EPD) for any workplace where explosive atmospheres may arise. The preparation of an EPD is mandatory for any petrol filling station and must take particular account of the potential hazards and risks presented by, amongst other things, its Stage 1B vapour recovery system.

[0006] International Patent Specification No WO 00/50334 describes a method of testing a volatile liquid tank farm and vapour recovery system using flow meters coupled to the fill pipes.

[0007] The flow-based tests interfere with system pressure by causing disruption to the flow of fluid in the system by the flow meter element of the test piece which substantially obstructs the flow path. For large valued flow rates, the resistance to the flow by the flow meter element results in relatively small deviations in the measurement of the actual flow rate, however when measuring small flow differentials these deviations are relatively substantial compared with the actual flow rate pressures. This makes it impossible to measure back pressures, for example.

[0008] The deviations are particularly detrimental when testing the vapour recovery system with a focus on safety and environmental issues of vapour recovery. In this case, accurate readings of small flow rate pressures are required.

[0009] According to a first aspect of the present invention there is provided a test apparatus locatable in a vapour recovery system for recovering a volatile organic compound comprising means for measuring pressures and/or pressure intervals at at least one point and/or across at least one interval in the vapour recovery system, the means for measuring pressures and/or pressure intervals being adapted to perform the measurement without substantially affecting the flow rate pressures of fluid in the vapour recovery system.

[0010] Preferably, the test apparatus comprises a means for testing pressure deviations caused by the test apparatus.

[0011] More preferably, the test rig comprises a low pressure drop aspect. In this way, the test rig avoids any significant pressure deviations in the vapour recovery system caused by the test apparatus and allows for substantially normal vapour recovery system operation under test conditions.

[0012] Suitably, the test rig comprises element parts for testing pressures as may be required across various intervals along the vapour recovery system pressure gradient. In this way, the test rig can be employed to extract pressure readings at a truck vapour recovery line termination valve, at a site vapour recovery line termination valve, at a tank vent manifold or at a site underground tank.

[0013] Preferably, the test apparatus comprises a means for avoiding significant pressure deviations in the vapour recovery system caused by the test apparatus.

[0014] According to a second aspect of the present invention there is provided a method of testing a vapour recovery system for recovering a volatile organic compound comprising locating a test apparatus in the vapour recovery system and extracting pressure readings and/or pressure interval readings, the test apparatus comprising means for measuring pressures and/or pressure intervals at at least one point and/or across at least one interval in the vapour recovery system, the means for measuring pressures and/or pressure intervals being adapted to perform the measurement without substantially affecting the flow rate pressures of fluid in the vapour recovery system.

[0015] Preferably, the test method comprises a means for testing pressure deviations caused by the test apparatus.

[0016] Preferably, the test method comprises a means for avoiding significant pressure deviations in the vapour recovery system caused by the test apparatus.

[0017] In a preferred embodiment, the test method comprises a self testing aspect. In this way, the test method provides a means for testing any pressure deviations which might be introduced into the vapour recovery system by the test rig/apparatus and allows for confidence that the test method can be applied under normal vapour recovery system operation.

[0018] Suitably, the test method comprises a self correcting aspect. In this way, the test method provides a means for correcting any pressure deviations which might be introduced into the vapour recovery system by the test rig/apparatus and allows for confidence that the test method can be applied under normal vapour recovery system operation.

[0019] According to a third aspect of the present invention there is provided a vapour recovery system explosive atmosphere (VRSEA) risk assessment method comprising using pressure readings and/or pressure interval readings

to assess risks and hazards in a vapour recovery system for recovering a volatile organic compound, the pressure readings and/or pressure interval readings being extracted from a method of testing the vapour recovery system, the method of testing comprising locating a test apparatus in the vapour recovery system and extracting pressure readings and/or pressure interval readings using a test apparatus, the test apparatus comprising means for measuring pressures and/or pressure intervals at at least one point and/or across at least one interval in the vapour recovery system, the means for measuring pressures and/or pressure intervals being adapted to perform the measurement without substantially affecting the flow rate pressures of fluid in the vapour recovery system.

**[0020]** Preferably, the risk assessment method comprises a means for testing pressure deviations caused by the test apparatus.

**[0021]** Preferably, the risk assessment method comprises a means for avoiding significant pressure deviations caused by the test apparatus.

**[0022]** In a preferred embodiment, the risk assessment method comprises an environmental aspect to vapour recovery system tests/inspections. In this way, the risk assessment identifies environmental concerns about vapour balancing/vapour tightness around the efficiency of vapour recovery system operations in recovering petrol vapours from petrol tanks during petrol liquid deliveries.

**[0023]** In a further preferred embodiment, the risk assessment method comprises a safety aspect as well as an environmental aspect to vapour recovery system tests/inspections. In this way, the risk assessment identifies safety concerns about explosions and/or fires around any possible petrol vapour leaks, any possible petrol liquid spills associated with any noted abnormal/malfunctioning/inefficient vapour recovery system operation.

**[0024]** The present invention relates to a stage 1B vapour recovery system pressure based test rig set. The test apparatus and method facilitate the measurement of pressures and pressure intervals at various points in the system. These pressure readings are obtained while causing minimal resistance to the vapour flow rate pressures in the system. A high level of accuracy in the pressure measurements is particularly important when determining leaks from the vapour recovery system, particularly when there is a focus on the safety and environmental impacts of volatile organic compound vapour emissions from the system.

**[0025]** The stage 1B vapour recovery system pressure based test rig set may also be used to test pressures where Stage 2 vapour recovery (described below) is installed and/or active.

**[0026]** This test apparatus can also be "self testing" and can determine whether pressure differentials are caused by the test apparatus itself. This can enable the identification of leaks and/or defects caused by faults in the test apparatus, as distinct from the vapour recovery system.

**[0027]** Importantly, the test confirms complete vapour tightness of the 1BPTRS test piece assembly itself to eliminate the 1BPTRS apparatus as a possible vapour leak source. It can also confirm the accuracy of any site particular pressure readings on the basis of any site pre-test or mid-test of the 1BPTRS.

**[0028]** The installation and operation of Stage 1B vapour recovery systems can be monitored for compliance with the objectives of EU Directive 94/63/EC using a Stage 1B Pressure based test rig set (1BPTRS). Tests must be conducted to establish compliance with the objectives of EU Directive 94/63/EC and the 1BPTRS apparatus can be used to conduct these tests. The test method uses the Stage 1B Vapour Recovery System Pressure Based Test Rig Set (1BPTRS).

**[0029]** A Stage 1B Vapour recovery system pressure based test rig set (1BPTRS) of the invention is set up in series with a routine vapour recovery flexible hose connection between a petrol delivery tanker and a petrol filling station fixed vapour return line of the stage 1B vapour recovery system. An induced pressure gradient across the site drives vapour transfer. The in-line set up of the 1BPTRS apparatus avoids the introduction of any significant system pressure deviations by the test apparatus itself across the site. The 1BPTRS apparatus is configured in various arrangements so as to identify and test various pressure parameters at the site. In particular tests, the 1BPTRS apparatus also provides test related temporary venting as may be required to check and correct any noted pressure imbalances.

**[0030]** The 1BPTRS is a totally pressure based test rig as opposed to any flow based test rig or any combined flow and pressure based test rig. It is designed to target reading various pressure parameters in stage 1B vapour recovery systems at petrol filling stations.

**[0031]** The target readings are taken across pre-selected pressure intervals along pre-determined, and where satisfactory, well-balanced pressure gradients. The 1BPTRS does not introduce any significant resistance to vapour flows and does not present any significant pressure drop of its own accord.

**[0032]** The 1BPTRS has a total flow resistance of less than 1mb pressure drop across all test set up combinations of test piece elements. The pressure drops across elements of 1BPTRS apparatus are less than 0.5mb. The 1BPTRS enables pressure levels of the site particular vapour recovery system to be measured to within 1.0mb accuracy of actual or prevailing pressure parameters. This accuracy enables confident identification of any site particular pressure gradient imbalances by deviations from a general satisfactory target pressure gradient profile.

**[0033]** The 1BPTRS also comprises a test piece temporary vent for the discharge of any test generated site vacuum or pressure capacity. Thus at any time during the tests it is possible to re-establish a normal targeted site particular pressure gradient for vapour balancing test checks or rechecks. The provision of a test piece temporary vent also

facilitates the discharge of any test generated unforeseen excessive pressure or vacuum build-up which could develop into a test generated unsafe situation for the tanker or the site.

**[0034]** The test method of the invention employs the 1BPTRS test rig. The test method describes the set up of the 1BPTRS for testing. It is a dynamic pressure based test method. This mode of test is distinct from any static pressure test, dynamic (reactive or interactive) flow test or dynamic mixed flow and pressure test. A live test is conducted when the site vapour recovery system is operational. Tests for vapour balancing and back pressures are typically conducted during a petrol liquid delivery from tanker to site and the return of petrol vapours from site to tanker. Tests for vapour tightness and blow backs require pressures and/or vacuums to be induced and, as such, these tests can also be considered dynamic. The test of the invention identifies substantially all possible concerns related to stage 1B vapour recovery systems at petrol filling stations as described below:

### **Vapour balancing**

**[0035]** The test method investigates correct vapour balancing where this is necessary to ensure that vapour recovery flows are smooth without any vapour plug surges and that flows are proportionate to a target pressure gradient. Vapour plug surges can cause intermittent high site side pressure gradient spiking. Vapour recovery flows include complementary pressure and vacuum aspects and must not over rely on pressure elements alone.

**[0036]** The tests can confirm correct vapour balancing based on an acceptable pressure gradient with complementary pressure and vacuum aspects. The tests highlight any imbalances in pressure gradients, such as, the absence of tanker vacuum ("pull") factors or the over reliance on site pressure ("push") factors. The test method can also confirm correct installation and operation of the flame arrestor behind the site vapour recovery line (VRL) termination valve. The test highlights any possible need for servicing or replacement of this unit. The test determines correct flow patterns along the site vapour return lines and highlights any possible need to clear blockages of trapped petrol or water from these vapour return lines.

### **Vapour tightness**

**[0037]** The test method of the invention assesses the system and 1BPTRS test piece assembly vapour tightness. Vapour tightness is required to ensure the integrity of the stage 1B vapour recovery system and 1BPTRS apparatus. This will ensure that no dangerous fugitive emissions of petrol vapours are possible, especially at low levels, and eliminate the 1BPTRS as a possible leak source to confirm the accuracy of pressure readings.

**[0038]** The test can confirm correct vapour tightness under pressure across the complete stage 1B vapour recovery system and its separate elements. It shall ensure the correct emergency venting relief vacuum settings are in place for both the tanker and site pressure vacuum valve (PVV) units. The test can confirm acceptable closure operation of the site VRL termination spring loaded valve element to guarantee vapour tightness between petrol delivery intervals. It can also confirm acceptable closure operation of the site PVV units both in pressure and vacuum. It determines vapour tightness of site tank manhole cover fittings, where these must be checked for leaks which can cause a build-up of trapped explosive mixtures of petrol vapour and air, and their possible migration along ducts etc.

### **Blow backs**

**[0039]** The test method of the invention also determines where blow backs occur or might potentially occur. Blow backs are potentially extremely unsafe fugitive emissions of petrol vapours from open fill line caps which are always located at low levels. These blow backs may also be caused by faulty tank fill line internals and/or faulty overfill prevention valves.

**[0040]** The test method of the invention can confirm the extent of any tank fill line blow backs from open fill line caps and, if such a blow back exists, whether it is acceptable or unacceptable. It can confirm correct installation of tank fill line internals or otherwise highlight the need to repair faulty installation work to eliminate unacceptable blow backs. The test can verify correct installation of tank overfill prevention valves or highlight the possible need to repair faulty installation work or replace non vapour recovery compliant or pre-vapour recovery type units in order to eliminate unacceptable blow backs.

### **Back pressures**

**[0041]** The test method of the invention detects back pressures. Back pressures develop when emergency venting relief pressure is required and proves inadequate. This can result in tank ullage spaces being pressurised in excess of the site particular maximum allowable system pressure (MASP). Tank fill line vapour locks may also occur during petrol deliveries causing petrol liquid spills from open caps of well filled tanks.

**[0042]** The test method of the invention can confirm:

- Emergency venting relief pressure setting of the site pressure vacuum valves (PVVs).
- Extent of any possible back pressure build up in the site stage 1B vapour recovery system at emergency venting relief pressure of the site pressure vacuum valve(s) under various petrol liquid delivery flows and petrol vapour pressure build ups.
- Acceptability of any maximum possible back pressures on top of measured emergency venting relief pressure settings of the site PVV(s) when compared to the maximum allowable system pressure based on the site particular critical depth.

**[0043]** The test method of the invention can also measure site particular data regarding critical depth, maximum allowable pressure, emergency venting relief pressure and back pressure. This allows assessment of ways to minimise vapour recovery system back pressures by control of petrol liquid delivery flows or limiting petrol hose discharges. It is possible to accommodate stage 1B vapour recovery system back pressure by increasing the maximum allowable system pressures or by increasing critical depths between maximum levels of stored petrol and fill cap openings.

### **Risk Assessment Method**

**[0044]** Hazards and risks may be identified and assessed by means of a Vapour Recovery System Explosive Atmosphere (VRSEA) Risk Assessment Method. The test rig and the method of the invention facilitate a stage 1B vapour recovery system risk assessment and provide a novel approach to assessing some of the more significant hazards and risks concerned with delivery of petrol liquid and recovery of petrol vapours at petrol filling stations. Hazards and risks exist at petrol filling stations from the generic characteristics of petrol vapour and petrol liquid. As a result, the petrol delivery and vapour recovery operation is an inherently increased hazard and risk interval, illustrating the need for meticulous care during the vapour recovery process.

**[0045]** The risk assessment method provides a system to note substantially all possible defects of a stage 1B vapour recovery system at a petrol filling station employing the test rig and test method of the invention.

**[0046]** The risk assessment method enables identification of specific hazards based on the noted defects of the vapour recovery system.

**[0047]** The risk assessment method also evaluates the heightened potential of associated related risks of fires and explosions from petrol spills and vapour leaks around stage 1B vapour recovery systems at petrol filling stations. The risk assessment method identifies existing and/or potential hazards associated with such systems and the heightened potential for fires and/or explosions from incorrect installation or operation of elements of such systems.

**[0048]** Unambiguous recommendations for the prevention of hazards and the mitigation of risks from a stage 1B vapour recovery system can be obtained on the basis of the quality of the data obtained from the test method using a 1BPTRS test rig.

**[0049]** The risk assessment method provides the opportunity to introduce and define the relationships of the following parameters or concepts and to utilise these concepts and their relationships to assess hazards and risks related to stage 1B vapour recovery systems at petrol filling stations. This assessment may be included in an Explosion Protection Document (EPD). An EPD is a statutory requirement for all petrol filling stations under the EU Directive 99/92/EC and as transposed into member state laws throughout the EU.

**[0050]** The following concepts and their relationships are included in the risk assessment:

- Critical Depth

**[0051]** The critical depth (CD) is the height measurement from site tank maximum contents level to the tank fill line opening. This depth can be increased by lowering tank contents or raising fill caps.

- Maximum Allowable System Pressure

**[0052]** The maximum allowable system pressure (MASP) is the pressure in the ullage space or vent line of a tank which forces the petrol liquid contents of the tank to rise back up through the fill line to the fill line opening (over the height measurement of the critical depth). The maximum allowable system pressure may be increased by increasing the critical depth.

- Emergency Venting Relief Pressure

**[0053]** The emergency venting relief pressure is the pressure setting at which the site PVV units are designed to crack

open and allow full and free discharge of petrol vapours. This occurs when tank ullage spaces are tending toward over pressurisation and this cracking mechanism avoids related dangers. The emergency venting relief pressure should be decreased to compensate for back pressure only where back pressures cannot be reduced.

## 5 - Back Pressure

**[0054]** Back pressure is the increase in contained pressure in a stage 1B vapour recovery system greater than the emergency venting relief pressure. The back pressure can be reduced by reducing flow volumes. An unacceptable back pressure level is any back pressure which, when added to the emergency venting relief pressure, brings the system pressure value to a greater value than the maximum allowable system pressure. An acceptable back pressure level is the amount of back pressure which can be tolerated in addition to the emergency venting relief pressure without their combined value exceeding the maximum allowable system pressure.

**[0055]** The risk assessment method of the invention provides the opportunity to assess the impacts of the installation and operation of the stage 1B vapour recovery system at a petrol filling station against objectives of obtaining correct vapour balancing and correct vapour tightness. Critical defects such as the presence of blow backs (that is, serious vapour leaks from fill lines where vapours can escape under pressure at low levels) and back pressures, (that is, significant pressure build up beneath fully open pressure vacuum valves (PVVs)) are assessed.

**[0056]** The assessment method also addresses known stage 1B vapour recovery system defects by clearly outlining specific responses as follows:

- Improvement of vapour balancing by removing stage 1B vapour recovery system blockages and specifying vapour flows to fit stage 1B vapour recovery system constraints;
- Improvement of vapour tightness by reducing the extent of vapour leaks to acceptable levels, (such as fugitive vapour emissions from sticking open PVV units) and eliminating, as far as practically possible, vapour leak entrapment, (such as fugitive vapour emissions into underground manholes);
- Elimination of blow backs by repairing or replacing leaking fill line internals and/or faulty overfill prevention valves;
- Neutralising the impact of back pressures by increasing emergency venting volume capacity and increasing maximum allowable system pressures;

**[0057]** The risk assessment method of the invention enables reclassification of areas around test proven fill cap leaks, PVV leaks, manhole leaks etc from a "Hazard Zone 2" to a "Hazard Zone 1" on a temporary basis as an emergency response procedure. These hazard zones define stringent criteria for equipment and products operating in hazardous areas so that they have suitable protection to avoid the possibility of becoming a source of ignition. The risk assessment method also enables reclassification of areas around untested vapour recovery systems fill caps, PVVs, manholes etc on a interim basis as a pre-emptive control pending tests. This reclassification is a risk and hazard mitigation-measure rather than a prevention means.

**[0058]** Embodiments of the invention will now be described, by way of example only, with reference to the accompanying drawings in which:

- Figure 1 is a schematic representation of an operational vapour recovery system during a petrol delivery;
- Figure 2 is a schematic representation of a side view of apparatus for vacuum tests;
- Figure 3 is a schematic representation of a side view of apparatus for pressure gradient tests for vapour balancing and detection of flow path blockages;
- Figure 4 is a schematic representation of a side view of apparatus for pressure gradient tests for vapour tightness and determination of maximum back pressures;
- Figure 5 is a schematic representation of a side view of apparatus for fill line tests for normal blow backs;
- Figure 6 is a schematic representation of a side view of apparatus for fill line tests for maximum blow backs;
- Figure 7 is a schematic representation of a side view of apparatus for pressure gradient tests upstream of vapour recovery line termination valve;
- Figure 8 is a schematic representation of a side view of apparatus for pressure gradient tests to determine pressure vacuum valve pressure interval;
- Figure 9 is a schematic representation of a side view of apparatus for pressure gradient tests to measure pressure in tank ullage space;
- Figure 10 is a schematic representation of a cross section view of a fixed double female connector;
- Figure 11 is a schematic representation of a cross section view of a flexible double female connector;
- Figure 12 is a schematic representation of a front elevation of a test piece;
- Figure 13 is a schematic representation of a cross section view of a fill cap adaptor;
- Figure 14 is a schematic representation of a front elevation of a fill cap monitoring manifold;

Figure 15 is schematic representation of a front elevation view of a pressure relief tee;  
 Figure 16 is a schematic representation of a front elevation of a bypass venturi;  
 Figure 17 is a schematic representation of a cross section view of a vapour recovery line access port;  
 Figure 18 is a schematic representation of a cross section view of a pressure vacuum valve access port;  
 Figure 19 is a schematic representation of a cross section view of a tank lid access port;  
 Figure 20 is a schematic representation of a side view of a vapour recovery system;  
 Figure 21 is a schematic representation of a cross section view of a free vent;  
 Figure 22 is a schematic representation of a cross section view of a PVV;  
 Figure 23 is a schematic representation of a partial sectional view of a fill cap;  
 Figure 24 is a schematic representation of a partial sectional view of a fill cap;  
 Figure 25 is a schematic representation of a cross section view of a tank with satisfactory critical depth;  
 Figure 26 is a schematic representation of a cross section view of a tank with unsatisfactory critical depth;  
 Figure 27 is a schematic representation of a cross section view of a vapour recovery system with a blockage in the vapour return hose;  
 Figure 28 is a schematic representation of a cross section view of a tank with satisfactory critical depth;  
 Figure 29 is a schematic representation of a cross section view of a tank with unsatisfactory critical depth;  
 Figure 30 is a schematic representation of a partial sectional view of a fill riser pre vapour recovery;  
 Figure 31 is a schematic representation of a partial sectional view of a fill riser post vapour recovery, and  
 Figure 32 is a schematic representation of a cross section view of an in line fill cap adaptor.

**[0059]** Figure 1 shows a Stage 1B vapour recovery system (1) in operation during a petrol delivery. A delivery tanker (2) is unloading petrol or diesel liquid to a site tank (3). An unloading flow path (4) of the petrol or diesel liquid is shown by arrows. The petrol liquid is discharged under gravity from a truck pot (5) of the delivery tanker (2) along the flow path (4) to the bottom of the site tank (3) via a fill manifold, which is not shown. The pressure rise in the underground site tank (3) pushes petrol vapours through tank vents (6) into a vent manifold (7). A pressure vacuum valve (10) is connected to the vent manifold (7). The pressure vacuum valve (10) can alleviate excess pressures or vacuum build up in the system. The vapours then flow along a site fixed vapour recovery line (8) into a flexible vapour recovery hose (9) connected between the site fixed vapour recovery line (8) and vapour return port, not shown, of the tanker (2). The vapour then enters into a coaming, which is not shown, and back into the ullage space of the truck pot (5).

**[0060]** A graph of a theoretical pressure gradient is superimposed on the Figure showing the expected or normal pressures across the Stage 1B vapour recovery system. These pressures range from approximately - 15mb in the truck pot (5) and varies linearly across the system, as shown by the broken line, to approximately +15mb in the site tanks (3).

**[0061]** Figures 2 to 9 to show various test apparatus for conducting tests on a stage 1B vapour recovery system (1), these apparatus are known collectively as the stage 1B Pressure based Test Rig Set (1BPTRS) apparatus. Each test apparatus is connected in series with a vapour recovery flexible hose (9) connection between a delivery tanker (2) and a vapour return line (8) of the stage 1B vapour recovery system. Depending on the test, the vapour recovery path (9) may be closed or connected. That is, the vapour recovery system may be operational or inactive. Each apparatus comprises a first test piece (11), one end of the first test piece (11) being connected via a first fixed or flexible double female connector (13) to the petrol delivery tanker (2) and the other end of the first test piece (11) being connected to one end the vapour recovery flexible hose (9). The other end of the vapour recovery flexible hose (9) being connected to one end of a second test piece (12), the other end of the second test piece (12) being connected via a second fixed or flexible double female connector (13, 14) to the vapour return line (8) of the stage 1B vapour recovery system (1). Each distinct test comprises varied combinations and set up of additional different components, which are described below:

**[0062]** Figure 2 shows a vacuum capacity test apparatus (15) for conducting tests before commencement of a petrol delivery while the vapour recovery path (9) is closed. The vacuum capacity test apparatus (15) also comprises a bypass venturi (17) coupled with a gas mover, the bypass venturi (17) being connected via hose connections (18) to the first test piece (11) and the second test piece (12) and a manometer (16), the manometer (16) being connected to the first test piece (11) and the second test piece (12). The vacuum capacity test apparatus (15) enables measurement of truck side vacuum capacity and site side vacuum capacity before start of petrol delivery from pressure readings on the manometer (16).

**[0063]** Figure 3 shows a pressure gradient test apparatus (19) with the vapour recovery path (9) connected. The apparatus (19) also comprises a pressure relief tee (20) being connected to the first and second test pieces (11, 12) via hose connections (21), the pressure relief tee (20) also being coupled to a temporary vent riser. The manometer (16) is connected to the first and second test pieces (11, 12). The apparatus (19) may be used to test the system while the vapour recovery path is open and under normal delivery hose profile. The pressure or vacuum developed at the site side of a truck VRL valve, not shown, can be measured from manometer readings. The pressure or vacuum developed at the truck side of a site VRL valve can also be measured. Imbalances in vapour transfer gradient may be detected by

comparing pressure readings with a standard vapour recovery system pressure gradient model. These imbalances indicate the necessary pressure gradient interval tests to conduct, for example behind site VRL units or under the PVV.

**[0064]** Excess pressures behind any suspected VRL blockages can also be detected using this test apparatus (19).

**[0065]** Figure 4 shows a pressure gradient test apparatus (23) for testing vapour tightness and measuring maximum back pressures. The apparatus (23) also comprises a pressure relief tee (20) and a manometer (16) both being connected as shown in Figure 3. This test is conducted under conditions where vapour recovery path (9) is closed for selected delivery hose profiles. The truck vacuum with more than one petrol delivery hose (4) connected can be measured. The site pressures with at least one petrol delivery hose (4) connected can be measured. The site vapour tightness and vapour leak rates can also be measured. The vapour tightness at truck VRL closure under pressure can be determined. The vapour tightness at site VRL closure can be measured under pressure. The maximum back pressures in excess of the set PVV relief pressure can also be measured.

**[0066]** Figure 5 shows a fill line test apparatus (24) for normal blow backs. The fill line test apparatus (24) also comprises at least one petrol fill line (25) connected to a fill cap monitoring manifold (27). A manometer (16) is connected to at least one petrol fill line (25) via a fill cap access port (26). A pressure relief tee (20) is coupled with a temporary vent riser (22), the pressure relief tee (20) being connected across the first and second test pieces (11,12). The fill line test is conducted with normal delivery hose (9) connected and vapour recovery operational. This allows for testing selected petrol fill lines (25) during normal delivery to other fills with other delivery hoses not connected to these selected petrol fill lines. This provides evidence of normally experienced blow backs.

**[0067]** It is also possible to conduct this test without disconnecting the delivery hose from the selected petrol fill lines (25). The in line fill cap adaptor (described below) allows the valve access port to be connected in line with the delivery hose so that pressure readings can be taken while the delivery hose is connected. This minimises the pressure disturbances in the system due to conducting the test.

**[0068]** Figure 6 shows a fill line test apparatus (28) for conducting tests for maximum blow backs comprising at least one petrol fill line (25) connected via a fill cap access port (26) to a fill cap monitoring manifold (27). The manometer (16) is attached to the manifold (27) and the pressure relief tee (20) is coupled with the temporary vent riser (22), the pressure relief tee being attached to the first and second test pieces (11,12). The test must be conducted with at least one petrol delivery hose connected and the vapour recovery system (1) not connected. This allows for testing selected petrol fill lines (4) (at emergency pressure relief) of other fills with other delivery hoses not connected. This test provides evidence of simulated worst case scenario blow backs.

**[0069]** Figure 7 shows a pressure gradient test apparatus (29) for conducting tests upstream of the site VRL termination valve while the vapour recovery process is operational with the vapour recovery hose (9) connected. The apparatus (29) also comprises a VRL access port (30) mounted behind the VRL termination valve unit, not shown. The pressure relief tee (20) is coupled with the temporary vent riser (22), the pressure tee (20) also being connected to the first and second test pieces (11,12). The manometer (16) is connected via access ports to the first test piece (11) and the second test piece (12) and via the VRL access port (30) to the VRL termination valve unit. This allows for testing, as required, due to concerns regarding imbalances in the vapour recovery system. The test also measures the pressure interval at the site side of the site VRL termination valve unit.

**[0070]** Figure 8 shows a pressure gradient test apparatus (31) for measuring the PVV pressure interval while the vapour recovery process is operational with the vapour recovery hose (9) connected. The apparatus (31) also comprises a PVV access port (33) connected under the existing PVV (10) of the vapour recovery system. The pressure relief tee (20) is coupled with the temporary vent riser (22), the pressure tee (20) being connected to the first and second test pieces (11,12). The manometer (16) is connected via access ports to the first test piece (11), the second test piece (12) and the PVV (10). The manometer (16) is connected to the PVV (10) via the PVV access port (33). The apparatus (31) allows for testing when required as a result of concerns about imbalances in vapour transfer. The test measures the pressure interval at the vent manifold (7) just below the PVV (10).

**[0071]** Figure 9 shows a pressure gradient test apparatus (34) for testing the pressure gradient in the tank ullage space while the vapour recovery process is operational. The apparatus (34) also comprises a tank lid access port (35), the tank lid access port (35) being coupled to the underground tank lid. The pressure relief tee (20) is coupled with the temporary vent riser (22). The pressure relief tee (20) is also connected to the first and second test pieces (11,12). The manometer (16) is connected, via access ports, to the first test piece (11), the second test piece (12) and the tank ullage space of the underground storage tank (3). This allows for testing where there are concerns about imbalances in vapour transfer. The test measures the pressure developed in underground storage tank (3) ullage spaces.

**[0072]** Figures 10 to 20 show detailed schematics of components of the 1BPTRS apparatus.

**[0073]** Figure 10 shows a fixed double female connector (13,14) comprising two different sized female connectors (36,37), the female connectors (36,37) being attached to each other. The spigots (40,41) control the displacement of the valves in the tank VRL and the site VRL and can force the valves open to enable fluid pass through the connector (13,14) during vapour recovery.

**[0074]** Figure 11 shows a flexible double female connector (13,14) comprising two different sized female connectors

(36,37), the female connectors (36,37) being attached at each end of a hose (42). The spring loaded valve opening spigots (40, 41) operate in the same manner as those in Figure 10 to force open the tank VRL and site VRL valves to enable fluid to pass through the connector (13, 14) during vapour recovery.

**[0075]** Figure 12 shows a test piece (11,12) comprising a full bore ball valve (43), two access ports (44,45) attached at opposite sides to the full bore ball valve (43) and two differently sized male connectors (46,47) connected at polar ends of the test piece (11,12) to each of the access ports (44,45).

**[0076]** Figure 13 shows a fill cap adaptor (48) comprising a valve access port (49).

**[0077]** Figure 32 shows an in line fill cap adaptor (70) having a valve access port (71), a sensing arm (72), a cylindrical body (73), an input coupling (74) and an output coupling (75). The input coupling (74) is shaped to receive to an end of the delivery hose. The output coupling (75) is shaped to be attachable to the fill cap. The sensing arm (72) is attached at right angles to the cylindrical body (73) and the valve access port (71) is connected to an end of the sensing arm (72) remote from the cylindrical body (73). Pressures in the sensing arm (72) can be measured while the delivery hose is connected to the fill cap via the in line fill cap adaptor (70).

**[0078]** In line fill cap adaptors (70) can be used in the fill line test apparatus (24) shown in Figure 5 by connecting the in line fill cap adaptors (70) to the end of the delivery hose before the delivery commences.

**[0079]** Figure 14 shows a fill cap monitoring manifold (27) comprising a pipe (50), five fill caps (51) connected to the pipe (50), five fill cap valves (52) isolating each of the five fill caps (51) from the pipe (50), a monometer port (53) connected to the pipe (50) and a monometer isolation valve (54) isolating the manometer port (53) from the pipe (50). The fill cap monitoring manifold (27) enables measurement of pressure readings for individual fill caps or total pressure if any combination of fill caps.

**[0080]** Figure 15 shows an apparatus comprising a pressure relief tee (20) connected to two hoses (21), one end of each hose (21) is connected to the pressure relief tee (20) by an isolating valve (55) and the other end of each hose (21) is connected to a test piece access port (56). A temporary vent riser (22) is connected to the pressure relief tee (20) by an instantaneous coupling and a standard vent cap (57) is attached to the top of the temporary vent riser (22).

**[0081]** Figure 16 shows an apparatus comprising a bypass venturi (17), an instantaneous coupling to a gas mover being attached to the base of the bypass venturi (17) and two hose connections (18), the hose connections (18) being attached at one end to the bypass venturi (17) and being attached at the other end to test piece access ports (58).

**[0082]** Figure 17 shows a vapour recovery line (VRL) access port (30) comprising a valve access (59) to a VRL. The VRL access port (30) is temporarily installed on an end of the VRL (51) behind the VRL termination valve unit.

**[0083]** Figure 18 shows a PVV access port (33) comprising a valve access to a pressure monitor, the PVV access port (33) being temporarily installed on top of a vent manifold riser (60) and under the PVV (10).

**[0084]** Figure 19 shows a tank lid access port (35) comprising a valve (61), the tank lid access port (35) being temporarily connected as a replacement bung (62) for an existing bung.

**[0085]** Figure 20 shows a vapour recovery system (1) comprising first and second tanks (3), the first tank (3) is being loaded with petrol from the truck (2). The vents (6) of the first and second tanks (3) are connected to the manifold (7) and the vent manifold (7) is connected to a pressure vacuum valve (10). A fill cap (48a) of each tank (3) is open. As shown by the arrows, vapours are being emitted from the second tank (3) under pressure. The tanks (3) are situated underground and the fill caps (48a) are located at low levels. Therefore, the build up of pressure can result in blow backs causing substantial volumes of petrol vapour to be emitted from the fill caps (48a) at low levels where vapours do not disperse to the extent as petrol vapour emitted at high levels.

**[0086]** Figure 21 shows a free vent (65) and illustrates vapour emissions before vapour recovery system conversion. Before vapour recovery is activated there is free venting. Small volumes of vapour emissions are emitted from the free vent (65) at atmospheric pressure. Figure 22 shows a PVV (10) and illustrates vapour emissions after vapour recovery system conversion. Large volumes of vapour may be emitted from the PVV (10) under emergency pressure relief. Figures 21 and 22 illustrate the need to revise hazard zone limits upward based on the possible emissions of vapours before and after the vapour recovery system conversion.

**[0087]** Figure 23 shows a fill cap (48a) which is just open. Pre-vapour recovery system conversion, small volumes of vapour could leak from the open fill cap (48a) at atmospheric pressure. Figure 24 shows a fill cap (48a) which is just open. Post-vapour recovery system conversion, large volumes of vapour are emitted under pressure from the open fill cap (48a) caused by blow backs. Figures 23 and 24 illustrate that there is a minimised hazard zone around the fill cap (48a) pre vapour recovery. The hazard zone limit must be increased during the vapour recovery process after vapour recovery system conversion due to the risk of vapour leaks from blow backs.

**[0088]** Figure 25 shows a tank (3), an open fill riser (66) and a PVV (10). The pressure in the tank (3) is around 35mb to 40mb which can support around 450mm to 500mm product. The height of the fill riser above ground level, known as the critical depth (68), is 600mm and the height of the product (69) is contained in the fill riser (66) with satisfactory critical depth (68).

**[0089]** Figure 26 shows the same apparatus as figure 25 with the distinction that the critical depth is only 300mm. The pressure in the tank (3) is around 35mb to 40mb, as before. The product is not contained in the fill riser (66) and product

spills from the top of the fill riser (66). The critical depth (68) is clearly inadequate.

**[0090]** Figure 27 shows a vapour recovery system (1) comprising three tanks (3). Each tank (3) is being loaded with product at rates of 1000 l/min, 800 l/min and 700 l/min respectively as shown by the flow paths (4). Each tank (3) is attached to a common venting manifold (7) where emergency venting relief is provided by a pressure vacuum valve (10). In this case, there is a blockage, as indicated by the marking "X", in the vapour return line (8) which means that pressure may increase above the usual maximum system pressure of 35mb to 40mb. In this case, the emergency venting relief pressure will be inadequate to deal with these excess pressures and there will be a build up of back pressure which may lead to petrol spills.

**[0091]** Figure 28 and 29 show tanks (3), each tank (3) comprises a fill riser (66) and a pressure vacuum valve (10). The critical depth (68) in each fill riser (66) is approximately 700mm. In Figure 28, there is no back pressure built up and the maximum system pressure remains around 35mb to 40mb which supports approximately 500mm of product. The critical depth (68) is satisfactory since product is contained in the fill riser (66). In Figure 29 there is 20mb back pressure built up in the vent manifold riser (60) and the maximum system pressure rises to around 50mb to 60mb in the tank (3) supporting a height of product (69) of approximately 800mm. This causes petrol to spill from the top of the fill riser (66). The critical depth (68) is unsatisfactory since the maximum system pressure with the addition of back pressures has exceeded the maximum allowable system pressure.

**[0092]** Figures 30 and 31 show fill risers (66), each fill riser (66) having an open fill cap (48a) and vapour being emitted from each fill riser (66). These figures illustrate the need to revise hazard zone boundaries around fill points to accommodate vapour leaks or spills when vapour recovery is operational. In Figure 30, the vapour recovery process is not operational and small volumes of vapour may leak from the fill riser (66) at atmospheric pressure. In Figure 31, the vapour recovery process is complete and on opening the fill cap (48a), large volumes of petrol may spill under pressure from the top of the fill riser (66). These petrol spills are caused by a build up of back pressure.

## The Test Method

**[0093]** This test method is a Stage 1B vapour recovery system test method using the Stage 1B pressure based test rig set (1BPTRS) apparatus. The test method targets the monitoring of various pressure parameters of, so called, Stage 1B vapour recovery systems. These pressure parameters are targeted along the developed pressure gradient which drives the transfer of vapours in the Stage 1B vapour recovery system. The 1BPTRS apparatus is used in any actual/live or simulated dynamic test. The test method allows for measuring particular pressure parameters so as to identify compliance fits or highlight non-compliance anomalies.

**[0094]** The test method establishes whether correct vapour balancing is in place. This involves checking for back pressures (caused by system returned petrol vapour flow path induced defects or blockages) and checking for back pressures (caused by system returned petrol vapour flow paths due to intrinsic defects or line resistance). The test ensures that the vapour recovery system is of satisfactory vapour tightness by checking for blow backs at fill caps (48a) and checking for system element petrol vapour leaks. The test identifies any significant fire and explosion hazards associated with the installation and operation of stage 1B vapour recovery systems at petrol filling stations as required by Safety at Work Regulations as per EU Directive 99/92/EC. This includes checking for petrol vapour leaks particularly leaks at fill caps (48a) caused by blow backs and checking for petrol liquid spills, in particular, spills at fill caps (48a) caused by back pressures.

**[0095]** A Stage 1B vapour recovery system (1) at a petrol filling station is used when a petrol liquid delivery is made from the compartments (5) of a delivery tanker (2) to the site tanks (3) and the petrol vapours in the site tanks (3) are returned back through the Stage 1B vapour recovery system (1) to the tanker compartments or truck pots (5). The test is conducted as part of a normal petrol delivery or a petrol and diesel delivery from a tanker (2) to the site, since petrol vapours are recovered via a properly functioning Stage 1B vapour recovery system (1) as part of these deliveries.

**[0096]** The test method is a dynamic pressure test as opposed to a static pressure test since it is conducted during a live petrol liquid delivery and petrol vapour return situation with petrol liquid flowing from the tanker (2) to the site and petrol vapours flowing from the site to the tanker (2). A dynamic pressure test allows for site particular characteristics of the Stage 1B Vapour Recovery System (1) to be tested during operation.

**[0097]** The 1BPTRS test rig elements are connected at specific intervals along the normal vapour recovery flow path and pressures at various points and across specific intervals are measured.

**[0098]** The 1BPTRS test rig and the test method are designed as a pressure based test means as opposed to any flow based test means. Thus the prerequisite attribute of presenting negligible interference with the normal site particular petrol vapour flow paths to expressly avoid introducing any flow constrictions, which could cause pressure drops, facilitate back pressures etc. These flow constrictions can interfere with normal site particular vapour balancing and vapour tightness characteristics etc. The vapour recovery flow path should be via a "closed system" except for emergency pressure or vacuum relief openings (10). These openings (10) can dissipate pressures or vacuums when malfunctions occur in the vapour recovery system (1). For example, when a blockage interrupts the free flow of returning vapours

and induces excess pressure and/or vacuums in the vapour recovery system (1).

**[0099]** When the vapour recovery system (1) is operational during a delivery, petrol liquid is discharged under gravity flow from the tanker compartments (5). The ullage space of each tanker compartment (5) is fitted with a tank topside pressure vacuum valve (PVV). Each tanker compartment (5) is also connected to a topside common manifold, known as coaming, via isolating valves which are interconnected with the bottom side petrol liquid discharge valves, known as footvalves. The coaming is connected to a vapour return port adjacent to the petrol liquid discharge ports on the middle/near side of the tanker (3). When the footvalve of any pot (5) is opened, the ullage space isolating valve also opens providing a connection to the coaming and tanker vapour return port. As petrol liquid drops out of the tanker pots (5) via open footvalves, a vacuum develops in the ullage spaces of these pots (5) and extends into the tanker side vapour recovery line (VRL) (5) via the coaming and the tanker vapour return port.

**[0100]** At the same time pressures develop in the ullage spaces in the site underground storage tanks (3). The pressure rise in the underground tanks (3) "pushes" petrol vapours back along the tank vents (6), into the vent manifold (7), along the site fixed VRL (8) into the flexible vapour recovery hose (9) connected between the site fixed vapour return line (8) and the tanker vapour return port, up into the coaming and then back into ullage spaces of the pots (5) from which petrol has been dropped. The vacuum developed in these same tanker pots (5) "pulls" the returning petrol vapours back through the same vapour flow path where the vapours replace the volumes of liquid petrol, which has been dispatched.

**[0101]** During petrol liquid delivery there is a pressure gradient along the returned vapour flow path. The following are the normal expected pressures developed across a routine vapour recovery flow path. The vacuums in the tanker pots (5) will range from -15mb at the start of the petrol liquid delivery and petrol vapour recovery operation to 0mb at the end. The site tank (3) pressures will range from a maximum of +15mb at the start of the petrol liquid delivery and petrol vapour recovery operation to 0mb at the end. Hence the total pressure gradient ranges from +15mb down to -15mb. Therefore there exists a total system pressure differential range of approximately 30mb maximum across the complete Stage 1B Vapour Recovery System (1).

## Pressure Differentials and Blockages

**[0102]** If a partial blockage exists or is introduced into the stage 1B vapour recovery system (1), increased resistance to the vapour flows results, which is identified as a sudden pressure drop across the blockage interval. The total system pressure differential then needs to increase by the amount of the resistance pressure drop to contend with this resistance.

**[0103]** The following are examples of blockage induced pressure drops:

| Pressure Drop        | Effect On Total System Pressure Differentials          |
|----------------------|--------------------------------------------------------|
| 15mb slight blockage | need to increase by this amount i.e. from 30mb to 45mb |

**[0104]** For a slight blockage the tanker pot (5) vacuums tend if possible to exceed -20mb but these vacuums cannot provide in excess of this amount of "pull" so the site tank (3) pressures need to provide the equivalent extra "push" of up to approximately 25mb, allowing the site pressure vacuum valve (PVV) (10) to remain closed at a pressure interval of approximately 15mb.

| Pressure Drop         | Effect On Total System Pressure Differentials          |
|-----------------------|--------------------------------------------------------|
| 35mb serious blockage | need to increase by this amount i.e. from 30mb to 65mb |

**[0105]** For a serious blockage the tanker pot (5) vacuums tend to exceed -20mb but the tanker pot (5) vacuums cannot provide in excess of this amount of "pull" so the site tank (3) pressures need to provide the equivalent extra "push" of, up to approximately 45mb, which may or may not allow the site pressure vacuum valve (PVV) to remain closed at a pressure interval of approximately 35mb. This is a borderline example.

| Pressure Drop                      | Effect On Total System Pressure Differentials          |
|------------------------------------|--------------------------------------------------------|
| 50mb or more almost total blockage | need to increase by this amount i.e. from 30mb to 80mb |

**[0106]** Where there is almost a total blockage, the tanker pot vacuums tend to exceed -20mb but the tanker pot (5) vacuums cannot provide in excess of this amount of "pull" so the site tank (3) pressures must provide the equivalent extra "push" of up to 60mb, requiring the site pressure vacuum valve (PVV) (10) to open at a pressure interval of tending to approximately 50mb but, in effect, the pressure interval is closer to approximately 40mb with the site PVV (10) fully

opened at its set pressure of 35mb.

### Pressure venting relief and Back pressures

**[0107]** The site PVV (10) must relieve a total volume of vapours at a rate equal to the rate of petrol liquid delivered. If the PVV (10) can achieve this effect, the maximum site tank pressures are around 35mb to 45mb, the PVV (10) is open and there is no significant back pressure build-up. If the PVV (10) cannot achieve this effect, the maximum site tank pressures tend to rise to towards 100mb, the PVV (10) is open, but there is a very substantial back pressure build-up of around 55mb to 65mb. This situation can be described as a system intrinsic back pressure as opposed to a blockage induced back pressure.

|                                 |                                                                                                 |
|---------------------------------|-------------------------------------------------------------------------------------------------|
| In general back pressures       | Are a major concern / cause of Petrol vapour leaks / liquid spills                              |
| Blockage induced back pressures | Can usually be identified and then eliminated                                                   |
| System intrinsic back pressures | Are not so easily identified and therefore much more difficult, if not impossible, to eliminate |

**[0108]** The following main defences can mitigate the impact of system intrinsic back pressures:

- Provision of extra emergency venting volume capacity i.e. installation of a second PVV unit where possible.
- Minimising flow rates i.e. restricting petrol liquid delivery hose (4) profiles-most standard site PVV (10) unit installations can cope with a three hose profile, with hose restrictions applied, this can be reduced to a two hose profile.
- Increasing critical depths (68) i.e. lowering tank maximum high level gauge alarm settings to effectively curtail the volume of petrol liquid stored in the site tanks (3). This measure increases the critical depth (68) and associated maximum allowable system pressure to cope with any identified system intrinsic back pressures.

### Test Method Target Pressure Parameters

**[0109]** The tests target certain pressure parameters:

| Pressure Parameter                                                                                                                                                                                                             | Relevant Pertinent Reason                                                                                                                                                                                                                                                                                         |
|--------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|-------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| Tanker PVV vacuum capacity @ approximately 20mb                                                                                                                                                                                | To confirm tanker "pulling" contribution to petrol vapour transfer from site tanks to tanker pots                                                                                                                                                                                                                 |
| Site PVV vacuum capacity @ approximately 2mb                                                                                                                                                                                   | To confirm emergency intake of air at site PVV when site tank ullage space pressure drops below this level under heavy petrol dispensing into site customer vehicles between tanker petrol liquid deliveries                                                                                                      |
| Site PVV pressure capacity @ approximately 35mb                                                                                                                                                                                | To confirm emergency release of petrol vapour when site tank ullage space pressure rises above this level during tanker petrol deliveries for any reason e.g. flow path blockages (partial / complete)                                                                                                            |
| Site vapour tightness (total system) @ total system pressure decays of less than 1mb per minute with system pressure = 25mb                                                                                                    | To confirm that any one or any number of combined total system fugitive vapour emissions do not render the total system return vapour flow path as not satisfactorily enclosed                                                                                                                                    |
| Site vapour tightness (particular elements include fill lines, VRL valves, manhole cover fittings etc. @ element pressure decays of less than 25mb / minute with system pressure = 25mb <u>or</u> where a "leak" is identified | To confirm that any one system element fugitive vapour emission does not render the total system return vapour flow path as not satisfactorily enclosed or constitute a leak - A "leak" is confirmed by a reading of 100% L.E.L. using an explosimeter in accordance with established oil/gas industry procedures |

Table continued

| Pressure Parameter                                                                                                                                                                                                                       | Relevant Pertinent Reason                                                                                                                                                                                                                                                                                            |
|------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| Total system vapour balancing i.e. prevailing pressure gradients during a normal petrol/diesel delivery to the site @ -15mb up to +15mb without Stage 2 vapour recovery active or @ +5mb up to +35mb with Stage 2 vapour recovery active | To confirm a total differential pressure between the tanker pots and the site tanks of approximately 30mb to help "pull" and "push" Petrol vapour transfer indicating correct vapour balancing and To confirm the absence of any pressure gradient imbalances which may indicate possible vapour flow path blockages |

**[0110]** Some petrol pumps have Stage 2 vapour recovery installed where the vapours emitted at the petrol pumps while petrol is being extracted are returned to the tank under pressure. Stage 2 vapour recovery is active in these pumps while cars or other vehicles refuelling. Vapour emissions are captured at the petrol dispenser nozzles and returned to the ullage spaces of underground tanks on site. Typically, the Stage 2 vapour recovery increases prevailing pressure gradients in the system during Stage 1B vapour balancing. Therefore, the theoretical or normal pressure values of the system where Stage 2 vapour recovery is active vary compared to where it is not installed and/or active. The test method can be conducted when Stage 2 vapour recovery is installed and/or active. However the theoretical or normal pressures will vary from the model where Stage 2 vapour recovery is not active.

### Test Method Procedure

**[0111]** An example of the test method procedure is as follows:

1. Check whether Stage 1B vapour recovery is active or not.
2. Check whether Stage 2 vapour recovery is active or not.
3. Prepare test method statement.
4. Prepare test risk assessment.
5. Obtain test work clearance permit etc.
6. Obtain necessary authorisation to conduct work.
7. Obtain tank gauge report to check tank (3) contents, temperatures etc.
8. Note any anomalies on tank gauge reports.
9. Note number of petrol tanks (3) and diesel tanks (3) .
10. Check for corresponding petrol and diesel tank fill line caps (48a) and diesel tank fill line caps (48a).
11. Check the corresponding petrol and diesel tank vents (6).
12. Note number of vents (6) connected into petrol vent manifold (7) and the level of the petrol tank vent manifold (7). The manifold is classified as high level if it is greater than four meters above ground level and low level if it is less than one meter above ground level.
13. Check information signs to confirm the installation of overfill prevention valves in conjunction with presence of a low level petrol tank vent manifold (7) and check that the overfill prevention valve type is vapour recovery compliant.
14. Check the location of petrol tank lid access manholes.
15. Set out cones to flag hazard areas in accordance with Hazard Zone Classification and check individual petrol tank lid access manholes for vapour accumulations (indicative of leaks).
16. Test for the presence of pre-test petrol vapours in each petrol tank lid access manhole. Note any Lower Explosive Limit (LEL) readings on explosimeter in order to conduct comparisons.
17. Clear any traces of petrol vapours found in petrol tank lid access manholes by venting or other appropriate means.
18. Measure the height difference between highest tank lid and its fill cap opening. This is the critical depth and should be greater than 500mm.
19. Calculate corresponding pressure required to lift petrol liquid by this height. This is the site particular Maximum Allowable System Pressure and should be greater than 40mb.
20. Set out test rig parts in preparation for arrival of delivery tanker (2). Connect the double female connectors (13,14) to the test pieces (11,12) and close all test rig element valves.
21. When the delivery tanker (2) arrives, the truck driver is to be notified of possible delays with delivery due to requirement to start and/or stop hose drops to facilitate conducting tests.
22. Connect the double female connectors (13,14) directly to the site vapour recovery line (VRL) valve and the tanker VRL valve.
23. The vapour recovery hose (9) is connected at each end to the test pieces (11,12).
24. Connect the bypass venturi (17) between the tanker side and the side of the test pieces isolating full bore ball

valves (43).

25. "Pull" vacuum (using venturi (17)) from tanker (2) to site to determine tanker pressure vacuum valve (PVV) vacuum capacity. This should be approximately 20mb.

26. Pull vacuum from site to tanker (2) to show site PVV vacuum capacity. The site PVV vacuum capacity should be 2mb.

27. Remove bypass venturi (17).

28. Replace bypass venturi (17) with a pressure relief tee (20) and temporary vent (22). This apparatus is used only if excess vacuums or pressures are noted during the course of test procedures.

29. Connect delivery hoses (4) for a normal standard site particular delivery of, say, 2 hose petrol and 1 hose diesel. The site particular delivery may be in accordance with a delivery schedule agreed by the appropriate persons.

30. Run diesel hose only.

31. Check for any excess pressure build up on the site side. There should be no pressure build up (w.r.t. atmospheric pressure) at the site side to confirm that diesel vent is separate from the petrol vent manifold (7) i.e. the diesel vent is not connected to the petrol vent manifold (7).

32. Relieve any pressure variations from atmospheric pressure in either the tanker pots (5) or the site tanks (3) using the pressure relief tee (20) and temporary vent (22).

33. Note the tanker pots vacuum at zero and the site tanks pressure at zero.

34. Open the test piece full bore ball valves (43).

35. Run the standard site particular delivery of say 2 hose petrol/1 hose diesel with vapour recovery active as per normal procedures.

36. Note the pressure prevailing at the tanker VRL valve. This should be approximately —15mb vacuum.

37. Note the pressure prevailing at the site VRL valve. This should be approximately -10mb vacuum.

38. These pressure readings confirm a normal pressure gradient for Stage 1B vapour recovery - without Stage 2 vapour recovery active.

39. Note that if pressure readings deviate substantially from a standard pressure gradient model intermediate pressure gradient tests may be required. For example pressures behind site VRL valve, under pressure vacuum valve (PVV) (10) or at tank lids may be read, as required, by way of a separate follow up retest.

40. If required install VRL access port (30) and check the pressure differential across site flame arrestor between the test piece (12) and the VRL access (30). A pressure differential in excess of around 5mb indicates that the site flame arrestor needs to be serviced or replaced.

41. If required, install a PVV access port (33) and check the pressure differential across site VRL pipe (51) length from vent manifold (7) to termination unit between the PVV access (33) and VRL access (30). An excess of greater than 5mb indicates that there is a blockage in this pipe length which needs to be cleared.

42. If required, install tank lid access port (61) on any selected tank (3) and check pressure differential across the vent pipe (6) of the selected tank (3) to the vent manifold (7) between the tank lid access port and the PVV access port (33). A pressure excess of greater than 10mb indicates that there may be a blockage in this vent pipe (6), which must be cleared, or that the vent pipe diameter is too small and a larger diameter vent pipe (6) must be installed.

43. Monitor the pressures in the system as the petrol delivery or petrol and diesel delivery proceeds.

The pressure vacuum levels in the system should be gradually dissipating towards 0mb.

44. Allow all hoses to fully discharge to empty their respective tanker pots (5).

45. Note the final pressures at the tanker VRL valve and site VRL valve. These pressures should be close to 0mb. These intervals may be pressurised if air has been drawn in along the return vapour flow path indicating that there is a possible leak.

46. Close test piece full bore ball valves (43).

47. Connect 1 No fill cap adaptor to 1 No petrol fill cap selected to receive petrol.

48. Connect delivery hose (4) to new petrol tanker pot (5) and site tank (3). The delivery schedule may be agreed with appropriate persons.

49. Run one petrol hose only with no vapour recovery active.

50. Measure pressure rise on site side towards emergency relief pressure value.

51. Note pressure at which site PVV (10) cracks. This should be normally approximately 35mb +/- 20%, that is, between 28mb and 42mb.

52. Stop petrol delivery.

53. Note pressure at which site PVV (10) sticks closed. This should be within 5mb of cracking value of the PVV (10) and is normally approximately 30mb.

54. Open site side test piece full bore ball valve (43) and charge up tanker vapour recovery hose (9) to site side trapped system pressure.

55. Close site side test piece full bore ball valve (43).

56. Break site side test rig connector to site VRL valve, which should close tight.

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57. Break tanker side test rig connector to tanker VRL valve, which should close tight.
58. Test isolated tanker vapour recovery hose (9) for vapour tightness, pressure decays and leaks.
59. Remake tanker side test rig connector to tanker VRL valve, which should now open.
60. Remake site side test rig connector to site VRL valve, which should now open.
- 5 61. Reduce site side trapped pressure via the pressure relief tee (20) and the temporary vent (2) to approximately 25mb.
62. Measure the site vapour tightness or the total system pressure decay. This should be less than 1mb in 1 minute at 25mb trapped pressure. The borderline or worst case acceptable to pass is where it is less than 5mb in 5 minutes.
63. Connect up fill cap adaptors (48), access ports on these fill cap adaptors (48) and access port on connected fill cap adaptor to the fill cap manifold (27).
- 10 64. Check for vapour tightness of fill line internals to identify any blow backs under maximum working pressure, which now prevails with site side trapped pressure of 25mb. This should be less than 25mb rise in 1 min.
65. Break site side test rig connector (12) to site VRL valve, the VRL valve should close tight.
66. Check for vapour tightness of the closed VRL valve using an explosimeter to identify any leaks under normal maximum contrived working pressure, which now prevails with site side trapped pressure of 25mb.
- 15 67. Remake site side test rig connector (12) to site VRL valve, which should now open.
68. Connect a second delivery hose (4) on another new tanker pot (5) and site tank (3). This may be in accordance with an agreed delivery schedule.
69. Run two petrol hoses only with no vapour recovery active.
- 20 70. Measure pressure rise at the site side towards emergency relief value.
71. Note pressure at which site PVV (10) cracks, as before. Normally this pressure should be at approximately 35mb +/- 20%, that is, between 28mb and 42mb.
72. Note any pressure rise in site side trapped pressure above the PVV cracking pressure. Record any access pressure increment above the PVV cracking pressure as the site particular system back pressure, while the two petrol hoses are running.
- 25 73. Compare this maximum developed system pressure (i.e. PVV cracking pressure and back pressure) against the site particular maximum allowable system pressure as determined by the site particular critical depth. This two hose maximum developed system pressure should be less than maximum allowable system pressure, otherwise petrol deliveries must be restricted to one hose at a time. One criterion for determining where two hose delivery is satisfactory is where maximum system pressure is less than maximum allowable system pressure throughout vapour recovery.
- 30 74. If two hose delivery is satisfactory, proceed to test three hose delivery.
75. Connect a third delivery hose on another new tanker pot and site tank. The delivery schedule may be agreed with appropriate persons.
- 35 76. Run the three petrol hoses only with no vapour recovery operational.
77. Measure pressure rise on the site side towards emergency relief value.
78. Note pressure at which site PVV cracks, as before. Normally this should be approximately 35MB +/- 20%, that is, between 28mb and 42mb.
79. Note any pressure rise in site side trapped pressure above the PVV cracking pressure. Record any access pressure increment above the PVV cracking pressure as the site particular system back pressure, for three hoses running.
- 40 80. Compare the maximum developed system pressure, (i.e. the PVV cracking pressure + back pressure), against the site particular maximum allowable system pressure, as determined by the site particular critical depth (68). The three hose maximum developed system pressure should be less than the maximum allowable system pressure otherwise petrol deliveries must be restricted to two hoses at a time.
- 45 81. With maximum developed system pressure, open truck side test piece full bore ball valve and note the closure of any open pressure vacuum valve(s).
82. Note the pressure prevailing at the tanker VRL valve. This should be approximately +5mb.
83. Note the pressure prevailing at the site VRL valve. This should be approximately +10mb.
- 50 Note: These pressure readings at the tanker and site VRL valves confirm a worst case inflated pressure gradient for Stage 1B vapour recovery - with Stage 2 vapour recovery active.
84. Check full bore ball valves (43) are open on both test pieces (11,12).
85. Allow completion of delivery. This may be in accordance with the agreed delivery schedule.
86. Disconnect all delivery hoses (4) on completion.
- 55 87. Close all valves on test rig equipment.
88. Disconnect tanker vapour recovery hose (6).
89. Disconnect tanker side test rig equipment.
90. Await departure of delivery tanker (2) from site.

91. Check residual pressure in the site side system.
92. Monitor pressure drops in the site side system as petrol liquid is dispensed into site customer vehicles.
93. Conduct a re check of the site PVV vacuum capacity to ensure that the site side system is in the same condition as before commencement of test. This should be approximately 2mb vacuum.
- 5 94. Disconnect site side test rig equipment.
95. Fix site VRL locking cap and snap locked.
96. Confirm prominent display of all required warning signs.
97. Confirm presence of site VRL drain port, if required.
98. Purge all test rig equipment of any residual trapped petrol vapours using site air line.
- 10 99. Set out cones in accordance with hazard zone boundaries and check petrol tank lid access manholes one at a time.
100. Test for the presence of post test petrol vapours in each of the petrol tank lid access manholes. Note any Lower Explosive Limit (LEL) readings on explosimeter against pre-test readings.
101. Note any instances where readings are greater than 100% LEL. This confirms that there are vapour leaks from site tank manhole cover fittings, which need to be eliminated.
- 15 102. Clear any traces of petrol vapours found in petrol tank lid access manholes.
103. Obtain tank gauge report to check tank's (3) contents, temperatures etc. Note any anomalies on tank gauge reports.
104. Report site vapour recovery system is in the same condition as before commencement of the tests.
105. Write up all test log notes.
- 20 106. Complete work task end paperwork.
107. Report - no accidents.

#### The Vapour Recovery System Explosive Atmospheres (VRSEA) Risk Assessment Method

25 **[0112]** The VRSEA risk assessment method accounts for potential hazards and associated risks of stage 1B vapour recovery systems. These hazards and risks are identified by determination of general pressure parameters using the 1BPTRS apparatus to carry out the test method. The VRSEA risk assessment reports on these hazards and risks through analysis and interpretation of these pressure parameters. This risk assessment report, as required by ATEX regulations, is to be included in the explosion protection document (EPD).

30 **[0113]** The explosion protection document (EPD) must contain:

- Description of the workplace, work area, work task and substances likely to form an explosive atmosphere.
- An explosion hazard determination and risk assessment.
- Conditions for associated prevention and mitigation measures.
- 35 - A relevant zoning plan based on the likely occurrences of explosive atmospheres.
- Verification of electrical equipment versus zone certification.
- Statement of management control and line responsibilities.
- Confirmation of adequate training of relevant persons.
- Directions regarding a permit to operate system for workers involved in maintenance, repairs and installation tasks.
- 40 - Clear instructions on emergency actions.
- Confirmation of provision of explosion warning signs.

45 **[0114]** Where a stage 1B vapour recovery system is installed at a petrol filling station a significant proportion of the preparation of the EPD is concerned with ongoing issues, such as, the proper installation and functioning of the vapour recovery system and related new safety hazard and associated safety risk issues. Another element of the EPD is concerned with more intermittent maintenance, repair, and installation issues. These include the possibility of petrol spills vapour leaks from:

- Underground petrol tanks (3);
- 50 - Petrol supply lines from underground tanks (3) to dispensers; and
- Petrol dispenser housings and petrol dispenser use.

55 **[0115]** The required EPD is the responsibility of the petrol filling station local authority licensed operator whether this is the site owner or the site management contractor. This responsibility should be delegated to a person who is competent, has appropriate qualifications and experience and possesses adequate professional indemnity insurance to underwrite liabilities to the site or local authority.

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| Standard appendix For explosion protection document At petrol filling stations With stage 1B vapour recovery systems |      |                                                                 |
|----------------------------------------------------------------------------------------------------------------------|------|-----------------------------------------------------------------|
| No.                                                                                                                  | Item | Details                                                         |
| 5                                                                                                                    | A    | Name                                                            |
|                                                                                                                      |      | Pitstop Filling station                                         |
|                                                                                                                      |      | Address                                                         |
| 10                                                                                                                   |      | Junction 99 on M 100                                            |
|                                                                                                                      |      | Work area                                                       |
|                                                                                                                      |      | Installation / operation Vapour Recovery System (VRS)           |
| 15                                                                                                                   |      | Work task                                                       |
|                                                                                                                      |      | Statutory testing of VRS plus associated risk assessment of VRS |
|                                                                                                                      |      | Potential Explosive substances                                  |
| 20                                                                                                                   |      | Petrol vapours in air mixtures                                  |
|                                                                                                                      | B    | Explosion Hazard determination                                  |
|                                                                                                                      |      | Refer to VRSEA risk assessment                                  |
| 25                                                                                                                   |      | Explosion Risk assessment                                       |
|                                                                                                                      |      | Refer to VRSEA risk assessment                                  |
|                                                                                                                      | C    | Prevention measures                                             |
| 30                                                                                                                   |      | Refer to VRSEA risk assessment                                  |
|                                                                                                                      |      | Mitigation measures                                             |
|                                                                                                                      |      | Refer to VRSEA risk assessment                                  |
| 35                                                                                                                   | D    | Zoning plan / electrics                                         |
|                                                                                                                      |      | Refer to VRSEA risk assessment                                  |
|                                                                                                                      | E    | Zoning electrics                                                |
| 40                                                                                                                   |      | Refer to VRSEA risk assessment                                  |
|                                                                                                                      |      | assessment                                                      |
|                                                                                                                      | F    | Management control                                              |
| 45                                                                                                                   |      | Refer to VRSEA risk assessment                                  |
|                                                                                                                      | G    | Training                                                        |
|                                                                                                                      |      | Refer to site manager / operating manual                        |
| 50                                                                                                                   | H    | Permits to work                                                 |
|                                                                                                                      |      | Refer to site manager / operating manual                        |
|                                                                                                                      | I    | Emergency procedures                                            |
| 55                                                                                                                   |      | Refer to VRSEA risk assessment                                  |
|                                                                                                                      | J    | Warning signs                                                   |
|                                                                                                                      |      | Refer to VRSEA risk assessment                                  |
| Prepared by                                                                                                          |      | Michel O'Kane                                                   |
| Competence qualifications                                                                                            |      | Chartered engineer                                              |
| Insurance cover / reference                                                                                          |      | As may be required                                              |

**[0116]** The main safety issues of concern regarding stage 1B vapour recovery systems are those likely to allow formation of an explosive atmosphere. The explosive atmosphere may form as a result of a vapour leak and/or a petrol spill.

**[0117]** EU directive 99/92/EC - primarily requires:

- Determination and identification of prevalent hazards.
- Assessment of potential risks to workers and the public.

**[0118]** In the case of a petrol filling station stage 1B vapour recovery system, the hazards are determined by a relevant focused inspection and test procedure. This procedure is conducted as part of a normal petrol and/or diesel transfer from a delivery tanker (2) to the site underground tanks (3).

**[0119]** The inspection and test allows for determination of a profile of any target concerns. The determined results and identified concerns are capable of being assessed as to their potential risk of facilitating the development of explosive atmospheres. Since fires and explosions are caused by the presence of an explosive atmosphere, situations where explosive atmospheres can arise must form part of the profile of target concerns. The possibility of vapour leaks and petrol spills facilitating the development of explosive atmospheres must also be considered.

**[0120]** The method for analysing and interpreting the vapour recovery system inspection and test results is referred to as the vapour recovery system explosive atmospheres (VRSEA) risk assessment method.

**[0121]** The revised criteria for stage 1B vapour recovery system risk assessment under EU ATEX directive and all member state regulations requires petrol filling station operators and regulators to pay substantial attention to hazard identification and reviews of associated risk assessment methods.

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**[0122]** Vapour tightness means that the system must be free of vapour escape paths, which may leak when working pressures are applied. A leak is an emission of vapour from a vapour escape path and may be identified as being potentially explosive. Sometimes leaks cannot be clearly identified in which case pressure decay rates must be examined.

**[0123]** In order to satisfy vapour tightness criteria, pressure decay rates at 25mb working pressure which are:

- Less than 1.0mb over 1 min are defined safe passes
- Less than 5.0mb over 5 min are defined borderline passes

**[0124]** Pressure decay rates which exceed these levels will render a vapour recovery system to be classified "not vapour tight". A stage 1B vapour recovery system which is classified "not vapour tight" will facilitate fugitive vapour emissions from identified and unidentified vapour escape paths. Some or all of these vapour emissions may be considered leaks. If a stage 1B vapour recovery system is to be effective it must be vapour tight.

|                                    |                                                                                                                                                                                                                    |
|------------------------------------|--------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| Hazards And risks                  | Vapour tightness                                                                                                                                                                                                   |
| Test result                        | Not vapour tight                                                                                                                                                                                                   |
| Noted defect                       | Vapour emission paths due to poor pipe joints etc                                                                                                                                                                  |
| Hazards                            | • Vapour leaks Especially at low levels from poor pipe joints etc.                                                                                                                                                 |
| Risks                              | • Fires and explosions                                                                                                                                                                                             |
| Prevention                         | Seal all identified vapour emission paths                                                                                                                                                                          |
| Mitigation                         | Review hazardous zone limits                                                                                                                                                                                       |
|                                    | Around identified vapour leaks                                                                                                                                                                                     |
| Zoning                             | Classify surrounding area as increased hazard - Zone 1                                                                                                                                                             |
| Zone equipment                     | Use Zone 1 electrics in the surrounding area                                                                                                                                                                       |
| Line responsibility                | 1. Manager / competent person<br>2. Site operator<br>3. Site owner                                                                                                                                                 |
| Emergency action With serious leak | 1. Demarcate hazardous zone<br>2. Set out explosion warning signs<br>3. Instruct staff of hazard / risk<br>4. Keep public away from hazard                                                                         |
| Notes to site                      | Where<br>• Vapour leaks are identified / suspected<br>The ongoing response should entail<br>1. Being aware of emergency actions<br>2. Taking steps to mitigate impacts<br>3. Commissioning works to prevent causes |

**[0125]** Vapour balancing is the transfer of vapours between the underground site tanks (3) and over ground truck compartments (5) driven by a pressure gradient. This pressure gradient is developed from petrol flowing under gravity from the over ground tanker (2) to the site underground tanks (3) in a closed system.

**[0126]** A vacuum situation is developed in the ullage spaces of the over ground truck compartments (5) as they empty. This causes vapours to be pulled from the ullage spaces of the underground site tanks (3). A pressure situation is developed in the ullage spaces of the underground site tanks (3) as they fill with petrol causing vapours to be pushed toward the ullage spaces of the over ground truck compartments (5) .

**[0127]** The over ground truck (2) system can hold vacuums down to approximately -20mb. With satisfactory vapour balancing these will be typically of the order of —15mb. The underground site tanks (3) system can hold pressures of up to approximately +35mb. With satisfactory vapour balancing these will typically be of the order of +15mb. The typical pressure difference is between +15mb and -15mb and provides a driving force of 30mb to ensure effective vapour transfer over an evenly balanced pressure gradient.

**[0128]** Where pressure gradients are not evenly balanced pressure surges occur and excess pressure differences

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develop. Vapours are transferred in intermittent plugs and proper even vapour balancing does not occur. This can cause vapour recovery system excess pressure differences, which can lead to vapour leaks and/or petrol spills.

|    |                               |                                                                                                                                                                                                                                                                                                                                                                                                                     |
|----|-------------------------------|---------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| 5  | Hazards And risks             | Vapour balancing                                                                                                                                                                                                                                                                                                                                                                                                    |
|    | Test result                   | Not vapour balanced                                                                                                                                                                                                                                                                                                                                                                                                 |
|    | Noted defect                  | Deficient tanker vacuum capacity leading to higher than normal site side tank pressures                                                                                                                                                                                                                                                                                                                             |
| 10 | Hazards                       | <ul style="list-style-type: none"> <li>• Vapour leaks</li> <li>• Petrol spills (especially at low levels from open fill lines)</li> </ul>                                                                                                                                                                                                                                                                           |
|    | Risks                         | • Fires and explosions                                                                                                                                                                                                                                                                                                                                                                                              |
| 15 | Prevention                    | Ensure good tanker vacuum capacity                                                                                                                                                                                                                                                                                                                                                                                  |
|    | Mitigation                    | Review hazardous zone limits around fill line caps                                                                                                                                                                                                                                                                                                                                                                  |
|    | Zoning                        | Classify surrounding area as increased hazard - Zone 1                                                                                                                                                                                                                                                                                                                                                              |
|    | Equipment Line responsibility | Use Zone 1 electrics                                                                                                                                                                                                                                                                                                                                                                                                |
| 20 |                               | <ol style="list-style-type: none"> <li>1. Manager / competent person</li> <li>2. Truck driver</li> <li>3. Truck / tanker owner</li> <li>4. Petrol supply company</li> </ol>                                                                                                                                                                                                                                         |
| 25 | Emergency action              | <ol style="list-style-type: none"> <li>1. Demarcate hazardous zone</li> <li>2. Set out explosion warning signs</li> <li>3. Instruct staff of hazard / risk</li> <li>4. Keep public away from hazard</li> </ol>                                                                                                                                                                                                      |
| 30 | Notes to site                 | <p>Where</p> <ul style="list-style-type: none"> <li>• Vapour leaks are identified / suspected</li> <li>• There is increased potential for petrol spills to possibly occur</li> </ul> <p>The ongoing response should entail</p> <ol style="list-style-type: none"> <li>1. Being aware of emergency actions</li> <li>2. Taking steps to mitigate impacts</li> <li>3. Commissioning works to prevent causes</li> </ol> |
| 35 |                               |                                                                                                                                                                                                                                                                                                                                                                                                                     |

**[0129]** Vapour return line blockages distort the typical pressure gradient and are caused by trapped liquids such as water and/or petrol or a dirty flame arrestor.

**[0130]** Blockages result in excess pressures building in the underground site tanks (3), requiring emergency pressure relief at the site PVV (10), and excess vacuums building in the over ground truck compartments (5) requiring emergency vacuum relief at the truck PVVs. There will be more vacuum venting than pressure venting and, as a result, more air is sucked into the closed vapour recovery system at the truck side PVVs than petrol vapours expelled from same system at the site side PVVs (10). At the end of the petrol delivery and vapour recovery transfer operation the vapours contained across the whole system are more likely to be in pressure. Typically the vapours are at pressures up to +15mb.

**[0131]** It is recommended that to the following hose disconnection procedures be carefully adhered to:

- Close truck faucets, footvalves and manifold vent valves.
- Disconnect all petrol hoses (4) from truck side then from site side.
- Disconnect site side of vapour recovery hose (9)-site VRL valve to close.
- Disconnect truck side of vapour recovery hose (9)-truck VRL valve to close.
- Replace VRL end cap and snap locked.

**[0132]** Blockages from trapped liquids in the vapour recovery line result in pressure surges of intermittent plugs of vapours and entrained liquids with potential for static surcharges. Blockages from dirty flame arrestors restrict flows. In this case the flows may be steady but they must still be classified as "imbalanced", since normal balanced vapour recovery is prevented.

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**[0133]** Blockages of any type in the vapour return path can lead to vapour leaks and/or petrol spills.

|                     |                                                                                                                                                                                                                                                                                                                                                                                                        |
|---------------------|--------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| Hazards and risks   | Vapour return line blockages                                                                                                                                                                                                                                                                                                                                                                           |
| Test result         | Vapour return path pressure surges                                                                                                                                                                                                                                                                                                                                                                     |
| Noted defect        | Partial petrol liquid / water plugs in vapour recovery line traps                                                                                                                                                                                                                                                                                                                                      |
| Hazards             | <ul style="list-style-type: none"> <li>• Vapour leaks</li> <li>• Petrol spills Especially At low levels From open fill lines</li> </ul>                                                                                                                                                                                                                                                                |
| Risks               | <ul style="list-style-type: none"> <li>• Fires and explosions</li> </ul>                                                                                                                                                                                                                                                                                                                               |
| Prevention          | Remove any petrol liquid / water trapped in vapour recovery line                                                                                                                                                                                                                                                                                                                                       |
| Mitigation          | Review hazardous zone limits Around fill line caps                                                                                                                                                                                                                                                                                                                                                     |
| Zoning              | Classify surrounding area As increased hazard- Zone 1                                                                                                                                                                                                                                                                                                                                                  |
| Equipment           | Use Zone 1 electrics                                                                                                                                                                                                                                                                                                                                                                                   |
| Line responsibility | 1. Manager / competent person<br>2. Site operator                                                                                                                                                                                                                                                                                                                                                      |
|                     | 3. Site owner                                                                                                                                                                                                                                                                                                                                                                                          |
| Emergency action    | 1. Demarcate hazardous zone<br>2. Set out explosion warning signs<br>3. Instruct staff of hazard / risk<br>4. Keep public away from hazard                                                                                                                                                                                                                                                             |
| Notes to site       | Where <ul style="list-style-type: none"> <li>• Vapour leaks are identified / suspected</li> <li>• There is increased potential for petrol spills to possibly occur</li> </ul> The ongoing response should entail: <ol style="list-style-type: none"> <li>1. Being aware of emergency actions</li> <li>2. Taking steps to mitigate impacts</li> <li>3. Commissioning works to prevent causes</li> </ol> |

Overfill prevention valves are closure devices which are fitted into replacement tank internals. They have been in widespread use prior to the advent of vapour recovery. Primarily overfill prevention valves are used to prevent petrol overfills. When a stage 1B vapour recovery system is commissioned pre vapour recovery system valves may provide leak paths for petrol vapours.

**[0134]** These leak paths allow petrol vapours to be forced, under the system pressure, into the fill line (25) of any tank (3), which is not being filled, adjacent to tanks (3), which are currently being filled. The petrol vapours are then expelled under pressure from open fill caps (48a) or the vapours can force fill caps (48a) off when the caps (48a) are being routinely opened. Later generation (or vapour recovery) overfill prevention valves are fabricated and installed to withstand vapour recovery system pressures. With an active stage 1B vapour recovery system, overfill prevention valves should be vapour recovery compliant. Defective overfill prevention valves can cause vapour leaks from fill line caps (48a). These leaks are known as blow backs.

|                   |                                                                                                                |
|-------------------|----------------------------------------------------------------------------------------------------------------|
| Hazards and risks | Overfill prevention valves                                                                                     |
| Test result       | Not vapour recovery compliant or Vapour recovery compliant but not properly installed                          |
| Noted defect      | Blow back of petrol vapours from relevant open fill line                                                       |
| Hazards           | <ul style="list-style-type: none"> <li>• Vapour leaks Especially at low levels from open fill lines</li> </ul> |
| Risks             | <ul style="list-style-type: none"> <li>• Fires and explosions</li> </ul>                                       |
| Prevention        | Replace / reinstall / retest Overfill prevention valves as vapour tight                                        |
| Mitigation        | Review hazardous zone limits Around fill line caps                                                             |
| Zoning            | Classify surrounding area as increased hazard - Zone 1                                                         |

Table continued

|                     |                                                                                                                                                                                                                    |
|---------------------|--------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| Equipment           | Use Zone 1 electrics                                                                                                                                                                                               |
| Line responsibility | 1. Manager / competent person<br>2. Site operator<br>3. Site owner                                                                                                                                                 |
| Emergency           | 1. Demarcate hazardous zone                                                                                                                                                                                        |
| action              | 2. Set out explosion warning signs<br>3. Instruct staff of hazard / risk<br>4. Keep public away from hazard                                                                                                        |
| Notes to site       | Where<br>• Vapour leaks are identified / suspected<br>The ongoing response should entail<br>1. Being aware of emergency actions<br>2. Taking steps to mitigate impacts<br>3. Commissioning works to prevent causes |

**[0135]** Tank internals are fitted to supply filled petrol to the bottom of underground petrol tanks (3). Tank internals should be located alongside petrol supply lines to provide a liquid seal arrangement. When properly installed, these tank internals provide liquid seals which prevent vapours escaping from the ullage spaces (when tanks (3) have been run down by supply lines) and prevent splash filling of petrol into a tank (3) with a low product level. Deliveries of parcels of 5000 litres of petrol for periods of up to 7 minutes, commonly take place two or three times per week, on average and on very busy sites there can be up to two or three deliveries per day. Over time, the regular vortex-type filling path can loosen connections from internals to tank lids. If internals to tank lid connections become loose and the vapour recovery system is activated vapour pressures will build up in the tank ullage spaces allowing the opportunity for vapour emissions into the tank fill lines. This will result in blow backs allowing petrol vapours to be expelled under pressure at the fill caps (48a). There may also be opportunity for vapour emissions into the tank manholes causing explosive atmospheres to build up.

**[0136]** Defective fill line internals can cause vapour leaks, known as blow backs, from fill line caps (48a), or into underground tank manholes where explosive mixtures can persist.

|                     |                                                                                                                                    |
|---------------------|------------------------------------------------------------------------------------------------------------------------------------|
| Hazards And risks   | Tank internals                                                                                                                     |
| Test result         | Not vapour tight / not liquid sealed                                                                                               |
| Noted defect        | Blow back of petrol vapours / petrol sprays from relevant open fill line or vapour presence in tank manhole                        |
| Hazards             | • Vapour leaks<br>• Petrol spills Especially at low levels from open fill lines or Build up of explosive mixtures in tank manholes |
| Risks               | • Fires and explosions                                                                                                             |
| Prevention          | Replace / reinstall / retest Tank internals as vapour tight                                                                        |
| Mitigation          | Review hazardous zone limits Around fill line caps                                                                                 |
| Zoning              | Classify surrounding area as increased hazard - Zone 1                                                                             |
| Equipment           | Use Zone 1 electrics                                                                                                               |
| Line responsibility | 1. Manager / competent person<br>2. Site operator                                                                                  |
|                     | 3. Site owner                                                                                                                      |
| Emergency action    | 1. Demarcate hazardous zone<br>2. Set out explosion warning signs<br>3. Instruct staff of hazard / risk                            |

Table continued

|               |                                                                                                                                                                                                                                                                                                                                                                                                                     |
|---------------|---------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
|               | 4. Keep public away from hazard                                                                                                                                                                                                                                                                                                                                                                                     |
| Notes to site | <p>Where</p> <ul style="list-style-type: none"> <li>• Vapour leaks are identified / suspected</li> <li>• There is increased potential for petrol spills to possibly occur</li> </ul> <p>The ongoing response should entail</p> <ol style="list-style-type: none"> <li>1. Being aware of emergency actions</li> <li>2. Taking steps to mitigate impacts</li> <li>3. Commissioning works to prevent causes</li> </ol> |

A blow back is the phenomenon where petrol vapours are expelled, under pressure, from open fill lines (25). A blow back can occur at fill points where fill caps (48a) have been removed.

**[0137]** They occur when tank internals are:

- Not properly fitted.
- Too short causing the loss of any liquid seal.
- Replaced by pre-vapour recovery generation overfill prevention valves.

**[0138]** Blow backs supply substantial volumes of petrol vapours at ground level. These vapour emissions are extremely serious, therefore, blow backs must be eliminated.

|                     |                                                                                                                                                                                                                                                                                                                                         |
|---------------------|-----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| Hazards and risks   | Blow backs                                                                                                                                                                                                                                                                                                                              |
| Test result         | Overfill prevention valves / tank internals are not vapour tight                                                                                                                                                                                                                                                                        |
| Noted defect        | Petrol vapours emissions under pressure from relevant open fill line                                                                                                                                                                                                                                                                    |
| Hazards             | • Vapour leaks Especially at low levels From open fill lines                                                                                                                                                                                                                                                                            |
| Risks               | • Fires and explosions                                                                                                                                                                                                                                                                                                                  |
| Prevention          | Replace / reinstall / retest Overfill prevention valves Tank internals as vapour tight                                                                                                                                                                                                                                                  |
| Mitigation          | Review hazardous zone limits Around fill line caps                                                                                                                                                                                                                                                                                      |
| Zoning              | Classify surrounding area as increased hazard - Zone 1                                                                                                                                                                                                                                                                                  |
| Equipment           | Use Zone 1 electrics                                                                                                                                                                                                                                                                                                                    |
| Line responsibility | <ol style="list-style-type: none"> <li>1. Manager / competent person</li> <li>2. Site operator</li> <li>3. Site owner</li> </ol>                                                                                                                                                                                                        |
| Emergency action    | <ol style="list-style-type: none"> <li>1. Demarcate hazardous zone</li> <li>2. Set out explosion warning signs</li> <li>3. Instruct staff of hazard / risk</li> <li>4. Keep public away from hazard</li> </ol>                                                                                                                          |
| Notes to site       | <p>Where</p> <ul style="list-style-type: none"> <li>• Vapour leaks are identified / suspected</li> </ul> <p>The ongoing response should entail</p> <ol style="list-style-type: none"> <li>1. Being aware of emergency actions</li> <li>2. Taking steps to mitigate impacts</li> <li>3. Commissioning works to prevent causes</li> </ol> |

Vapour recovery line termination valve and locking cap are usually situated to the left of over ground fill points. They may also be located in a separate underground manhole where there are no other fill points. During vapour recovery system tests the VRL termination valve must be checked for leaks as a leaking valve unit allows petrol vapours under pressure to seep out at a low level.

**[0139]** Depending on the scale of seepage of petrol vapours, as measured by an explosimeter, an explosive petrol

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vapour/air mixture may be detected around the vapour return line termination valve and persists until the stage 1B vapour recovery system pressure dissipates to a sufficient extent. This dissipation may occur over a short period of time on a busy site but may take a considerable length of time on a more normal use site. This is most likely to occur after any wetstock product delivery where the closing, contained stage 1B vapour recovery system pressure is significantly elevated. Where the problem is likely to persist, the area around the vapour return line valve will need to be classified as Zone 1.

**[0140]** This scenario of an elevated stage 1B vapour recovery system pressure is an indication of interference with proper vapour balancing. Therefore confirmation of proper vapour balancing can be a mitigating factor with deficient termination valve units. This situation can be prevented by servicing the leaking termination valve unit or by replacing any seriously deficient termination valve unit with a workshop tested and verified vapour tight serviced unit or new factory certified unit. The vapour recovery termination valve unit should be fitted with a lockable cap to prevent unauthorised or vandal access to the spring loaded valve mechanism. Vapour recovery line termination valves should be leak proof and secured with a locking cap.

|                     |                                                                                                                                                                                                                    |
|---------------------|--------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| Hazards And risks   | Vapour recovery line termination valve / cap                                                                                                                                                                       |
| Test result         | Not vapour tight                                                                                                                                                                                                   |
| Noted defect        | Petrol vapours emissions under pressure from closed termination valve Absence of locking cap                                                                                                                       |
| Hazards             | • Vapour leaks Especially at low levels From termination closed valve Vandal access without locking cap                                                                                                            |
| Risks               | • Fires and explosions                                                                                                                                                                                             |
| Prevention          | Service / replace / reinstall / retest Termination valve / locking cap                                                                                                                                             |
| Mitigation          | Review hazardous zone limits Around fill line caps                                                                                                                                                                 |
| Zoning              | Classify surrounding area As increased hazard - Zone 1                                                                                                                                                             |
| Equipment           | Use Zone 1 electrics                                                                                                                                                                                               |
| Line responsibility | 1. Manager / competent person<br>2. Site operator<br>3. Site owner                                                                                                                                                 |
| Emergency action    | 1. Demarcate hazardous zone<br>2. Set out explosion warning signs<br>3. Instruct staff of hazard / risk<br>4. Keep public away from hazard                                                                         |
| Notes to site       | Where<br>• Vapour leaks are identified / suspected<br>The ongoing response should entail<br>1. Being aware of emergency actions<br>2. Taking steps to mitigate impacts<br>3. Commissioning works to prevent causes |

**[0141]** Underground fills are located in the tank manhole chamber and there is always the possibility of petrol drips or trickles occurring from tank lid connections. These petrol drips or trickles collect after the completion of a petrol drop via a hose delivery and the disconnection of the hoses to fill point interface. They occur more frequently where two or more petrol fill points are located in any dedicated remote fill manhole chamber.

**[0142]** As a result, free petrol accumulates in underground manholes which then evaporates to fill the manhole with a potentially explosive mixture of petrol vapours and displaced air of various concentrations at some level in these underground manholes. Such manholes must be vented to clear any petrol vapours, and, any liquid petrol must be removed before vapour recovery testing for leaks on the tank manhole lid.

**[0143]** The possibility of such petrol drips and petrol trickles cannot be prevented even with the most careful attention to petrol delivery holes to petrol fill line (25) disconnection techniques. Therefore every effort should be made to install over ground petrol fill points to eliminate petrol vapour entrapment in underground tank manhole chambers.

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|    |                      |                                                                                                                                                                                                                                                     |
|----|----------------------|-----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
|    | Hazards And risks    | Underground fills                                                                                                                                                                                                                                   |
|    | Test result          | Petrol vapours / free petrol Noted in fill manholes                                                                                                                                                                                                 |
| 5  | Noted defect         | Very slight petrol vapours emissions under pressure from relevant open fill line and/or petrol spills from filler hoses                                                                                                                             |
|    | Hazards              | Build up of<br>• Explosive atmospheres in underground fill manholes                                                                                                                                                                                 |
| 10 | Risks                | • Fires and explosions                                                                                                                                                                                                                              |
|    | Prevention           | Replace / reinstall / retest Fill lines to above ground location                                                                                                                                                                                    |
|    | Mitigation           | Review hazardous zone limits Around underground fill manholes                                                                                                                                                                                       |
| 15 | Zoning               | Classify surrounding area As increased hazard - Zone 1                                                                                                                                                                                              |
|    | Equipment            | Use Zone 1 electrics                                                                                                                                                                                                                                |
|    | Line responsibi lity | 1. Manager / competent person<br>2. Site operator<br>3. Site owner                                                                                                                                                                                  |
| 20 | Emergency            | 1. Demarcate hazardous zone                                                                                                                                                                                                                         |
|    | action               | 2. Set out explosion warning signs<br>3. Instruct staff of hazard / risk<br>4. Keep public away from hazard                                                                                                                                         |
| 25 | Notes to site        | Where<br>• Explosive atmospheres are identified in fill manholes (or tank manholes)<br>The ongoing response should entail<br>1. Being aware of emergency actions<br>2. Taking steps to mitigate impacts<br>3. Commissioning works to prevent causes |
| 30 |                      |                                                                                                                                                                                                                                                     |

**[0144]** Pre vapour recovery small volumes of vapours are emitted at atmospheric pressure from the vents and the recommended hazard zone limit around a free vent position is 1.5m. After vapour recovery, large volumes of vapours are emitted under emergency pressure relief from PVV units. Therefore once the vapour recovery system is operational the hazard zone limit around a PVV (10) should be increased to 3.0m.

|    |                      |                                                                                               |
|----|----------------------|-----------------------------------------------------------------------------------------------|
|    | Hazards and risks    | Separation distances / vents                                                                  |
|    | Test result          | Controlled petrol vapour emissions under test                                                 |
|    | Noted defect         | Simulated vapour return line blockage                                                         |
|    | Hazards              | • Vapour leaks Uncontrolled Under emergency relief pressure from site side PVV at high levels |
| 45 | Risks                | • Fires and explosions                                                                        |
|    | Prevention           | Avoid uncontrolled vapour emissions (even at high levels)                                     |
|    | Mitigation           | Review hazardous zone limits around site side PVV                                             |
| 50 | Zoning               | Classify surrounding area as increased hazard - Zone 1                                        |
|    | Equipment            | Use Zone 1 electrics                                                                          |
|    | Line responsibi lity | 1. Manager / competent person<br>2. Site operator<br>3. Site owner                            |
| 55 | Emergency action     | 1. Demarcate hazardous zone<br>2. Set out explosion warning signs                             |

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Table continued

|               |                                                                                                                                                                                                                    |
|---------------|--------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
|               | 3. Instruct staff of hazard / risk<br>4. Keep public away from hazard                                                                                                                                              |
| Notes to site | Where<br>• Vapour leaks are identified / suspected<br>The ongoing response should entail<br>1. Being aware of emergency actions<br>2. Taking steps to mitigate impacts<br>3. Commissioning works to prevent causes |

On opening a fill cap (48a), before commencement of the vapour recovery process, a small volume of vapours leak at atmospheric pressure and the pre-vapour recovery recommended hazard zone limit around a fill point is 4.5m. When the vapour recovery system is operational, on opening a fill cap (48a) a large volume of vapours may leak under pressure resulting in blow backs. The hazard zone limit around the fill point position should be increased to at least 6.0m to take into consideration possible vapour leaks from blow backs.

|                     |                                                                                                                                                              |
|---------------------|--------------------------------------------------------------------------------------------------------------------------------------------------------------|
| Hazards And risks   | Separation distances / fills                                                                                                                                 |
| Test result         | Blow backs from open fill lines                                                                                                                              |
| Noted defect        | Overfill prevention valves / tank internals are not vapour tight                                                                                             |
| Hazards             | • Vapour leaks — Under pressure Especially at low levels                                                                                                     |
| Risks               | • Fires and explosions                                                                                                                                       |
| Prevention          | Replace / reinstall / retest Overfill prevention valves Tank internals as vapour tight                                                                       |
| Mitigation          | Review hazardous zone limits Around fill line caps                                                                                                           |
| Zoning              | Classify surrounding area as increased hazard - Zone 1                                                                                                       |
| Equipment           | Use Zone 1 electrics                                                                                                                                         |
| Line responsibility | 1. Manager / competent person<br>2. Site operator<br>3. Site owner                                                                                           |
| Emergency action    | 1. Demarcate hazardous zone<br>2. Set out explosion warning signs<br>3. Instruct staff of hazard / risk<br>4. Keep public away from hazard                   |
| Notes to site       | Where<br>• Vapour leaks are identified / suspected                                                                                                           |
|                     | The ongoing response should entail<br>1. Being aware of emergency actions<br>2. Taking steps to mitigate impacts<br>3. Commissioning works to prevent causes |

For PVV venting at around 35mb to 40mb critical depth contained pressure can support product in an open fill riser (66) to around 450mm to 500mm. The fill riser height between full tank (3) and open fill cap (48a) must be greater than 500mm. Insufficient critical depths (68) between the fill tank and open fill cap (48a) increase the risk of petrol spills.

|                   |                                                                              |
|-------------------|------------------------------------------------------------------------------|
| Hazards and risks | Critical depth                                                               |
| Test result       | Less than 500mm                                                              |
| Noted defect      | Underground tanks are not installed to adequate depth below fill cap opening |
| Hazards           | • Petrol spills Under pressure Especially at high tank contents levels       |

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Table continued

|    |                     |                                                                                                                                                                                                                                             |
|----|---------------------|---------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
|    | Risks               | • Fires and explosions                                                                                                                                                                                                                      |
| 5  | Prevention          | Replace / reinstall / retest Fill cap opening to higher level if possible E.g. replace u/g fills with o/g fills Decrease tank maximum stored volume                                                                                         |
|    | Mitigation          | Review hazardous zone limits                                                                                                                                                                                                                |
|    |                     | Around fill line caps                                                                                                                                                                                                                       |
| 10 | Zoning              | Classify surrounding area as increased hazard - Zone 1                                                                                                                                                                                      |
|    | Equipment           | Use Zone 1 electrics                                                                                                                                                                                                                        |
| 15 | Line responsibility | 1. Manager / competent person<br>2. Site operator<br>3. Site owner                                                                                                                                                                          |
| 20 | Emergency action    | 1. Demarcate hazardous zone<br>2. Set out explosion warning signs<br>3. Instruct staff of hazard / risk<br>4. Keep public away from hazard                                                                                                  |
| 25 | Notes to site       | Where<br>• There is increased potential for petrol spills to possibly occur<br>The ongoing response should entail<br>1. Being aware of emergency actions<br>2. Taking steps to mitigate impacts<br>3. Commissioning works to prevent causes |

**[0145]** Evaluate critical depth (68) by measuring the height from top of tank to fill cap opening. The following examples are for critical depth (68) measurement for unleaded petrol with densities of 0.75 and 0.80:

| Petrol density        | 0.75                                    | 0.80 |
|-----------------------|-----------------------------------------|------|
| Critical depth(CD) mm | Max allowable system pressure (MASP) mb |      |
| 300                   | 23                                      | 25   |
| 400                   | 30                                      | 33   |
| 500                   | 38                                      | 41   |
| 600                   | 46                                      | 49   |
| 700                   | 54                                      | 57   |
| 800                   | 60                                      | 65   |
| 900                   | 69                                      | 73   |
| 1000                  | 76                                      | 81   |

The results above illustrate that for critical depths (68) less than 500mm there is no accommodation for any back pressure and that for critical depths (68) greater than 500mm there is at least some accommodation for back pressures. The greater the critical depth, the greater the back pressure the system is capable of accommodating without petrol spills. Capacity to accommodate back pressures is relative to the actual critical depth less 500mm. Any system pressures that exceed MASP can cause petrol spills.

|                   |                                                            |
|-------------------|------------------------------------------------------------|
| Hazards and risks | Maximum allowable system pressure                          |
| Test result       | Lower than site side PVV emergency venting relief pressure |
| Noted defect      | Critical depth is inadequate                               |

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Table continued

|    |                     |                                                                                                                                                                                                                                             |
|----|---------------------|---------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
|    | Hazards             | • Petrol spills Under pressure Especially at high tank contents levels                                                                                                                                                                      |
| 5  | Risks               | • Fires and explosions                                                                                                                                                                                                                      |
|    | Prevention          | Increase critical depth if possible Decrease emergency venting relief pressure Of site side PVV from 35mb to say 20mb Decrease tank maximum stored volume                                                                                   |
|    | Mitigation          | Review hazardous zone limits Around fill line caps                                                                                                                                                                                          |
| 10 | Zoning              | Classify surrounding area as increased hazard - Zone 1                                                                                                                                                                                      |
|    | Equipment           | Use Zone 1 electrics                                                                                                                                                                                                                        |
| 15 | Line responsibility | 1. Manager / competent person<br>2. Site operator<br>3. Site owner                                                                                                                                                                          |
| 20 | Emergency action    | 1. Demarcate hazardous zone<br>2. Set out explosion warning signs<br>3. Instruct staff of hazard / risk<br>4. Keep public away from hazard                                                                                                  |
| 25 | Notes to site       | Where<br>• There is increased potential for petrol spills to possibly occur<br>The ongoing response should entail<br>1. Being aware of emergency actions<br>2. Taking steps to mitigate impacts<br>3. Commissioning works to prevent causes |

**[0146]** The PVV (10) opens at pressure of around 35mb to 40mb. However back pressure may build beyond 35mb to 40mb where emergency venting relief pressure is inadequate.

**[0147]** Ideally 2,500 litres per minute enter the system and the PVV (10) is able to relieve 2,500 litres per minute so the maximum system pressure remains around 35mb to 40mb. However, if 2,500 litres per minute enter the system and the PVV is not able to relieve 2,500 litres per minute, the maximum system pressure may rise to around 50mb to 60mb. This results in around 15mb to 20mb back pressure. Large back pressures can cause the maximum system pressure to exceed the maximum allowable system pressure resulting in petrol spills.

|    |                     |                                                                                                                                                                                                                                     |
|----|---------------------|-------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
|    | Hazards And risks   | Back pressure                                                                                                                                                                                                                       |
| 40 | Test result         | Site side vapour recovery system pressures exceed PVV emergency venting relief pressure (under controlled conditions)                                                                                                               |
|    | Noted defect        | Site side emergency venting relief capacity is inadequate                                                                                                                                                                           |
|    | Hazards             | • Petrol spills Under pressure Especially at high tank contents levels                                                                                                                                                              |
| 45 | Risks               | • Fires and explosions                                                                                                                                                                                                              |
|    | Prevention          | Increase site side emergency venting relief pressure if possible. E.g. install extra PVV unit<br>Decrease emergency venting relief pressure of site side PVV unit by extent of back pressure<br>Decrease tank maximum stored volume |
| 50 | Mitigation          | Limit possible back pressure build up (see maximum delivery hose profile) Review hazardous zone                                                                                                                                     |
|    | Zoning              | Classify surrounding area as increased hazard - Zone 1                                                                                                                                                                              |
|    | Equipment           | Use Zone 1 electrics                                                                                                                                                                                                                |
| 55 | Line responsibility | 1. Manager / competent person<br>2. Site operator                                                                                                                                                                                   |
|    |                     | 3. Site owner                                                                                                                                                                                                                       |

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Table continued

|    |                  |                                                                                                                                                                                                                                                                                                                                                                  |
|----|------------------|------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| 5  | Emergency action | <ol style="list-style-type: none"> <li>1. Demarcate hazardous zone</li> <li>2. Set out explosion warning signs</li> <li>3. Instruct staff of hazard / risk</li> <li>4. Keep public away from hazard</li> </ol>                                                                                                                                                   |
| 10 | Notes to site    | <p>Where</p> <ul style="list-style-type: none"> <li>• There is increased potential for petrol spills to possibly occur</li> </ul> <p>The ongoing response should entail</p> <ol style="list-style-type: none"> <li>1. Being aware of emergency actions</li> <li>2. Taking steps to mitigate impacts</li> <li>3. Commissioning works to prevent causes</li> </ol> |

15 **[0148]** The relationships between BP, MASP and CD are crucial to understanding the vapour recovery system and deciding upon adjustments to be made to these values in order to ensure the risks of leaks and spills are minimised.

20 **[0149]** Any back pressure (BP) of 15mb to 20mb developed on top of normal emergency venting relief pressure (EVRP) of 35mb to 40mb will allow the build up of system pressures to a maximum of around 50 to 60mb. Such maximum system pressures require a review of the CD (68). For example, if the maximum allowable system pressure (MASP) is 60mb, this requires 750mm to 800mm CD (68). If CD (68) is actually 700mm the actual MASP will be 54mb to 57mb. Back pressure will be a real concern even though 700mm is an ordinarily acceptable CD (68).

25 **[0150]** Where the sum of maximum back pressures and max generated pressures is greater than maximum allowable system pressure there is a risk of petrol spills.

|    |                     |                                                                                                                                                                                                                                                                                                                                                                  |
|----|---------------------|------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| 25 | Hazards And risks   | Relationships BP/MASP/CD                                                                                                                                                                                                                                                                                                                                         |
| 30 | Test result         | The relationships between these factors is not satisfactory                                                                                                                                                                                                                                                                                                      |
| 35 | Noted defect        | Critical depth is inadequate and Relevant MASP is low especially Where back pressure is identified                                                                                                                                                                                                                                                               |
| 40 | Hazards             | • Petrol spills Under pressure Especially at high tank contents levels                                                                                                                                                                                                                                                                                           |
| 45 | Risks               | • Fires and explosions                                                                                                                                                                                                                                                                                                                                           |
| 50 | Prevention          | Try to achieve a CD and associated MASP Greater than site side PVV emergency venting relief pressure value + back pressure value                                                                                                                                                                                                                                 |
| 55 | Mitigation          | Limit possible back pressure build up (see maximum delivery hose profile) Review hazardous zone                                                                                                                                                                                                                                                                  |
|    | Zoning              | Classify surrounding area As increased hazard - Zone 1                                                                                                                                                                                                                                                                                                           |
|    | Equipment           | Use Zone 1 electrics                                                                                                                                                                                                                                                                                                                                             |
|    | Line responsibility | <ol style="list-style-type: none"> <li>1. Manager / competent person</li> <li>2. Site operator</li> <li>3. Site owner</li> </ol>                                                                                                                                                                                                                                 |
|    | Emergency action    | <ol style="list-style-type: none"> <li>1. Demarcate hazardous zone</li> <li>2. Set out explosion warning signs</li> <li>3. Instruct staff of hazard / risk</li> <li>4. Keep public away from hazard</li> </ol>                                                                                                                                                   |
|    | Notes to site       | <p>Where</p> <ul style="list-style-type: none"> <li>• There is increased potential for petrol spills to possibly occur</li> </ul> <p>The ongoing response should entail</p> <ol style="list-style-type: none"> <li>1. Being aware of emergency actions</li> <li>2. Taking steps to mitigate impacts</li> <li>3. Commissioning works to prevent causes</li> </ol> |

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**[0151]** Maximum delivery hose profile (MDHP) is the number of hoses that are allowed to be connected to the system at a time. Maximum delivery hose profiles may need to be restricted to avoid the possibility of back pressures. The MDHP depends on the back pressure associated with the site compared to the MASP (as determined by the CD (68)).

**[0152]** If back pressure (BP) concerns exist, the maximum allowable system pressure (MASP) must be contained. The hose profile from the truck discharge connections to the tank fill line connections will need to be managed.

**[0153]** For a site with a marginal CD (68) and the possibility of BP-hoses to fills will need to be limited by a sign:

"PETROL HOSES TO BE CONNECTED only ONE AT A TIME" Here the MDHP will be one.

**[0154]** For another site with ample CD (68) but still having the possibility of BP-hoses to fills may need to be limited by a sign:

"PETROL HOSES TO BE CONNECTED only TWO AT A TIME" Here the MDHP is two.

**[0155]** Unrestricted delivery hose profiles on untested vapour recovery systems at petrol filling stations can lead to petrol spills.

|                     |                                                                                                                                                                                                                                                                         |
|---------------------|-------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| Hazards And risks   | Maximum delivery Hose profile                                                                                                                                                                                                                                           |
| Test result         | Back pressures identified                                                                                                                                                                                                                                               |
| Noted defect        | Site side PVV emergency venting relief capacity is inadequate                                                                                                                                                                                                           |
| Hazards             | • Petrol spills Under pressure Especially at high tank contents levels                                                                                                                                                                                                  |
| Risks               | • Fires and explosions                                                                                                                                                                                                                                                  |
| Prevention          | Increase site side emergency venting relief Capacity if possible. E.g. install extra PVV unit<br>Decrease emergency venting relief pressure of site side PVV unit by extent of back pressure<br>Decrease tank maximum stored volume Limit maximum delivery hose profile |
| Mitigation          | Review hazardous zone limits                                                                                                                                                                                                                                            |
|                     | around fill line caps                                                                                                                                                                                                                                                   |
| Zoning              | Classify surrounding area as increased hazard - Zone 1                                                                                                                                                                                                                  |
| Equipment           | Use Zone 1 electrics                                                                                                                                                                                                                                                    |
| Line responsibility | 1. Manager / competent person<br>2. Site operator<br>3. Site owner                                                                                                                                                                                                      |
| Emergency action    | 1. Demarcate hazardous zone<br>2. Set out explosion warning signs<br>3. Instruct staff of hazard / risk<br>4. Keep public away from hazard                                                                                                                              |
| Notes to site       | Where<br>• There is increased potential for petrol spills to possibly occur<br>The ongoing response should entail<br>1. Being aware of emergency actions<br>2. Taking steps to mitigate impacts<br>3. Commissioning works to prevent causes                             |

**[0156]** Emergency venting relief pressure (EVRP) is the pressure at which the PVV (10) cracks open facilitating the release of petrol vapours. The EVRP is usually 35mb to 40mb with the maximum acceptable range usually being 28mb to 42mb. Excessively high emergency venting relief pressure (EVHP) can lead to petrol spills.

**[0157]** For example, where the CD (68) is inadequate, say 350mm, the MASP will be around 26mb to 29mb. EVRP setting should be reduced well below the standard 35mb setting to, say a range from around 17mb to 20mb. This should be appropriate to avoid any possibility of back pressure (BP) developing. Where the CD (68) is satisfactory, say 1000mm, but there is a concern about BP then MDHP may need to be limited or emergency pressure venting capacity may need

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to be increased. This can be achieved by provision of a larger diameter PVV (10) or vent riser (60) or alternatively a second standard PVV (10) or vent riser (60).

|    |                     |                                                                                                                                                                                                                                                                         |
|----|---------------------|-------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| 5  | Hazards and risks   | Emergency venting relief pressure                                                                                                                                                                                                                                       |
|    | Test result         | Back pressures identified                                                                                                                                                                                                                                               |
|    | Noted defect        | Site side PVV emergency venting relief capacity is inadequate                                                                                                                                                                                                           |
|    | Hazards             | • Petrol spills under pressure Especially at high tank contents levels                                                                                                                                                                                                  |
| 10 | Risks               | • Fires and explosions                                                                                                                                                                                                                                                  |
|    | Prevention          | Increase site side emergency venting relief capacity if possible. E.g. install extra PVV unit<br>Decrease emergency venting relief pressure of site side PVV unit by extent of back pressure<br>Decrease tank maximum stored volume Limit maximum delivery hose profile |
| 15 | Mitigation          | Review hazardous zone limit around fill line caps                                                                                                                                                                                                                       |
|    | Zoning              | Classify surrounding area as Zone 1                                                                                                                                                                                                                                     |
|    | Equipment           | Use Zone 1 electrics                                                                                                                                                                                                                                                    |
| 20 | Line responsibility | 1. Manager / competent person<br>2. Site operator<br>3. Site owner                                                                                                                                                                                                      |
| 25 | Emergency action    | 1. Demarcate hazardous zone<br>2. Set out explosion warning signs<br>3. Instruct staff of hazard / risk<br>4. Keep public away from hazard                                                                                                                              |
| 30 | Notes to site       | Where<br>• There is increased potential for petrol spills to possibly occur<br>The ongoing response should entail<br>1. Being aware of emergency actions<br>2. Taking steps to mitigate impacts<br>3. Commissioning works to prevent causes                             |

**[0158]** A pressure vacuum valve (PVV (10) needs regular servicing. PVVs are factory tested to specified standard relief settings. These relief settings have been decided by a broad industry consensus. The pressure relief setting is generally around +35mb and the vacuum relief setting is generally approximately -2mb. Pressure and vent valves which stick open can cause vapour leaks pressure and vent valves which stick closed can cause petrol spills.

**[0159]** Where the PVV (10) sticks open allowing for free venting, this prevents the system being declared vapour tight and the system is not vapour recovery compliant. Where the PVV (10) sticks closed preventing cracking at standard setting, this allows pressure build up to occur resulting in increased pressures in the system. These increased system pressures may rise above the maximum allowable system pressure (MASP), as determined by the critical depth (CD), resulting in petrol discharges from full tanks (3) via open fill caps (48a). Such petrol discharges cease only when the system pressure dissipates to MASP.

|    |                   |                                                                                                                   |
|----|-------------------|-------------------------------------------------------------------------------------------------------------------|
| 50 | Hazards And risks | Pressure vacuum valve                                                                                             |
|    | Test result       | Site side vapour recovery system is not vapour tight - PVV is hissing when opening fully instead of rattling free |
|    | Noted defect      | PVV is sticking open / PVV sticking closed                                                                        |
|    | Hazards           | • Vapour leaks — PVV sticking open<br>• Petrol spills — PVV sticking closed                                       |
| 55 | Risks             | • Fires and explosions                                                                                            |
|    | Prevention        | site side PVV needs serviced / replaced                                                                           |
|    | Mitigation        | Review hazardous zone limits around site side PVV                                                                 |

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Table continued

|    |                      |                                                                                                                                                                                                                                                                                                                                                                                                        |
|----|----------------------|--------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
|    | Zoning               | Classify surrounding area as increase hazard - Zone 1                                                                                                                                                                                                                                                                                                                                                  |
| 5  | Equipment            | Use Zone 1 electrics                                                                                                                                                                                                                                                                                                                                                                                   |
|    | Line responsibi lity | 1. Manager / competent person<br>2. Site operator<br>3. Site owner                                                                                                                                                                                                                                                                                                                                     |
| 10 | Emergency action     | 1. Demarcate hazardous zone<br>2. Set out explosion warning signs<br>3. Instruct staff of hazard / risk<br>4. Keep public away from hazard                                                                                                                                                                                                                                                             |
| 15 | Notes to             | Where                                                                                                                                                                                                                                                                                                                                                                                                  |
| 20 | site                 | <ul style="list-style-type: none"> <li>• Vapour leaks are identified / suspected</li> <li>• There is increased potential for petrol spills to possibly occur</li> </ul> <p>The ongoing response should entail</p> <ol style="list-style-type: none"> <li>1. Being aware of emergency actions</li> <li>2. Taking steps to mitigate impacts</li> <li>3. Commissioning works to prevent causes</li> </ol> |

**[0160]** Where vapour locks occur in fill lines (25), the flow of petrol under gravity from the over ground delivery tanker (2) to the underground storage tanks (3) may be impeded to such extent that petrol cannot be off loaded. When this happens there is no way of determining the cause, location or size of the vapour plug involved. Any previous evidence of blow back from the open fill line (25) can indicate that the source or cause of the leak was a leak path on the internal or any overfill prevention valve fitted.

**[0161]** The solution can be effected by stopping other hose drops to prevent further pressure build-up or by allowing cars to draw of petrol from the subject tank (3) to relieve pressure from the surrounding ullage space.

**[0162]** If the effected tank (3) is syphon connected to another tank (3) that has just received a petrol drop, the cause of the leak could be the continuing transfer of liquid product across the syphon. This raises the liquid level in the effected tank, putting the vapour plug in a vapour tight internal or overfill prevention valve under increasing pressure.

**[0163]** In this case the solution can be effected by closing any isolating valve on the syphon connection to prevent further pressure build up or by allowing cars at dispensers to draw of petrol from the effected tank to relieve pressure from the surrounding ullage space.

**[0164]** Vapour locks can cause petrol spills where delivery hoses are cracked at the truck side during attempts to relieve trapped vapour plugs.

|    |                      |                                                                                                                                                                           |
|----|----------------------|---------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| 40 | Hazards and risks    | Vapour locks                                                                                                                                                              |
|    | Test result          | A petrol discharge via a delivery hose is very slow or stops completely                                                                                                   |
|    | Noted defect         | A vapour lock has occurred in the fill line most likely due to a back flow of petrol into the target delivery tank from a syphon connected tank previously delivered into |
| 45 | Hazards              | <ul style="list-style-type: none"> <li>• Vapour leaks</li> <li>• Petrol spills Especially at low levels from attempts to relieve problem</li> </ul>                       |
|    | Risks                | • Fires and explosions                                                                                                                                                    |
| 50 | Prevention           | Close of any syphon connections from delivery target tank to all other tanks                                                                                              |
|    | Mitigation           | Allow cars to draw off petrol from target delivery tank Review hazardous zone                                                                                             |
|    | Zoning               | Classify surrounding area as increased hazard - Zone 1                                                                                                                    |
|    | Equipment            | Use Zone 1 electrics                                                                                                                                                      |
| 55 | Line responsibi lity | 1. Manager / competent person<br>2. Site operator<br>3. Site owner                                                                                                        |

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Table continued

|                  |                                                                                                                                                                                                                                                                                                                                                                                                                     |
|------------------|---------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| Emergency action | <ol style="list-style-type: none"> <li>1. Demarcate hazardous zone</li> <li>2. Set out explosion warning signs</li> <li>3. Instruct staff of hazard / risk</li> <li>4. Keep public away from hazard</li> </ol>                                                                                                                                                                                                      |
| Notes to site    | <p>Where</p> <ul style="list-style-type: none"> <li>• Vapour leaks are identified / suspected</li> <li>• There is increased potential for petrol spills to possibly occur</li> </ul> <p>The ongoing response should entail</p> <ol style="list-style-type: none"> <li>1. Being aware of emergency actions</li> <li>2. Taking steps to mitigate impacts</li> <li>3. Commissioning works to prevent causes</li> </ol> |

**[0165]** Hydrostatic gauges are a form of gauging system where a gauge tube is inserted into the tank manhole cover and extending to the bottom of the tank (3) is pressurised to relief. The relief pressure indicates the volume of liquid in the tank (3), since this pressure is a factor of the displaced head of product.

**[0166]** If the ullage space of the tank (3) is in pressure the tank contents volume can be overestimated. If the ullage space of the tank (3) is in vacuum the tank contents volume can be underestimated.

**[0167]** If the tank ullage space is in normal vacuum, of say down to 2mb, the maximum underestimation of tank contents volume is of the order of 300 to 400 litres and the minimum is around 100 to 200 litres. If the tank ullage space is in substantial vacuum, say down to 6mb, the maximum underestimation of tank contents volume is be around 900 to 1200 litres and the minimum is around 300 to 600 litres. In these vacuum scenarios, the head in the gauge tube entering the petrol volume is lowered by approximately 25mm to 75mm and the tank appears to have correspondingly less petrol volume stored.

**[0168]** The root problem here is a tendency for the ullage space vacuum to build without relief at the predetermined value of 2mb. The PVV (10) is sticking closed allowing excess vacuums to develop during very heavy out-loading of petrol via the dispensers. Where hydrostatic gauging systems are employed it is prudent to revise maximum tank content levels downward and reset high level alarms to lower cutoffs. Hydrostatic gauging systems should not be used to check tank contents when the site is busy.

|                     |                                                                                                                                                                                                                |
|---------------------|----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| Hazards and risks   | Hydrostatic gauges                                                                                                                                                                                             |
| Test                | Observation that tank contents are                                                                                                                                                                             |
| result              | overfilled or tended to be overfilled When hydrostatic gauges are employed                                                                                                                                     |
| Noted defect        | Contents of the target delivery tank have been underestimated by incorrect use of hydrostatic gauges                                                                                                           |
| Hazards             | • Petrol spills From open fill lines                                                                                                                                                                           |
| Risks               | • Fires and explosions                                                                                                                                                                                         |
| Prevention          | Take care not to use hydrostatic gauges when site side vapour recovery system is in vacuum i.e. during petrol dispensing                                                                                       |
| Mitigation          | Allow cars to draw off petrol from target delivery tank Review hazardous zone                                                                                                                                  |
| Zoning              | Classify surrounding area as increased hazard - Zone 1                                                                                                                                                         |
| Equipment           | Use Zone 1 electrics                                                                                                                                                                                           |
| Line responsibility | <ol style="list-style-type: none"> <li>1. Manager / competent person</li> <li>2. Site operator</li> <li>3. Site owner</li> </ol>                                                                               |
| Emergency action    | <ol style="list-style-type: none"> <li>1. Demarcate hazardous zone</li> <li>2. Set out explosion warning signs</li> <li>3. Instruct staff of hazard / risk</li> <li>4. Keep public away from hazard</li> </ol> |

Table continued

|               |                                                                                                                                                                                                                                                                                                                                                    |
|---------------|----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| Notes to site | Where <ul style="list-style-type: none"> <li>• There is increased potential for petrol spills to possibly occur</li> </ul> The ongoing response should entail <ol style="list-style-type: none"> <li>1. Being aware of emergency actions</li> <li>2. Taking steps to mitigate impacts</li> <li>3. Commissioning works to prevent causes</li> </ol> |
|---------------|----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|

**[0169]** Before commencement of the vapour recovery process, on opening a fill cap (48a) small volumes of vapours will leak out at atmospheric pressure. The pre-vapour recovery recommended hazard zone limit around a fill point is 4.5m. On opening the fill cap (48a) during the vapour recovery system operation a large volume of petrol may spill under pressure causing back pressure. The hazard zone limit around a fill point position should be increased to at least 9.0m where there is concern about possible petrol spills resulting from back pressures.

|                     |                                                                                                                                                                                                                                                                                                                                                    |
|---------------------|----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| Hazards and risks   | Separation distances / fills                                                                                                                                                                                                                                                                                                                       |
| Test result         | Note potential for petrol spills from fills                                                                                                                                                                                                                                                                                                        |
| Noted defect        | Any one or combination of other defects, for example: CD less than 500mm <ul style="list-style-type: none"> <li>- MASP less than site side PVV emergency relief pressure</li> <li>- Evidence of back pressure</li> <li>- Site side PVV sticks closed</li> <li>- Incorrect use of hydrostatic gauges</li> </ul>                                     |
| Hazards             | <ul style="list-style-type: none"> <li>• Petrol spills from open fill lines</li> </ul>                                                                                                                                                                                                                                                             |
| Risks               | <ul style="list-style-type: none"> <li>• Fires and explosions</li> </ul>                                                                                                                                                                                                                                                                           |
| Prevention          | Implement prevention measures for any/all of above noted defects                                                                                                                                                                                                                                                                                   |
| Mitigation          | Review hazardous zone around fill line caps                                                                                                                                                                                                                                                                                                        |
| Zoning              | Classify surrounding area as increased                                                                                                                                                                                                                                                                                                             |
|                     | hazard - Zone 1                                                                                                                                                                                                                                                                                                                                    |
| Equipment           | Use Zone 1 electrics                                                                                                                                                                                                                                                                                                                               |
| Line responsibility | <ol style="list-style-type: none"> <li>1. Manager / competent person</li> <li>2. Site operator</li> <li>3. Site owner</li> </ol>                                                                                                                                                                                                                   |
| Emergency action    | <ol style="list-style-type: none"> <li>1. Demarcate hazardous zone</li> <li>2. Set out explosion warning signs</li> <li>3. Instruct staff of hazard / risk</li> <li>4. Keep public away from hazard</li> </ol>                                                                                                                                     |
| Notes to site       | Where <ul style="list-style-type: none"> <li>• There is increased potential for petrol spills to possibly occur</li> </ul> The ongoing response should entail <ol style="list-style-type: none"> <li>1. Being aware of emergency actions</li> <li>2. Taking steps to mitigate impacts</li> <li>3. Commissioning works to prevent causes</li> </ol> |

**[0170]** While various embodiments of the invention have been described, it will be apparent to those skilled in the art once given this disclosure that various modifications, changes, improvements and variations may be made without departing from the scope of the invention.

**Claims**

1. A test apparatus locatable in a vapour recovery system for recovering a volatile organic compound comprising means for measuring pressures and/or pressure intervals at at least one point and/or across at least one interval in the vapour recovery system, the means for measuring pressures and/or pressure intervals being adapted to perform the measurement without substantially affecting the flow rate pressures of fluid in the vapour recovery system.
2. A test apparatus according to claim 1 wherein the test apparatus comprises a means for testing pressure deviations caused by the test apparatus.
3. A test apparatus according to Claim 1 or Claim 2 wherein the test rig comprises a low pressure drop aspect.
4. A test apparatus according to any of Claims 1 to 3 wherein the test rig comprises element parts for testing pressures as may be required across various intervals along the vapour recovery system pressure gradient.
5. A test apparatus according to any of Claims 1 to 4 wherein the test apparatus comprises a means for avoiding significant pressure deviations in the vapour recovery system caused by the test apparatus.
6. A method of testing a vapour recovery system for recovering a volatile organic compound comprising locating a test apparatus in the vapour recovery system and extracting pressure readings and/or pressure interval readings, the test apparatus comprising means for measuring pressures and/or pressure intervals at at least one point and/or across at least one interval in the vapour recovery system, the means for measuring pressures and/or pressure intervals being adapted to perform the measurement without substantially affecting the flow rate pressures of fluid in the vapour recovery system.
7. A method of testing a vapour recovery system according to Claim 6 wherein the test method comprises a means for testing pressure deviations caused by the test apparatus.
8. A method of testing a vapour recovery system according to Claim 6 or Claim 7 wherein the test method comprises a means for avoiding significant pressure deviations in the vapour recovery system caused by the test apparatus.
9. A method of testing a vapour recovery system according to any of Claims 6 to 8 wherein the test method comprises a self testing aspect.
10. A method of testing a vapour recovery system according to any of Claims 6 to 9 wherein the test method comprises a self correcting aspect.
11. A vapour recovery system explosive atmosphere (VRSEA) risk assessment method comprising using pressure readings and/or pressure interval readings to assess risks and hazards in a vapour recovery system for recovering a volatile organic compound, the pressure readings and/or pressure interval readings being extracted from a method of testing the vapour recovery system, the method of testing comprising locating a test apparatus in the vapour recovery system and extracting pressure readings and/or pressure interval readings using a test apparatus, the test apparatus comprising means for measuring pressures and/or pressure intervals at at least one point and/or across at least one interval in the vapour recovery system, the means for measuring pressures and/or pressure intervals being adapted to perform the measurement without substantially affecting the flow rate pressures of fluid in the vapour recovery system.
12. A vapour recovery system explosive atmosphere (VRSEA) risk assessment method according to Claim 11 wherein the risk assessment method comprises a means for testing pressure deviations caused by the test apparatus.
13. A vapour recovery system explosive atmosphere (VRSEA) risk assessment method according to Claim 11 or Claim 12 wherein the risk assessment method comprises a means for avoiding significant pressure deviations caused by the test apparatus.
14. A vapour recovery system explosive atmosphere (VRSEA) risk assessment method according to any of Claims 11 to 13 wherein the risk assessment method comprises an environmental aspect to vapour recovery system tests/inspections.

- 15.** A vapour recovery system explosive atmosphere (VRSEA) risk assessment method according to any of Claims 11 to 14 wherein the risk assessment method comprises a safety aspect as well as an environmental aspect to vapour recovery system tests/inspections.

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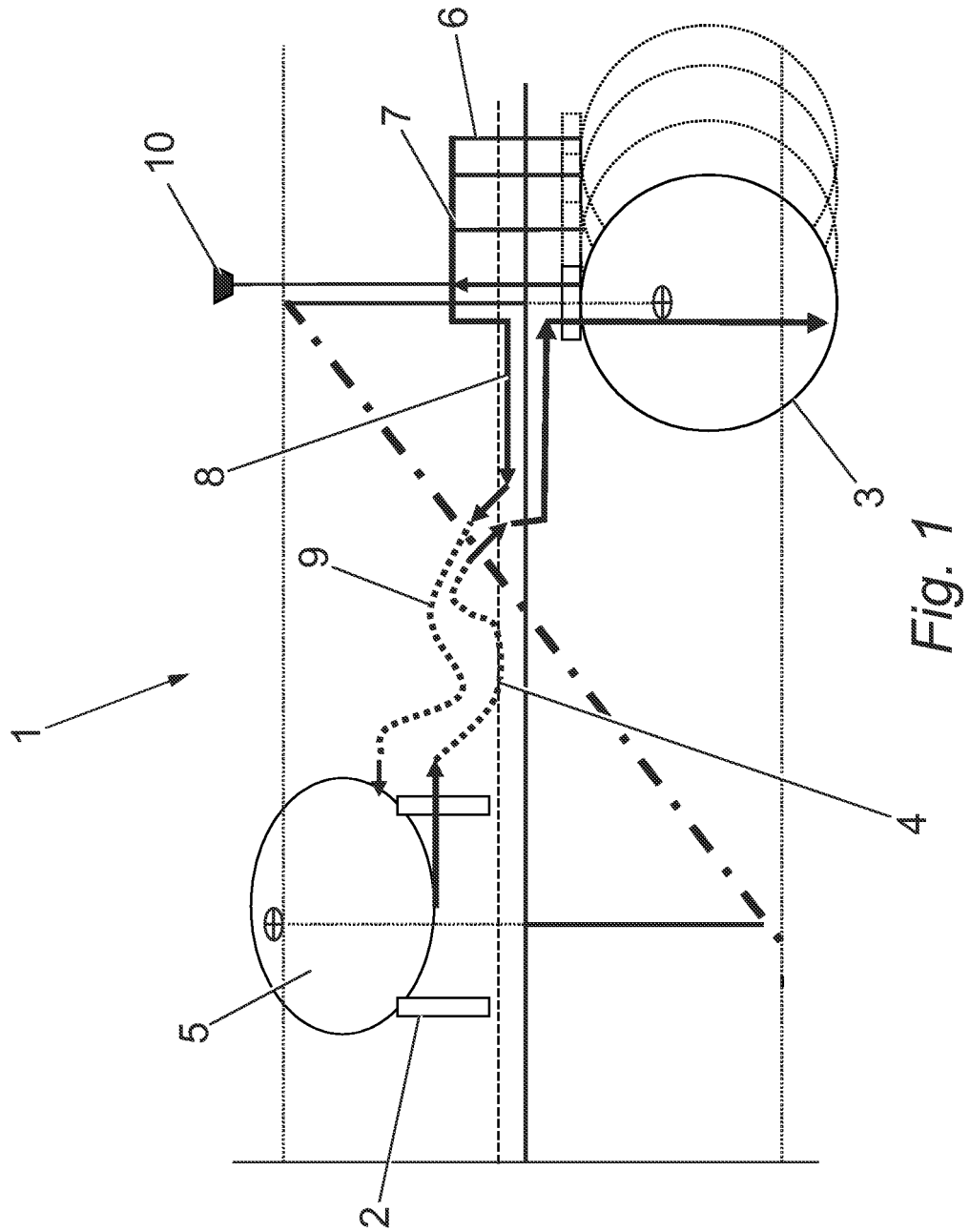
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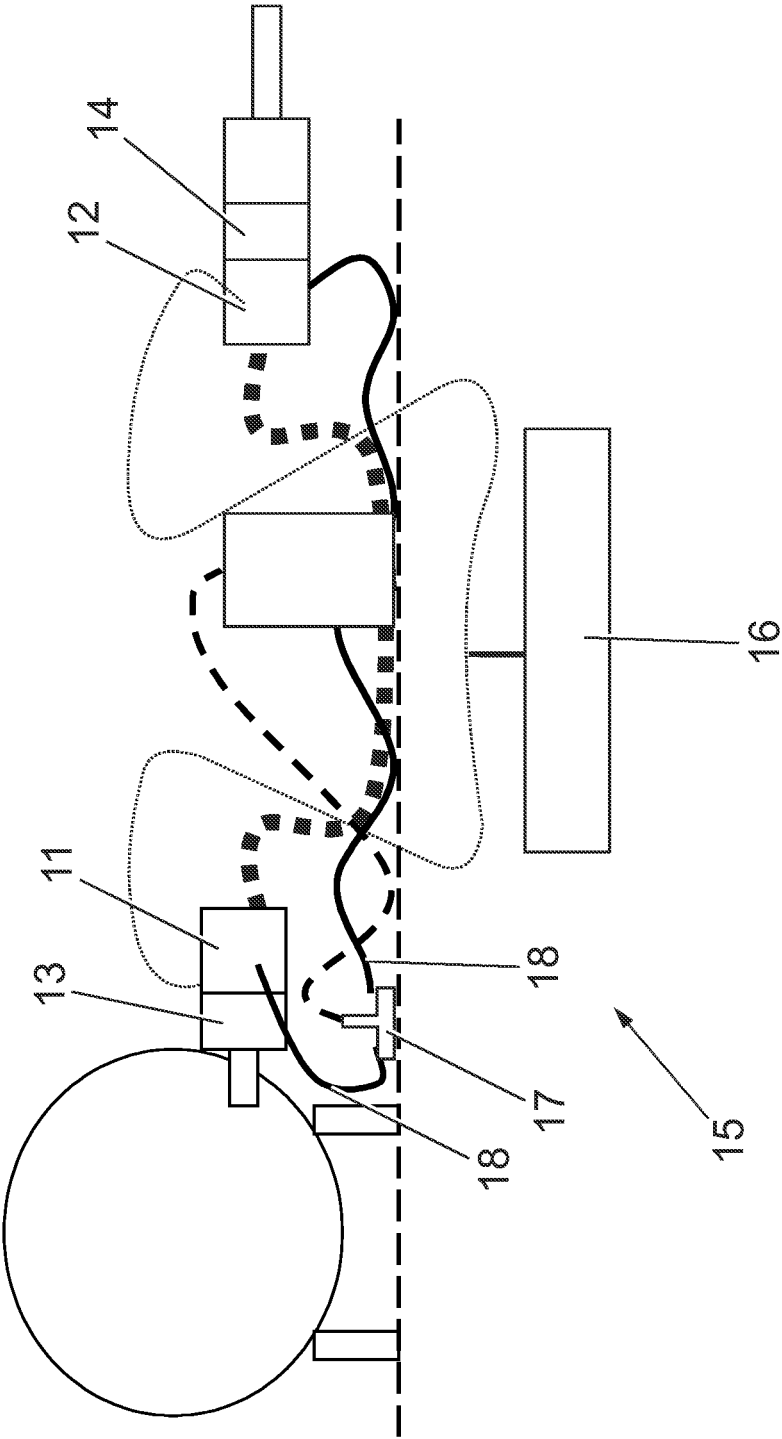


Fig. 2

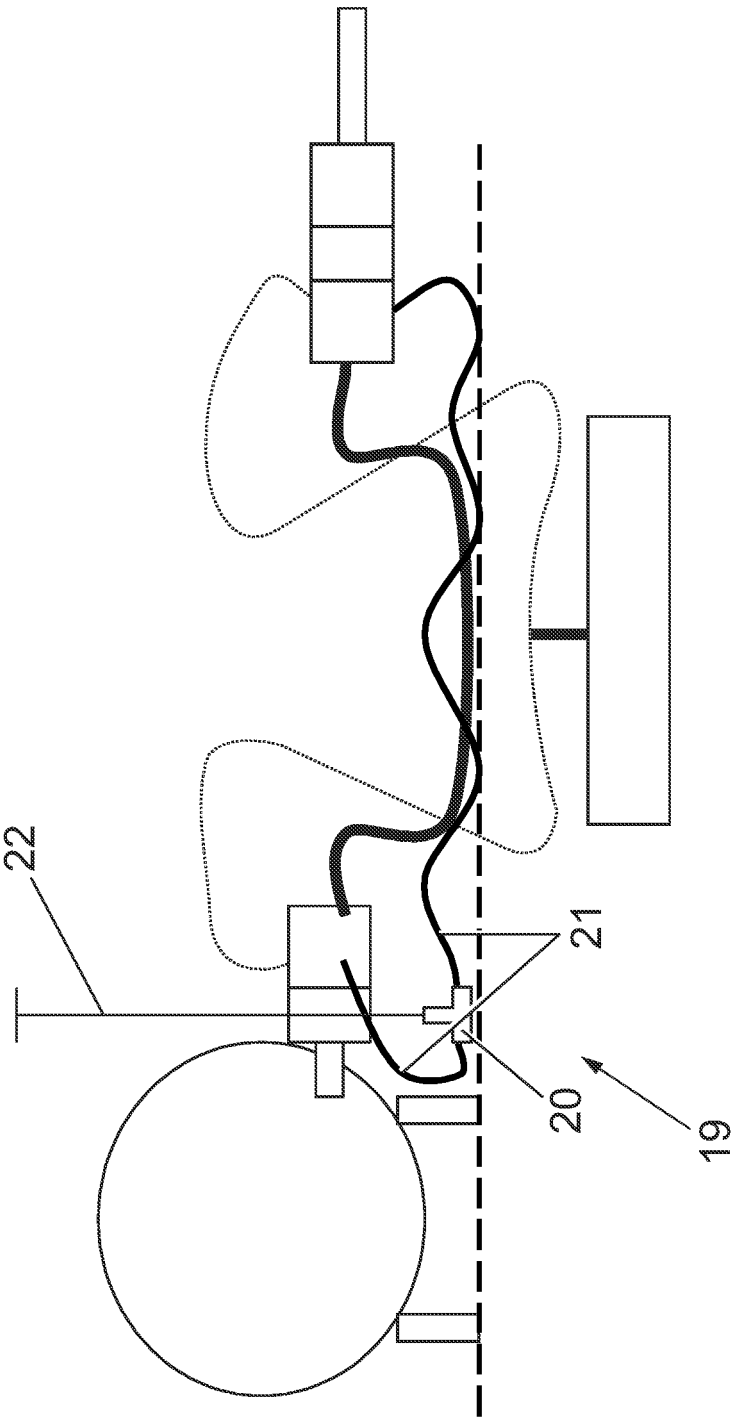


Fig. 3

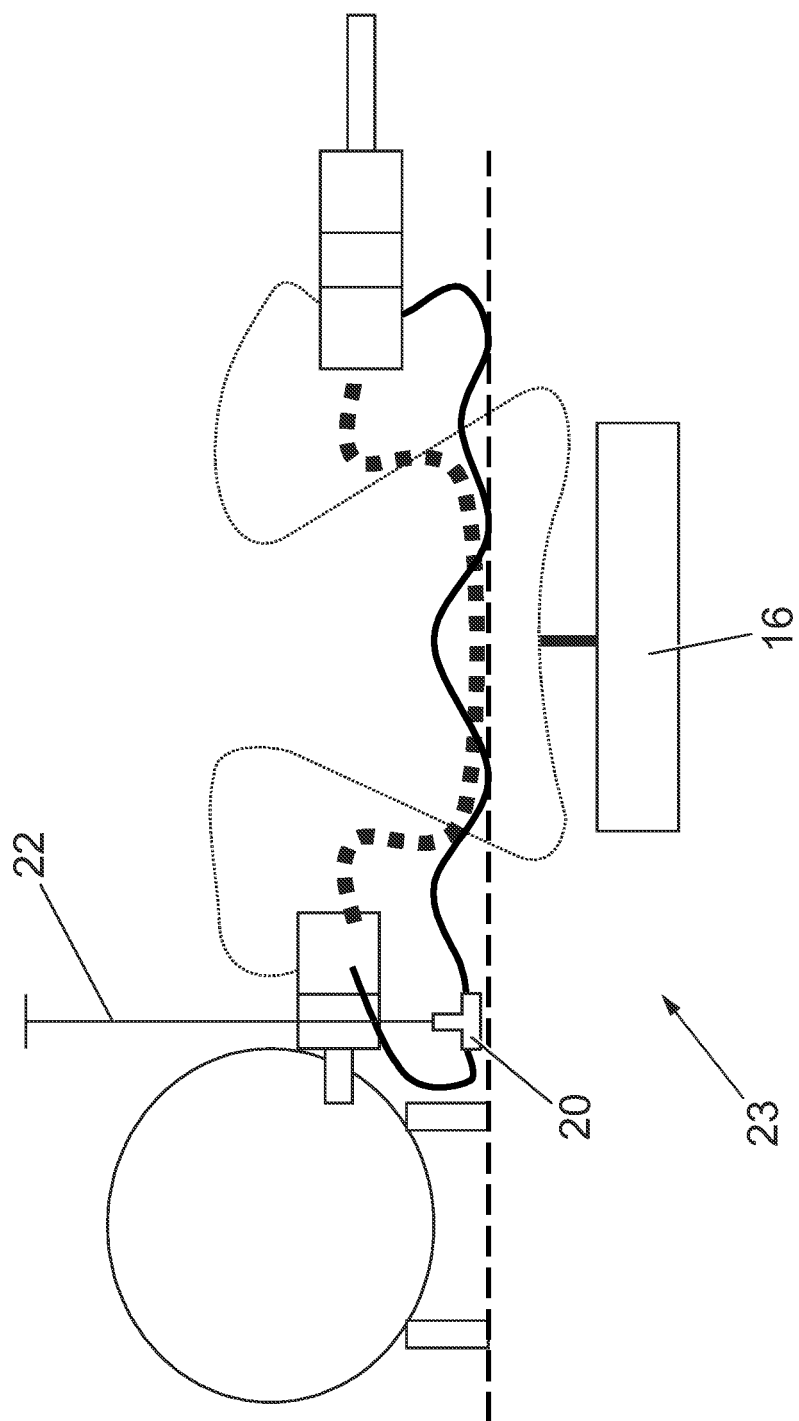


Fig. 4

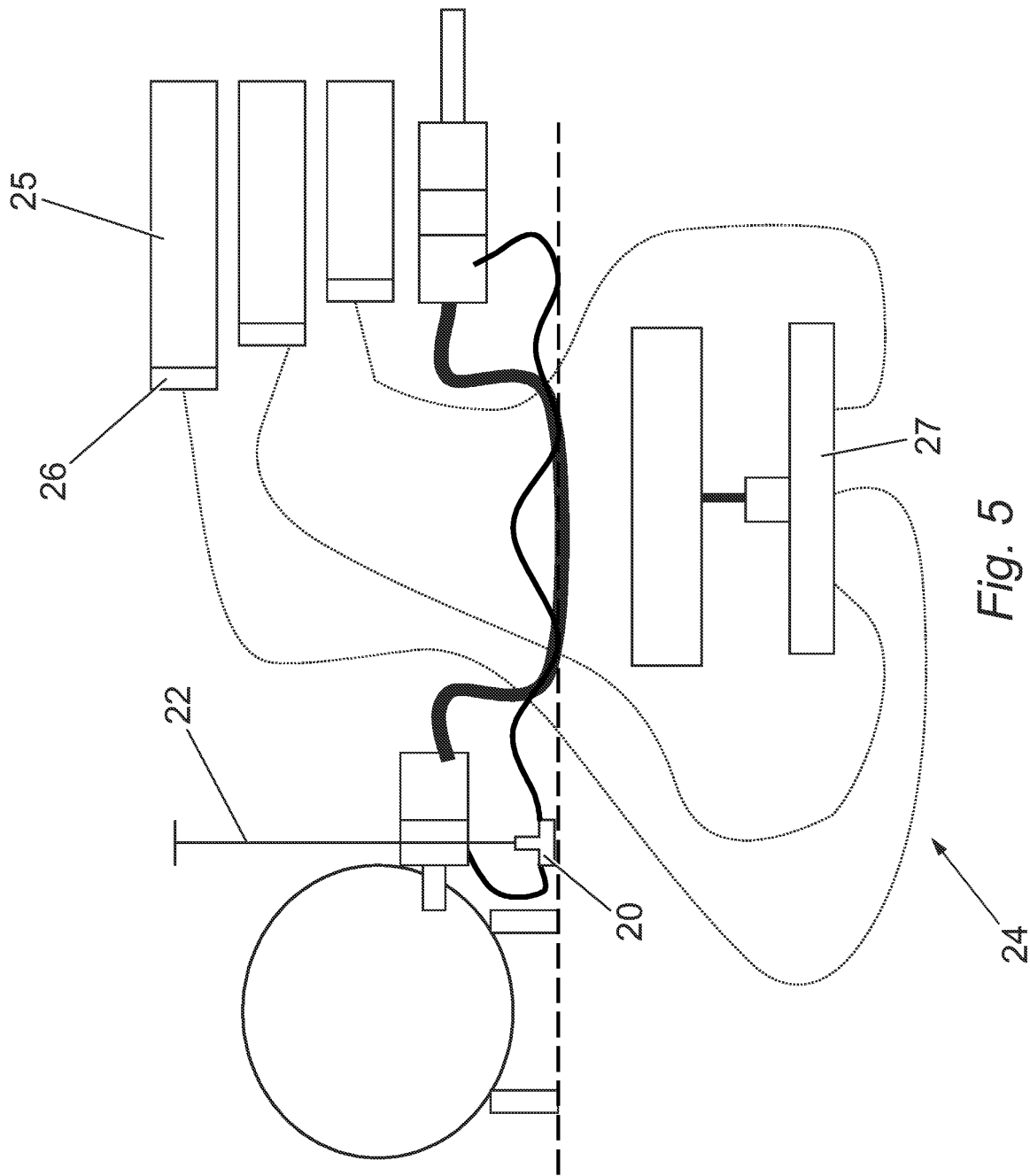


Fig. 5

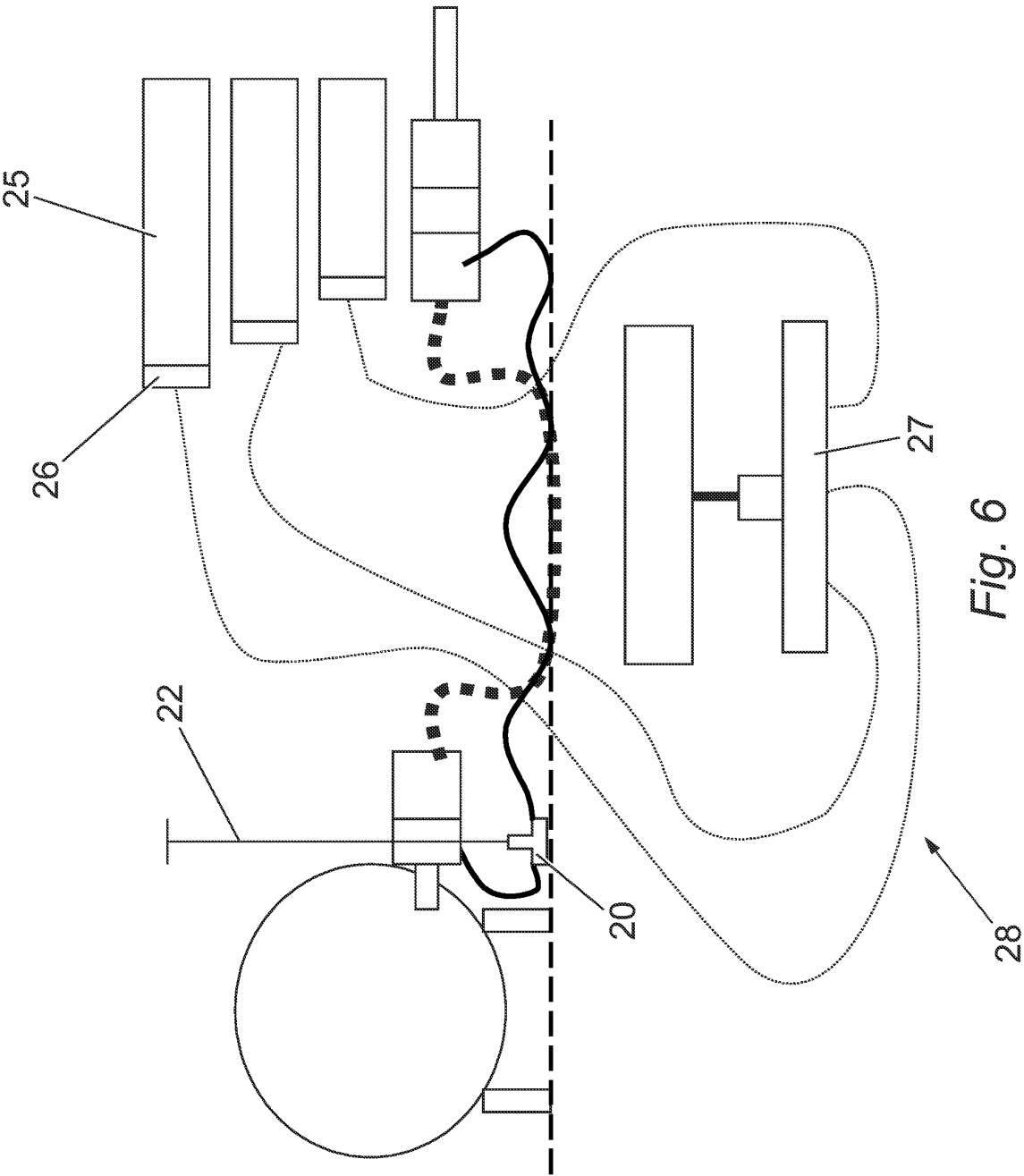


Fig. 6

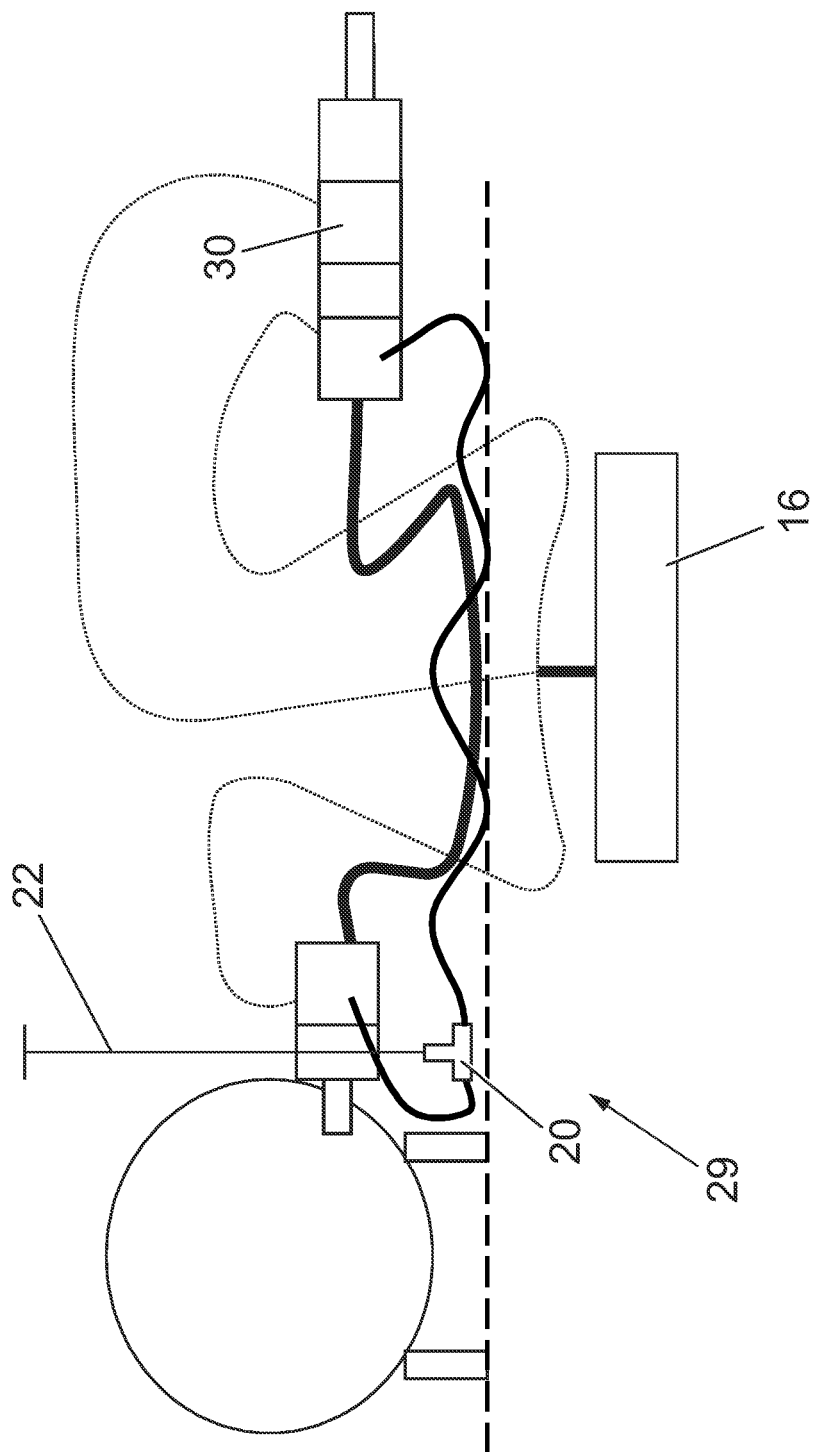


Fig. 7

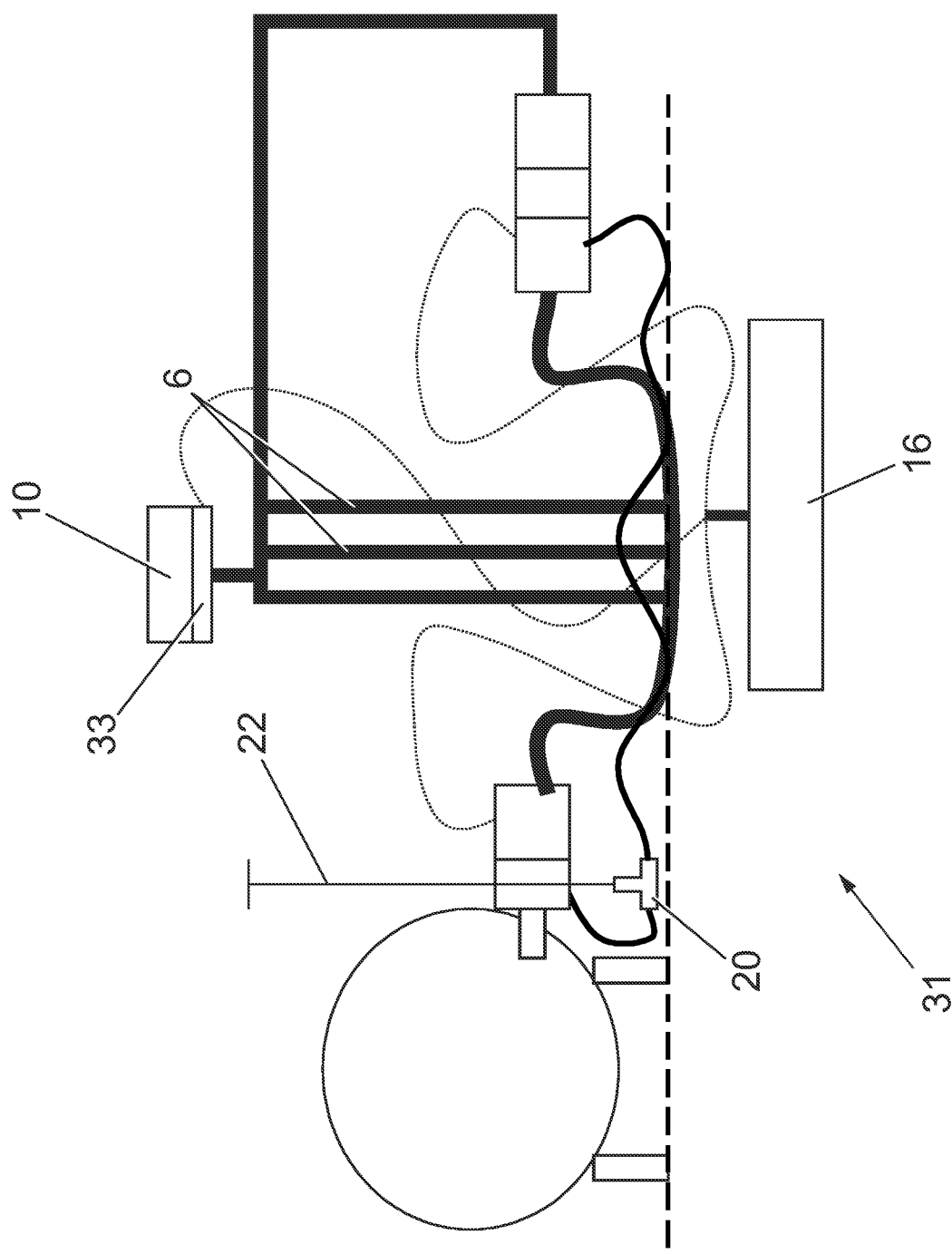


Fig. 8

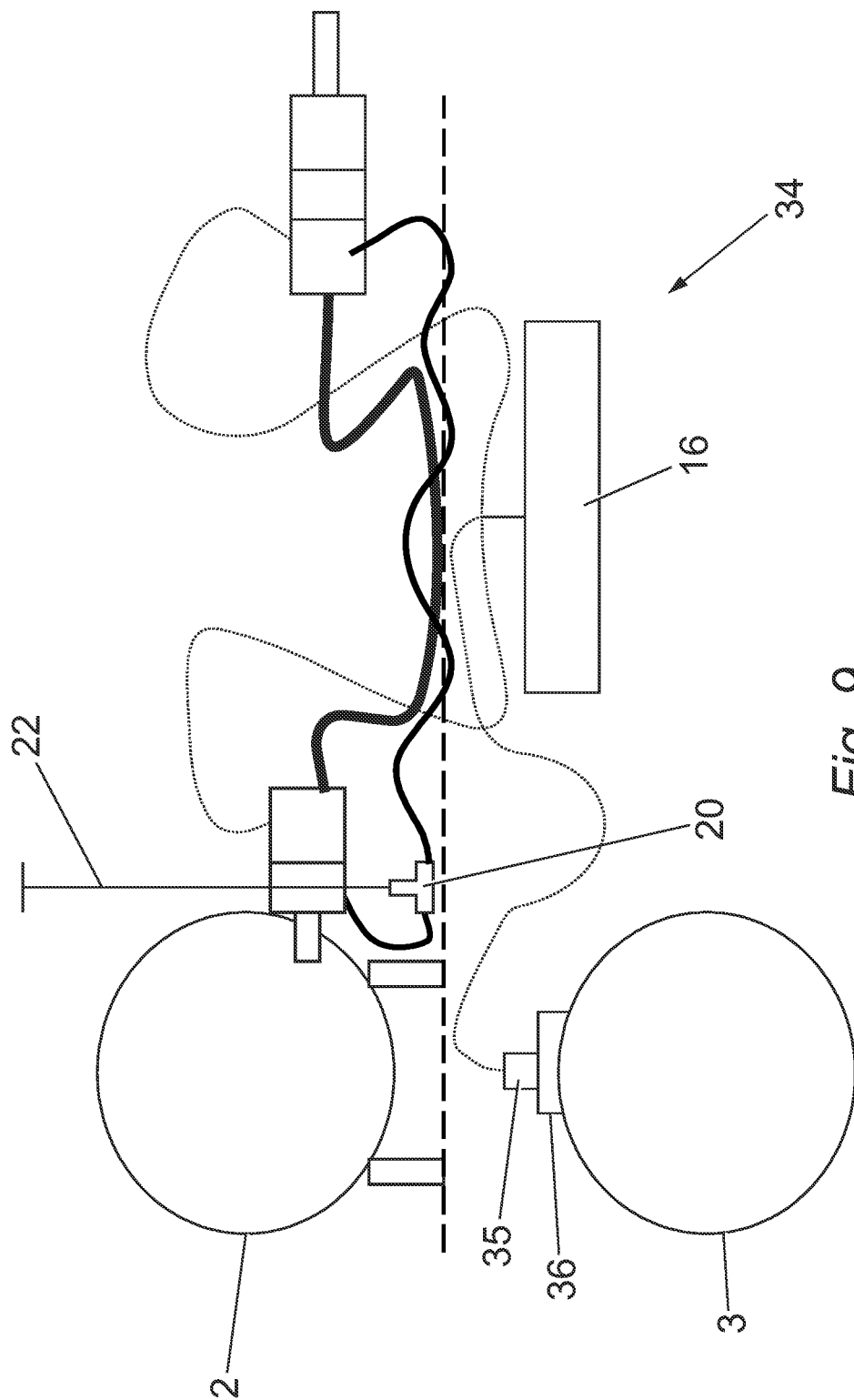
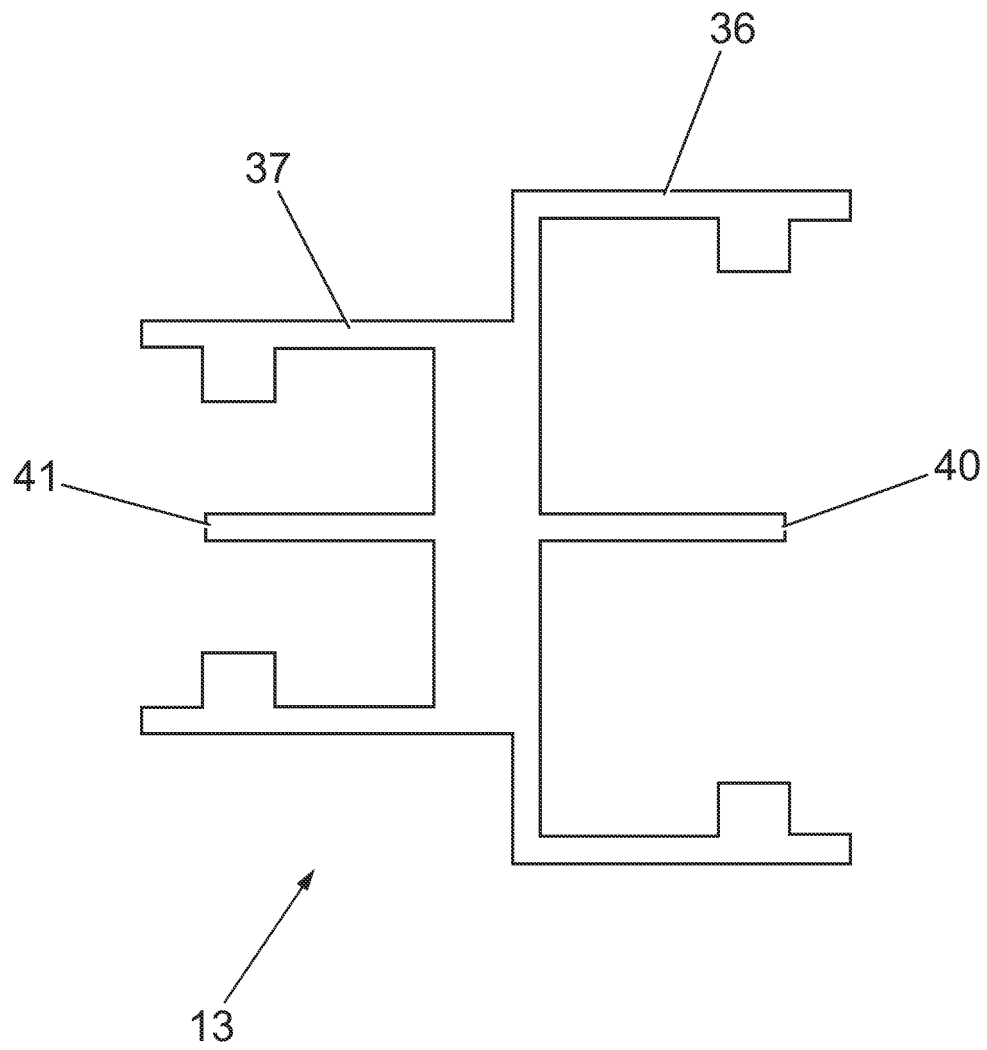
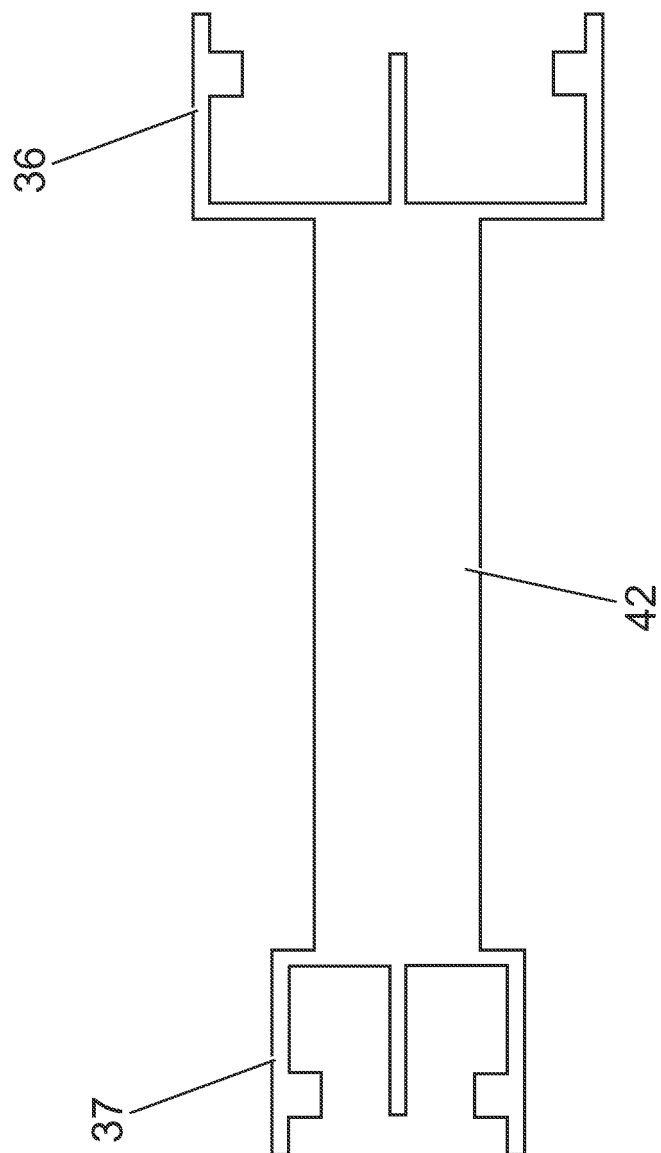


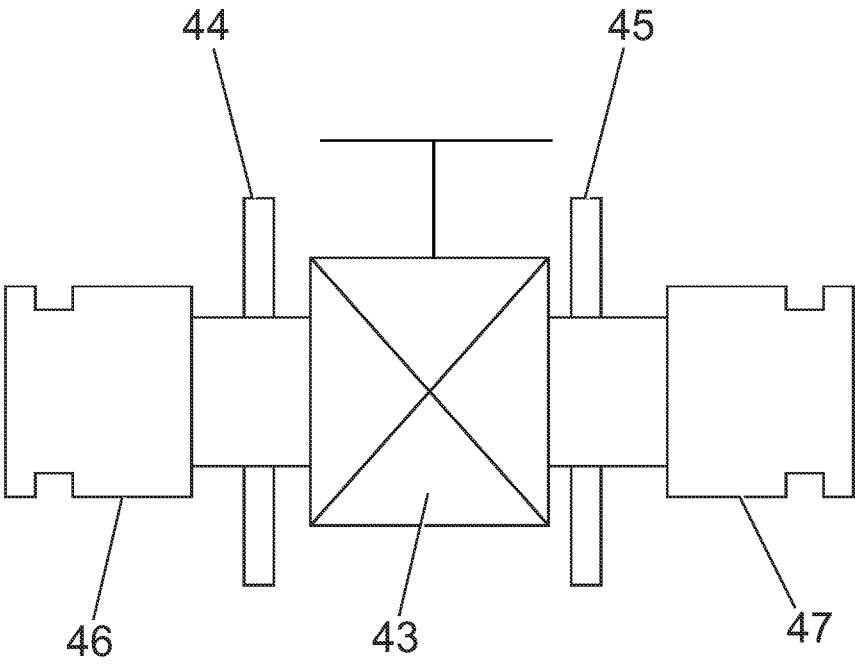
Fig. 9



*Fig. 10*

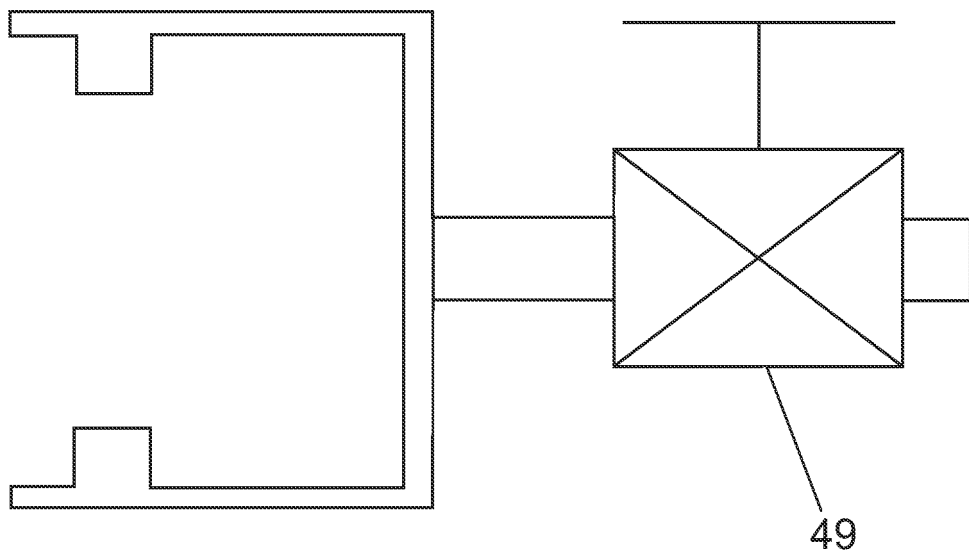


*Fig. 11*



*Fig. 12*

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*Fig. 13*

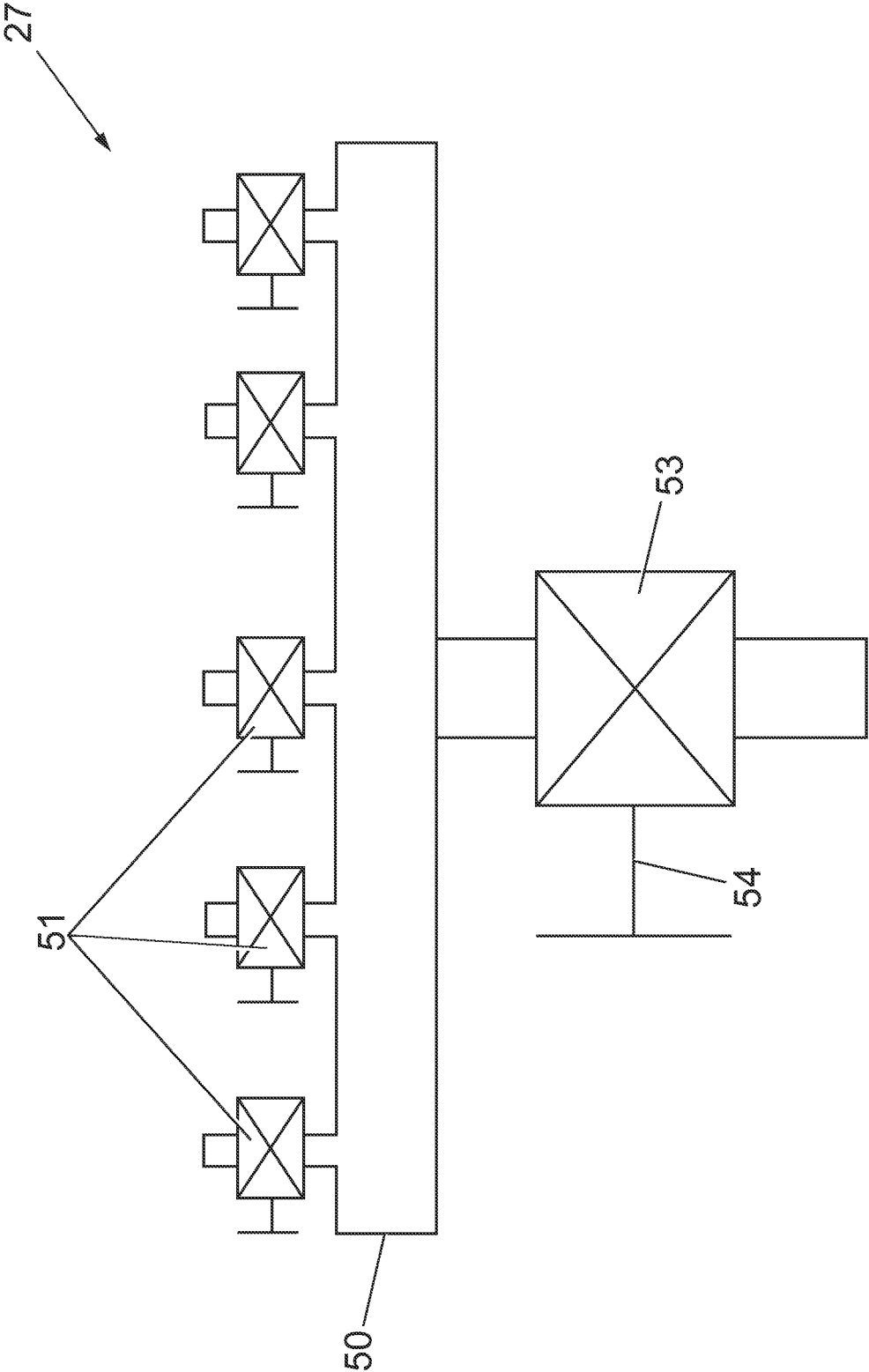


Fig. 14

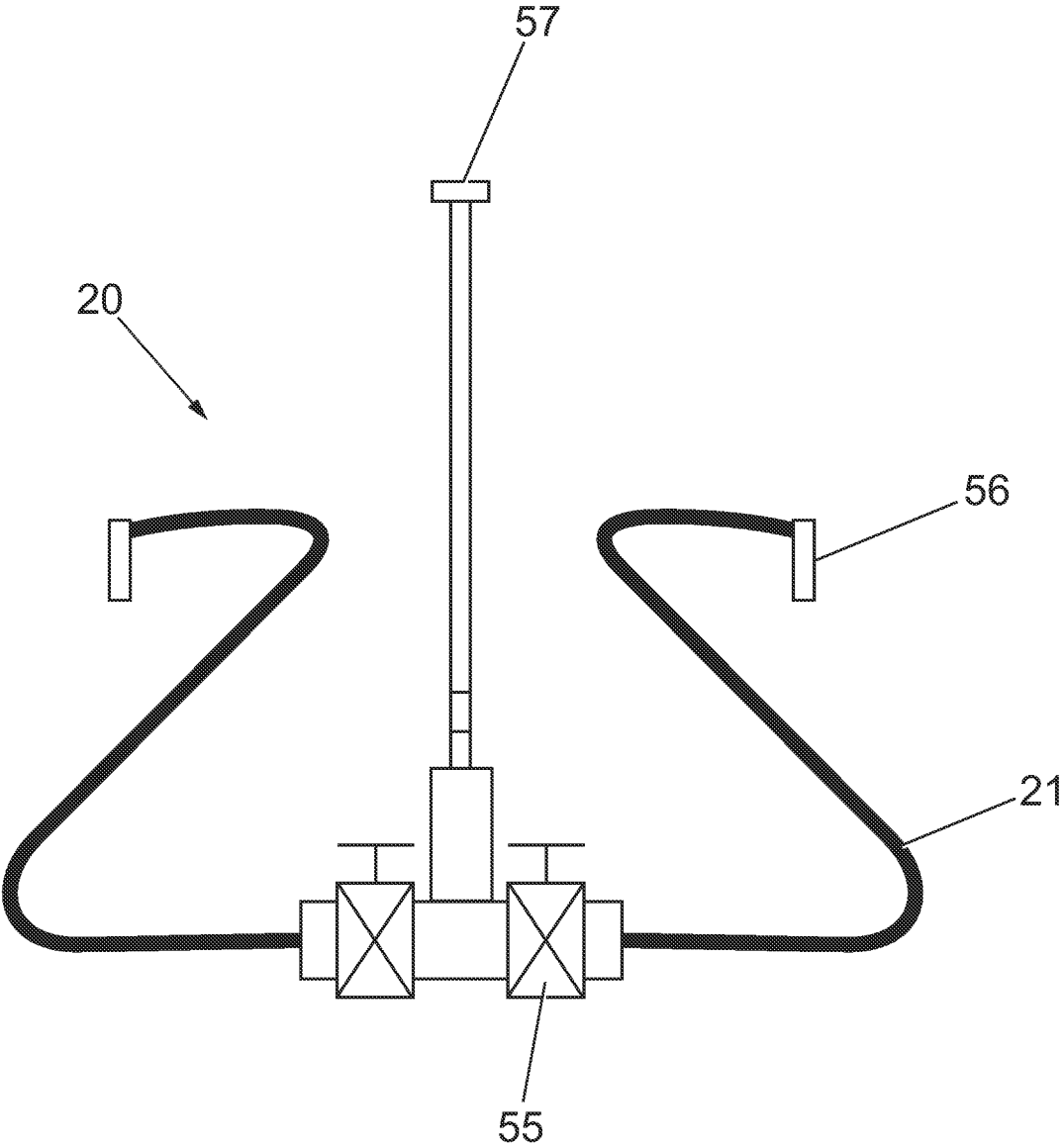
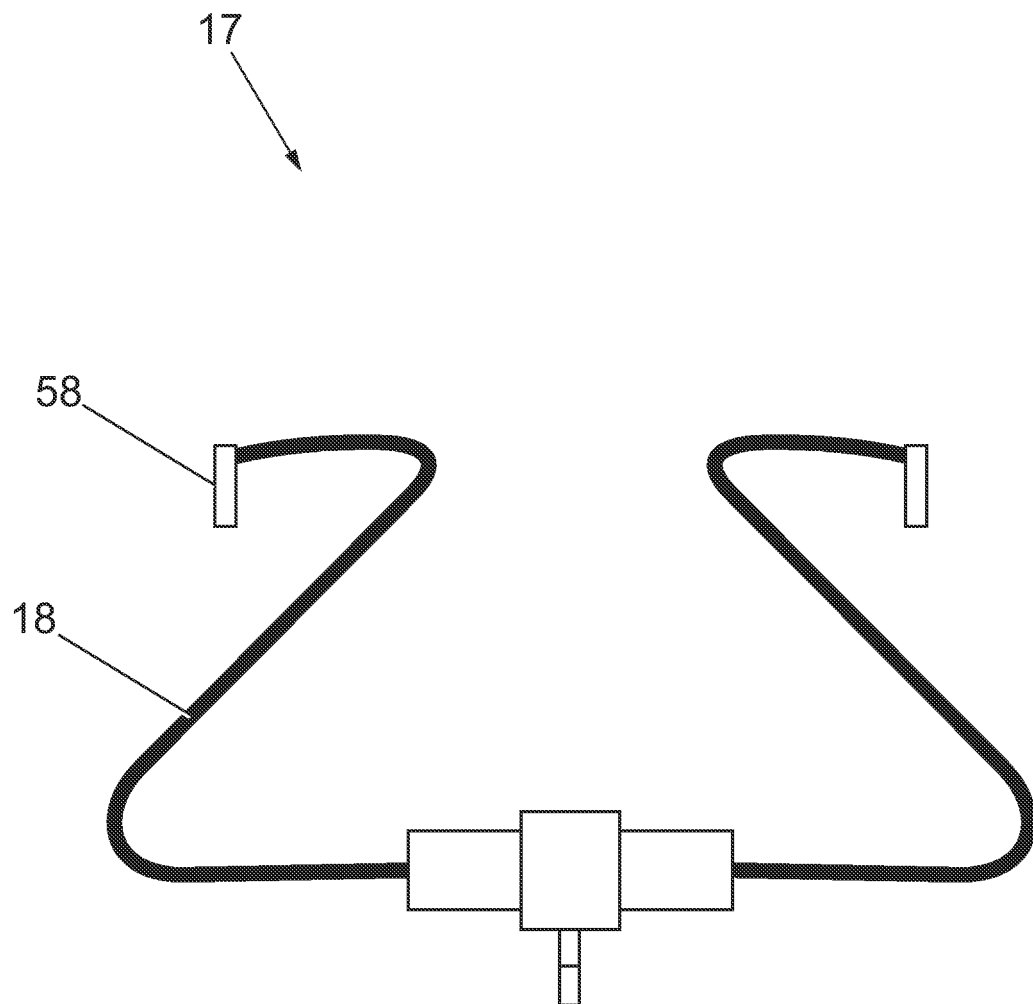


Fig. 15



*Fig. 16*

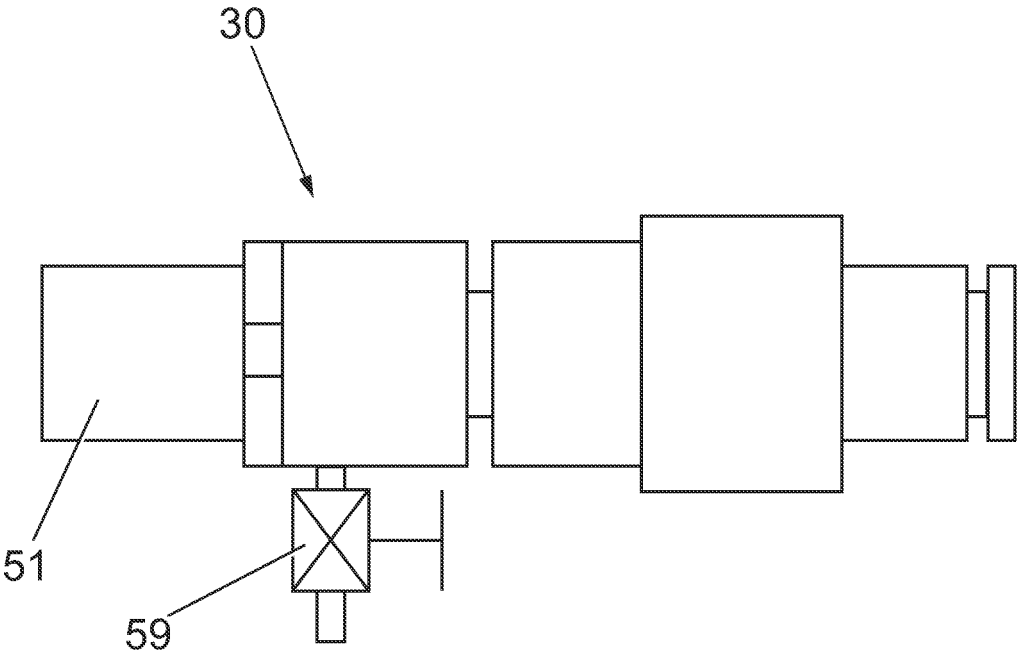
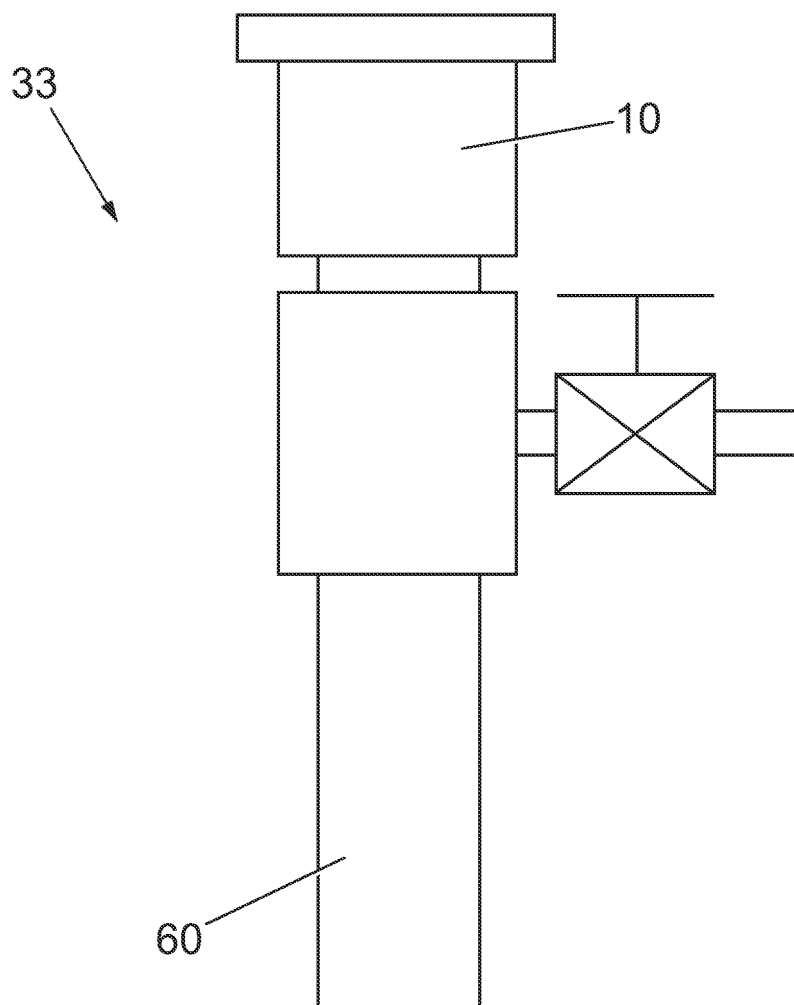
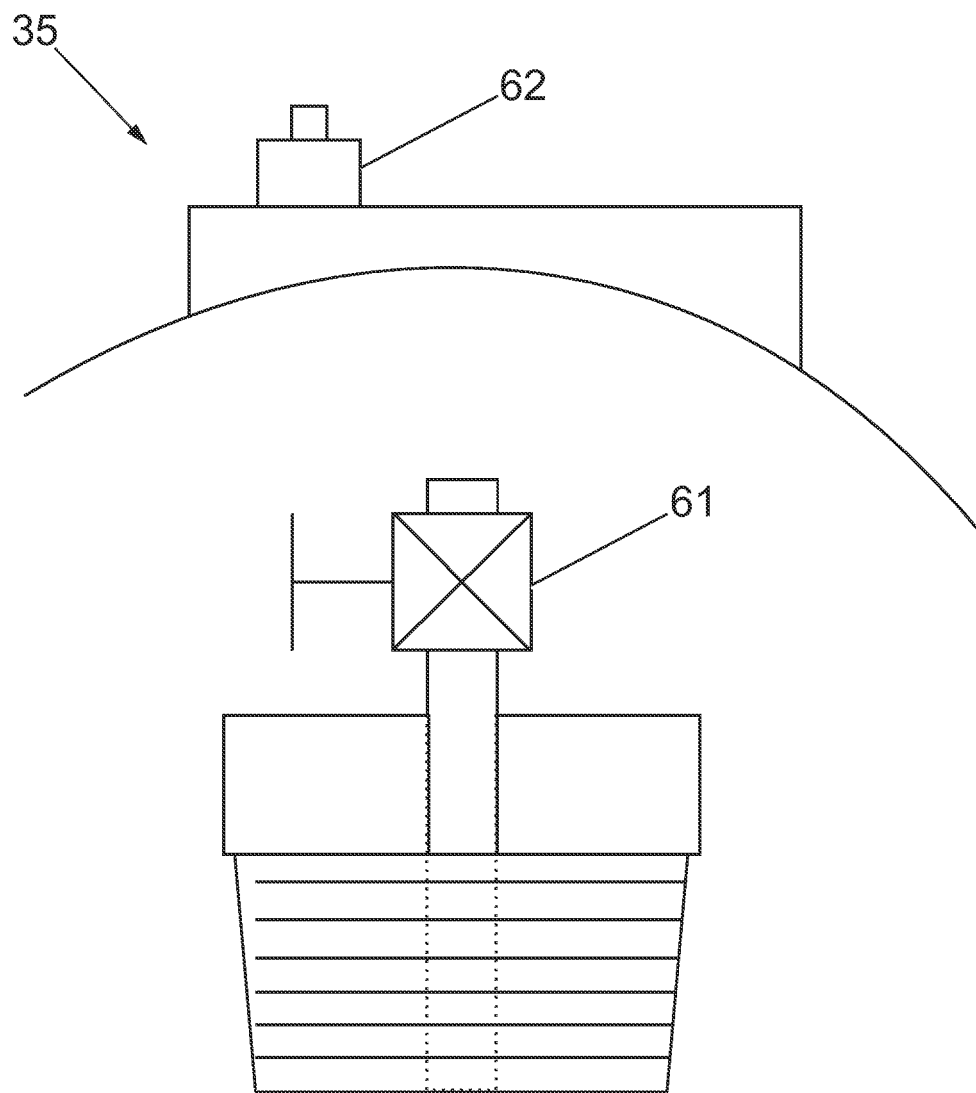


Fig. 17



*Fig. 18*



*Fig. 19*

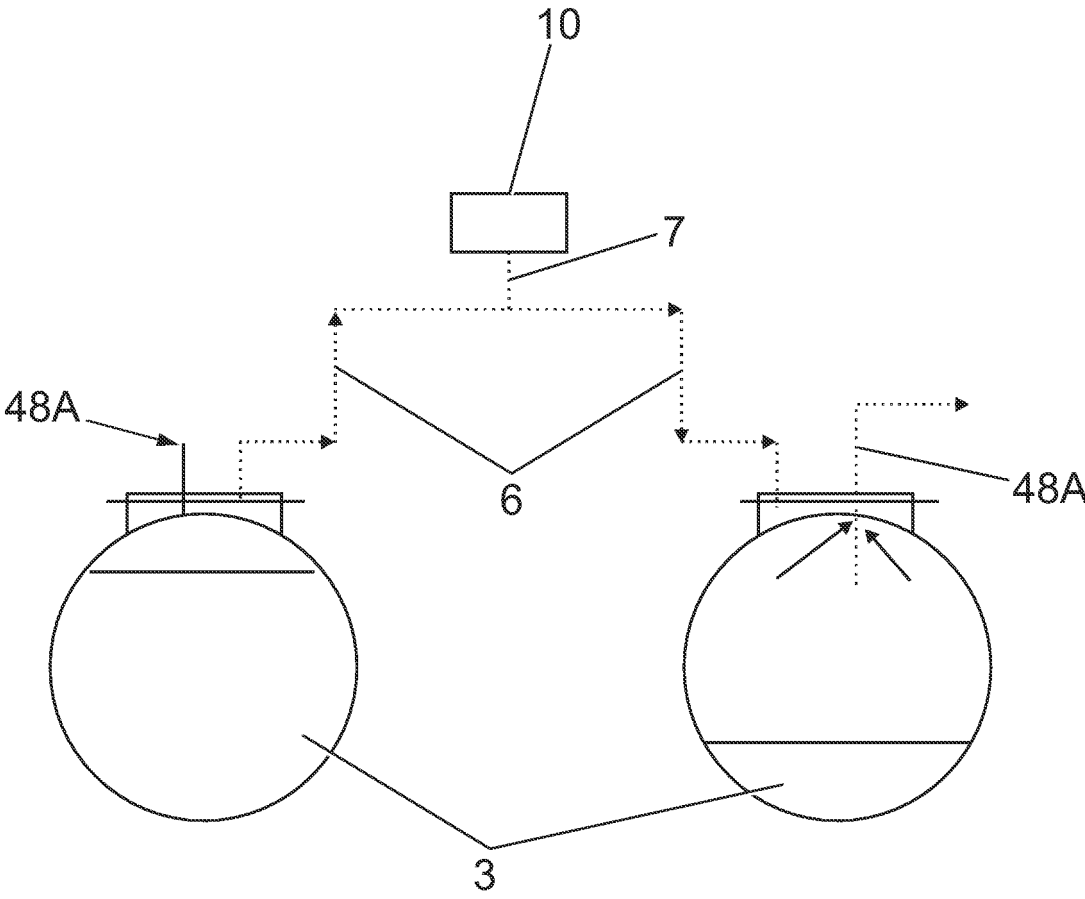
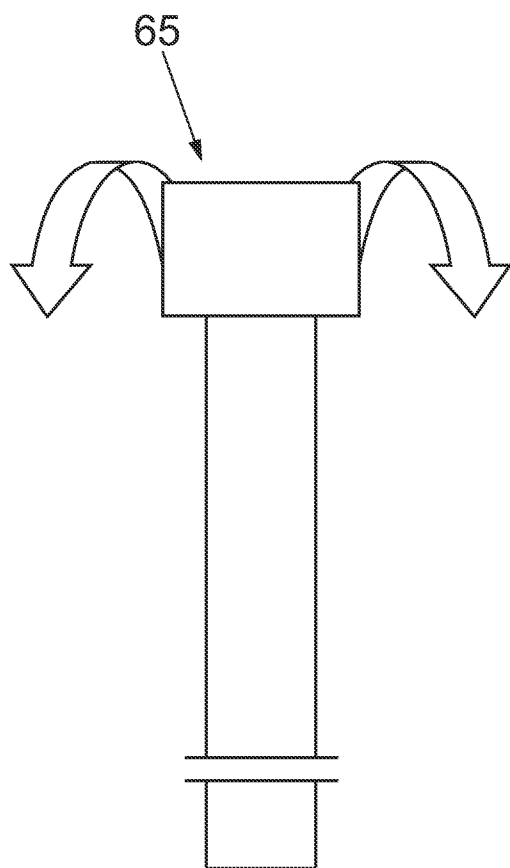
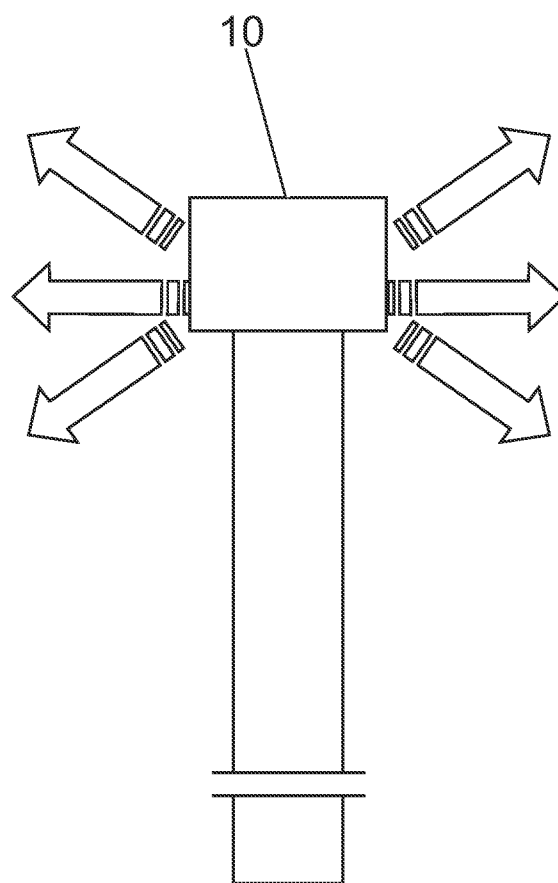


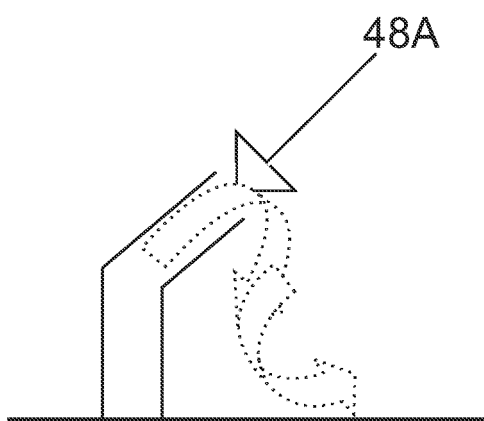
Fig. 20



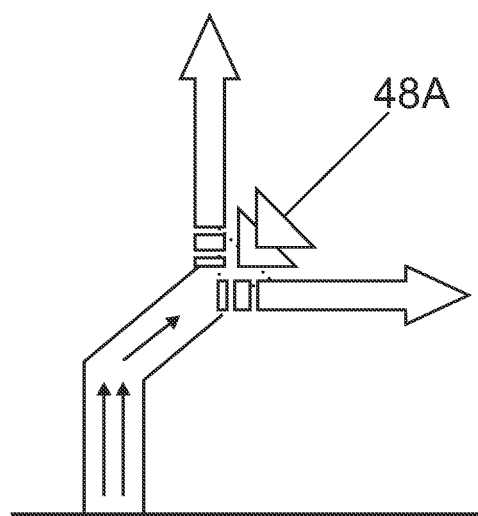
*Fig. 21*



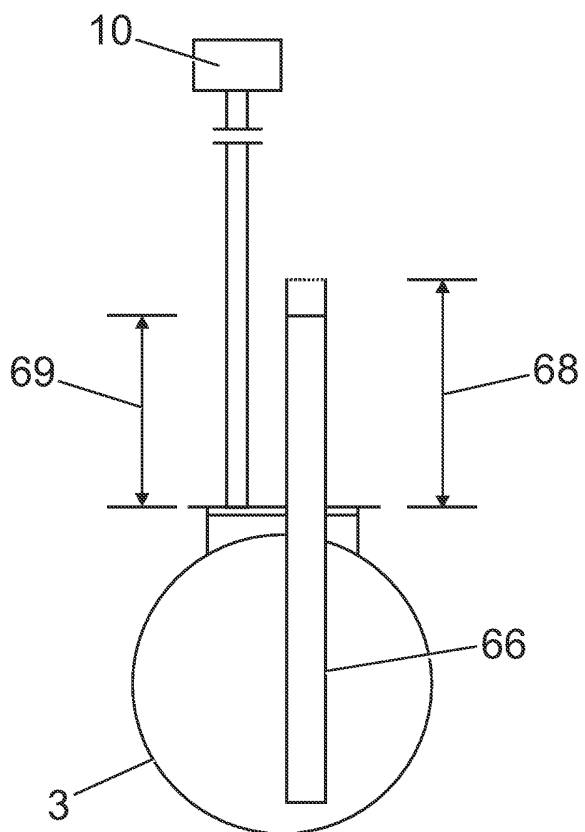
*Fig. 22*



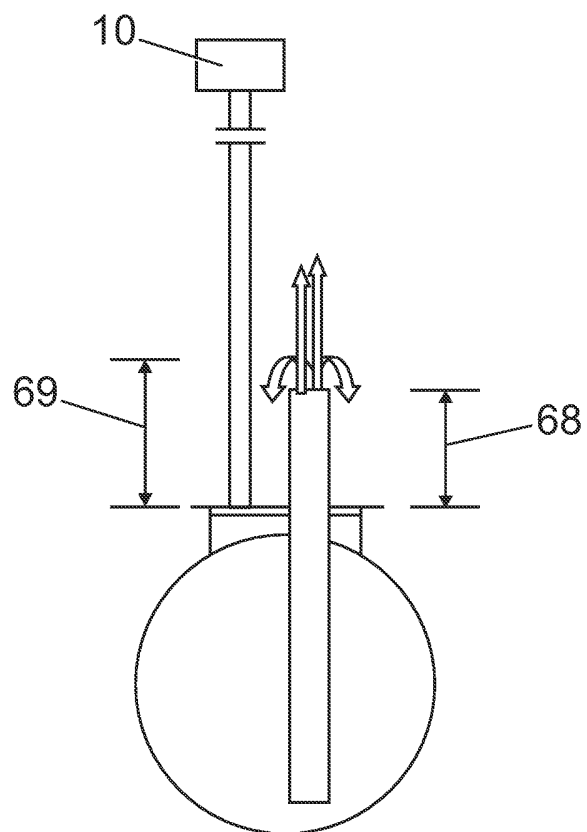
*Fig. 23*



*Fig. 24*



*Fig. 25*



*Fig. 26*

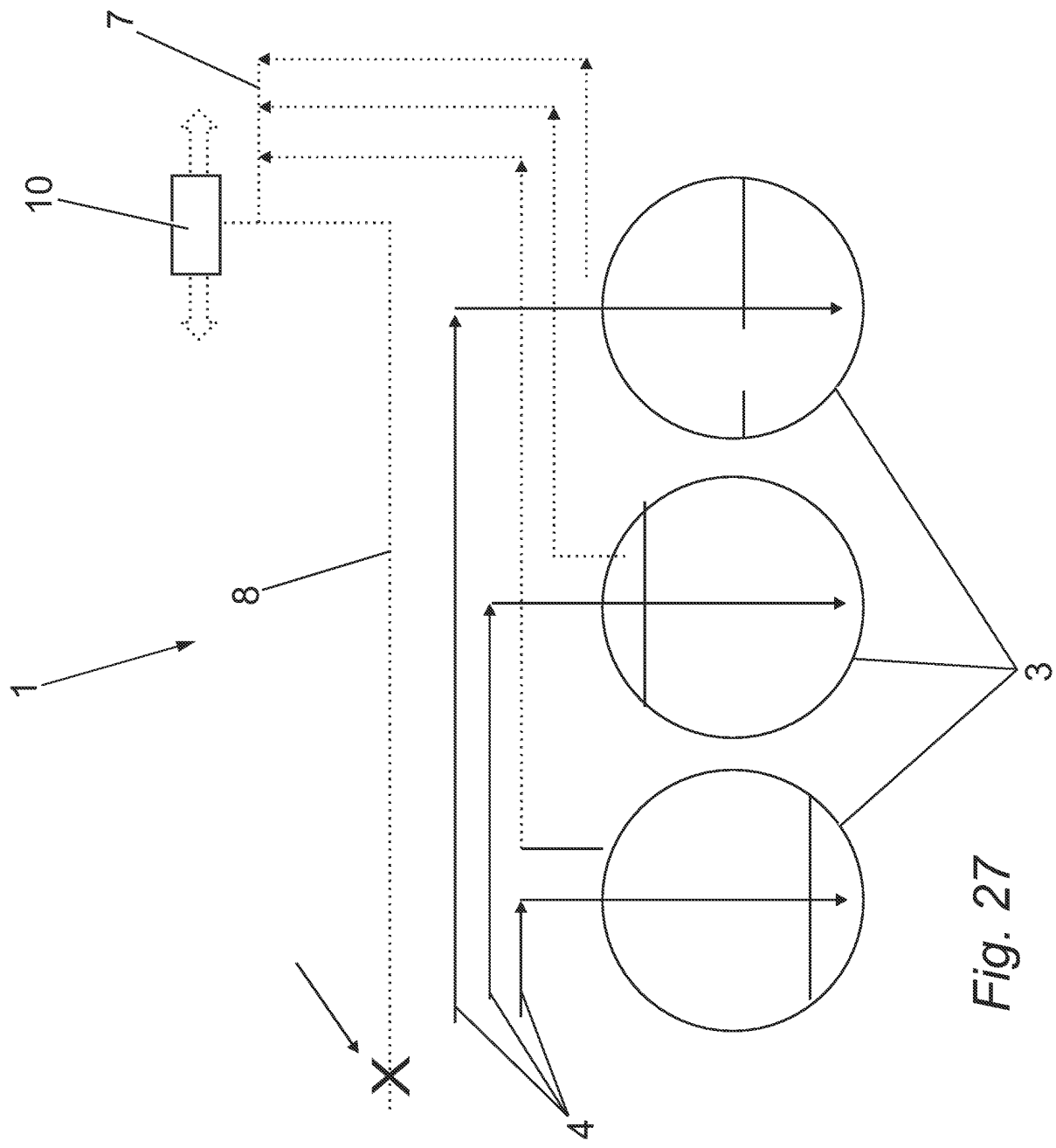
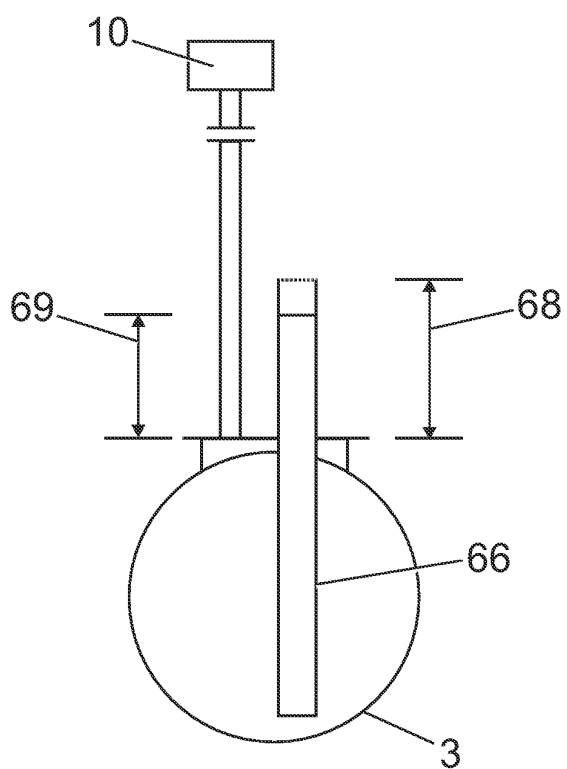
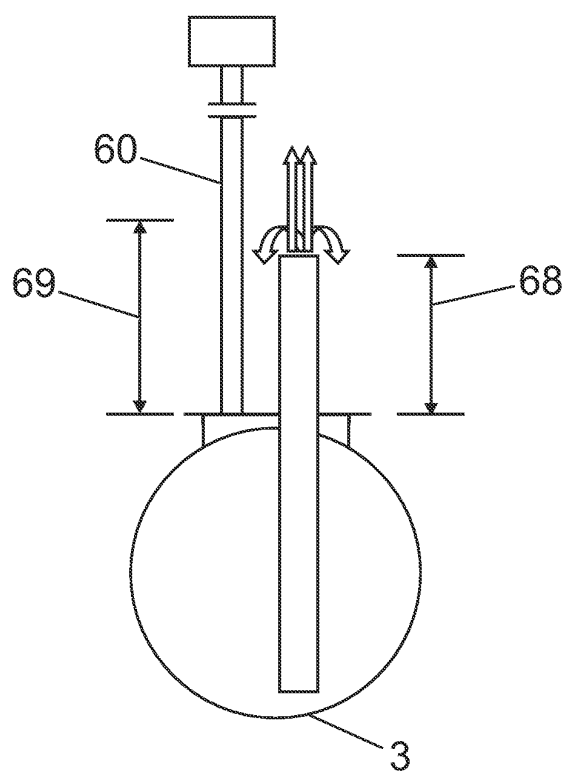


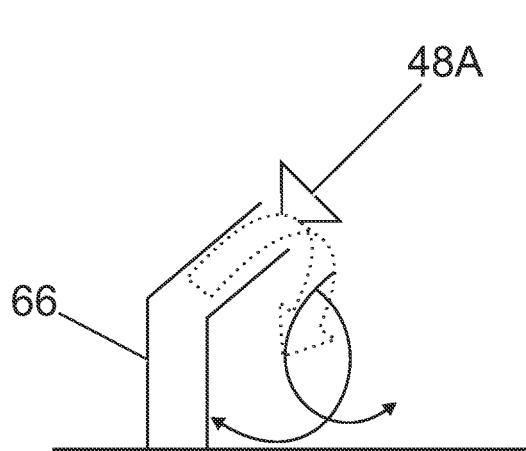
Fig. 27



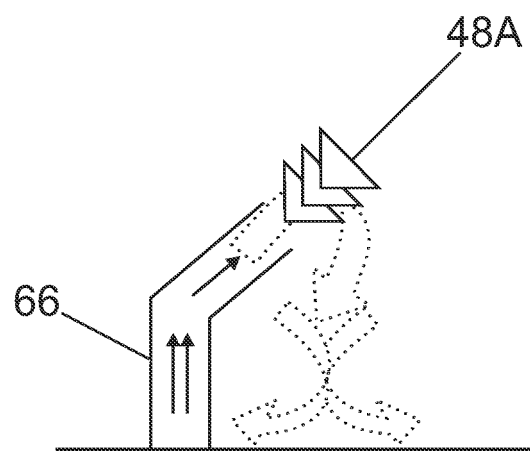
*Fig. 28*



*Fig. 29*



*Fig. 30*



*Fig. 31*

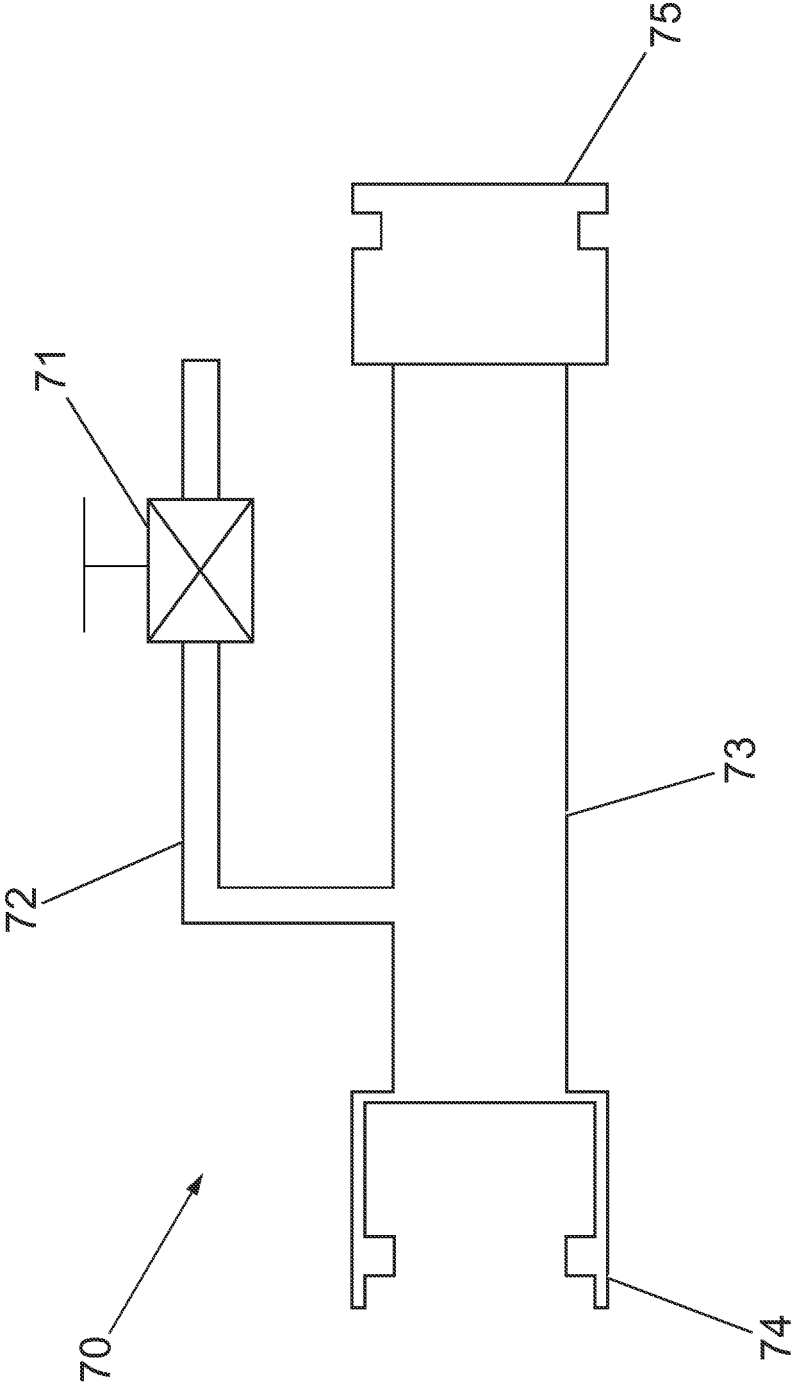


Fig. 32



European Patent  
Office

# EUROPEAN SEARCH REPORT

Application Number  
EP 05 27 0043

| DOCUMENTS CONSIDERED TO BE RELEVANT                                                                                                                                                                                                                    |                                                                                                                    |                                                                                                                                                                                                                                                                              |                                         |
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| Place of search<br>The Hague                                                                                                                                                                                                                           |                                                                                                                    | Date of completion of the search<br>21 November 2005                                                                                                                                                                                                                         | Examiner<br>Martínez Navarro, A.        |
| CATEGORY OF CITED DOCUMENTS<br>X : particularly relevant if taken alone<br>Y : particularly relevant if combined with another document of the same category<br>A : technological background<br>O : non-written disclosure<br>P : intermediate document |                                                                                                                    | T : theory or principle underlying the invention<br>E : earlier patent document, but published on, or after the filing date<br>D : document cited in the application<br>L : document cited for other reasons<br>& : member of the same patent family, corresponding document |                                         |

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EP 05 27 0043

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