GAS INFLATED SEAL FOR A FLOATING ROOF STORAGE TANK

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This invention relates to an improved type of seal for a floating roof tank for the storage of volatile products.

For many years, one of the most efficient storage containers for volatile liquid products has been the flat bottomed cylindrical walled floating roof type of tank that is well known in the art. In such a tank there is generally provided a circular roof having a diameter somewhat less than the diameter of the cylindrical tank which is adapted to float upon the surface of the liquid stored in the tank. A suitable sealing device of annular shape is arranged about the periphery of the floating roof within the shell of the tank for the purpose of sealing the annular space defined by the rim of the floating roof and the inner surface of the tank shell against the escape of volatile fractions of the stored product. It is not economically feasible to construct the floating roof of exactly the same diameter as the inner surface of the cylindrical shell so as to fit together as a piston fits in an automobile cylinder; because in a tank of the size under consideration the cylindrical shell is of relatively thin plate material which is subject to local distortion caused by such factors as thermal shrinkage of welded joints, wind forces, uneven foundation settlement and fabrication and erection tolerances. For this reason the diameter of the floating roof may be from twelve to twenty-four inches less than the diameter of the tank shell, and in such cases the annular space between the rim of the roof and the shell presents a significant source of evaporation loss if not properly sealed.

According to the practices well known in the art, sealing devices for the annular space between the floating roof rim and the tank shell have been of the mechanical or liquid tube type. In the mechanical type, relatively thin flexible metal sheets are placed in sliding contact with the tank shell, supported by various mechanical linkages from the tank roof, with a curtain of seal material extending from the rim of the tank roof to the metallic sheets. This type of sealing device has certain inherent disadvantages, among them being corrosion and abrasion of metallic parts, distortion of the flexible metal sheets causing imperfect contact with the tank shell with resulting high evaporation loss of the stored volatile product, and sparking resulting from electrical charges arcing across various metallic components thus increasing the hazard from fires if not properly protected.

On the other hand, the liquid filled tube type of sealing device known to the art, which in its basic form comprises a rubberized fabric seal material extending across between the roof and the tank shell and distended by means of a liquid filled annular tube, also presents certain inherently undesirable characteristics. For example, the pressure exerted by an adequate depth of liquid may cause excessive abrasion of the fabric material in sliding contact with the tank shell. Furthermore, it frequently happens that the weight of the liquid causes the seal to sag rather than disintegrate outward against the tank shell.

In accordance with the instant invention there is provided a gas inflated rubberized fabric type sealing device for a floating roof tank that is not subject to the difficulties outlined above with respect to conventional types of sealing devices. The invention also provides a source of constant gas pressure within the seal irrespective of variations in temperature of the tank or its surrounding atmosphere and also irrespective of a moderate loss of gas by diffusion through the fabric and by leakage. Additional advantages of the invention will become apparent in the detailed disclosure which follows.

In a preferred embodiment of the invention, there is provided a floating roof tank with a fabric seal extending from the roof rim to the inside or outside of the tank shell which is held in place by means of a flexible tube containing gas such as air under a controlled pressure, together with means for maintaining the pressure within said tube regardless of local temperature variations or other conditions which otherwise might affect the pressure and the performance of the sealing device.

The invention will be better understood from the following detailed description thereof taken in conjunction with the accompanying drawings, in which:

FIGURE 1 is a vertical cross-sectional view of a flat bottomed cylindrical liquid storage tank with a pontoon type floating roof and a sealing device constructed in accordance with the preferred embodiment of this invention;

FIGURE 2 is a similar view, on an enlarged scale, of a portion of the tank shell, the pontoon portion of the roof and the related sealing device with the pressure control means positioned in its normal operating position;

FIGURE 3 is a similar view of the same device with the pressure control means in its most extended or "venting" position;

FIGURE 4 is a similar view of the same device at a time when the pressure regulating means is in its most retracted or "demand" position; and

FIGURE 5 is a vertical cross-sectional view of another embodiment of the invention which makes possible the elimination of a gasholder that is included in the preferred embodiment.

In FIGURES 1 and 2 there is shown a cylindrical tank having a flat bottom 19 and vertical cylindrical sidewalls 41, within which is positioned a floating roof 12 supported by the stored liquid. In these figures the floating roof is of the pontoon type, having a central single deck 13a and a plurality of pontoons 13 arranged annularly about the single deck so as to provide buoyancy for the roof even when great amounts of rain water may have accumulated thereon.

As shown more clearly in FIGURE 2, an annular tube 14 completely encircles the rim 15 of the floating roof and, when inflated, bears against the interior surface of the tank shell 41. A connection 16 to the tube 14 is provided as a source for supplying gas under pressure to the tube.

In the preferred embodiment shown in FIGURE 2, a gasholder 17 is located inside one of the pontoons 13 and is connected by a suitable conduit 18 to the connection 16 supplying gas to the tube 14. This gasholder constitutes a reservoir for the storage of a supply of gas under suitable pressure to accommodate the change in volume of the gas resulting from thermal contraction and expansion. The gasholder 17 consists essentially of a sump 17a and a cover 19, said sump and cover being sealed to each other by a flexible diaphragm 20. The diaphragm 20 permits the cover to rise and fall within rather wide limits to accommodate varying volumes of gas stored in the gasholder 17. The weight of the cover 19 is selected so as to place the gas stored within the gasholder at the optimum pressure desired for maintaining the tube 14 in proper sliding relationship with the tank shell 41.

A suitable inlet valve 21 permits replacement of gas within the gasholder, and in the preferred embodiment this valve 21 is actuated mechanically to open when the roof 19 is near its lowest operating position. Also provided in this embodiment is a venting valve 22 connected by means of a suitable conduit 23 to the gasholder 17 and
to connection 16, and in the preferred embodiment the venting valve will be supplied with mechanical means for opening when the gasholder cover nears its fully inflated position.

As shown in FIGURES 2, 3 and 4, the automatic means for actuating the gas supply valve 21 and the venting valve 22 may be quite simple. In these figures the actuating means for both valves consist merely of vertical rods 21a and 22a extending from the operating mechanism of the valve downwardly to a selected point of contact with another member. In all cases the supply valve 21, this vertical control rod 21a is actuated by contact with the bottom of the gasholder, which in this embodiment is also the bottom of the pontoon in which the gasholder is located. The actuating means for the venting valve comprises a vertical control rod 22a positioned to be contacted by the cover 19 shortly before the roof reaches its upper limit of travel. While this is a preferred embodiment, it should be obvious to anyone skilled in the art that it is not the only method of achieving automatic gas supply valve opening and closing and gas venting valve opening and closing. In fact, these valves could be operated manually rather than automatically, though this is not the preferred method.

The cover 19 of the gasholder 17 shown in FIGURE 2 is in a position within the range of normal operation, at which time there is a sufficient supply of gas within the gasholder to maintain the desirable pressure for most effective operation. In this position, both the supply valve 21 and the venting valve 22 are closed.

FIGURE 3 shows the condition of the gasholder cover 19 when the gasholder is nearly full. In this position cover 19 has become elevated to its extreme uppermost position and has thereby actuated the control rod 22a for venting valve 22. In this position, therefore, the venting valve is opened and the gas within the system is released to the atmosphere. In this preferred embodiment the gasholder maintains the proper operating pressure within the tube 14 despite tendencies for the pressure to increase or decrease because of "breathing" caused by such factors as daily temperature variations, changes in climatic conditions, stretching or other dimensional changes in the tube, and minute loss of gas from diffusion or leakage, and the like. The capacity of the gasholder should be at least equal to the difference between the maximum and minimum volumes occupied by the gas contained within the system.

By way of an example of the method of operation of this preferred embodiment, a synthetic rubber impregnated material of tube 14 is selected of such quality and dimensions that the desirable inflating pressure range for the tube which will permit maintaining the tube at all times in sliding contact with the shell 11 without locking the roof into place and inhibiting sliding, is 1 to 3 inches of water. A gasholder cover is selected having a top hologram (including appendances) that creates this level of pressure in the gasholder. A sufficient supply of gas is then let into the gasholder to inflate the tube to the desired pressure, which may be of the order of approximately 2 inches of water, and to provide a reserve supply within the gasholder at a time during the day when the average temperature of the system is, for example, 70° F. It may be expected that, after the sun has set and nocturnal cooling to about 50° F. has taken place, the volume of gas within the system at the established pressure is reduced by a substantial amount, thus permitting the cover to descend towards its low operating position. No additional gas, however, need be supplied to the system to maintain its pressure until the volume is decreased to such an extent that the cover 19 descends to its lowest position and actuates supply valve 21. As the next day progresses, the temperature may increase until in the early afternoon the average temperature within the system may be as high as 100° F., at which time the gas at the selected pressure will have expanded so as to raise the cover 19 to a much higher level without increasing the pressure. If this expansion raises the cover to its highest operating position, then the venting valve 22 will automatically be actuated to vent a sufficient quantity of gas to prevent the pressure from exceeding the selected level.

It is obvious from the foregoing example that the dimensions of the gasholder should be selected so as to provide a reserve capacity of gas sufficient to accommodate the maximum volume change of the gas at the selected pressure which may be expected to result from normal temperature variations. In a typical example of a floating roof tank having a diameter of 120 feet designed for use in a temperature zone where daily temperature variations may be as much as 50° F., the amount of gas reserve to be provided in the gasholder is approximately 31 cubic feet. Floating roof tanks having a smaller diameter or designed for use in other areas where the temperature variation is not so extreme will require a commensurately smaller gas reserve, whereas larger tanks or larger temperature variations will necessitate a larger gas reserve.

The gas which is introduced through inlet valve 21 may come from any one of a number of convenient sources, including a replaceable gasket, more commonly called a gas bottle; a pressure vessel commonly called an air receiver used in combination with a compressor to maintain the gas pressure; a vessel containing a liquefied gas such as propane; a gas pump consisting of a closed container with inlet and outlet check valves arranged to take advantage of temperature changes in the container (for example, the container might be one or more of the closed pontoon spaces of the floating roof); an electrically powered compressor operated by means of limit switches arranged to operate when the gasholder roof nears its extreme bottom position; or a compressor attached to the floating roof movement caused by filling and emptying the tank.

The gasholder shown in the figures is located within a pontoon of a pontoon type floating roof. Although this is the preferred embodiment, it is obvious that the gasholder can be positioned elsewhere on the floating roof, or used in conjunction with a floating roof other than the pontoon type, all without departing from the scope of the present invention.

The utilization of a gasholder is preferred because it permits trouble-free and maintenance-free operation of a floating roof having a gas inflated seal. Such an arrangement, being almost entirely self-operating and automatic, does not require the constant attendance of maintenance personnel that would otherwise be required if the gasholder, which provides an ample reserve of gas at the desired pressure, were omitted. When a gasholder is used, the only maintenance required is the periodic checking of the working parts and replenishment of the gas supply. Obviously, however, since the gasholder in the system provides a sufficient reserve for daily fluctuations, the demands upon the gas supply are so minor that it would not be necessary to check the gas supply except at infrequent intervals, perhaps once a month. This maintenance-free feature of the roof is of particular importance at bulk terminals and marketing terminals, where maintenance and repair personnel are not ordinarily employed.

In cases in which the tank owner maintains a close
inspection and maintenance program, as for example in an oil refinery, it is feasible to eliminate the gasholder from the system and to keep the seal tube inflated directly from an outside source of gas. Such an arrangement is shown in FIGURE 5, which is a vertical cross-sectional view of an embodiment of the invention which omits the gasholder. In FIGURE 5 conduit 31 is connected directly to a supply valve 32 which is selected of a type to open when the pressure in the tube 14 is less than a predetermined relatively low pressure. The venting valve 33 is also of a type selected to open when the pressure in the tube 14 exceeds a predetermined relatively higher pressure. In this embodiment it is apparent that the normal breathing volumetric changes are accommodated by the inlet valve 32 and venting valve 33, rather than by the movement of a gasholder roof as in the previous embodiment. For this reason a greater amount of gas will be wasted on account of breathing and an equivalently increased amount of gas will have to be supplied from the gas source. This means that a much greater amount of attention is required in operating the system. If the gas supply consists of pressure bottles of gas or of vessels of liquefied gas, as described above, it will be necessary to change the bottles or tanks more often than is the case where a gasholder is employed. Moreover, because both the inlet valve and the venting valve must operate more frequently, the maintenance of these valves becomes more critical. Likewise, in the event that some type of gas compressor is used as the source of supply, the compressor will be turned on and off much more frequently than is the case where a gasholder is employed and the maintenance of this type of equipment becomes more critical. It will, therefore, be apparent that the cost of operating such a system is greater than one in which a gasholder is used.

The foregoing detailed description has been given for clearness of understanding only, and no unnecessary limitations should be understood therefrom, as modifications will be obvious to those skilled in the art.

I claim:

1. In a cylindrical tank for the storage of a volatile liquid, a floating roof having a diameter less than the internal diameter of said tank and adapted to float on said liquid, said floating roof having at least one pontoon for providing buoyancy thereto, an annular impervious flexible tube supported by said roof and disposed between said floating roof and the interior surface of said tank, inflating means for inflating said tube by gas pressure, pressure-regulating means for maintaining in said tube a gas pressure within a predetermined range comprising a constant-pressure, variable-volume gas reservoir located entirely within said pontoon, and conduit means connecting said reservoir with said tube for gas flow therebetween.

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