METHOD OF COOLING AND STORING PROPANE AND THE LIKE

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Application September 15, 1951, Serial No. 246,734

3 Claims. (Cl. 62—1)

This invention relates to a system and method for storing a volatile liquefied petroleum gas, and more particularly concerns the cooling for storing of large batches of propane in pressure vessels.

Liquefied petroleum gas and particularly propane is coming into increasingly widespread use. The handling of this fuel, however, is more difficult than that necessitated by gasoline since normally propane is a gas at atmospheric pressure and temperature. As a gas, propane occupies considerably more space than it does as a liquid and hence it is most desirable to store propane as a liquid where possible.

In the past propane receiving terminals have provided a great number of relatively small high pressure storage vessels for receiving propane. These vessels ordinarily have been able to withstand pressures upward of 250 p.s.i.g. so that under most atmospheric temperature conditions the propane could be stored as a liquid. Often these terminals receive the propane in quite large batches of the order of 15,000 barrels and upward in a single day, necessitating storage facilities for receiving the whole batch. While the batch might be received either from a pipe line or a barge in a very short period of time, the withdrawal thereof generally occurs over a much longer period.

The provision of a very large number of relatively small pressure vessels in which to store the propane has resulted in the utilization of a great amount of steel. The present invention provides a storage system utilizing as little as 20% of the steel heretofore required at the propane receiving terminals. At the same time the method of storage herein employed permits storage of propane as a liquid at a reduced temperature and pressure with little added cost over that required previously for receiving large batches. In fact, the savings in steel alone much overshadows the increased cost in the present method of storage.

The figures of the accompanying drawings illustrate four systems for receiving, cooling and storing a large batch of propane. These systems are all similar in that they employ spherical storage vessels 5 in which propane is stored as a liquid. These pressure vessels are insulated and adapted to store the propane at approximately 75 p.s.i.g. The vessels are all provided with safety valves 6 which will not permit the pressure within the vessel to exceed the safety limit thereof.

Propane is usually received in the pipe lines at the terminals at a pressure of approximately 250 p.s.i.g. and depending upon the atmospheric temperature, the propane liquid may have a temperature within the range of 60° F. to 85° F. In order to store the liquid at a pressure of approximately 75 p.s.i.g., its temperature must be lowered to approximately 40° F. The method of this invention concerns the manner in which the temperature of the incoming propane batch may be lowered to the storage temperature and at the same time thus effecting a lowering of the pressure of the stored liquid.

The system of Fig. 1 shows a single spherical vessel 5 which is capable of containing approximately 15,000 barrels of liquid. Ordinarily at a receiving terminal, there will be a number of such vessels 5 connected together in a series arrangement with a total storage capacity equal to or greater than the contemplated volume of the batch to be received.

Propane is received from the pipe line, barge or tanker through an inlet line 10 which leads directly to one side of an out-of-contact heat exchanger 11. The other side of the heat exchanger 11 is supplied by means of a pump 12 and a connected pipe 13 with a tank 14 which contains ice and a brine or liquid in contact with the ice. The term "ice" as used herein and throughout the specification and claims is meant to include frozen water with or without added ingredients.

The tank 14 operating under atmospheric pressure is adapted to hold a sufficient quantity of ice to cool the entire incoming propane batch from its incoming temperature to approximately 40° F. The brine or other liquid is circulated by the pump 12 through one side of the exchanger 11 to cool the incoming batch. A temperature regulated valve 15 is situated in the line 16 connecting the exchanger 11 with the interior of the storage vessel 5. A control line 17 is arranged to be sensitive to the temperature of the propane at 18 so that the valve 15 which is normally open will be closed when the temperature of the propane at point 19 tends to exceed about 40° F.

Thus, by the utilization of this system, the incoming propane 10 is cooled in the heat exchanger 11 and upon reaching approximately 40° F. will be admitted into the storage vessel 5. A vapor line 19 or vapor line 19'a connected with the upper portion of the storage vessel 5 to conduct away from the vessel the vapors which fill the space above the liquid level. These vapors are caused by boiling of the liquid upon entering a warm vessel, and also by heat loss through the walls of the vessel during storage. These vapors may be conducted to a point of use or may be compressed, cooled and returned to storage if desired.

The system illustrated in Fig. 2 receives warm propane by the line 20 connected directly with the storage vessel 5. Since the incoming liquid is at a pressure of approximately 250 p.s.i.g. and at a temperature above 40° F., the liquid upon entering the storage vessel 5 will boil exceedingly and fill the space above the liquid surface. Upon boiling some cooling will occur, however, the pressure within the vessel, if permitted to mount, will exceed the storage pressure of 75 p.s.i.g. A vapor line 21 is provided for conducting the vapors to one side of the heat exchanger or condenser 22. A control valve 23 is sensitive to the pressure within the storage vessel through a connecting control line 24. This valve is so arranged as to maintain a pressure within the vessel 5 of approximately 75 p.s.i.g. The vapors removed through the line 21 are cooled in the exchanger 22 by brine or water circulated through the other side of the exchanger by a pump 25 which passes the brine in contact with the ice within a tank 26. The condensed vapors flow into a receiving tank 27 from which they are pumped in means of pump 26 back into the storage vessel 5. The returned condensate is generally cooler than the propane within the storage vessel and thus aids in cooling the bulk. A small vapor line 29 permits vapors from the liquid within the receiving vessel 27 to return to the condenser 22.

The system of Fig. 3 differs from that of Fig. 2 primarily in the placement of the condenser or heat exchanger relative to the storage vessel 5. Cooling warm propane is admitted by pipe line 30 to the storage vessel 5, and vapors boiling from the liquid enter a line 31 at the top of the storage vessel and are conducted to one side of the heat exchanger 32. The other side of the
The exchanger is provided with cooled brine or water from a pump 33 through line 34 into the exchanger to cool and condense the vapors which were previously conducted into the exchanger. The brine is returned by means of line 35 to an ice tank 36 containing sufficient ice to cool the entire batch which will be received within the storage vessel 5. As the vapors are condensed within the exchanger 32, they flow to the bottom of the exchanger and back into the storage vessel 5 through the line 31. This process continues until the vessel 5 is filled to its capacity with cooled propane at about 75 p. s. i. g.

The system of Fig. 4 differs from that of Fig. 3 only in the placement of the coils within the exchanger. In this embodiment, warm propane is introduced into the vessel through line 40. The liquid boils within the vessel and the vapor rises to the upper part of the spherical vessel where they come in contact with coils 41 which are cooled by brine pumped through them by a pump 42 and connected piping 43. The brine or other liquid is returned to the ice tank 44 through piping 45 connected with the coil and the tank. If desired, sufficient brine may be continuously pumped through the coils to maintain the liquid stored at a sufficiently low temperature to keep the pressure within the vessel at or below 75 p. s. i. g. It is contemplated that the large batches of propane which are received at the terminals will be initially cooled by utilizing out-of-contact heat exchange wherein the cooling medium is essentially water ice. This method of cooling the batch is very economical and does not require a great initial outlay of equipment and machinery as would a mechanical or absorption refrigerating unit of sufficient capacity to supply the refrigeration during the relatively short time the batch is being received. Smaller equipment may be used to make ice over a long period of time and the ice used to supply cooling for the batch of propane.

Once the batch has been received and cooled for storage in the spherical vessels, it may be maintained cool by permitting sufficient boiling of the stored liquid and removal of vapor from the vessels to maintain the remaining liquid at the storage temperature. The vapors which are withdrawn from the vessels may be conducted to a separate storage vessel wherein they may be stored until such time as they may be delivered for sale. At some terminals, compressing equipment may be available whereby the vapors withdrawn from the storage vessels may be compressed to liquefy them and the resulting liquid stored in a smaller higher pressure vessel or the liquid could be cooled and returned to the spherical storage vessels.

The particular embodiments of the invention described herein show the ice tank and heat exchanger separate with lines connecting them. In some installations, the coils of the exchanger may be immersed in liquid (water or brine) in the ice tank and propeller type agitators may be used to circulate the liquid around the coils. The propane would be passed through the coils and cooled by the circulating liquid around the coils.

The foregoing detailed description is given for clearness of understanding only, and no unnecessary limitations should be understood therefrom as some modifications may occur to those skilled in the art.

I claim:

1. The method of storing large batches of the order of large loads of liquid propane which comprises the steps of; receiving large batches of liquid propane in a short period of time at pressures of the order of 250 p. s. i. g. and at temperatures above 40° F. and conducting said liquid to a normally closed storage tank of sufficient capacity to receive such batches in a short period of time; permitting some of the liquid to vaporize in said tank and thereby cool the contents of the tank; cooling and condensing said vapors by the use of a heat exchanger; returning the condensed vapors to the liquid contents of the tank and further cooling the liquid propane in the tank and reducing the pressure within the tank to approximately 75 p. s. i. g.; and maintaining the pressure in the tank at approximately 75 p. s. i. g.

2. The method of storing large batches of the order of large loads of liquid propane which comprises the steps of; receiving large batches of liquid propane at pressures of the order of 250 p. s. i. g. and at temperatures above 40° F. in a short period of time and conducting said liquid to a normally closed storage tank of sufficient capacity to receive such batches in a short period of time; cooling the liquid in the tank by permitting the liquid to partially vaporize in said tank; removing sufficient vapors from the tank to maintain the pressure within the tank at approximately 75 p. s. i. g.; passing the vapors through a heat exchanger; cooling the heat exchanger by ice, thus cooling and condensing the removed vapors; and returning the condensed vapors to said tank and thus further cooling the liquid propane in said tank.

3. The method of storing large batches of the order of large loads as defined in claim 2 wherein the cooling and condensing of the removed vapors comprises the steps of; circulating removed gases through one side of a heat exchanger and circulating a liquid, cooled by ice, through the other side of the heat exchanger to remove sufficient heat from the propane vapors to lower its temperature to at least below its boiling point.

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