Accurate Metering of Butane and Propane

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BUTANE-PROPANE News SEPTEMBER — 1947

A SUBJECT of growing importance is that of properly safeguarding meter accuracy in the measurement of butane and propane in both bulk plant and tank truck installations. Careful consideration must be given to the piping layout and particularly to proper provision for the necessary elimination of vapor bubbles before passage of the liquid through the measuring chamber of a positive displacement volumetric meter. Where this is not done, and it is possible for any appreciable volume of vapor to pass through the meter, such vapor will, of course, be measured the same as that much additional volume of liquid. This results in a false registration, greater than would be represented by the actual volume of liquid delivered.

Due to the unavailability of any especially designed LP-Gas metering equipment, it has so far been the practice to adapt substantially standard gasoline metering equipment to this service, including so-called "air eliminators," restyled as "vapor eliminators."

There is no reason why the meter measuring mechanism itself need be materially changed, except to give due consideration to the fact that butane and propane have a liquid viscosity of about one-tenth that of gasoline. This makes it imperative that the meter will operate under the lowest possible head pressure and that slippage clearances be reduced to a minimum. One important feature, apparently overlooked by some meter manufacturers, is the advantage of having the incoming fluid enter through the top of the metering device, instead of at the bottom. This is so as to permit any vapor which may have accumulated in the meter, between operations, to pass upward into the vapor eliminator and so insure an initial solid liquid content of the meter.

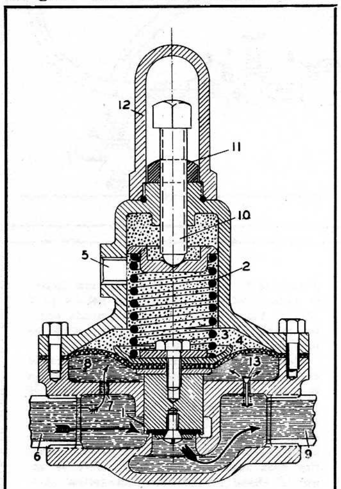

FIG. 1—Type A Diaphragm Back Pressure Valve. Valve (1) is normally closed under pressure of spring (2). Space (3) above flexible diaphragm (4) is placed under pressure from tank through connection (5) (see Fig. 3). Fluid entering valve inlet (6) passes through drilled port (7) filling space (8) below diaphragm (4). Fluid pressures above and below diaphragm are thereby normally balanced. However, when pump is started and pressure below the diaphragm reaches a desired pre-determined pressure in excess of normal tank pressure, or that above the diaphragm, valve (1) is lifted against the tension of spring (2) and fluid is permitted to pass through valve to outlet (9). The exact differential pressure which is developed before valve opens is determined by the tension of spring (2). Spring pressure may be adjusted by screw (10) which is secured in position by locknut (11). Cap (12) prevents leakage around adjusting screw threads, and may be sealed to prevent tampering. Outlet hose is protected against excessive pressures which may be developed through sun heat, etc., by relief valve (13). However, valve (2) in itself will normally afford adequate relief protection when the spring tension is properly proportioned to the valve area.

The elimination of vapor bubbles or vapor pockets in an LP-Gas system is quite a different problem than that of the elimination of air such as may be entrained in a gasoline stream. Particular attention will be given in this article to a review of just what differences do exist in these two problems, and why, in the opinion of the writer, the "air eliminator" developed for the separation of air from gasoline may be a somewhat superfluous item in an LP-Gas metering setup.

The reason that air gets into the gasoline line is that gasoline is handled under atmospheric pressure. Under these conditions tanks, pipe lines, valves and hose connections become filled with air after each complete tank discharge. This air, lying in pockets throughout the system, can then very readily be drawn into the gasoline stream during the discharge of the succeeding load.

Air Separation is Vital in Gasoline Metering

The separation of this air, prior to passage of the liquid through the meter, therefore, becomes a subject of the greatest importance. And such air elimination can only be accomplished by actually blocking the liquid flow to slow it down when necessary, and so permit time for the air bubbles to rise and separate out in a so-called "eliminator pot," from which the air may be released by a ball float and valve mechanism back to the tank.

On the other hand, in the case of butane and propane, operating pressures are far above atmospheric, and it is therefore normally impossible for any air to enter the system. Nevertheless, we will have the formation of vapor bubbles or gas pockets at almost any point in the flow stream should there be even the slightest reduction of pressure to below the pressure in the supply tank. And as has been previously mentioned, the passage of such vapor bubbles through the meter would result in over-registration, the same as would be the case with air bubbles in gasoline metering. For this reason some positive means of vapor elimination must be provided, if we are to be assured of accurate metering.

There are today two types of back pressure valves which have come into use to perform this function. One type is commonly referred to as the diaphragm back pressure valve. This device is illustrated in Fig. 1 and designated as Type A. Its position in the complete assembly is diagrammatically shown at A, Fig. 3. A brief description of its operation is given with the drawings.

It will be seen that this valve is designed to maintain a uniform increase of the pressure within the meter over the pressure in the supply tank. It is located on the meter "down stream," and even though the discharge line beyond this valve were to be completely open to atmosphere, no liquid could pass through this valve except under conditions where the 10 lb. or other desired pressure differential is first established within the meter and its measuring chamber, *above that existing in the supply tank.*

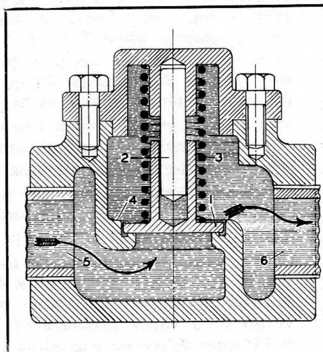

FIG. 2 — Type B Spring-Loaded Check Valve. This drawing is merely schematic to show the general principle involved in this type valve. Many variations in form are possible. Valve (1), guided on fixed pin (2), is normally closed under pressure of spring (3). Shoulder (4) requires valve to lift high above valve seat, so avoiding chatter. Fluid enters through valve inlet (5), and establishes a pressure below valve (1) sufficient to overcome spring loading, plus fluid or vapor pressure above valve. Fluid then passes to upper part of valve housing and is discharged through port (6). Reference to Fig. 4 will show position of this valve in the complete assembly line.

Vapor Eliminated by Pressure

How is the elimination of such vapor to be effected? Very simply, by placing the meter intake under a positive pressure somewhat greater than the normal vapor pressure developed by the fluid within the supply tank. This excess pressure in the meter section of the flow line will result in the instant collapse of all vapor which might otherwise exist.

How much pressure must be raised to collapse all the LP-Gas bubbles? Just enough to be in excess of the vapor pressure in the supply tank. Or, it might be better to say, to a pressure equal to the vapor pressure of the fluid at the temperature under which it exists in the meter or intake lines. And to be safe we should figure that a few pounds more might be required because, in the passage of the liquid through the meter, there may be sharp edges, or changes in sectional area of the passages, sufficient to cause pressure reductions. All in all, an increase of 5 to 10 lbs. above the tank vapor pressure proves, in practice, to be a very satisfactory margin.

But this 5 to 10 lbs. excess pressure, which must be maintained, should always be based on the pressure within the supply tank, and not be established on the basis of a definite arbitrary pressure, or on the basis of the pressure existing in the outflow line. For example, if we are handling 100% propane under 80° F. tank temperature, we will have a gauge vapor pressure in the tank of 128 lbs. (See LP-Gas pressure-temperature tables). In this case, we need to withhold the flow until the pressure within the meter is approximately 10 lbs. higher, or 138 lbs. gauge.

In another case, if we are metering a butane-propane mixture which at a certain temperature is under a tank pressure of 80 lbs. gauge, we want the pressure within the meter held up to 90 lbs. before flow starts. And if, on another day, the atmospheric temperature rises so this same fluid shows a tank pressure of 90 lbs. gauge, our meter pressure must be held to 100 lbs.

Excess Pressure Held to 10 Lbs.

In each case above, it will be noted that the pressure in the meter is held to 10 lbs. greater than the pressure which has been established in the supply tank, in accordance with the type of fluid and the tank temperature. This is an assurance that all vapor bubbles and gas pockets will be collapsed and the fluid contents reduced to solid liquid before passage from the meter.

Pump Must Be Operating

In other words, no discharge could take place until the pump was started and such excess pressure developed as may have been found necessary to collapse all possible vapor pockets, and so insure accurate measurement.

A second type of back pressure valve which is recently coming into quite general acceptance is illustrated as Type B in Fig. 2. Its position in the complete assembly is diagrammatically shown at B, Fig. 4. This valve is, in effect, merely a spring-loaded check valve, similar in design to that usually provided as a by-pass or relief valve. These valves are sometimes supplied as a part of the metering device, and are then placed at the meter outlet. Sometimes they are placed in the discharge line just beyond the meter as is shown in Fig. 4, and sometimes they form a part of the dispensing assembly.

In any case they hold a fixed back pressure in the meter, in excess of the pressure which may exist *in the discharge line* beyond the meter. This valve does not adjust the point at which it will pass fluid, in accordance with the vapor pressure of the fluid *in the meter* or *in the supply tank.*

It is important that some study be given to these two types of valves, as shown in Figs. 1 and 2, in order to distinguish between them, and to understand the reasons for the greater effectiveness under many conditions of the one valve over the other.

With the Type A valve, regardless of variations of pressure established within the supply tank, the fluid in the meter will always be held to a higher pressure. This pressure will therefore always be above the vaporization pressure of the actual fluid within the meter. This condition will be maintained regardless of any variation which may occur in the meter discharge line pressure.

In fact, no discharge can ever be made through this valve without operating the pump, because a higher pressure than that in the supply tank must be developed before this valve will open and permit the passage of fluid.

On the other hand, with the type B valve, the point at which fluid is passed is solely dependent on having a higher pressure in the meter than in the *discharge line* to the customer's tank. The opening of the valve is not related back to the vapor pressure of the *supply tank*, nor does the pressure at which this valve will pass fluid automatically adjust itself in conformity with the vapor pressure of the particular fluid being handled, or with the pressure variation which may result due to temperature changes from day to day.

Variation in Services

Just what discrepancies in accuracy do occur in average use seem to be subject to some differences of opinion. Many meters equipped with Type B valves do give excellent results with apparently equal accuracy under certain operating conditions. There is no reason why this would not be the case where a meter so equipped was used exclusively to serve the same customers repeatedly with the same product and never into a totally empty tank.

But this accuracy is apparently not maintained where these meters are used in a more promiscuous service, as for tanks previously served by other supply stations carrying products which may differ considerably in vapor pressure, as would be the case with cars and trucks traveling over the highways and operated on butane, or in the case of small tanks such as are used in camps or for automobile trailers.

Excessive Pressures Undesirable

To meet these varying pressure conditions it has been found necessary to repeatedly boost the valve spring loading when Type B back pressure valves are used. A pressure setting as high as 30 or 40 lbs. is frequently found to be inadequate to prevent some vaporization and "meter spinning" under such conditions. The combination of a lower temperature in the tank receiving the fluid, in addition to a possible difference in the type of fluid previously used, to say nothing of the totally empty tank frequently presented for filling, may result in a vapor pressure of the fluid being delivered, exceeding that of the receiving tank by as much as 50 or even 100 lbs.

It is believed that such experiences, with inaccurate metering as a result, may have been responsible for the adoption by some dispensing equipment manufacturers of Type B valves set as high as 100 lbs. of differential pressure. While anyone must admit that such excessive pressures would certainly aid in correcting any meter inaccuracy due to not having solid liquid, it should also be apparent that this result would only be accomplished at the expense of very severe and unnecessary punishment of the pumping equipment. Not only would the pump be doubly overloaded, under these conditions, but burned-out motors must frequently result under such excessive loading, while under a normal pressure development these same motors would have ample power capacity for long-life service.

In this article, particular attention has been called to the superior flow control which appears to be had by use of the Type A diaphragm, back pressure valve. It should be quite apparent that this valve with a differential setting of not to exceed 10 lbs. can be made to serve the purpose far better than does the Type B valve, even under excessive pressure buildup.

It is the opinion of the writer that in many cases of reported pump failure and motor overload, such trouble would be eliminated if meters were to be equipped with Type A valves. Operation of the entire equipment would be smoother and greater accuracy could be maintained under the varying conditions of service. Also, certain safety features reflecting on the entire installation may then be incorporated, at perhaps an even lower total equipment cost.

Reference has been made relative to the omission of the usual somewhat delicate float and valve mechanism such as in the past has been provided with gasoline "air eliminators." It has been quite definitely established that this is possible and that a constant by-pass, through a fixed orifice, as shown in Fig. 3, prevents the accumulation of vapor in the meter during idle periods, and allows for a complete wash out of any small amount of air or other noncondensable gas upon starting the flow.

It is necessary, however, when a fixed orifice is used in connection with the Type B valve, to add a light check valve in the orifice return line. This is to prevent the reverse flow of gas or liquid from the tank, which might otherwise occur should the outlet line from the meter be opened prior to starting the pump.

Such a reversal of flow also apparently takes place under certain conditions where the conventional float valve mechanism is used, with a possible result of erratic meter registration.

FIG. 4—This diagram shows position in meter assembly of Type B, Fig. 2 valve. Flow from pump enters at (1) and, passing through the meter and through spring-loaded valve (B), is discharged through globe shut-off valve (2), and relief valve fitting (3), into the hose line (4) to outlet valve (5). Valve (2) is necessary to shut off hose connection in case of emergency. Relief valve (6) is necessary to relieve excess pressure in hose in case valve (2) is closed. Other features in this drawing are similar to those described in Fig. 3.

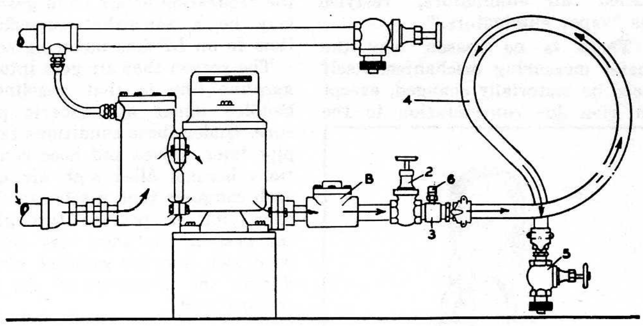

FIG. 3

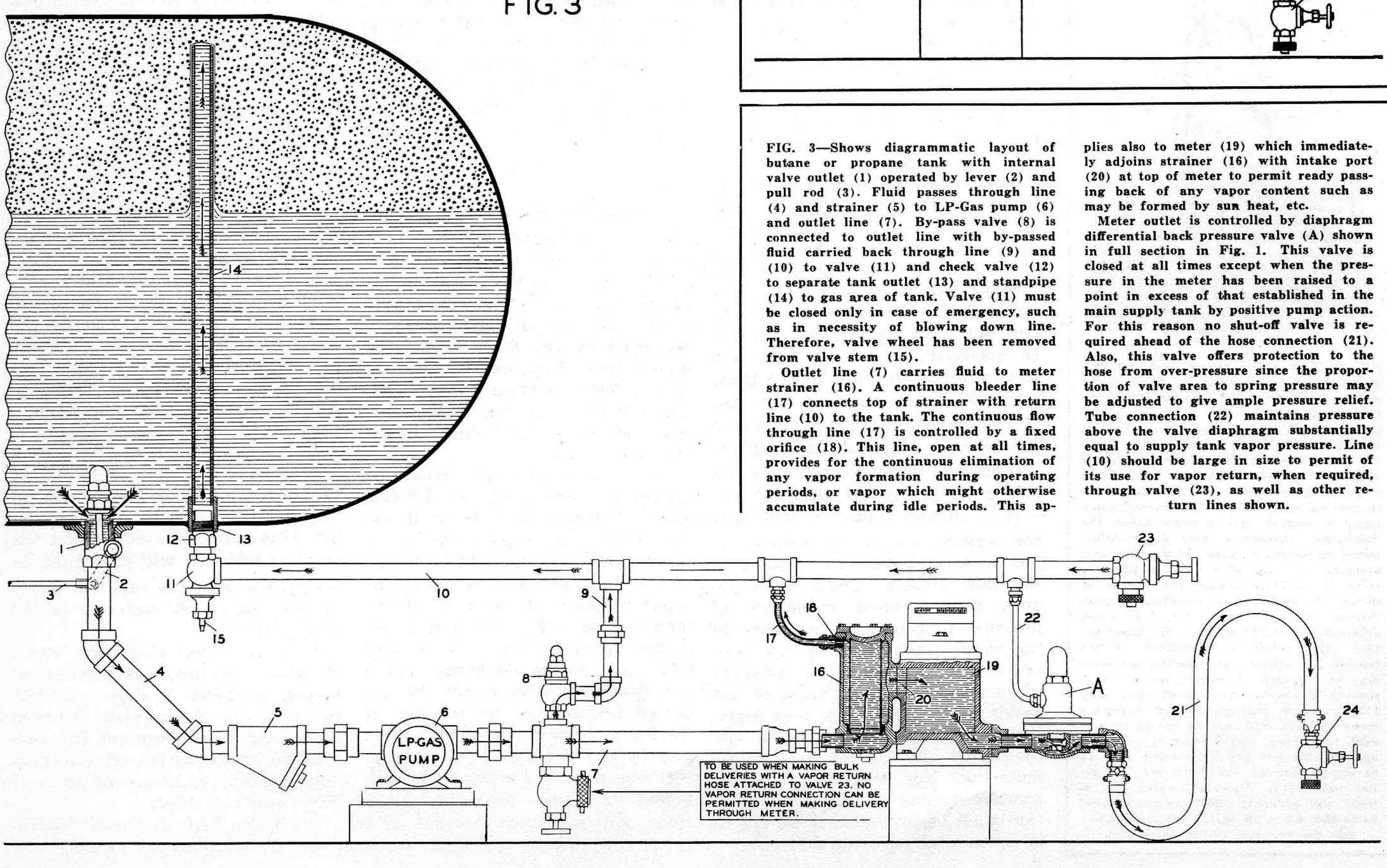

FIG. 3—Shows diagrammatic layout of butane or propane tank with internal valve outlet (1) operated by lever (2) and pull rod (3). Fluid passes through line (4) and strainer (5) to LP-Gas pump (6) and outlet line (7). By-pass valve (8) is connected to outlet line with by-passed fluid carried back through line (9) and (10) to valve (11) and check valve (12) to separate tank outlet (13) and standpipe (14) to gas area of tank. Valve (11) must be closed only in case of emergency, such as in necessity of blowing down line. Therefore, valve wheel has been removed from valve stem (15).

Outlet line (7) carries fluid to meter strainer (16). A continuous bleeder line (17) connects top of strainer with return line (10) to the tank. The continuous flow through line (17) is controlled by a fixed orifice (18). This line, open at all times, provides for the continuous elimination of any vapor formation during operating periods, or vapor which might otherwise accumulate during idle periods. This applies also to meter (19) which immediately adjoins strainer (16) with intake port (20) at top of meter to permit ready passing back of any vapor content such as may be formed by sun heat, etc.

Meter outlet is controlled by diaphragm differential back pressure valve (A) shown in full section in Fig. 1. This valve is closed at all times except when the pressure in the meter has been raised to a point in excess of that established in the main supply tank by positive pump action. For this reason no shut-off valve is required ahead of the hose connection (21). Also, this valve offers protection to the hose from over-pressure since the proportion of valve area to spring pressure may be adjusted to give ample pressure relief. Tube connection (22) maintains pressure above the valve diaphragm substantially equal to supply tank vapor pressure. Line (10) should be large in size to permit of its use for vapor return, when required, through valve (23), as well as other return lines shown.