Provide Ample Inlet Line Capacity

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IN an earlier issue of BUTANE-PROPANE *News* (July, 1945), we introduced tables to show the approximate loss of pump capacity which occurs due to the one item of insufficient gravity head to insure a flow of solid liquid to the pump. Many friends have since questioned the importance of this factor.

Frequently we hear the statement that with a pressure of 150 lbs. of propane vapor in the tank, it seems entirely unnecessary to be concerned with the few additional feet of gravity head obtainable by keeping the tank level well above the pump inlet level. Others compare the pumping of LP-Gas with the problems involved in pumping gasoline, or even that of pumping oil or water.

They do not appreciate the important fact that in LP-Gas pumping, we are handling a fluid *at its boiling point*, and that the slightest reduction in pressure or increase in temperature will develop a vapor content in the fluid proportional to the degree of heat, or pressure drop. In order to more fully emphasize this point, we are again reproducing, in a more readily visible form, the data presented in the table previously presented.

We believe it is the consideration given to this one major item of inlet line capacity which has helped the most to insure the success of the many very satisfactory installations which have recently been made. On the other hand, it is the total disregard of this consideration which has led to some very unsatisfactory installations, for the failure of which many other explanations have frequently been advanced.

We have had the opportunity of studying a great many plants and tank truck applications, and find great enthusiasm expressed over the excellent and sometimes almost unbelievable output performance of certain of these. These installations are invariably the ones where we find the larger sizes of excess flow valves applied, where plug type valves are used instead of globe valves, or where oversize globe valves are installed; where 45° ells have been substituted for 90° fittings, or better, where large radius bends of the welded type have been used; where oversize inlet lines from tank to pump have been applied, along with oversize and free-flow strainers in addition to providing the most direct flow line possible, eliminating all short bends and avoiding reduced flow areas.

Trouble From Small Pipe

Then we have been called to look over other installations where there was considerable dissatisfaction expressed, and in these cases have invariably found small size piping applied, smaller in actual inside area than appears to be the case because of the extra strong type of piping used. We have had to call attention to the extremely narrow and tortuous passageways provided in many standard valves designed for this service, involving many directional changes, along with velocity changes due to abrupt changes of flow areas within a single valve.

These valves seem to have been designed with the one thought of

Loss of Pump Capacity Due to Inlet Starvation

Fig 1—In pumping any LP-Gas fluid, if pressure at pump intake is reduced by suction to below that of supply tank by amounts shown in first column below, pump output will be reduced in percentage of total capacity approximately as indicated by figures in body of chart in accordance with pumping temperatures.

REDUCTION OF PRESSURE AT PUMP INTAKE BELOW TANK VAPOR PRESSURE	PROPANE			ISOBUTANE OR AVERAGE BUTANE-PROPANE MIXTURE			N-BUTANE		
	PUMPING TEMPERATURES			PUMPING TEMPERATURES			PUMPING TEMPERATURES		
	110° FAHR	70° FAHR	30° FAHR	110° FAHR	70° FAHR	30° FAHR	110° FAHR	70° FAHR	30° FAHR
SUCTION PRESSURE OF ONE POUND BELOW SUPPLY PRESSURE	2.6% VAPOR	5.8% VAPOR	14% VAPOR	14.5% VAPOR	29% VAPOR	55% VAPOR	19.5% VAPOR	41.5% VAPOR	62.5% VAPOR
SUCTION PRESSURE OF TWO POUNDS BELOW SUPPLY PRESSURE	5.2% VAPOR	10.8% VAPOR	25% VAPOR	25.5% VAPOR	45.5% VAPOR	70.5% VAPOR	32% VAPOR	59% VAPOR	77% VAPOR
SUCTION PRESSURE OF THREE POUNDS BELOW SUPPLY PRESSURE	7.2% VAPOR	15.2% VAPOR	33% VAPOR	34% VAPOR	55% VAPOR	78.5% VAPOR	42% VAPOR	69% VAPOR	83% VAPOR

low cost production plus the ability to pass underwriters' pressure test requirements. Such objectives are, of course, important, but should not be the sole considerations when, by the use of such valves, flow capacities may be cut in half, and expensive equipment, such as tank trucks and transports, are required to stand twice as long as necessary during loading and unloading periods.

In addition, and particularly in truck designs, we have often found unnecessary dips and bends as well as opposed streams directed through tee fittings; also tanks with dip tube outlets which have been made up with restricted tube areas within the tanks. These are among the difficult hidden impediments to fast flow.

Other Precautions to Take

We have also known of cases where the excess flow valve has been so shrouded by a continuation of the tank outlet collar beyond the valve end as to close off half the otherwise possible flow into the valve.

The same complaint may be brought against the internal valves which are sometimes used to replace excess flow valves, and which normally show such excellent output capacity. These also are frequently found having the valve head completely shrouded by the tank outlet fitting in such a way as to entirely offset their otherwise fine flow capacity. Such items as these *must* be guarded against at the time of installation, since correction, or even discovery, is practically impossible at a later time.

All the above is written pertaining to the pump inlet line. A point which we have always made is that the inlet line is the one item which invariably has the most to do with the pump output capacity. This can be understood readily when it is appreciated that there is no other force to bring fluid into the pump other than the gravity head. As we have often repeated, any reduction of pressure in any part of the system to below that in the supply tank, results in the formation of vapor. It is well known that if the pressure above the liquid in the tank is reduced by opening a valve to discharge vapor, instantly the fluid in the tank will start to boil and will continue to do so until the original vapor pressure is reestablished in accordance with the existing temperature.

Gravity Flow Determines Discharge

The same thing will happen in the intake line to the pump when, due to inadequate gravity head pressure, the fluid flow is equal to only a part of the pump displacement capacity. The pump can receive only what liquid does flow to it by gravity, and the balance of the pump capacity must be made up of vapor. This means that the pump discharge in liquid may be reduced far below its displacement capacity, since the pump cannot expel more than is received through the suction line.

The diagram accompanying this article (Fig. 1) gives a visible interpretation of just what this loss in output may be. It is fortunate that the reduction in capacity is much less with 100% propane than with butane, since propane appears to be constantly coming into greater use. The reason for propane being less affected by this pressure reduction is due to its lower boiling point and the consequently higher pressure under which it is normally pumped. The same explanation applies to the lesser loss of capacity found with all three fluids when they are being pumped at the higher temperatures. To many, these figures have appeared to be opposite to what might have been expected, but they show, nevertheless, what does actually happen.

In this article we are showing (Fig. 2) a schematic drawing of a tank truck installation which we consider very good and which has proven exceptional in fast-flow performance. We are also illustrating (Fig. 3) another installation which has proven very unsatisfactory in service. A study of these will, we believe, help to give a better understanding of the importance, in LP-Gas pumping, of the statements which we have frequently expressed in our catalog and literature as well as in our BUTANE-PROPANE *News* articles, and which we repeat here as follows:

Butane and propane pumps should always be placed as close as possible to the supply tank. Provide short, direct inlet connections, with the fewest possible bends or obstructions. Place the pump as far below the liquid tank level as may be conveniently done, so as to take advantage of the greatest possible liquid inlet head.

Since butane and propane are handled at their boiling points, suction should not be depended upon to draw the liquid into the pump, because any pressure reduction in the inlet line will result in the formation of a large volume of vapor. Such vapor will displace an equal volume of liquid and reduce the pump capacity to deliver.

A Very Satisfactory Installation

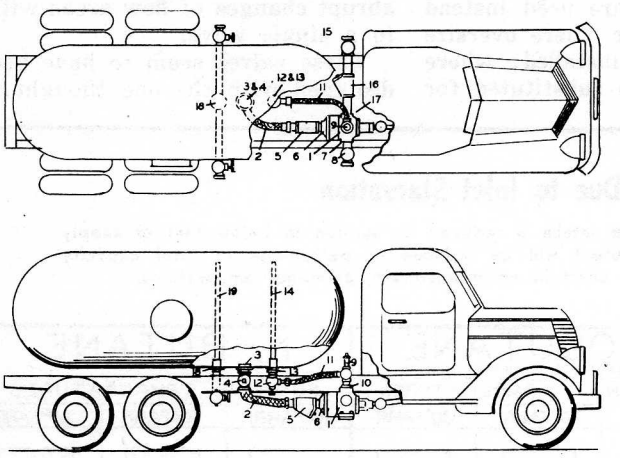

FIG. 2

In the schematic layout above, a 100 GPM pump (1) is shown which is supported as far below the tank level as is practicable. It is connected by a short 3" flexible tubing (2) from the main tank outlet which is provided with a 3" excess flow valve (3) and a 3" plug type valve (4). The strainer (5) is 3" in size and connects directly with the pump intake through the pump end cover (6). Outlet is through port (7), valve (8) and hose line not shown.

The spring-loaded by-pass valve (9) is inserted in the vertical pump outlet port (10) and is connected by flexible tube fitting (11) through valve (12) and check valve (13) inserted in tank vapor outlet, having an internal tube (14) extended vertically within the tank to the vapor area. Direction of fluid flow for discharging load is from tank through flexible tube (2), strainer (5), pump inlet (6) and pump outlet port (7).

This truck is provided with a reversible power take-off so that the same pump may be used for both loading and unloading. When loading, flow is through left-hand valve (15), strainer (16), pump side inlet port (17), with discharge to tank through pump end cover (6), flexible tube (2), valve (4), and excess flow valve (3).

A separate vapor return connection (18), with internal vapor tube (19), is piped to both sides of the truck to provide for hose connections for vapor pressure equalization in case of pumping in either direction. Filling and discharge rates of 80 to 90 GPM are readily made, and the extreme simplicity of the piping layout can readily be seen.

A Very Troublesome Installation

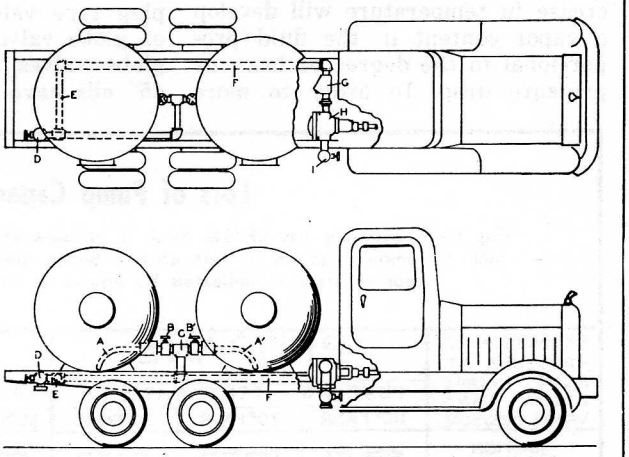

FIG. 3

The layout above is shown merely to indicate defects in a system which was quite expensive to install and yet gave very unsatisfactory results. The first bad item was the dip tube construction whereby the liquid must be raised a foot or more by syphon action. This results in immediate vapor formation when handling any LP-Gas product.

In addition, the dip tubes (A & A') were, in themselves, a bottleneck in the suction line due to small size, having a flow area considerably less than the already small size piping (1½") applied. Then the two valves (B & B') were of the globe type with reduced valve area and exceptionally narrow flow passages.

Next, it was intended to attain greater discharge speed by having both tanks opened simultaneously. But when this is done, there are two opposed streams of high velocity fluid meeting head-on in the tee fitting (C). After passing through this, the stream flows to the rear of the truck where a valve (D) was provided for loading the tanks.

From here the 1½" piping (E) passes across the width of the truck and back on the left-hand side (F) and finally through the strainer (G) on to the pump intake (H). Passing through the pump, discharge is through valve (I). In addition to the long length of 1½" piping and the two restricted valves, three elbows and two tees and the strainer are involved in the passage to the pump. The pump was operated only in one direction, filling of the tanks being accomplished by an outside stationary pump at the refinery.

The capacity of the truck pump was 60 GPM, but the best attainable discharge flow was approximately 15 GPM. Needless to say, this customer was greatly disappointed, but there was little that could be done to remedy the conditions aside from a total rebuild.