ARRANGING THE PUMP DISCHARGE LINE FOR FASTEST DELIVERY

By

LAWRENCE W. SMITH

Smith Precision Products Co., South Pasadena, California

(Reprinted from the article "How to Speed-Up Fuel Deliveries" in the *Butane-Propane News,* January, 1953)

METERS
BACK-PRESSURE VALVES
HOSE VALVES
SAFETY-FILL NOZZLES
DELIVERY HOSE
TANK FILLER VALVES
BACK PRESSURES IN TANKS
BASIC LPG PUMPING SYSTEM
PUMP CAPACITY AGAINST PRESSURE

Complete Index Begins on Page 17
Illustrating Figure A on Pages 10 & 11

SMITH PRECISION PRODUCTS COMPANY

1135 MISSION STREET • SOUTH PASADENA • CALIFORNIA • PHONE PYRAMID 12293

ARRANGING THE PUMP DISCHARGE LINE FOR FASTEST DELIVERY

THIS article is written for the benefit of the operators of delivery trucks and stationary dispensing systems. Our purpose is to show how it is often possible to make small changes in the pump discharge line that will allow a considerable speed-up in the delivery rate. We also want to show how to design new systems for the very fastest pumping.

To do this, we will present tables giving the pressure drop (resistance-to-flow) across various parts of pump delivery lines; we will explain the significance of these tables; and we will show how these tables can be used for estimating delivery rates in dispensing systems.

There are seven important parts or units in the pump discharge line that affect the delivery rate. These are all illustrated in the accompanying Figure A, and may be listed as follows:

Unit 1. Meter (12).
Unit 2. Back-pressure valve (14).
Unit 3. Valve on meter end of hose, if used (35).
Unit 4. Hose (16).
Unit 5. Valve on delivery end of hose (28).
Unit 6. Tank filler valve (36).
Unit 7. Back-pressure built up in tank when vapor return line is not used.

Other items, such as the short lengths of piping normally used in discharge lines, or the elbows, tees, and other simple fittings, can be neglected, as their effect is small in comparison with the items listed. Let us take up the above seven units one by one in the discussion to follow.

1. Meter (12 on drawing)

(Table numbers refer to corresponding paragraph numbers.)

TABLE 1

Resistance-to-flow of Average 5 to 30 GPM Meters Sold for LPG Service

Delivery Rate GPM (Gallons per minute)	Meter Resistance psi (Pounds per square inch)
5	0.5
10	1.0
15	1.5
20	2.0
25	2.7
30	3.5

Note how the amount of pressure absorbed by the meter is very low, only 3.5 psi even at the full 30 GPM recommended maximum flow rate. These figures apply only when the meter strainer is clean. If the strainer becomes clogged with dirt or other foreign matter, the resistance-to-flow or pressure drop will be much higher, and this will slow the delivery rate. Therefore, check your meter strainer periodically to be sure it is kept clean.

2. Back-Pressure Valve (14 on drawing)

There are two general types of back-pressure valves in service, the spring-loaded type and the diaphragm type. Both types sometimes come with the meter, and are sometimes sold and installed separately. The spring-loaded valve may be set to from 10 to 50 or more pounds. A setting of 15 pounds is common with those supplied by a meter manufacturer as a part of his metering assembly.

In any case, *the resistance-to-flow (pressure drop), of a spring-loaded back-pressure valve is equal to its setting.* Diaphragm type valves may be set to from 5 to 25 or more pounds, with a 10-pound setting recommended by us as being adequate. The *resistance-to-flow (pressure drop) of a diaphragm type back-pressure valve is practically zero* if it has a setting below 15 pounds[1], and thus it may be neglected in any calculations on common types of dispensing systems such as shown in the diagram, Figure A.

---

[1]In practice with most dispensing systems, a diaphragm-type, back-pressure valve set to 10 pounds remains wide open during most of the delivery. This is because the pressure drop of the other equipment downstream will total more than the 10-pound setting of the valve. This type of valve is designed to open whenever the pressure in the discharge line exceeds tank pressure by 10 pounds.

For a detailed description of both types of back-pressure valves and their uses in accurate metering, see article "Accurate Metering of Butane and Propane" in the September, 1947, issue of the "Butane-Propane News," or write for reprints which are available free of charge from the Smith Precision Products Co.

3. Valve on Meter End of Hose
(35 on drawing)

TABLE 3

Resistance-to-flow of Average Small Globe Valves in LPG Service

Delivery Rate GPM	Resistance of ¾" Valve, psi	Resistance of 1" Valve, psi
5	0.2	0.1
10	0.6	0.3
15	1.3	0.7
20	2.1	1.2
25	3.1	1.9
30	4.5	2.8

As in the case of the meter, the amount of pressure absorbed by the resistance of these valves is small. One-half inch size valves have considerably more resistance, and their use is not recommended. In some cases there is no valve in this position, although it is recommended as a shut-off point for added safety in case the hose is accidently ripped or broken, particularly where the back-pressure valve is of the spring-loaded type. Note how the resistance of these valves increases as the delivery rate increases.

4. Hose (16 on drawing)

TABLE 4[2]

Resistance of 50 ft. Lengths of LPG Delivery Hose of Various Sizes and at Various Flow Rates

Delivery Rate GPM	Resistance-to-flow, psi ½" Hose	¾" Hose	1" Hose
5	8.3	-	-
10	30.5	4.1	-
15	68.0	8.7	4.1
20	too high	14.8	7.0
25	too high	22.1	10.5
30	too high	31.8	15.0

For lengths of hose different than 50 feet, multiply figures in Table for hose by the following factors:

10 ft. hose	0.2
20 ft. hose	0.4
30 ft. hose	0.6
40 ft. hose	0.8
60 ft. hose	1.2
70 ft. hose	1.4
80 ft. hose	1.6
90 ft. hose	1.8
100 ft. hose	2.0

Note that a 50-ft. length of hose may easily have a considerable resistance. For example, a 50-ft. length of ½" hose carrying a delivery rate of 15 GPM develops a resistance of 68 psi, making this size very poor for fast delivery. The use of ¾" hose is therefore recommended, and 1" hose represents a further improvement wherever it can be installed.

A hose of unnecessary length needlessly penalizes the operator by slowing delivery. A hose too small in diameter does the same thing. Have your hose long enough to reach the tanks conveniently, but not so long that several coils always stay on the truck. Get the ¾" size and if the driver can handle the extra weight easily, a 1" hose is still better.

---

[2]This table was calculated from viscosity figures of propane and butane at 60° F. temperature, as given in Table 9 on page 34 of "Handbook Butane-Propane Gases, Third Edition." The procedure followed in the calculations was as outlined on pages 211 and 212 of Daugherty's "Hydraulics, Fourth Edition." The resistance of hoses carrying propane or butane was found to be so nearly the same that an average figure was placed in the table and it can be used for straight butane, isobutane, propane, or any LPG mix with good results. The resistance of hose is assumed to be equivalent to that of clean steel pipe of the same **inside diameter,** and this assumption is in accordance with the statement of a hose manufacturer's representative.

5. Valve on Delivery End of Hose (28 on drawing)

This may be another standard globe valve like No. 35 on the drawing, in which case the figures in Table 3 apply. If you have a Parkhill-Wade type PW-200 Safety-Fill Nozzle, use the figures shown in Table 6. Other special types of valves, such as the quick-closing ball and plug types, usually have smaller resistance values. Figures can ordinarily be obtained through the manufacturer's representatives, as required.

TABLE 6

Resistance of Tank Filler Valves at Various Flow Rates, with and without Parkhill-Wade Type PW-200 Safety Fill Nozzle

	Resistance-to-Flow, psi			
Delivery Rate GPM	1 ¼″ Filler Valve	¾″ Filler Valve	Special 1 ¼″ Filler Valve with PW-200 Nozzle	Special ¾″ Filler Valve with PW-200 Nozzle
5	0.4	2.9	0.9	2.1
10	2.0	9.2	2.5	6.8
15	2.8	20.0	4.7	16.0
20	4.5	35.0	8.3	28.0
25	6.8	too high	13.0	too high
30	10.0	too high	18.5	too high

6. Tank Filler Valve (36 on drawing)

Some of the above figures are averages of several tests and are not 100% accurate for any valve number or manufacturer. The values given should be used as guides only, but will be found reliable enough for most purposes. Note how the ¾″ size filler valve has much more restriction than the 1¼″ size. The ¾″ size should never be used on any but the smallest tanks, as its greater resistance represents a loss of delivery time that mounts to a considerable total when deliveries of over 100 gallons are made. It is almost impossible to force as much as 20 gallons per minute through a ¾″ filler valve with any type of pump, but the 1¼″ size handles up to 30 GPM with ease.

7. Tank Back Pressure

Considerable time has been spent in making up Table 7, which attempts to show the amount of back pressure that is developed in a consumer tank when it is filled without the use of a vapor return line. The back-pressure values given, which are found to vary depending on the temperature of the day and the type of fuel handled, are the same for *any size tank* that is filled from an almost empty to a completely full condition (*i.e.,* safe level). The figures in the table thus apply equally well to 100-pound cylinders, 1000-gallon tanks, and everything in between.

The back pressure built up when filling tanks without a vapor return line is one of the most important items in slowing the delivery rate to below that normally expected. From the standpoint of faster pumping only, it would be desirable to use a vapor return line to reduce this back pressure, and some pump manufacturers recommend this.

However, it is recognized by all metering authorities throughout the country that the vapor returned through a vapor return line causes inaccurate metering, as it is not accounted for in the measurement of the fuel delivered[3]. The inaccuracy involved through the loss to the customer of fuel returned through a vapor return line may run as high as 5% (one gallon in every 20) when propane is delivered on a hot day.

Of course, in the interest of good customer relations, such errors cannot be tolerated. For this reason, pumps capable of making fast fuel deliveries without the aid of a vapor return line are performing a very valuable service; less efficient pumping units should be replaced.

[3]Refer to paragraph 1054 on page 14 of the new "ASME-API Code for Installation, Proving, and Operation of Positive Displacement Meters in Liquid Hydrocarbon Service". This book is on sale for $2 by the American Petroleum Institute, 50 West 50th St., New York City, and is a valuable guide for interested meter users, having been prepared with the help of prominent men in the industry. Also, see pages 2 and 14 in **Operating and Maintenance Manual No. 717**, published by the Neptune Meter Co.

When filling any tank without a vapor return line, whether it be a 100-pound cylinder or a 1000-gallon storage tank, the vapor originally in the tank must be collapsed into liquid during the filling operation. This "collapse" takes extra pressure to accomplish, as when vapor is compressed into liquid it generates a considerable amount of heat. The amount of heat given off depends upon the temperature of the vapor when it collapses.

Now, during a fast filling operation there is not enough time for much of this heat to be radiated away through the tank walls to the atmosphere outside. Hence, the temperature of the vapor in the tank increases rapidly, and the increased temperature brings on an increase in pressure. This pressure increase, or back pressure, slows delivery. Thus it is important to dissipate the heat in the vapor space as much as possible. Ideally, some means should be provided to assure that the hot liquid and vapor *at the liquid level* be thoroughly mixed with the cooler liquid underneath, so as much heat as possible might be dissipated.

When a 100-pound cylinder is filled, the fast moving stream of incoming liquid hits the liquid level quite violently, causing much splashing and turbulence which effectively mixes the heat in the vapor space. However, in a larger tank, the area at the liquid level has a greater size, the incoming stream of liquid moves more slowly, and thus there is less turbulence with a reduced tendency for mixing. The worst possible case

TABLE 7

Amount of Back Pressure Built Up in Tanks Filled without Vapor Return Lines

Type of Fuel	Temperature (°F.)	Back Pressure, psi: Case 1, 100% Heat Mixed	Back Pressure, psi: Case 2, 25% Heat Mixed
Propane	100°	31.1	124.4
Propane	70°	16.9	67.6
Propane	40°	8.9	35.5
Propane	10°	4.1	16.3
Propane	– 20°	1.6	6.4
Butane	100°	3.8	15.1
Butane	70°	1.8	7.2
Butane	40°	0.8	3.1

would be a large tank which is filled through a dip tube, so the incoming liquid actually enters through the bottom of the tank. Here there could be almost no mixing of the heated vapor, and a high back pressure would certainly be built up.

Table 7 shows the amount of back pressure built up in tanks filled without vapor return lines, for two cases: (1) where 100% of the heat generated by the collapsing vapor is thoroughly mixed with the liquid in the tank, and (2) where only 25% of the heat generated is mixed. In most cases, actual fillings will be somewhere between these two extremes. Case 1 represents perfection in mixing, and perfection is always difficult to attain in anything; case 2 illustrates our estimate of the worst effect of filling large tanks through dip tubes, which we believe is also uncommon.

Note how butane fuel develops much less back pressure than propane, even at the higher temperatures. Note how the back pressure built up by propane at summer temperatures can be very high under bad mixing conditions; so high, in fact, that no pump now made could build up enough pressure to completely fill such tanks at any reasonable delivery rate. Extremely bad conditions such as this are rarely met, but the effect of the back pressure developed is certainly important, and has a great effect on pumping speed.

Distributors of an LPG mixture can estimate back pressure by averaging the figures in Table 7 for straight butane and straight propane. For example, for a 60-propane, 40-butane mix, case 1, 70°, take $60 \times 16.9 = 1014$, and add this to $40 \times 1.8 = 72$, giving a total of 1086. Then divide this number by 100, giving an estimated back pressure developed with a 60-40 mix of 10.86 psi.

The figures tabulated in the preceding tables now make it possible to estimate and improve pump delivery rates, as the following questions and answers will show:

Question I: We have a propane delivery truck equipped with one of your 50 GPM pumps and piping exactly as shown in Figure A. The by-pass valve is set to 75 psi in accordance with your recommendations. We use a meter having a built-in spring-loaded back-pressure valve set at 15 pounds, two hose valves as shown, one 50-foot length of ¾″ delivery hose, and most of our tanks have 1¼″ filler valves. We are now getting only 20 gallons per minute delivery, which seems very little for a 50 GPM pump. Is anything wrong, and can you tell us how to check this delivery, using the tables in this article?

Answer I: First refer to the tables and add up the values for back pressure (resistance-to-flow) that each item in the system requires. We have:

1. Back pressure of meter (Table 1) at 20 GPM	2.0 psi
2. Back pressure of back-pressure valve, spring loaded type	15.0 psi
3. Back pressure of first hose valve, ¾″ (Table 3) at 20 GPM	2.1 psi
4. Back pressure of hose, ¾″ (Table 4) at 20 GPM	14.8 psi
5. Back pressure of second hose valve, ¾″ (Table 3) at 20 GPM	2.1 psi
6. Back pressure of filler valve, 1¼″ (Table 6) at 20 GPM	4.5 psi
7. Back pressure of tank (assumed propane at 70°, twice as bad mixing as Case 1), 16.9 x 2 = 33.8 (Table 7)	33.8 psi
Total Back Pressure	74.3 psi

Since the calculated total back pressure, 74.3 psi, closely equals your by-pass valve setting, 75 psi, we would say that you *are* getting the best possible delivery from this pump in this setup when you get 20 GPM delivered.

Question II: But this rate takes us almost 30 minutes to fill a 500 gallon tank. Can you suggest something that would improve the delivery rate?

Answer II: Yes, we believe you could improve this speed considerably by making a few simple changes. *In answering this question, the whole purpose of this article is clearly demonstrated.* First, take off the spring-loaded back-pressure valve and install the diaphragm type. Second, use a 1″ hose and hose valves instead of the ¾″ size. Now, assuming an improved delivery rate of, say, 30 GPM, and running through the tables again, we have:

1. Back pressure of meter (Table 1) at 30 GPM	3.5 psi
2. Back pressure of back-pressure valve, diaphragm type	0.0 psi
3. Back pressure of first hose valve, 1″ (Table 3) at 30 GPM	2.8 psi
4. Back pressure of hose, 1″ (Table 4) at 30 GPM	15.0 psi
5. Back pressure of second hose valve, 1″ (Table 3) at 30 GPM	2.8 psi
6. Back pressure of filler valve, 1¼″ (Table 6) at 30 GPM	10.0 psi
7. Back pressure of tank (Table 7), same as previous example	33.8 psi
Total Back Pressure	67.9 psi

Note how by making these few simple changes a delivery rate of 30 GPM can be accomplished at a lower total back pressure than was formerly absorbed to deliver only 20 GPM. As a matter of fact, if you have a 30 GPM meter you should now reduce the setting of your by-pass valve from 75 psi to about 65 psi, in order to prevent meter overspeeding. The lower pressure setting of the by-pass valve would make things easier on the

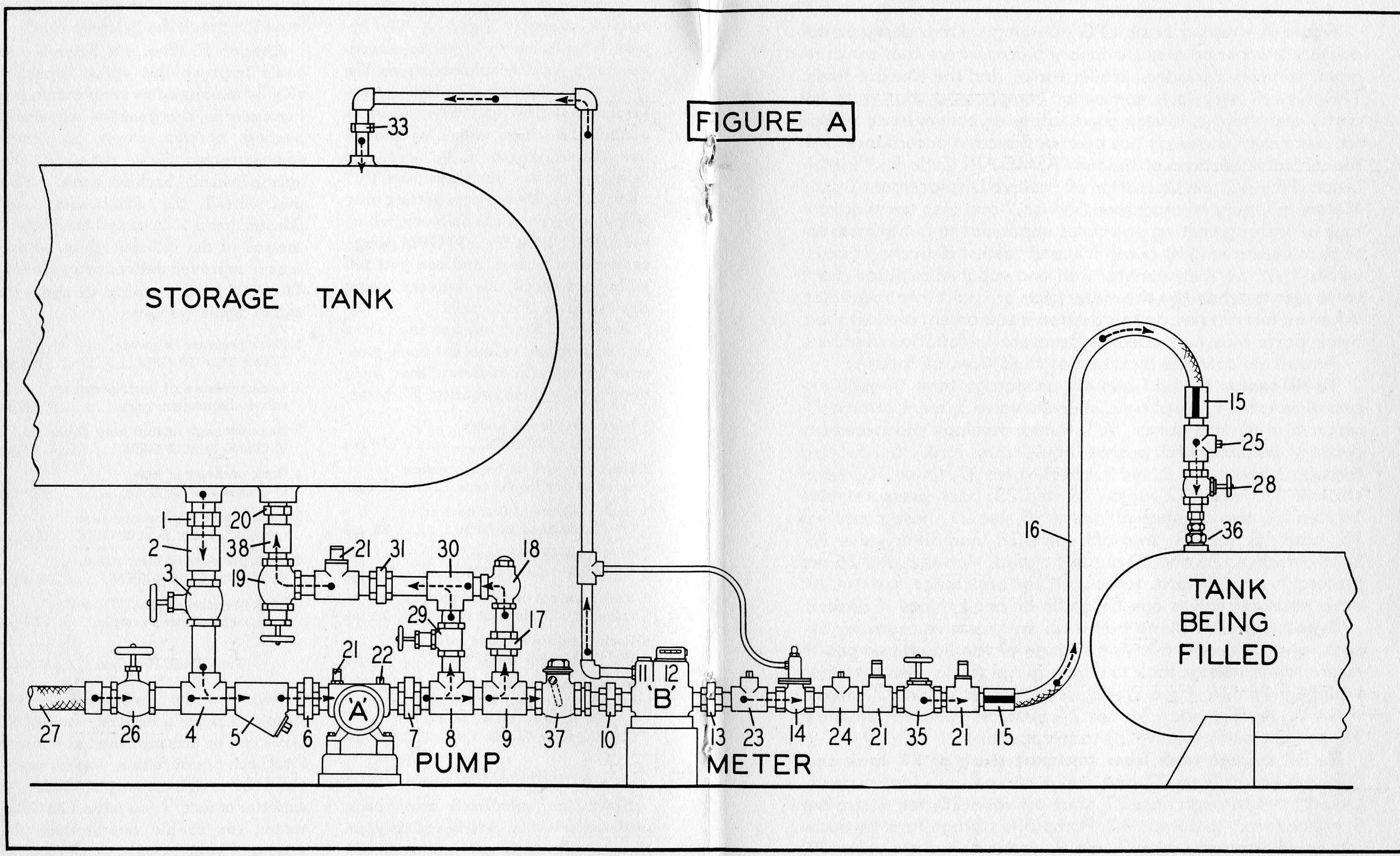
FIGURE A
STORAGE TANK
TANK BEING FILLED
PUMP
METER
'A'
'B'
1
2
3
4
5
6
7
8
9
10
12
13
14
15
16
17
18
19
20
21
22
23
24
25
26
27
28
29
30
31
33
35
36
37
38

FIGURE A.

Description of Figure A.

Figure A shows a basic LPG pumping system designed for delivery trucks and also stationary plants where fuel tanks on motor vehicles, cylinders, trailer tanks, and the like are filled. This system may look somewhat complicated, but it is not costly and there is a very good safety or convenience reason for every item shown. It has been designed in accordance with the recommendations of the new ASME-API Code for "Installation, Proving, and Operation of Positive Displacement Liquid Meters in Liquid Hydrocarbon Service," and also takes advantage of the engineering principles important to pump installation, to assure longest pump life and fastest delivery. It is assumed that the thermometer well and vapor-eliminator check valve recommended by the meter code are built into the meter. When meters not having this desirable equipment are installed, these parts may be added as separate installation features.

Arrows indicate the direction of fluid flow, as follows:

To fill tanks: Liquid flows out of storage tank through excess-flow valve 1, coupling 2, shut-off valve 3, tee 4, strainer 5, union 6, and into pump "A". Pump develops the necessary delivery pressure and pushes liquid into tank to be filled through union 7, tee 8, tee 9, check valve 37, union 10, meter strainer 11, meter 12, union 13, tee 23, back-pressure valve 14, tee 24, tee 21, shut-off valve 35, tee 21, hose couplings 15, hose 16, tee 25, shut-off valve 28, and filler valve 36. Shut-off valves 26 and 29 are left closed. Valves 3 and 26 are preferably plug or gate types with low resistance-to-flow. All other shut-off valves can be globe or angle types if desired.

Bypass valve: If pump builds up an excessive pressure, bypass valve 18 opens, allowing enough of the liquid pumped to return to the storage tank to relieve pump strain. This bypassed liquid comes out of tee 9 and runs through union 17, bypass valve 18, tee 30, union 31, tee 21, shut-off valve 19, coupling 38, and excess-flow valve 20 to storage tank.

To fill storage tank from transport truck or RR tank car: Connect liquid hose 27 and vapor return line (not shown). Liquid flows through hose 27, shut-off valve 26, tee 4, strainer 5, and union 6, to pump "A". Pump fills storage tank by pushing liquid through union 7, tee 8, opened shut-off valve 29, tee 30, union 31, tee 21, shut-off valve 19, coupling 38, and excess-flow valve 20. Shut-off valves 3 and 35 are left closed.

For best operation with a Smith pump, bypass valve 18 is set at about 75 pounds. For proper settings with other makes of pumps, consult the manufacturer. Fittings at positions marked 21 (4 pieces) are pop-off relief valves placed to relieve any hydrostatic pressure that might build up between closed shut-off valves when the system is not in use. Place ¼" pipe plugs at points 22, 23, 24, and 25. These are test places for inserting pressure gages which will help greatly in trouble-shooting if difficulties develop in the system after it has seen considerable service. See pages 98, 100, and 104 in "Butane-Propane News," September, 1951, for further details on this testing, or write for reprints of the article to Smith Precision Products Co.

Many modifications to this installation can be made to suit service conditions. The drawing is as complete as possible, but does not show everything that could be desired by all users. The storage tank is of the horizontal type, but spherical or vertical tanks are just as satisfactory if mounted as high above pump level. The meter outline is purely schematic, and is not intended to resemble any particular make. This layout should work very well with any type of pump or meter.

pump, and it would have a longer service life. So you see that in this case, merely changing a few valves and putting on a new hose would improve delivery 50%, as well as make the pump wear longer. It would now take less than 20 minutes to fill the 500 gallon tank.

WARNING: The reader must not draw the conclusion from these examples that the same changes on his own truck will make the same improvement in delivery rate. Each truck is a separate case and each must be figured individually. Follow the examples using data from your own trucks to calculate your particular problem.

Question III: Since the best delivery we can count on is 30 GPM due to the rating of our meter, would it not be better to use your 35 GPM pump instead of the 50 GPM pump now installed? It would seem that the smaller pump would fit the service better, and the lower initial cost and upkeep expense would be helpful.

Answer III: Our pumps have their capacities rated at zero differential pressure, not at the higher pressures developed when filling small tanks. We have found over the years that any of the models will lose from 3% to 5% of their rated capacity for every 10 pounds differential pressure which they pump against. Thus, our 50 GPM unit actually pumps 50 GPM less the quantity 6½ x 2½[4], or only 34-¾ GPM at a differential pressure (back pressure) of 65 psi. A 35 GPM unit would actually pump only 35 minus (6½ x 1¾), or 23⅝ GPM against 65 psi back pressure. Thus, the smaller pump does not have the required capacity at the higher pressures, and would not develop the full 30 GPM delivery rate. The smaller pump would, however, be as good as the larger pump in the system as first described, where the delivery capacity of the equipment on the discharge side of the pump was only 20 GPM.

Question IV: As a matter of interest, what would be our delivery rate with a ¾″ filler valve in place of the 1¼″ valves we normally use, assuming that every other part of the system is improved as in your answer to Question II?

Answer IV: We will probably go right down to a 20 GPM delivery again. Running through the figures, we have:

1. Back pressure of meter (Table 1) at 20 GPM	2.0 psi
2. Back pressure of back-pressure valve, diaphragm type	0.0 psi
3. Back pressure of first hose valve, 1″ (Table 3) at 20 GPM	1.2 psi
4. Back pressure of hose, 1″ (Table 4) at 20 GPM	7.0 psi
5. Back pressure of second hose valve, 1″ (Table 3) at 20 GPM	1.2 psi
6. Back pressure of filler valve, ¾″ (Table 6) at 20 GPM	35.0 psi
7. Back pressure of tank (Table 7), same as previous examples	33.8 psi
Total Back Pressure	80.2 psi

[4]There are 6½ 10's in 65; hence 6½. Five per cent of 50 GPM is 2½; hence 2½. 6½ x 2½ is 15¼, so a 50 GPM pump loses up to 15¼ gallons of its capacity when working against a 65 pound back pressure. In the figures for the 35 GPM pump 1¾ is 5% of 35 GPM. This pump loses up to 6½ x 1¾ = 11⅜ GPM of its capacity when working against a 65 pound back pressure.

Thus we see that it would require a differential pressure of 80.2 psi to force 20 GPM through a ¾″ filler valve, in the same system that would handle 30 GPM through a 1¼″ filler valve at a differential pressure of only 67.9 psi. This example speaks very plainly in favor of the 1¼″ filler valve over the ¾″ filler valve on large tanks.

Question V: In rugged country such as sparsely populated desert and mountain areas, it sometimes would save time to stop the truck about a hundred feet from the tank to be filled and use a hundred feet of light delivery hose to make the filling connection. Could our drivers get by with ½″ hose by improving every other feature of the discharge line as much as possible, and using the better 1¼″ size tank filler valves?

Answer V: Let us follow through with another calculation, assuming a flow rate of only 10 GPM, with parts of the discharge line sized as listed:

1. Back pressure of meter (Table 1) at 10 GPM	1.0 psi
2. Back pressure of back-pressure valve (diaphragm type)	0.0 psi
3. Back pressure of first hose valve, ¾″ (Table 3) at 10 GPM	0.6 psi
4. Back pressure of hose, ½″ (Table 4) at 10 GPM (2.0 x 30.5)	61.0 psi
5. Back pressure of second hose valve, ¾″ (Table 3) at 10 GPM	0.6 psi
6. Back pressure of filler valve, 1¼″ (Table 6) at 10 GPM	2.0 psi
7. Back pressure of tank (same as previous examples)	33.8 psi
Total Back Pressure	99.0 psi

Thus we see that the use of 100 feet of ½″ delivery hose would require a by-pass valve setting of almost 100 pounds, even to attain the very slow delivery rate of 10 GPM. The ease of handling the small-sized hose should be weighted against the time lost by slow delivery and the extra cost of possibly more frequent pump repairs at the higher differential pressure setting.

Question VI: It would help us in deciding upon this type of delivery system if you would show us what improvement would result from the use of 100 ft. of ¾″ hose in place of the ½″ size we suggested.

Answer VI: Let us see how much pressure would be absorbed by the same delivery system as in the previous example, except that it is now handling 20 GPM and has a ¾″ hose:

1. Back pressure of meter (Table 1) at 20 GPM	2.0 psi
2. Back pressure of back-pressure valve (diaphragm type)	0.0 psi
3. Back pressure of first hose valve, ¾″ (Table 3) at 20 GPM	2.1 psi
4. Back pressure of hose, ¾″ (Table 4) at 20 GPM (2 x 14.8)	29.6 psi
5. Back pressure of second hose valve, ¾″ (Table 3) at 20 GPM	2.1 psi
6. Back pressure of filler valve, 1¼″ (Table 6) at 20 GPM	4.5 psi
7. Back pressure of tank (still unchanged from previous examples)	33.8 psi
Total Back Pressure	74.1 psi

Thus we see that the mere substitution of 100 ft. of ¾″ hose for 100 ft. of ½″ hose results in doubling the delivery rate (from 10 to 20 GPM) and lowering pump pressure from 99.0 psi to 74.1 psi (a 25% reduction). The ¾″ size hose is highly recommended over the ½″ size in any installation.

Question VII: In previous articles we have read that the pump inlet line must also be properly designed in order to attain good delivery rates. Is this still true, or have you now decided that the pump discharge line is more important?

Answer VII: All these tables are based on the assumption that the inlet line is properly engineered so the pump is supplied with all the liquid it needs at all times. Of course, the inlet line is still important. But we must remember that it is foolish to pay attention to one line without also properly designing the other. Neither the inlet nor the discharge line is the full story within itself; attention must be paid to *all* parts of the pump piping.

The article "Transferring LP-Gas with Liquid Pumps" in the July, 1951, issue of "Butane-Propane News" contains tables for calculating your inlet line. This article and the two succeeding articles have been reprinted, and single copies in booklet form are available free of charge from the Smith Precision Products Co.

As a conclusion, we would like to point out that the previous questions and answers have been confined to pump problems connected with delivery trucks. However, the tables and methods that have been explained apply equally well to any piping layout that is substantially the same as that shown in the illustrating Figure A. Systems designed for filling fuel tanks on tractors or on trucks and other motor vehicles are usually very much like this figure. As a matter of fact, this type of piping arrangement is now so widely recommended and used that we have come to call it the *Basic LPG Pumping System.*

The tables and methods shown should apply to any make and type of pump, regardless of its manufacture, as the figures depend not on the pump but upon the individual characteristics of the other parts discussed.

The author wishes to give credit to engineers of the Neptune Meter Co., the Selwyn-Landers Co., and Hewitt-Robins, Inc., who supplied information used in some of the tables.

INDEX