The By-Pass "Merry-Go-Round"

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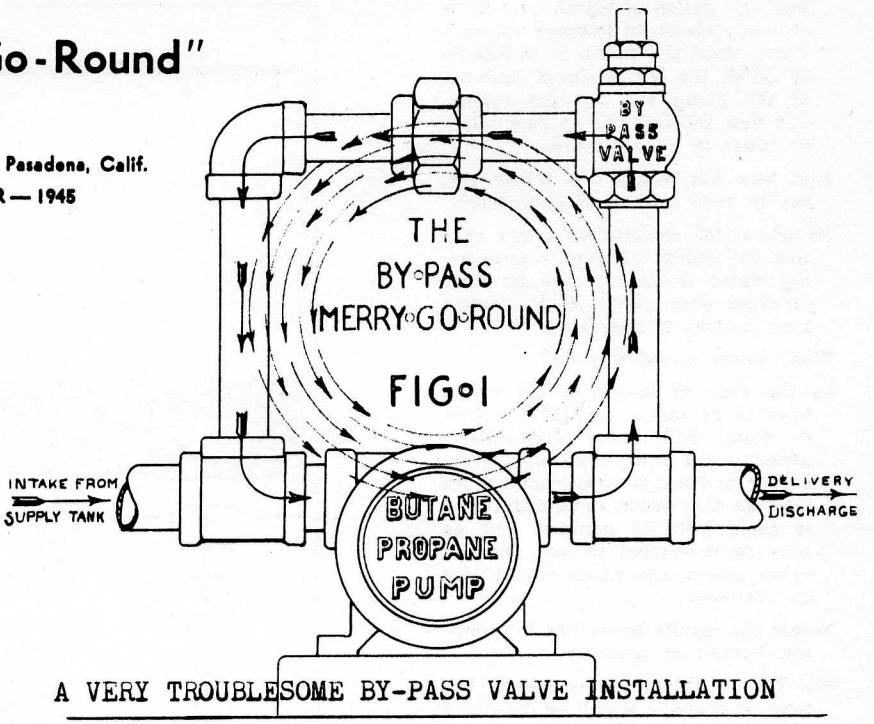
THE correct installation of the pump by-pass valve is an item of the greatest importance to the success of every butane or propane plant. Therefore, while this subject has been briefly mentioned in previous articles, it is intended to give it exclusive attention in this issue. In doing so, we wish particularly to condemn the still too frequent use of what might be called the "Merry-Go-Round" system of by-pass assembly, as shown in Fig. 1, and to advocate the "Back-to-Tank" type of installation, illustrated in Fig. 2.



A VERY TROUBLESOME BY-PASS VALVE INSTALLATION

What is the purpose of a by-pass valve in a butane or propane pump installation?

One important use is to provide a means of pressure relief in the event the pump is started against closed valves, or in the event valves are closed before the pump is stopped. We might say that this use of a by-pass valve is somewhat similar to that of a safety valve on a steam boiler, which is to permit the release of excess strain before any damage is done.

What other use has the by-pass valve?

A second very important use is to adapt the pump to various capacity requirements. This result is accomplished by the by-pass valve which permits the release of any excess volume of liquid pumped. By this means, a pump of 30 to 50 gallons per minute capacity, may serve at times to supply as little as 5 to 10 GPM, which might be desirable in the case of filling a single bottle or small container having a small valve.

At what pressure would such a by-pass valve be set to operate?

A by-pass valve for a pump in bottling service is usually set at 50 to 60 pounds differential, for either butane or propane. The valve then holds the pump outlet line up to this differential pressure, but permits all excess liquid to by-pass.

What is meant by "differential pressure?"

When we say we have a differential pressure of 50 pounds per square inch, we mean that the difference between the pump intake pressure and the pump outlet pressure is 50 pounds. For example, the pressure of 100% propane, entering the pump at 80°F., would be 128 pounds gage reading, in which case, if the by-pass valve were set for a 50 pound differential, the pump would discharge through the by-pass line under a pressure of 128 pounds plus 50 pounds, which is equal to 178 pounds total gage pressure. If, however, we were pumping a butane-propane mixture having a vapor pressure of 80 pounds, this same valve would hold the discharge pressure to 80 pounds plus 50 pounds, or 130 pounds. The 50 pounds of differential at which the valve is set would be the "working differential" in either case, and represents the difference between the pump discharge pressure and the vapor pressure in the tank. It is the force in pounds per square inch above the tank pressure, which is available to deliver the fluid through the outlet discharge fittings into another tank having the same vapor pressure.

What is meant by the "Merry-Go-Round" system of by-pass valve assembly?

This is the type of installation which has been quite universally adopted for rotary pumps designed to handle water or oil. It is the type of by-pass assembly wherein all the by-passed fluid is returned to the pump inlet. By this arrangement, the outlet pressure is relieved, but in turning back the by-passed liquid to the pump inlet, the very same body of liquid may be continuously recirculated. With the pump discharge valves completely closed, the entire pump capacity is forced through this "Merry-Go-Round" circuit, and after each passage through the valve, is returned to the pump inlet. Since there can be no discharge, no new liquid can enter the pump.

What is the result of this continuous recirculation?

Before stating the final result, we should first explain that a spring loaded by-pass valve is really a heat generator. It is a device which converts pressure energy to heat energy.

In what way does the by-pass valve create heat?

When power energy is used to turn the pump shaft, high pressure fluid is discharged at the pump outlet. The power energy is in this case, converted and stored up in the form of pressure energy. When this fluid pressure energy is then released through the by-pass valve, the energy is again reconverted into heat. The actual heating of the liquid is caused by the violent turbulence and fluid friction which results from the high pressure fluid escaping through the valve restrictions.

Is there any way of determining just how much heat will be developed when fluid under pressure is released?

Yes, this conversion follows exact mathematical laws. When a certain amount of fluid under a certain pressure is released, the exact energy lost is converted into an exact heat gain.

Can we then analyze what happens in a "Merry-Go-Round" system of by-pass assembly?

Let us take an example of a pump having a capacity of 50 GPM and unloading its entire output through a by-pass valve set at 60 pounds differential, and arranged in an assembly as shown in Fig. 1. In order to demonstrate the worst conditions, we can assume that the pump outlet is completely closed so the entire pump discharge passes through the by-pass valve and back to the pump intake in a continuous circuit. Suppose, for the first example, that we determine the results based on pumping water, because this is what pumps having this type of by-pass assembly were originally designed for. Let us assume that the pump and by-pass valve, including the by-pass piping circuit, contained

just one gallon of liquid, (which is probably about an average set-up.) Then, since the pump is to handle 50 GPM, the entire liquid contents of the pump and by-pass system will flow through the by-pass valve 50 times in each minute.

Just how hot would this water get, say in each minute of operation?

Mathematical calculation shows that this one gallon of rapidly circulating water would increase its temperature just about 25°F. during each minute of operation.

What harm would this do?

In the case of water, which would have to be raised to 212°F. before it would boil under atmospheric pressure, the pump could be operated for at least several minutes. As long as the water remained liquid it could still be pumped, but as soon as it started to boil and develop steam, the pump would lose its efficiency.

Would the results be similar in pumping butane or propane?

No. The conditions in the case of butane or propane would be decidedly worse.

Why is this?

We have seen that when pumping water at a normal temperature of 80°F., as in the example given above, this temperature is so far below the boiling point of water that such heat as is developed from a 50-pound setting of the by-pass valve, can be added for some time without changing the water from liquid into steam. On the other hand, with butane or propane, which are handled right at their boiling points, any addition of heat goes immediately into converting liquid to vapor. Now when this heat, which is capable of changing liquid into gas, is constantly conserved and returned to the pump inlet, it is possible almost instantly to convert the liquid content to gas at the pump intake. That is why the "Merry-Go-Round" system must be condemned for any B-P Gas installation.

Taking the same example as with water, what would happen when we started to pump butane or propane through the same, "Merry-Go-Round" by-pass system?

Again assuming that the pump outlet valves are closed, and that the entire capacity of the pump is forced through the by-pass system, and basing our estimates on the handling of propane at 80°F. tank temperature, this is what would happen: If we make no allowances for radiation or for what heat might be conducted through the pipe and metal walls, it would take just 10 seconds of operation to produce enough propane vapor to blow the entire liquid contents of the pump and by-pass system back into the tank, leaving the pump totally dry.

If the pump were operated with about 50% of its capacity being discharged, and with the other 50% going back through the by-pass "Merry-Go-Round," this would be a more usual condition. What would take place in this case?

Just half as much heat would be produced and this would be returned to the pump intake as before. Under these conditions, however, there would still be enough heat generated to create a large volume of gas, which would combine with the intake fluid in the form of foam, and very seriously reduce pump efficiency.

Does a pump with a "built-in" by-pass valve operate in the same way?

Yes, a "built-in" by-pass would be very definitely in the "Merry-Go-Round" class. In fact, the total contents of the circuit would no doubt be less than that of an exterior piped-up valve, and so there would be an even faster conversion to gas, and there would be less opportunity for radiation or loss of heat.

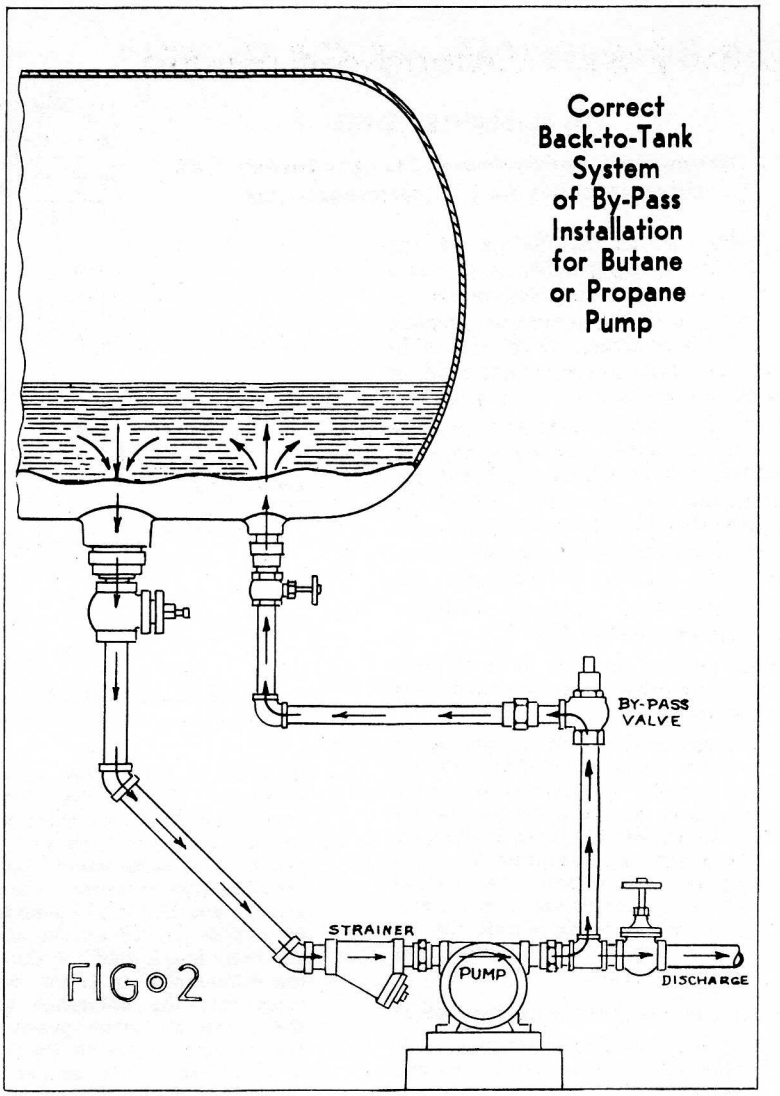


FIG. 2

How should a by-pass valve be installed to avoid these difficulties?

Fig. 2 shows the correct installation of a by-pass valve for a butane or propane pumping plant. Very little additional work or material is involved in this type of assembly, and, as can be readily seen, this slight change overcomes all the troubles which we have suggested relative to the "Merry-Go-Round" system.

Will you explain this?

In the first place, there is no cumulative effect in building up the temperature of the by-passing liquid through repeated recirculations. Whatever liquid is by-passed, and consequently charged with heat, is immediately returned to the supply tank, and it will not matter if the entire pump capacity is by-passed or only part of it. Whatever heat is produced is at once dispersed.

Will continuous return of hot by-passed fluid to the storage tank eventually produce any bad effects?

No, on the contrary, any heat returned to the supply tank merely builds up a slight additional tank pressure which in the end really aids in the development of discharge pressure.