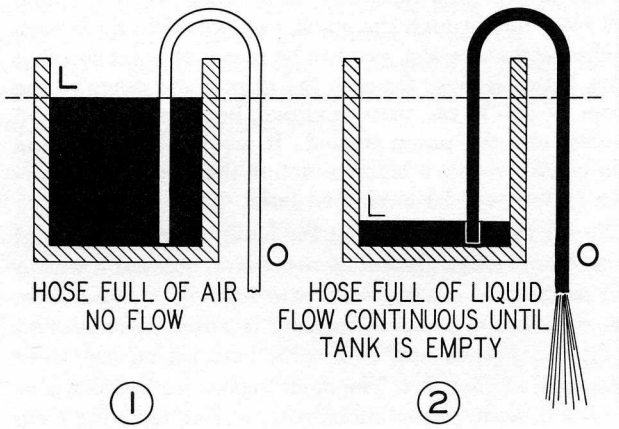
UNLOADING RAILROAD TANK CARS WITH LIQUID PUMPS: PART 1

By Lawrence W. Smith

Smith Precision Products Co. So. Pasadena, Calif.

FIGURE A

A SIMPLE SIPHON



UNLOADING railroad tanks cars is an important part of the job at almost every LPG bulk plant. Tank car unloading presents many problems, one of the most important being how to get the flow started to the pump. There are three methods that can be used—the differential pressure method, the blow-off method, and the open bypass method. The operator should understand these methods and the principles behind tank car unloading so that he may apply them to his own plant problems and attain better and safer operation.

Q. We have always understood that it is bad for a pump to try to move liquid out of a tank through a dip-tube. Yet, as we see it, all railroad cars have to be unloaded in just this way. How can we avoid trouble with pump starvation, vapor lock, and dry running, when we have to pump out of a dip-tube?

A. Unloading railroad cars with liquid pumps can be no more difficult than unloading transport trucks, or loading delivery trucks from your own bulk storage. As is true in every kind of LPG pumping operation, if the pump is properly installed, and if the operator knows the tricks in the installation, such as the proper order of opening the valves, etc., everything will be easy, with no troubles experienced. On the other hand, if little attention is given to proper piping, or if the operator does not do his valving correctly, continual trouble can be experienced to the point where expensive pump overhauls and eventual changes may be necessary. In the particular case of railroad tank cars, the proper piping installation will be discussed in Part 2 of this series. The main trick in proper valving lies in knowing which valves to leave closed and which to open so you can get an initial flow of liquid started through the pump. The proper piping setup for unloading tank cars makes this easy, and once the principles involved are understood, the operator should have no trouble.

Q. What are some of these principles in getting flow started to the pump?

A. Most of these are tied up in the word "siphon." In *Fig. A* we see a water tank ¾ full of water, with a hose thrown over the top. As long as the hose stays full of air (as in *Fig. A-1*), nothing will flow out of the siphon. However, if we suck on the outside end of the hose until water runs up to the top of the hose and down the other side, a continuous flow will result, and this flow will be maintained until the tank is empty, as long as the outside end of the hose (O) stays below the level of the liquid in the tank (L). (See *Fig. A-2.*) We have all had experience getting siphons started. Most of us have siphoned gasoline out of automobiles at one time or another, or we have emptied water tanks, fish ponds, or old-style washing machines with a hose in this way. From our experiences, we can list these two rules about a siphon:

(1) The siphon will not start when it is full of air. To get it going, you have to provide enough suction on the discharge end to bring liquid up and over the top of the loop. As soon as you have more liquid on the outside of the loop than on the inside of the loop, flow begins.

(2) Once flow begins in a siphon, it is self-maintaining, and flow will continue until the tank is empty or until enough air or vapor accidentally enters the system so that the total weight of the liquid on the outside of the loop becomes less than the weight on the inside of the loop.

Q. I recall that we studied siphons in high school, years ago. It comes back to me pretty well. However, I don't yet see how this applies to LPG tank cars.

A. The dip-tube in a railroad tank car, in combination with the liquid piping in the unloading system, makes a siphon. That part of the piping shown in *Fig. B,* from point X (inside the car) to point Y (at the bottom of the unloading riser) is the same simple siphon that you have in *Fig. A.*

Q. Then once you get the siphon in an LPG tank car unloading system started, it will be self-maintaining?

A. Yes. It will act just like the water system we have been discussing. Once started, the flow to the pump will continue automatically as long as the pump is installed below the bottom of the car, as shown, and no air (or vapor in the case of LPG) enters the system. However, we still have the problem of getting the siphon started.

Q. That doesn't seem like a real problem at all. One should just start the pump. The pump would suck liquid to its inlet, filling the piping in the siphon. What could be simpler?

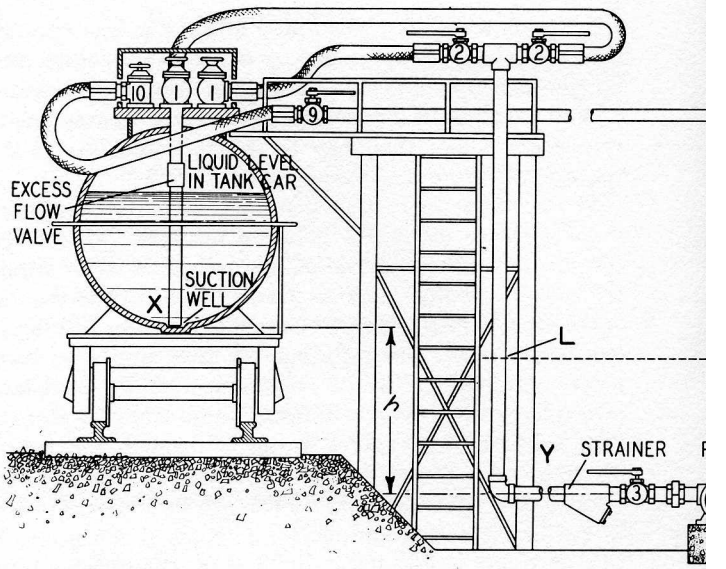
A. What you have suggested would work fine with ordinary fluids such as water, oil, or kerosene, if the pump was first primed. However, we must remember that in LPG we have a liquid very different from the ordinary, in that it is being handled *at its boiling point.* Because of this, no type of pump can suck LPG to its inlet. When a pump tries to suck, a boiling liquid "opens up into gas," that is, it "flashes" or "boils," producing vapor that normally maintains a vapor-locked condition in the siphon.

Q. Then what can we do to get the siphon started?

A. We know of three ways that this can be done. These methods we will call the "differential pressure method," the "blow-off method," and the "open bypass method."

I. DIFFERENTIAL PRESSURE METHOD

THE differential pressure method makes use of the difference in pressure between that in the storage tank and that in the tank car. In many areas of this country the liquid in the tank car is warmer than that in your storage. The tank car will thus carry perhaps 5- to 10-psi more pressure. After the liquid and vapor hoses are hooked up, open all the valves in the liquid line (in *Fig. B,* these are Nos. 1, 2, 3, 4, and 5) but *do not open* the valves in the vapor return line. The excess pressure in the tank car will then not be equalized, and this pressure will slowly force liquid up the tank car dip-tube, down the outside piping, through the pump, and into the storage tank. This flow will normally be quite slow, due to the resistance-to-flow in the pump, which has not yet been



started. After waiting a few minutes, you can be reasonably certain that the siphon is full of liquid, and that the liquid flow has pushed all the vapor and air originally in the hoses and the top of the tank car dip-tube into the storage tank. You can now safely start the pump, and slowly open the valves in the vapor return line only after the pump is running.

Q. This sounds like a good procedure when the pressure in the tank car is greater than that in the storage. But supposing the situation is reversed, and the pressure in the storage is highest. What can be done then?

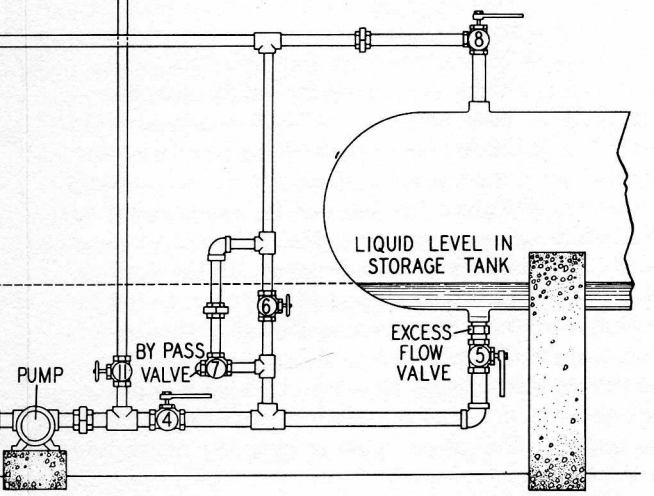
A. If the pump liquid discharge line runs to the bottom of the storage tank, as shown in *Fig. B,* then the siphon will be filled by liquid running out of the tank, through the pump, up the outside part of the siphon, and down the tank car dip-tube. After a few moments of waiting, you can start the pump and open the vapor valves as before. However, if the pump liquid discharge line should happen to run to the *vapor* space of the storage tanks, this differential pressure method will not work, as vapor, not liquid, would be forced through the pipes. In such event, the blow-off method, which will be described later, will have to be used.

Q. What about the extra liquid that would run into the tank car if the storage pressure was higher than tank car pressure? Wouldn't this overfill the car, causing a hazardous condition? And wouldn't this liquid be lost, resulting in additional fuel expense?

A. The liquid would not be lost, as you would get it back as soon as you started the pump. In answer

FIGURE B

BASIC RAILROAD TANK CAR UNLOADING SYSTEM



to the first query regarding a hazard, we would say that the few gallons of fuel that would enter the tank car this way would have a very negligible effect upon the liquid level in the car. We must remember that under usual conditions the pressure differentials we are talking about are very small, caused by differences in temperature of a very few degrees. Liquid flow would be slow, due both to the low differential, and the fact that a stopped pump is in the line. Of course, if you should be trying to unload LPG mix into a propane tank, or butane into a tank containing LPG mix, the higher differential should be allowed for, by waiting a shorter time before starting the pump.

Q. What would happen if the operator opened the valves in the liquid line, but forgot to start the pump?

A. After a period of an hour or so, depending on the height of the liquid level in the storage tanks, and the amount of the original temperature and pressure difference, the tank car *might* become completely filled with liquid. However, if you have the type of operator who forgets things like this, he shouldn't be working for you, as he can make other mistakes in other operations that are potentially much more dangerous.

Q. What happens in the rare event that pressure in both the storage and the tank car is the same? How can the siphon be filled with liquid in this case?

A. In this event, which would, as you say, be very uncommon, one of the other two methods of starting the siphon would have to be used.

II. BLOW-OFF METHOD

To illustrate the blow-off method, which is not recommended except where absolutely necessary, we show in *Fig. B* a blow-off valve, 11, connected at a tee in the pump discharge line, running to a blow-off stack, which should extend as high into the air as possible, certainly at least several feet higher than the top of the storage or the top of the railroad tank car. To fill the siphon with liquid, open valves 1, 2, and 3 in the liquid line, leaving valves 4 and 5 closed. The vapor line valves, 8, 9, and 10, should also be opened in this case. After these valves have all been adjusted, crack valve 11 slightly, allowing a discharge of fuel to atmosphere. The vapor in the siphon will blow off through the stack, and when liquid is seen discharging at the top, you can be reasonably certain that there is liquid clear through the siphon and down to the pump. Valve 11 can then be closed, liquid valves 4 and 5 opened, and the pump started. It would also be a good idea to open valve 6 before starting the pump. The purpose of this will be explained later.

We are of the opinion that the blow-off method should be used only when absolutely necessary, because it wastes fuel as well as tending to create hazardous conditions. The differential pressure method is much more certain to fill the siphon, and it is safer because no fuel ever escapes to atmosphere. The open bypass method can also be used in many installations without fuel escaping from the lines. If you do have to use the blow-off method, be sure to use a fairly high stack, connected as shown. Don't blow off the fuel at ground level, as LPG vapors lie on the ground and this greatly multiplies the hazard. Don't have the blow-off stack teed to the pump *suction* line, as this will assure solid liquid only up to the tee, not through the pump. And particularly do not connect the blow-off stack in the strainer blow-off plug. Systems so designed make it a major job to open the strainer for inspection of the screen, and this may have to be done quite frequently, particularly in the weeks after the system is first put into service.*

In the case of storage tanks piped so liquid enters through the vapor space (as through top openings that have no dip-tubes, or bottom openings connected to tubes running up almost to the top of the tanks), the blow-off method is the only way of the three here described to get the siphon started. Because of the wastage and the hazardous nature of this blow-off method, we strongly recommend that such tanks be re-piped so liquid can enter the liquid space, thus allowing use of a different method of getting the siphon started.

*A reprint of an article discussing LPG pump strainers in detail is available upon request from Smith Precision Products Co., 1135 Mission St., So. Pasadena, Calif.

III. OPEN BYPASS METHOD

IN *Fig. B* we show globe valve 6 in a pipeline running from the pump discharge line up to the vapor return line. Spring-loaded bypass valve 7 is piped around globe valve 6. Valve 6 gives us a means of opening the bypass line to return any vapor that may be in the liquid line to the vapor return line if necessary.

The open bypass method can often be used when there is no pressure difference between the tank car and the storage, providing that the pump discharges to the liquid space of the storage tank as shown. To illustrate the use of the open bypass valve, let us first assume that all liquid and vapor valves are fully opened after the hoses have been connected. With all pressures perfectly equalized in this manner, gravity will make liquid from the storage run down through valves 5 and 4, through the pump, through valve 3 and the strainer, and up the tank car unloading riser to point L, which will be the exact level of the liquid in the storage tank. Now, if the pump is started, it will move all the liquid in the inlet piping from point L to the pump, before the vapor that was above point L reaches it. During the time this liquid is being pumped, a suction will be created in the inlet piping, and the liquid in the tank car dip-tube will start to boil.

Now follow this reasoning closely, as it is not well understood by many in the LPG industry: When the liquid boils, it has to pick up heat from somewhere in order to produce the vapor. And since this reaction takes place almost instantly, the main place the heat comes from is the *liquid itself*. This means that the temperature of the liquid in the dip-tube will be reduced; and if the temperature goes down, so does the pressure. When the pressure of the liquid in the dip-tube is lowered, the higher pressure in the rest of the car will push that liquid up the dip-tube, and start it down the unloading riser.

All this happens in the space of a very few seconds, while the pump is working on the liquid in the piping that is below point L. As soon as the pump has transferred this small amount of liquid in the pipes, the vapor that was above point L will hit the pump, and the pump will no longer develop a suction to cause the liquid in the dip-tube to boil. The action that was tending to lift liquid out of the dip-tube and bring it down the unloading riser will be halted. If this action stops before enough liquid has come up the tank car dip-tube and down the unloading riser to keep the siphon going, all pumping action will stop, and no amount of further running of the pump can make it start again. In this case, we see that it is actually desirable to have the pump some distance from the railroad car (say 30 ft or slightly more), so there will be enough liquid from point L to the pump to maintain pump suction long enough to get the siphon started. Since the length of the piping in the siphon (point X to Y) will be about 30 ft, we can be assured of getting the proper action only if the distance from L to the pump is at least equal to this length.

Now, the purpose of the open bypass valve 6 in all this is to help purge the vapor in the system as quickly as possible. With this method, there will be a terrific churning and boiling of all the liquid in the pipes when first starting the pump. Since pumps do not handle vapor too well, means should be provided to purge the vapor created from the boiling as quickly as possible. An open valve leading to the vapor lines is the most direct route. After the pump has been running for a few minutes, and the siphon has been well established, no further boiling (with accompanying vapor formation) will take place. Hand bypass valve 6 may then be closed, and the entire output of the pump will be unloaded into storage through liquid valves 4 and 5.

IV. SUMMARY OF IMPORTANT POINTS

(1) A basic understanding of the workings of the siphon will help make it easy to unload railroad tank cars with liquid pumps.

(2) Of the three methods listed to get the siphon started, the pressure differential method, which depends on leaving the valves in the vapor line closed until after the pump is started, is most highly recommended.

(3) The blow-off method of getting the siphon started should not be used except where the design of existing unloading systems makes it absolutely necessary. This commonly used method is hazardous, as well as wasteful.

(4) The open bypass method will probably work only if the pump is 30 ft or slightly further from the tank car. ■