Leak Prevention

Tank-nically Speaking

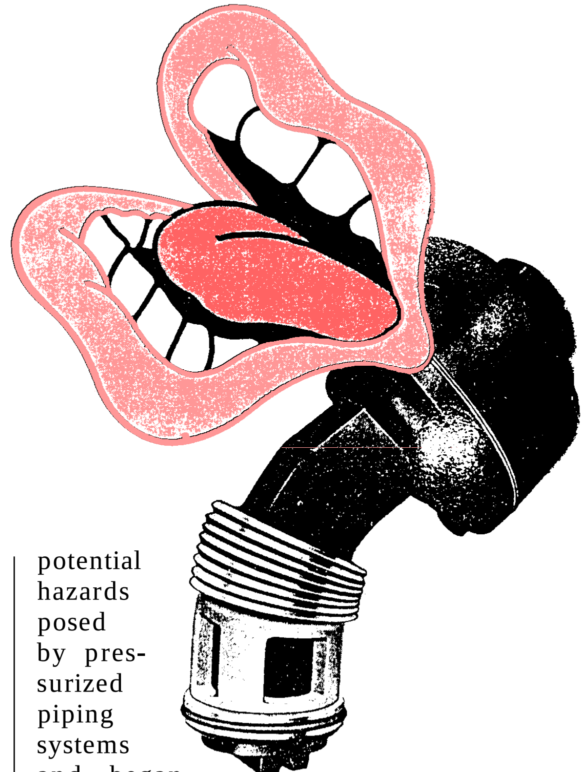
by Marcel Moreau

*Marcel Moreau is a nationally recognized petroleum storage specialist whose column, **Tank-nically Speaking**, is a regular feature of **LUSTLine.** As always, we welcome your comments and questions. If there are technical issues that you would like to have Marcel discuss, let us know.*

Of Blabbermouths and Tattletales

The Life and Times of Automatic Line Leak Detectors

Automatic Line Leak Detectors = Devices that alert the operator to the presence of a leak by restricting or shutting off the flow of a substance through piping or by triggering an audible or visual alarm. According to the federal rule [40CFR280.44(a)], a device used to meet this requirement must detect leaks of 3 gallons per hour at 10 pounds per square inch line pressure within 1 hour. An annual test of the operation of the leak detector must be conducted in accordance with the manufacturer's requirements.



An Antidote to Pressurized Piping Leaks

With a history going back to the late 1950s, the automatic line leak detector (ALLD) is probably the grandmother of all the "continuous" type of leak detection devices on the market today. ALLDs were developed not too long after submersible pumps began to be commonly used—an indication, perhaps, that the increasing use of pressure rather than suction to move product from underground tanks into motor vehicles had intensified the severity of piping leaks.

While line leaks in suction pumping systems certainly existed, they tended to be self-limiting; if the leak got too bad, the pump would cease to function. Even small leaks would cause noticeable interference with the fuel delivery operation and thereby alert the operator.

Although pressurized pumping systems had operational advantages, such as simplified piping and the absence of vapor lock (see *LUSTLine* #10, "Pumping Product—The Push Ups vs Pull Ups of Product Delivery Systems—Implications for Environmental Health"), they had a definite downside in terms of leaks. Because the piping operated under 25 to 30 pounds of pressure, leak rates from even small holes increased substantially over those in suction pumping systems. To compound the problem, there were no indications of a problem at the dispenser, so the operator had no way of knowing (except through inventory control) that there might be a piping leak.

Following the popular acceptance of the submersible pumping system, the industry developed a device that would automatically detect leaks in pressurized pumping systems. In one early ad, this new device was dubbed the "blabbermouth" because it would quickly "snitch" on a leaking pipe.

Over the years, a few refinements to the leak detector were introduced that shortened the time it took to complete the test of the piping from 5 seconds to 2 and added a chamber to help compensate for thermal contraction effects, but the basic operation of the mechanical device has remained unchanged to this day.

Meanwhile, back at the fire station, the fire codes recognized the potential hazards posed by pressurized piping systems and began mandating the use of line leak detectors long before they became an EPA requirement. The codes included a requirement that the devices be tested at least annually to ensure that they were functioning properly. Despite this requirement, ALLDs were often absent from pressurized pumps; most owner/operators did not test for proper operation on an annual basis. The inclusion of these requirements in the federal rule, however, resulted in significantly increased use of ALLDs...and many are even tested on an annual basis.

The Mechanics of a MALLD

The mechanical ALLD (MALLD) is basically a pressure-operated valve. The top of the MALLD contains a piston or diaphragm that is connected to a rod that controls the flow of product by operating a valve mechanism at the bottom of the device. The valve has three positions: wide open (full flow), test (flow limited to 3 gallons per hour), and restricted flow or "tripped" position (flow limited to 3 gallons per minute).

A spring inside the stem of the MALLD pushes down on the control rod, continually attempting to move the valve into the restricted flow position. Pressure produced by liquid in the piping system pushes against the piston or diaphragm inside the top of the MALLD, compressing the spring and keeping the valve open. Inside the MALLD, there is a continual tug-of-war going on between the spring that wants to close the valve and the liquid pressure that wants to keep the valve open. Let's look at who wins this tug-of-war under various operating conditions.

What happens when all is well?

In a pressurized piping system, the pump develops about 25-30 pounds per square inch when it is operating and delivering fuel. When the pump motor is turned off, pressure in the line is reduced to the "catch" pressure of a pressure relief valve that is incorporated in the submersible pump. If the piping is tight, the catch pressure is maintained in the pipe until the pump is turned on again. In this case, the liquid pressure wins the tug-of-war, the spring stays compressed, and the valve remains open.

What happens when there is a leak?

In a leaking pressurized piping system, the pressure in the piping will continue to drop below the pressure relief valve "catch" pressure as product leaks out of the piping. The rate of pressure decline depends on the size of the hole, but it is also a function of how rigid the piping system is. A steel piping system is quite rigid, so a small loss of liquid from inside the pipe will produce a large pressure drop.

Flexible piping systems are generally much more "stretchy" than steel. As the flexible piping is pressurized, it stretches, and as pressure is reduced, the flexible piping tends to contract—much the same way (although to a lesser degree) as a balloon expands when air is blown in and contracts when air is removed. When liquid leaks out of flexible piping, the piping contracts somewhat, maintaining some of the pressure in the pipe.

Thus, for a given leak rate, the pressure will drop precipitously in steel piping and more slowly in flexible piping. The point is, however, in both cases the pressure will drop to very low levels if the piping is not liquid-tight. This sets the stage for the spring to win the tug-of-war and move the valve mechanism to the restricted flow position.

How the MALLD responds...

When the pressure in the piping drops below a threshold pressure, the spring in the MALLD takes control and moves the valve past the test position and into the restricted-flow position. Different manufacturers of MALLDs have different threshold pressures, but they are all in the range of a few pounds.

The MALLD stays in this restricted-flow, or "tripped," position, waiting for the next customer to come along and turn on the pump. When the pump is turned on, the flow through the MALLD is restricted to about 3 gallons per minute. Unless there is a leak in the piping that is greater than 3 gallons per minute, this flow into the piping system will increase the pressure in the line. This increase in pressure will press against the piston or diaphragm of the leak detector and begin to move the control rod that activates the valve mechanism. At about 10 pounds per square inch of pressure in the line, the control rod will have moved the valve mechanism into the "test" position. In the test position, the flow into the piping system is reduced dramatically to 3 gallons per hour.

...To a false alarm.

If the leak detector has been tripped because of a false alarm (see below) and the piping is tight, this small flow of liquid into the piping will continue to increase the pressure in the line. At a few additional pounds of pressure, the valve mechanism moves past the test position and into the wide-open position, where the dispensing of product can proceed unimpeded. The time required to go from the tripped position through the test cycle and into the open position is about 2 seconds.

...To a leak of 3 gallons per hour or more.

If the piping has a leak of greater than 3 gallons per hour, the 3 gallons per hour of liquid flowing past the leak detector into the piping will flow out of the pipe as fast as it is coming in. The pressure in the piping will not increase, and so the valve mechanism will not move out of the 3-gallon-per-hour test position.

Now, keeping in mind that the reason the pump was turned on in the first place was to dispense fuel, we turn to the customer, who opens the nozzle in anticipation of pumping some product at a flow rate of 10 gallons per minute. If the leak detector is still in the test position, however, this will not happen. With the nozzle open, whatever pressure was in the piping is now lost, the leak detector valve returns to its restricted-flow position, and the customer receives a flow of 3 gallons per minute. It is this reduced flow rate that is supposed to be noticed by the customer and reported to the station attendant (assuming a self-service type of operation).

...To smaller leaks.

For leaks of less than 3 gallons per hour or for flexible piping systems, the time required for the leak detector to go through the test phase and reach the wide-open flow position will be longer than 2 seconds. But if enough time is allowed, the piping should be able to build enough pressure to move the leak detector into the wide-open flow position. Whether a customer experiences restricted flow will depend on the length of time between when the pump is turned on and when the customer opens the nozzle.

A Few Rubs

A number of factors can cause MALLDs to restrict flow when a leak is not present (i.e., false alarm):

- **Malfunctioning check valves**

  The valve mechanism in the submersible pump that retains product in the line between the times when customers pump product can leak. This is not a leak into the environment; rather, the product merely returns to the underground tank. The loss of product in the line, however, will cause the leak detector to trip, and it may take many seconds to refill the line, greatly increasing the likelihood that the customer will have opened the nozzle and, thereby, set the MALLD in the restricted flow position.

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- **Thermal contraction**
  In cold climates, the ground temperature around the piping is often significantly colder than the ground temperature around the tank. As a result, relatively warm product flows into the piping. When it is allowed to sit, especially overnight, it cools and contracts. This reduction in temperature can reduce the pressure in the line and trip the ALLD.

- **Air pockets**
  Air pockets in the piping introduce "springiness" into the piping system, because the air is very compressible. As a result, it will take more product (and therefore longer time) for the MALLD to move from the tripped to the open position.

There are also some factors that can cause MALLDs to miss leaks:

- **Excessive height of the piping**
  In order to move into the tripped position, the pressure at the MALLD must drop to a threshold pressure that can be as low as 1 pound per square inch. A column of product about 3 feet high is sufficient to produce a pressure of about 1 pound per square inch at the bottom of the column.

  Let's say, for example, there is a 4-foot height differential between the MALLD and the dispenser shear valve. In order for the MALLD to trip and conduct a leak test, the height of the product would have to drop about 1 foot below grade. If the leak is at the shear valve, however, the piping below the shear valve will remain full of product, the hydrostatic pressure at the MALLD will never go below the trip pressure, and the leak will never be detected. In the old days, deep burial of tanks was quite uncommon, but now that we are paying more attention to piping slope, particularly with Stage II piping, MALLD burial depths can sometimes be well below 3 feet.

- **Mechanical wear**
  The tolerances in the valve mechanism of the MALLD are quite fine, but as the device wears, these tolerances tend to become less fine (i.e., greater). The result is that as the MALLD ages, the minimum-size leak that it will detect tends to increase.

- **Sticking**
  Because the MALLD is mechanical, it relies on the physical movement of parts to detect the leak. If piping is tight and pressure is always maintained in the line, the mechanism of the MALLD may move little or not at all for months or even years on end. Deposits can build up on moving parts, tending to lock them in place. The result is that when a leak does develop, the MALLD fails to respond.

- **Satellite dispensers**
  In this era of self-serve gasoline dispensing, there is a remotely operated solenoid valve located in the dispensers and controlled by the cashier. This valve is often programmed to remain closed until after the MALLD has completed its test to prevent false alarm when a customer opens the nozzle while the MALLD is still looking for leaks. As a result, leaks downstream of the solenoid valve are invisible to the MALLD. In normal dispensers, such "invisible" leaks are not a big problem, because all of this piping is above ground, and leaks can be discovered visually.

  However, many large truck fueling facilities have what are known as satellite dispensers that allow the driver to fuel tanks on both sides of the truck at the same time. The satellite dispenser is essentially another hose that is routed from the master dispenser to a nozzle about a dozen feet away. The routing of this "hose" is typically underground, and typical piping materials (e.g., FRP, flexible pipe) are used.

  In older model satellite dispensing systems, the piping that branches off to the satellite dispenser is typically downstream of the solenoid valve. Because of this, leaks in piping that goes to the satellite dispenser are not detected by the MALLD. A possible solution to this problem is to add a dispenser-mounted electronic line leak detector to monitor just the satellite piping.

  Newer model master/satellite dispensers incorporate two solenoids—one in the master and one in the satellite. In this configuration, the satellite piping branches off from the master dispenser at a point that is upstream of the solenoid in the master dispenser. This dual solenoid system does allow the satellite piping to be tested by the line leak detector.

- **Lack of pump cycling**
  In the vast majority of fueling facilities, the pump motor is turned off most of the time and operates only while fuel is being dispensed. This cycling of the pump motor is essential to the operation of the MALLD. However, there are a few facilities that I've heard about where, for various reasons, the pump motor is on continuously for long stretches of time. At this type of facility, the MALLD fails to meet the regulatory criteria for detecting a leak within 1 hour, because the pump may be on continuously for days or weeks; until the pump is turned off and then restarted, any leak of any magnitude will not be detected by the MALLD.

- **The human element**
  Historically, the restriction of flow produced by the leak detector was often dismissed as a problem with the leak detector, because the problem went away when the leak detector was removed (and, all too often, not replaced). Even today, knowledge of the meaning of restricted-flow rates is not universal.

  For example, I was fueling up in northern New Mexico not too long ago and noted that it took a very long time to complete my purchase. When I mentioned this to the attendant, his response was, "Oh yeah, that pump always runs slow." Admittedly, clogged fuel filters in dispensers, malfunctioning pumps, and partially closed shear valves can all produce symptoms of restricted flow, so this condition is not a conclusive indication of a leak, but it is also not a condition that should be accepted as normal.

The Electronics of EALLDs

Over the past decade, the emphasis on leak detection in piping created by the federal rule has spurred the development of a new breed of line leak detectors that are electronically, rather than mechanically, based. This new breed of electronic automatic line leak detectors (EALLDs) usually incorporates a microprocessor to enable the EALLD to make more informed decisions about the data that it is receiving as well as to run more sensitive tests on the piping. Typically, but not always, EALLDs control power to the pump. Very often, the EALLD microprocessor is incorporated into an automatic tank gauge console.

Most EALLDs use a pressure transducer (a device that converts changes in pressure to variations in voltage) to monitor pressure in the piping. Except for the fact that both MALLDs and EALLDs monitor pressure in the piping, they have little else in common. The EALLD usually checks for a leak after the pump motor has been turned off. As with MALLDs, when the pump motor is turned off, the pressure in the piping is allowed to drop to some “catch” pressure determined by the pump’s pressure relief mechanism. The EALLD then monitors the pressure in the system to see if there is a continuing precipitous drop in pressure. If such a pressure drop is detected, most devices will cut off the pump power and not allow power to be restored by the mere push of a button. A knowledgeable technician must reset the unit to restore power to the pump, presumably after he or she has determined the cause of the pressure drop.

This leak detection feature of the EALLD is fairly straightforward and works well as long we are looking for a leak in the 3 gallons per hour range. However, in addition to 3-gallon-per-hour tests, many EALLDs also have the ability to conduct 0.2-gallon-per-hour and sometimes even 0.1-gallon-per-hour tests. Leak detection at this level is somewhat more challenging because of thermal effects, piping resiliency, air pockets, and the effectiveness of system hardware such as check valves—but that discussion will have to wait until another issue of *LUSTLine.*

There are a few EALLDs that work on a slightly different principle—by taking over control of the pump motor and leaving the pump motor running for a brief period after the fuel dispensing operation is completed. With the piping system at operating pressure, an electrically controlled valve near the pump closes and a small alternate flow path from the pump side of the valve to the dispenser side of the valve opens. As long as the pressure on both sides of the closed valve is equal, there will be no flow through the alternate flow path. However, a hole in the piping on the dispenser side of the valve will cause the pressure to drop, thus allowing product to flow through the alternate flow path. The flow rate is then measured, and if it exceeds the threshold leak rate for the device, a leak is declared.

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Several EALLDs incorporate “wireless” technology to transmit information from the pressure or flow sensor located near the pump to a control unit that is typically located near the pump power supply. This means that the sensor signal is sent through the same wires used to power the pump, thus avoiding the cost of running new wires for the EALLD. A number of EALLD devices can also be installed in the same opening as was used for a MALLD. These features make retrofit of EALLD on existing installations relatively straightforward.

Keep in mind that the UST rules do not distinguish between MALLD and EALLD with regard to annual testing. Whatever device is used to meet the 3-gallon-per-hour leak detection requirement must be tested annually for operation according to manufacturer’s instructions.

A Few Rubs

EALLDs have their own problems when it comes to software. Most EALLDs complete a 3-gallon-per-hour leak test in a matter of seconds after the pump is turned off. I am aware of at least one model, however, that requires three consecutive failed tests conducted at 5-minute intervals before declaring that piping is leaking. Thus, the detection of a leak requires a minimum of 10 minutes, during which no fuel can be dispensed. To meet the regulatory standard of detecting a leak within 1 hour, this device would require 10 minutes with no fuel dispensing every hour. There are a good many facilities where 10 minutes of downtime will happen only in the wee hours of the night. It seems to me that devices such as this one do not meet the standard for ALLDs set by the federal rule.

Note that EALLDs work when a pump is cycled from on to off, as opposed to MALLDs that test the piping when the pump is cycled from off to on. EALLDs still require that the pump be cycled to conduct a test and do not meet regulatory requirements on systems where the pump motor is on all or most of the time.

EALLDs have the same issues as MALLDs with regard to satellite dispensers. Pressure-based EALLDs may have false alarms from malfunctioning check valves, and flow-based EALLDs have moving parts that can get clogged, but the other problems mentioned above with MALLDs have largely been overcome.

Future ALLDs

After several decades of stability, ALLDs have experienced an explosion of technical development since the emergence of the federal rule. These developments are continuing with the introduction of more sophisticated pumps that feature automatic adjustment of pump motor speed according to the number of nozzles that are open. This allows the pump to operate more efficiently and to rapidly fuel a greater number of customers. At least one manufacturer of these intelligent pumps monitors the pressure in the line to determine the pump motor speed. This same pressure monitor is then used after the pump is shut off to look for pressure drops in the piping that may indicate a leak. Leak detection for pressurized piping has at last become an integral part of the pump design rather than an afterthought. It’s about time. ■