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 him know at* **marcel.moreau@juno.com.**

Of Saws, Hammers, and Leak Detection

Why Inventory Can't Find Leaks in Satellite Piping

The preamble to the federal rule, published over a quarter century ago, stated that all the methods of leak detection described in the rule, "appear to be successfully detecting releases when properly applied."[1] The USEPA's position at the time was that all leak detection methods included in the federal rule would work equally well if the guidelines presented in the rules were followed.

Policy versus Science

While equality among leak detection methods may be politically correct from a rule-writing perspective, it is not scientifically correct from a physics perspective. For example, groundwater monitoring is founded on vastly different principles than automatic tank gauging. A tank-tightness test is worlds away from inventory control as a leak detection method. The actual mechanics of how leak detection methods work require that different methods have different abilities to detect different types of leaks. Although any of the leak detection methods described in the federal rule may be used to comply with the regulations (assuming all the guidelines in the regulations are followed), the magnitude and locations of the leaks that can be detected by these different methods vary greatly.

This was brought home to me by a recent query from a regulator who wondered why line-leak detectors could be used for leak detection on the satellite piping that runs between the master and the satellite dispenser at a truck stop but statistical inventory reconciliation (SIR) could not. As I thought about my answer, I realized that part of the regulator's issue was taking the regulatory philosophy that all leak detection methods are effective a bit too literally, combined with an understanding of the workings of various leak detection methods that was a bit too shallow.

Why I'm Writing this Article

I have two goals in writing this article: first, to point out that all leak detection methods are not created equal, and second, to provide a concrete example by discussing why it is that line-leak detectors can find leaks in satellite piping but inventory-control-based methods of leak detection, whether traditional, SIR, or automated, cannot.[2]

The methods of leak detection described in the federal UST rule are tools we can use to find leaks. While most people are familiar with visible leak detection whereby you observe drips from a faucet or a ceiling, leak detection involving flammable liquids escaping from components of a storage system buried beneath the ground is a pretty esoteric topic of discussion at most cocktail parties. For this reason, I'll start by discussing some tools that most people can relate to: saws and hammers.

While saws and hammers can both be used to build a wooden birdhouse, they have very different roles to play in the construction process. Likewise, automatic line-leak detectors and SIR can both be used to detect leaks in pressurized piping, but they have very different roles to play because they operate on very different principles.[3] While it is obvious to most people why you can't drive a nail with a saw, it is perhaps not so obvious why you can't find leaks in satellite piping with inventory control. Let's start by looking at the operating principles behind each of these two methods of leak detection.

Operating Principles of Line-Leak Detectors

Line-leak detectors operate on the following general principles:

- Electronic line-leak detectors (ELLDs) monitor pressure in the piping between two defined points. Usually these points are the check valve in the submersible turbine pump (STP) and the solenoid valve(s) in the dispenser(s). Piping that is NOT between these points in the piping system is not monitored.
- For the piping to be considered tight, the ELLD needs to see that the pressure in the piping between the check valve and the solenoid valve(s) remains reasonably constant during the test period.
- Mechanical line-leak detectors (MLLDs) also use pressure to find leaks in piping but the operating principle is different. MLLDs want to see a rapid rise in the pressure in the piping when the submersible pump is first turned on.
- MLLDs find leaks between the point where the fuel leaves the MLLD and the solenoid valve(s) in the dispenser(s). Piping that is

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not between these two points is not monitored.

- Both ELLDs and MLLDs work by monitoring *pressure* in the piping.
- ELLDs and MLLDs don't give a hoot how many gallons are pumped through the piping each hour or each day or each month. To conduct a test, they must monitor the pressure in the piping during a period when no fuel is moving through the piping.[4]

Operating Principles of Inventory Control

Inventory control operates on the following general principles:

- Inventory is all about arithmetic. Inventory is all about calculating how much fuel went into the storage system, how much came out, and how much is left. Inventory is an accounting procedure.
- Inventory works by comparing the volume of fuel delivered (based on the bill of lading), the volume of fuel dispensed (based on the dispenser meter measurements), and how much is left in the tank (based on ATG or gauge stick measurements).
- Measuring how much fuel goes through the piping each day is a key part of the inventory procedure.
- Inventory finds leaks between the fill pipe and the meter(s) in the dispenser(s). If fuel leaves the storage system for any reason between the fill pipe and the meter(s) it will show up as missing product in the inventory records.
- Inventory doesn't give a hoot about pressure; it works on both suction and pressure piping systems.
- Once the fuel has gone through the dispenser meter and has been accounted for, inventory has no way of knowing what happens to the fuel. If the dispensing hose has a hole and one out of every ten gallons that goes through the

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Automated Inventory: A more recently developed method of leak detection where all of the inventory data are automatically gathered. Delivery volumes, sales volumes, and volume in the tank are all simultaneously recorded at frequent intervals throughout the day without any human intervention. Because no humans are involved in the data gathering, the accuracy of the data is greatly improved and the number of data points that can be gathered is greatly increased. Proprietary statistical techniques are applied to the data to determine if a leak may be present. As for SIR, automated inventory vendors must show that their software can detect leaks of 0.2 gallons per hour with a probability of detection of at least 95 percent and a probability of false alarm of no more than 5 percent to be acceptable as a leak detection method. Because the data gathering techniques for automated inventory are so different from the once-a-day data gathered for SIR, automated inventory control must be evaluated using a different protocol. This protocol is commonly referred to as the Continuous In-Tank Leak Detection (CITLD) protocol.

Check Valve: A valve in a piping system that only allows fluid to flow in one direction. The flow of the fluid opens the valve and the valve closes automatically when fluid flow stops. In both pressurized and suction fuel piping systems, the check valve serves to keep the piping full of fuel when the pump is turned off. In suction pumping systems the check valve is normally located in the dispenser cabinet. In pressurized pumping systems the check valve is located in the pump head at the top of the tank. The check valve in a pressurized pumping system is sometimes referred to as a "functional element" because it serves as a pressure-relief device as well as a check valve.

Line-Leak Detector: In the federal regulations a line-leak detector is defined as a device that will detect a leak in a pressurized piping system of three gallons per hour within a time frame of one hour. The three-gallon per hour leak rate is defined at a pressure of 10 pounds per square inch.

Master/Satellite Dispenser: Most long-distance trucks have two fuel tanks, one on each side of the vehicle. To simplify and speed up the fueling of these trucks, most truck stops provide fueling lanes where there are two nozzles connected to a single meter so tanks on both sides of a truck can be fueled at the same time in a single sales transaction. The dispenser that contains the meter and the credit-card reader is called the master dispenser. The dispenser on the other side of the vehicle has no meter or credit-card reader (it's basically just a stand to hold the nozzle) and is known as the satellite dispenser.

Solenoid Valve: A solenoid valve controls the flow of a fluid using an electromagnet (solenoid) to open and close the valve mechanism. In a fuel dispenser, the solenoid valve controls the flow of fuel to the nozzle. The solenoid valve is normally closed and opens only after a method of paying for the fuel has been established. Solenoid valves are in the closed position when both mechanical and electronic line-leak detectors conduct a test.

Statistical Inventory Reconciliation (SIR): A method of leak detection first developed in the 1980s that takes traditional inventory data and applies statistical techniques to these data to determine whether a leak may be present. The statistical techniques used by each SIR vendor are usually proprietary. To be acceptable as a leak detection method, a SIR vendor must show that their software can detect leaks of 0.2 gallons per hour with a probability of detection of at least 95 percent and a probability of false alarm of no more than 5 percent.

Traditional Inventory: Inventory control that uses simple arithmetic to analyze the inventory data. The sum of the daily variances at the end of the month is compared to the regulatory standard of 1 percent of sales plus 130 gallons to determine whether the inventory data may indicate a problem. This standard will find leaks of about a gallon per hour with a probability of detection of 95 percent and a probability of false alarm of 5 percent.

meter falls on the ground instead of going into a vehicle, the inventory records will still come out perfectly (assuming there are no other holes in the system). Inventory has no way of knowing where the fuel goes after it leaves the meter.

- Inventory is like a bank account. You track how much is deposited, how much is withdrawn, and how much is left. If you withdraw $50 from an ATM (the equivalent of a dispenser meter), the bank subtracts $50 from your account and the reconciliation at the end of the month will accurately reflect the remaining funds in your account. But there is no way for the bank to know whether you spent the $50 on food, or movies, or clothes, or whether the money fell out of your pocket and was lost.

What Happens When These Operating Principles Are Applied to Satellite Piping?

- With regard to the satellite piping that runs between a master dispenser and a satellite dispenser, consider the following: In a master/satellite dispenser setup there is only one meter. The whole purpose of the master/satellite dispenser is so that two nozzles can be used to simultaneously fill the tanks on both sides of a truck in a single sales transaction. In today's electronic world it would be possible to use two meters, one in the master dispenser and one in the satellite dispenser, and automatically add the volume measured by each meter to calculate a total volume dispensed. But satellite dispensers go back to a time when all meter mechanisms were mechanical, and adding the sales volume from two meters and calculating the cost would have involved pencil and paper and a mathematically competent fueling attendant. While technology today is vastly different, the tradition of a single meter in the master dispenser persists.

- In the early master/satellite dispensers, a single solenoid valve

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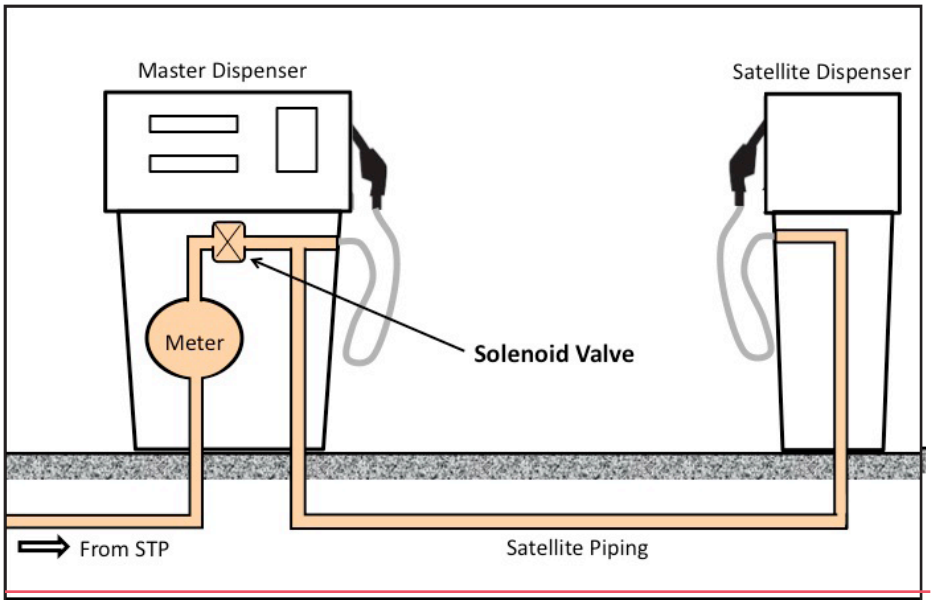

Figure 1. *In the earlier days of master/satellite dispensers, a single solenoid valve was installed upstream of the point where the satellite piping branched off the master dispenser piping. The single solenoid valve controlled the flow of fuel to both the master and satellite nozzles. Line-leak detectors conduct their tests when the solenoid valve is closed, so they cannot "see" leaks beyond the solenoid valve. When the piping was set up in this way the satellite piping was not in compliance with line-leak detection requirements. The satellite piping is also downstream of the master dispenser meter, so inventory-based leak detection methods would not find leaks in the satellite dispenser piping.*

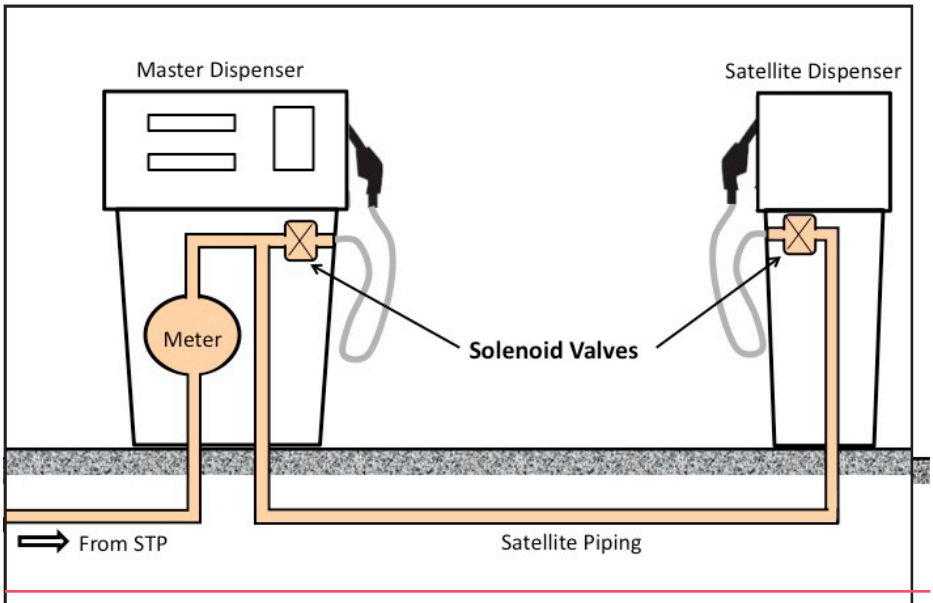

Figure 2. *These days, two solenoid valves are installed in master/satellite dispensers. Because there are no valves in the piping between the line-leak detector and the satellite piping, the leak detector can "see" leaks in the satellite piping and the satellite piping is in compliance with line-leak-detection regulations. But the satellite piping is still downstream of the master dispenser meter, so inventory-based leak detection methods still cannot be used on satellite dispenser piping.*

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was positioned in the piping before the point where the piping to the satellite dispenser branched off from the master dispenser piping (see Figure 1). Because both MLLDs and ELLDs do their testing when the solenoid valve is closed, this meant that the piping to the satellite dispenser was beyond the solenoid valve and leaks in the satellite piping would not be detected by either a MLLD or ELLD. Fortunately, the technology to solve this problem was quite simple: just use two solenoid valves, one in the master dispenser and one in the satellite dispenser. The solenoid valve in the master dispenser is positioned after the point where the satellite piping branches off from the master dispenser piping (see Figure 2). Because there is no valve between the line-leak detector and the satellite piping, leaks in the satellite piping can be detected by both MLLDs and ELLDs.

➤ While there are two solenoid valves in master/satellite dispensers sold today so that line-leak detection for satellite piping is typically not a problem, master/satellite dispensing systems still have only *one* meter in the master dispenser. Inventory cannot know what happens to fuel after it leaves the meter in the master dispenser. If there is a hole in the piping that leads to the satellite dispenser, the inventory records will still come out perfectly (assuming no other holes in the system) because the fuel has gone through the meter and has been accounted for. This is true for all inventory-based leak detection systems, including traditional inventory reconciliation, SIR, and automated inventory systems certified under the continuous in-tank leak detection (CITLD) protocol.

But Wait, You Protest...

SIR and automated inventory are certified by the manufacturer to find leaks in piping and these methods are accepted by the National Work Group on Leak Detection Evaluations (NWGLDE) as piping leak detection methods! That is correct, these methods can be used for leak detection on pressure and suction piping in general, they just can't be used for satellite piping. Although the certification protocol is silent on whether these methods apply to satellite piping, I'm hoping that the discussion above has made it clear that these methods will not find leaks in satellite piping.

Then how come the rules don't include traditional inventory control as a piping leak detection method? Good question. It is clear that traditional inventory will detect leaks in piping (except satellite piping) if the leak is big enough and the inventory records are kept carefully enough. I couldn't find a direct statement in the preamble of the 1988 federal rule for why traditional inventory is not an acceptable leak detection method for piping. I think it can be inferred from the discussion in the preamble that USEPA did not believe that traditional inventory, which the agency determined could only reliably detect leaks of a gallon an hour, was sufficiently protective of human health and the environment in light of the risk of large leaks posed by pressurized piping.[5]

Amen

So there you have it. Because of their different principles of operation, MLLDs and ELLDs can find leaks in satellite piping if the solenoid valves are set up correctly, but inventory control, no matter where the solenoid valves are located or how automated or sophisticated the inventory analysis, cannot find leaks beyond the dispenser meter. This could change someday if a second meter were installed in the satellite dispenser, but as far as I know, there is no such satellite dispenser in existence today.

Any other leak detection questions? Send me a note at: marcel.moreau@juno.com ■

Endnotes

1. *Federal Register,* Vol. 53, No. 185, September 23, 1988, p. 37142.
2. See terminologies that accompany this article for the distinctions I make among these three methods of inventory control.
3. For purposes of this discussion, I'm going to set aside the different sizes of leaks that line leak detectors and SIR are able to detect. The point I want to make is that SIR cannot find leaks in satellite piping no matter how big the leak might be.
4. For a more detailed discussion of the workings of line leak detectors, see "Of Blabbermouths and Tattletales: The Life and Times of Automatic Line Leak Detectors," *LUSTLine* Bulletin #29, June 1998, available in the *LUSTLine* archives at *www.neiwpcc.org*.
5. *Federal Register,* Vol. 53, No. 185, September 23, 1988, p. 37157.