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.**

What Does Stage I Vapor Recovery Have to Do with ATGs?

The tank owner was perplexed. He had been doing leak detection conscientiously for years. His single-walled tanks were only a dozen years old. His ATG had been conducting continuous leak detection since his tanks were installed and he had never had an issue with failed tests. In the last few years, however, he'd been getting frequent failed test results, especially on his regular tank. To track down the problem he'd had numerous tightness tests conducted, using a number of different testing technologies, but all the tests indicated that his tanks were tight. His inventory records showed nothing amiss.

He brought in the company that had installed the ATG. The service tech that came checked all the ATG settings and could find nothing wrong. The tech then called the ATG manufacturer, who asked the technician if the failed tests had appeared after Stage I vapor recovery had been installed. The service tech relayed the question to the tank owner. Reviewing his records, the tank owner realized that the problem had indeed arisen not long after he installed Stage I vapor recovery. The puzzled service tech scratched his chin as both men asked aloud: "What does Stage I have to do with ATGs?"

NOTE:: I last wrote about Stage I vapor recovery and its effects on UST systems back in *LUSTline* #62 in August 2009 (available in the *LUSTLine* archives at *www.neiwpcc.org*). In that article, I focused on two issues: 1) the relationship between Stage I and inventory measurements made with a gauge stick, and 2) the conflict between co-axial Stage I vapor recovery and ball float valves installed for overfill prevention. The widespread implementation of Stage I as a result of the *National Emission Standards for Hazardous Air Pollutants* (NESHAP) regulations has brought to light a different issue: the interactions of Stage I and ATGs. Thanks to Heather Peters of the Missouri Department of Natural Resources for educating me on this issue.

Some Hardware Basics

There are three aspects of Stage I vapor recovery that need to be understood to get to the bottom of how Stage I affects ATGs: pressure/vacuum (P/V) vent valves, drop tubes, and tank vapor tightness.

Pressure/Vacuum (P/V) Vent Valves

Stage I vapor recovery rules require the installation of P/V vent valves on tank vent openings. Although many models of P/V vent valves look somewhat similar to standard vent caps on the outside, P/V vent valves do not allow air and vapors to freely enter and exit the tank as standard vent caps do. P/V vent valves incorporate mechanisms that prevent vapors from leaving the tank until the pressure inside the tank is in the range of 2.5 to 6 inches of water, and air from entering the tank until the vacuum in the tank is in the range of 6 to 10 inches of water. These pressure and vacuum levels are quite small. You can generate a similar pressure when you blow bubbles through a straw that is submerged 2.5 to 6 inches deep into a glass of water, or when you drink water through a straw where the top of the straw is 6 to 10 inches above the liquid level in the glass.

Why Are P/V Vent Valves Necessary?

If we're trying to prevent the escape of gasoline vapors from a tank into the environment, why isn't a vent cap that keeps vapors in the tank by maintaining pressure in the tank enough? Why do we also need a mechanism that prevents air from entering the tank? There are two reasons.

One role of P/V vent valves is to increase the efficiency of balance Stage II vapor recovery systems. Almost all of the early Stage II vapor recovery systems were balance systems, which relied on the flow of fuel into the automobile gas tank to drive the vapors back to the underground tank. By preventing the ingress of air through the tank vent line as liquid was pumped from the tank, the vacuum portion of the P/V vent valve created a small vacuum in the tank ullage that also helped draw the vapors from the automobile gas tank back to the UST.

Balance Stage II systems were largely replaced by vacuum-assist Stage II systems some 20 years ago. In today's world, carbon canisters in vehicles in most states are supplanting Stage II, so this role of P/V vent valves is not so important as it once was.

A second role of the vacuum valve is to make sure that no fresh air enters the tank during fuel deliveries. Tank trucks equipped for Stage I fuel deliveries also have P/V vent valves. Though different in design, they serve the same function as P/V vent valves on the UST. The tank on the truck must also be vapor tight, so that when fuel flows from the truck into the UST, the P/V vent valve in the truck tank maintains a vacuum that helps draw the vapors from the UST into the truck. The P/V vent valve in the UST, meanwhile, prevents the ingress of fresh air into the UST so that only the vapors in the UST and not fresh air from the atmosphere flow back to the truck.

Drop Tubes

Another requirement of Stage I vapor recovery regulation is that drop tubes be installed in fill risers. Drop tubes are typically aluminum tubes that slide down inside fill risers and extend from the top of the fill riser to within six inches of the bottom of the tank.

Why Do We Need Drop Tubes?

During a delivery, product flows through the drop tube and enters the tank below the liquid level. In the absence of the drop tube, fuel free-falls from the top of the tank where the fill riser ends to the level of the fuel in the tank. The fuel falling through the air together with the splashing of the fuel as it hits the surface of the liquid in the tank substantially increases the amount of fuel vapor in the tank ullage. The more vapors present in the tank ullage, the greater the quantity of gasoline vented to the atmosphere (if Stage I vapor recovery is not present) or transferred back into the delivery truck (if Stage I vapor recovery is present). Remember that NESHAP rules specify that gas stations pumping between 10,000 and 100,000 gallons per month are required to have drop tubes but not Stage I vapor recovery.

As a side benefit, the drop tube also increases the velocity of the fuel flowing into the tank, thus decreasing the time required to deliver a load of fuel.

Vapor-Tight Tanks

The third requirement of Stage I regulations that we need to understand is that UST systems should be vapor tight. To enforce this requirement, UST systems must be tested periodically. The test involves applying a slight pressure to the tank ullage using nitrogen. The pressure level is then monitored for a period of time to see if it decreases. A certain amount of pressure loss is allowed, but if too much pressure is lost, the UST fails the test and the vapor leaks must be found and corrected.

One element of this pressure-decay test protocol is that the fill cap must be removed while the test is conducted. This requirement is designed to ensure that minimal amounts of vapors are released when the fill cap is removed during the fuel-delivery process. What this means for drop tubes, however, is that no vapors must be able to flow between the tank ullage and the inside of the drop tube.

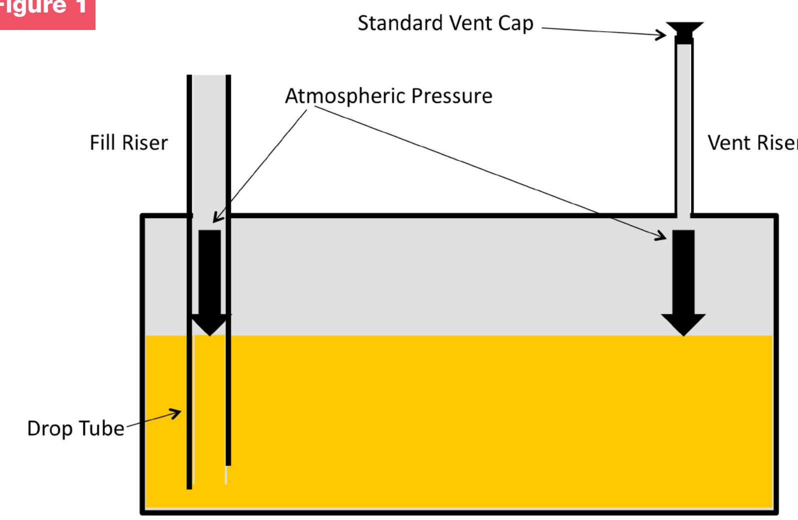
Okay, So Now What?

The combination of P/V vent valve, drop tube, and a vapor-tight tank creates a scenario where the ullage of the tank and the space above the fuel inside the drop tube are likely to be at different pressures. And because the bottom of the drop tube is open, gasoline flows from the area of higher pressure to the area of lower pressure. As a result, gasoline will likely be at a different level inside the drop tube than outside in the main body of the tank.

There are a number of variables that complicate this scenario, so let's start simple. Imagine there is a vapor-tight tank with a standard vent cap,

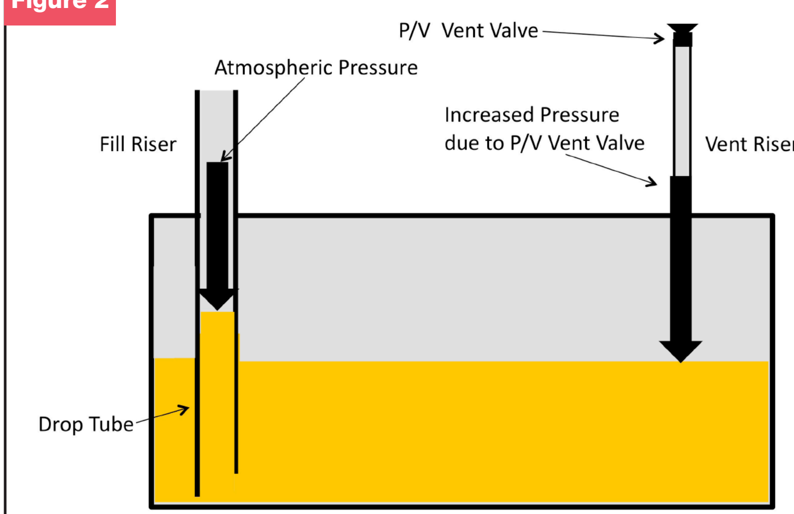
■ continued on page 8

Figure 1



When the pressure inside both the tank and the drop tube are equal, the liquid level inside the drop tube and the tank will be equal.

Figure 2



When the pressure inside the tank is greater than the pressure inside the drop tube, the liquid level inside the drop tube will be higher than the liquid level in the tank.

■ **Tank-nically Speaking**

from page 7

a drop tube, and the cap on the fill pipe is off. There are no fuel deliveries or pumping activity going on. In this scenario, both the fuel in the drop tube and the fuel in the tank are under atmospheric pressure. Because the pressures are equal, the level of fuel in the drop tube and the level of fuel in the tank are exactly equal. This is the scenario in Figure 1.

Now let's replace the standard vent cap with a P/V vent valve. The fuel in the drop tube is still subject to atmospheric pressure, but let's say the P/V vent valve is maintaining a small pressure inside the tank. The result is what we see in Figure 2: The pressure in the main body of the tank is greater than the pressure in the drop tube, so the fuel level is higher in the drop tube than inside the tank. The fuel in the drop tube rises up to a level where the weight per square inch of the column of fuel inside the drop tube, plus the pressure of the atmosphere above the liquid in the drop tube equal the weight per square inch of the fuel in the main body of the tank, plus the air pressing down on the surface of the fuel.

The situation is reversed if the P/V vent valve is maintaining a slight vacuum in the tank (Figure 3). The fuel level in the drop tube is lower than the fuel level in the main body of the tank.

How Pressure and Vacuum Are Produced in Tanks

In the examples just described, the tank was inactive. But in the real world, tanks are having fuel added and withdrawn on a regular basis. This is how pressures and vacuums are generated inside the tank.

In the days of vacuum-assist Stage II vapor recovery, where in many cases the amount of vapor returned to the UST was greater than the volume of liquid pumped out, it was common to generate pressure inside the ullage of USTs.

In the absence of Stage II, the result of withdrawing liquid without adding any vapors or allowing any air to enter the tank is to create a vacuum in the UST that increases until the set point of the P/V vent valve is reached and the valve opens to allow some air into the tank.

The examples I just discussed also left the fill cap off the fill riser. The picture gets a bit more complicated when we place the cap on the fill opening of the tank. Now the space inside the drop tube is closed. If the pressure in the body of the tank increases, the liquid level inside the drop tube rises, compressing the vapors inside the drop tube. If that pressure is released by removing the fill cap, then the sudden change in pressure inside the drop tube causes the liquid in the drop tube to rise up and then oscillate up and down for a bit until equilibrium is reached.

When equilibrium is reached we will have the scenario in Figure 2, where the level of fuel in the drop tube is significantly higher than the level of fuel in the tank.

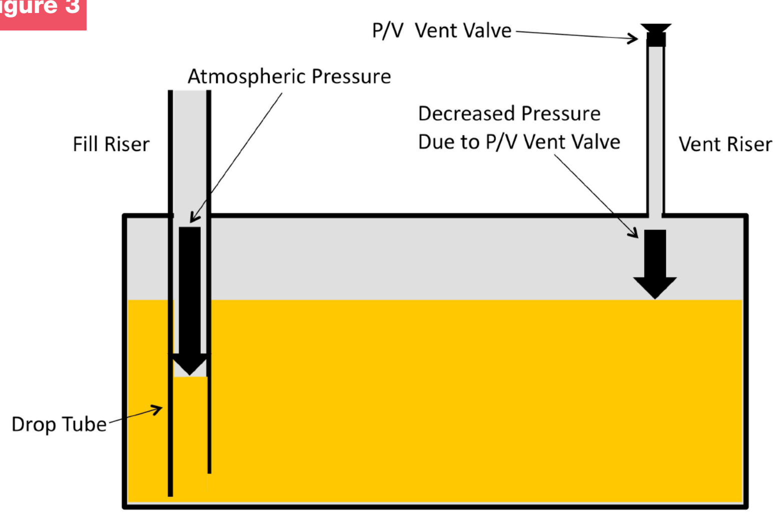
Likewise, if a vacuum develops in the tank, the liquid level inside the drop tube drops and a vacuum also develops inside the drop tube as long as the fill cap is vapor tight. This may make the fill cap a bit difficult to remove because the difference between the atmospheric pressure pressing on the top of the fill cap and the reduced pressure inside the drop tube must be overcome. When the cap is removed, the fuel level in the drop tube falls because of the increased pressure on the surface of the fuel in the drop tube. Here again, the liquid level in the drop tube oscillates up and down for a bit until equilibrium is reached. When equilibrium is reached, we have the scenario in Figure 3, where the level of fuel in the drop tube can be significantly less than the level of fuel in the tank.

If you are a fuel delivery driver sticking the tank to determine the amount of fuel that can be delivered, the stick measurement in this scenario will lead you to believe that there is more room available in the tank than is actually present. This is not a good thing.

And What About ATGs?

So right about now you're probably asking, "So when is he going to get to the failed ATG tests?" I'm almost there, but there is one more element that must be added to the picture, and that is that most tanks are not truly vapor tight. The pressure-decay testing that is done identifies substantial vapor leaks, but a tank does not have to be absolutely vapor tight in order to pass the test. Studies in New Hampshire indicate that true vapor tightness of a tank is very difficult to achieve, and that even brand new fittings such as fill caps, ATG caps, and vapor adaptors frequently leak. (*Impact of Inspection and Vapor Mitigation Technologies on Vapor Leak Rates and MtBE Concentrations in Groundwater, Environmental Research Group*, University of New Hampshire, November 22, 2010.)

Figure 3



When the pressure inside the tank is less than the pressure inside the drop tube, the liquid level inside the drop tube will be lower than the liquid level in the tank.

Finally!

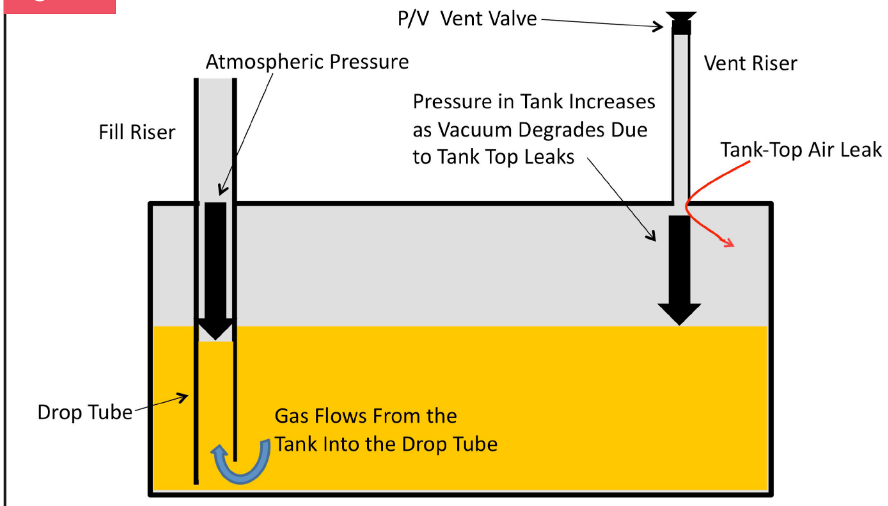
What does all of this mean for a tank with Stage I vapor recovery using an ATG for periodic tank testing? During the day, when fuel sales are brisk, a vacuum develops in the tank as liquid is removed and the P/V vent valve prevents air from entering the tank. There are vapor leaks in the system, but they are reasonably small relative to the rate at which fuel is being sold, so the vacuum is maintained at the set point of the P/V vent valve. As we get to the wee hours of the morning and pumping activity is quite infrequent, the rate at which air leaks into the tank is greater than the rate at which liquid is removed, so the level of vacuum in the tank decreases slowly.

To simplify the picture a bit, let's assume that the fill cap on the UST is not vapor tight, so the pressure inside the drop tube is at atmospheric pressure. During the busy part of the day, the vacuum in the tank lowers the fuel level inside the drop tube relative to the fuel level in the tank (the situation in Figure 3). As night arrives and fuel pumping activity slows down, the vacuum level inside the tank decreases (i.e., the pressure increases) as air leaks into the tank. As the vacuum in the tank decreases, fuel slowly flows from the tank into the drop tube (Figure 4).

Now let's add that ATG to this picture. Let's say it's late at night and the ATG is in test mode and watching the fuel level in the tank very closely. As the vacuum level in the tank decreases, fuel flows from the tank to the inside of the drop tube, and the fuel level in the tank decreases. To the ATG, a decrease in the fuel level that is not due to changing temperature is a leak. Of course, this is not a leak to the environment. Fuel is merely being transferred from one part of the tank to another, but the result is still a failed test and a perplexed tank owner.

The scenario would be the same if the fill cap were vapor tight. In this case there would be a vacuum in the drop tube that would help draw fuel into the drop tube from the main part of the tank. If the rate of fuel transfer exceeded the threshold leak rate for the ATG, the result would be a failed test.

Figure 4



During periods when the tank is relatively inactive, tank-top leaks allow air to enter the tank, the vacuum decreases (i.e., the pressure in the tank increases), and product flows from the tank to the drop tube. The ATG monitoring the liquid level in the tank sees the drop in liquid level as a leak.

What's to Be Done?

P/V vent valves have been around for some 40 years now, so this is not a new problem. The American Petroleum Institute (API) identified the issue back in the 1990s in their publication on inventory control (API Recommended Practice 1621, *Bulk Liquid Stock Control at Retail Outlets*, Fifth Edition, May 1993). The API was focusing on the issue of incorrect stick readings produced because the fuel level in the drop tube was substantially different from the fuel level in the tank. The solution provided in that document was to drill a ¼-inch hole in the drop tube near the level of the top of the tank. This would allow the pressures in the tank and inside the drop tube to equalize, thus equalizing the level of the fuel inside and outside the drop tube.

This was only a partial solution, however, because if the fill cap and tank top were reasonably vapor tight the inside of the tank would not be at atmospheric pressure when the fill cap was removed. Removing the fill cap would suddenly bring the liquid in the drop tube to atmospheric pressure, but the pressure or vacuum in the tank would take longer to get to atmospheric pressure because of the much larger volume of air in the tank and the small opening in the drop tube available for air to flow. The liquid level in the drop tube would not accurately reflect the liquid level in the tank until the pressure in the tank reached atmospheric pressure.

Even this solution became unworkable, however, when the California Air Resources Board (CARB) modified the pressure-decay-test protocol by requiring the removal of the fill cap during the test. The ¼-inch hole in the drop tube now produced failed pressure-decay tests and was no longer an acceptable solution.

Would a Hole in the Drop Tube Solve the Failed ATG Test Problem?

Please note that I am not advocating drilling holes in drop tubes as the solution to the failed ATG test problem. This may not be a legal measure under current NESHAP requirements for a vapor-tight tank. But let's set those issues aside for a moment and imagine that we did drill a hole in the drop tube. Would that solve the failed ATG test problem? Because the pressures (and therefore liquid levels) inside and outside the drop tube are the same, there is no reason for the liquid level in the tank to change and you would think that the ATG failed test problem would go away. However, Heather Peters in Missouri tells me that some folks who have tried the small-hole-in-the-drop-tube solution have found that failed ATG tests, though less frequent, still occur.

■ *continued on page 10*

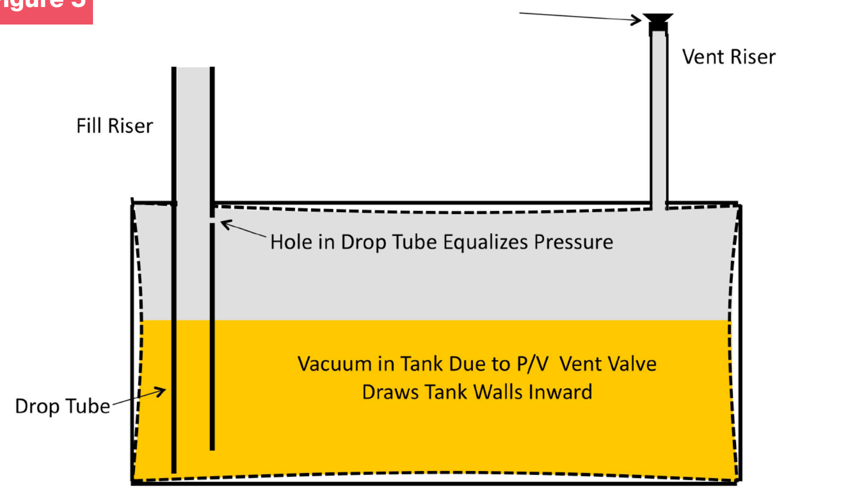
■ Tank-nically Speaking

from page 9

How can this be? It's because the USTs that we think of as rigid are actually quite flexible. If you look up the criteria for a tightness test in the federal rule, you will find that one of the things a tightness test must compensate for is tank deformation. At the time the rule was written, the issue was that where tightness tests needed to overfill the tank to conduct the test, the tank tended to bulge out, essentially increasing the tank volume. In some cases the bulging would happen slowly during the course of the test, causing the liquid level to fall and the test to fail.

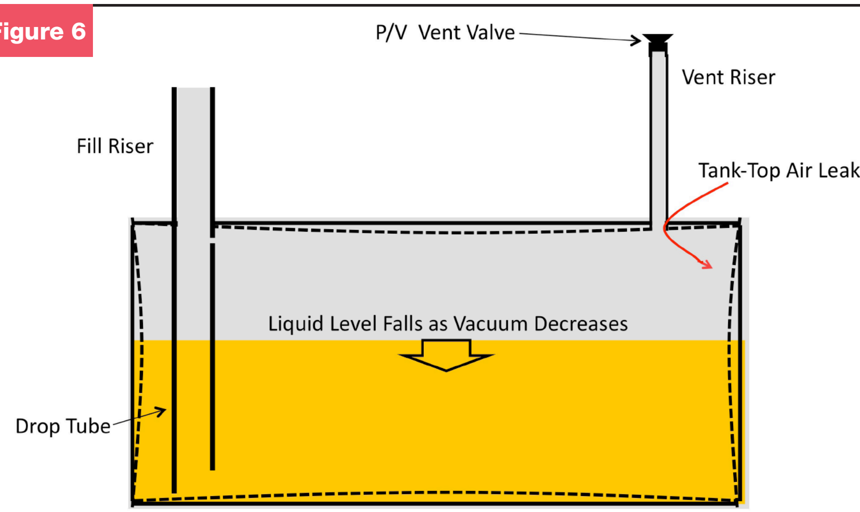
I believe a similar tank deformation scenario may be occurring when a tank is subject to a slowly decreasing vacuum. While I do not have any field data, my hypothesis is that when the tank is under vacuum, the sides and ends of the tank are "drawn in," (Figure 5) thus decreasing the tank volume. As the vacuum level slowly declines, the tank relaxes a bit (Figure 6), causing the liquid level to decrease slightly, producing a failed test. So the issue of ATGs and P/V vent valves is not just limited to liquid flow into the drop tube. It appears that just the vacuum itself is sufficient to cause leak detection problems with ATGs.

Figure 5



If we drill a hole in the drop tube, the pressure and liquid level inside and outside the drop tube are equal. Liquid flowing from the tank into the drop tube will no longer cause failed ATG tests. However, the presence of a vacuum in the tank may draw the sides and ends of the tank inward slightly.

Figure 6



As the vacuum decreases due to a small air leak, the walls of the tank straighten out and the liquid level drops slightly. If an ATG is in test mode when this happens, the falling liquid level may produce a failed test result.

Something's Gotta Give

Because failed ATG tests, especially ones that cannot be easily explained, have the potential to raise a lot of eyebrows (especially among UST regulators), tank owner solutions to this issue have been practical but not necessarily legal. Finding ways to defeat the offending P/V vent valve by creating a less than vapor-tight UST seems an obvious solution. Loosening the P/V vent valve so it does not seal to the vent riser will do the trick nicely without being obvious. But solutions such as this could seriously compromise the effectiveness of the air rules. Are we okay with that?

The status quo is not calculated to make anyone happy. Tank owners are faced with explaining failed tank tests to the UST regulator or circumventing the air regulations. UST regulators who understand the problem have no legal solution to offer to their tank owners. Air regulators are likely not aware that the effectiveness of their regulations is being compromised because of the unforeseen interactions of ATGs and P/V vent valves.

I Say It's Time to Reconvene

Perhaps it's time to revisit the issue of the role of P/V vent valves in limiting vapor emissions from UST systems. Is the "V" part of P/V really necessary in the absence of balance Stage II vapor recovery systems? While the vacuum may play a role in helping the transfer of vapors from the tank to the delivery vehicle, how significant a role is this? If the delivery vehicle is vapor tight and the vacuum vent valve on the truck is doing its job, shouldn't that be doing most of the work in transferring the vapors to the truck? If the goal is to keep vapors in the tank, isn't a "pressure" vent valve that requires a small pressure to build up before vapors are allowed to escape all you really need?

Is it time to convene a meeting of knowledgeable air regulators, UST regulators, petroleum equipment manufacturers, tank owners, and any other stakeholders out there to figure out a solution to this issue that does not make outlaws out of tank owners by forcing them to choose between compliance with UST regulations and air regulations?

How Widespread Is This Problem?

I don't know. Do you? I would appreciate any reports regarding failed ATG tests that may be associated with P/V vent valves. Send your data and/or thoughts to: marcel.moreau@juno.com. ■

Field Notes

from Robert N. Renkes, Executive Vice President, Petroleum Equipment Institute (PEI)

Realistic, Fair, and Evenly Applied Tank Rules Are Just Fine for Some Tank Owners

If you read the trade press on a regular basis, you might get the impression that tank owners are against regulations like those proposed by USEPA on November 11, 2011. But just like anything else, there are always two sides to every story. Let me share with you some candid observations from a tank owner who welcomes realistic, fair, and evenly applied tank rules.

First, a little background. I was fortunate to spend an hour alone with the owner of a medium-size (100-200 USTs) convenience store chain. The conversation skipped around from the price of crude to industry mergers to alternative fuels to electronic payment systems. When it turned to government regulation, I asked him this question: "If the final UST regulation looks anything like the rule proposed by EPA in 2011, how bad will it hurt your company?" I'll paraphrase his response:

I don't think the new UST rule will hurt my company. In fact, I think it will actually help it. Let me give you four reasons why.

1. To begin with, EPA's proposed rule mandates UST best practices that my company has followed for years. We want our spill buckets and overfill protection systems to work—it costs us money and gives us a corporate black eye if they don't. We feel the same way about our tanks. We want them to contain the product they are designed to hold. So our company already performs most of the inspections and tests proposed in the proposed regulation. We figure it's not going to cost us the $7,000 per site annual expenditure that you read about every so often in the press—for us it will run $200–$250 more per year, which we can absorb. We find it interesting that our figure is even below the $900 per site in annual compliance costs that EPA estimated in their proposed rule.

2. Second, we have some competitors out there that have been hanging on by a thread for years. They spend no money on their UST systems. They fight NOVs every chance they get. They transfer ownership of their store when something bad happens. They are the rotten apples in our industry, and they make all of us look bad. If and when this proposed rule becomes law, one of two things will happen. One, those tank owners will spend the money that our company already spends, which is good for the entire industry because it levels the playing field. Or two, they will fold up their tents and leave the industry, which is also good for us—we'd have one less bad actor in the competition.

3. Third, more and more states already require that we test overfill devices, spill buckets, and the integrity of secondary containment systems. Anyone in the industry will tell you that the USTs in use today are most prone to problems at these three specific locations and, overall, are the least tested portion of the UST system. Testing these components will reduce releases and reduce the drain on the state funds, which our company relies on in event of a catastrophic release.

4. And last but not least—and call me corny and old-fashioned—we believe that keeping our water and soil clean is part of our corporate responsibility to our customers and/or neighbors. It's simply the right thing to do. ■