Petrol PLAZA

Venting Aboveground Tanks: Part 2 -Getting the Proper Devices

As discussed in Part 1 of this article in the May issue of PE&T, we are addressing the venting standards for aboveground storage tanks designed to API 650.

Continuing Education

This is the second part of a two-part continuing education article on venting of aboveground storage tanks. "Part 1: Tank Types and the API Standards" (May, p. 22), discussed the different types of tanks and how the American Petroleum Institute's (API's) venting standards relate to each type. A quick review of Part 1 is suggested to enhance understanding of Part 2. To further aid in the understanding of this complex subject, a glossary of technical terms is presented in a side bar. Also, the bracketed numbers in the text—i.e., [1] through [9]—refer to the list of references at the end of the text.This second part discusses how venting devices and systems work, how to inspect them and how to deal with some special issues and misconceptions. It will culminate in the authors' specific recommendations to tank owners for specifying venting for aboveground tanks.

As discussed in Part 1 of this article in the May issue of PE&T, we are addressing the venting standards for aboveground storage tanks designed to API 650. API 650 addresses tanks that are either freely vented to the atmosphere or have design pressures up to 2.5 pounds per square inch gauge (psig). These are sometimes referred to as atmospheric tanks. Tanks with design pressures above 2.5 psig but not more than 15 psig are called low-pressure tanks. The design of these tanks is governed by API Standard 620. Tanks designed to pressures above 15 psig are called pressure vessels, and are specified in the ASME Boiler and Pressure Vessel Code.

Internal floating-roof tanks are to be vented in accordance with API 650 Appendix H. API 650 specifies the venting requirements for external floating roofs and for internal floating-roof tanks without a gas blanket. API 650 invokes the venting requirements of API 2000 for internal floating-roof tanks with a gas blanket and for certain fixed-roof tanks without floating roofs (see Sidebar 1). API 650 references API 2000.

Other fixed-roof tanks (without floating roofs), however, are not subject to API 2000 unless so specified by the purchaser. The purchaser should specify compliance with API 2000 venting requirements and should supply sufficient information to allow proper vent selection and tank design. Given the required set pressure, design pressure, and flow capacity for normal venting conditions (as well as for emergency conditions due to fire exposure, if required), venting can be properly sized for API 650 fixed-roof tanks.

Our specific recommendations for specifying aboveground tank venting are at the end of this article. But first, let's look at some basic venting design and inspection technology and clear up some confusion and regulatory misconceptions.

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Figure 1, 2 and 3: Photos of a typical pressure/vacuum vent (1) and two cutaway views (2) and (3). Courtesy of Protectoseal.

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Venting lingo 101

The market for pressure and vacuum venting devices for aboveground storage tanks supports several different types of devices. For atmospheric tanks, the most common are simple gravity-operated devices. Figures 1, 2 and 3 illustrate a typical PV venting device and its inner workings.

A vent relieves pressure by allowing air and vapor to escape at a sufficient rate to avoid further buildup of pressure in the tank. This requires that the vent accommodate a specified flow rate. As mentioned previously, the type of vents typically used on API 650 tanks begin to open at a set pressure, but are not open sufficiently to handle the necessary flow rate until a higher pressure—called the relieving pressure—is reached.

The difference between the set pressure and the higher relieving pressure is defined in API 2000 as the overpressure. Overpressure often is confused with accumulation, which is defined in API 2000 as a pressure increase above the maximum allowable working pressure (MAWP), which API 650 refers to as the design pressure. So let's get it straight: Overpressure is the difference between the set pressure and the relieving pressure, while accumulation refers to pressure in excess of the tank's design pressure.

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Figure 4: Accumulation of not more than 10 percent above design pressure (MAWP) is allowed for API 620 tanks and ASME boiler and vessel code tanks.

Errors under pressure

Confusing overpressure with accumulation can lead to serious trouble. A common error is to specify a limit on overpressure when the intent is to limit accumulation. API and ASME requirements (API Standard 620, Design and Construction of Large, Low-Pressure Storage Tanks [6] and the ASME Boiler and Pressure Vessel Code [7]; see Sidebar 1) both allow the tank pressure to exceed the design pressure by 10 percent for normal conditions and 20 percent for emergency conditions. These are limits on accumulation. Neither standard limits the overpressure, which is the increase in the tank pressure above the set pressure of the vent valve. Applying the limits to the overpressure can result in grossly inefficient operation of the vent and would not achieve the intended purpose of allowing limited accumulation above the design pressure.

Another error is to apply the 10 or 20 percent limit on pressure accumulation to API 650 tanks with

design pressure that exceeds the weight of the roof plates. Such tanks must meet the requirements of Appendix F, paragraph 2.1 of the standard, which specifies that the venting for normal operating conditions shall prevent the internal pressure from exceeding the design pressure. In other words, the venting requirements for these API 650 tanks allow no accumulation. However, the type of vents used may require 70 to 100 percent overpressure in order to function properly.

To get a better handle on the terminology and concepts discussed above, check out Figures 4 and 5 illustrating the relationships among operating pressure, set pressure, overpressure, design pressure and accumulation. Figure 4 applies to tanks designed to meet API 620 or ASME's boiler and vessel code (cited above).

Figure 5 applies to API 650 tanks with design pressure that exceeds the weight of the roof plates. Both figures apply to normal, rather than emergency, venting scenarios.

Figure 5: No accumulation is allowed for API 650 tanks with design pressure greater than the weight of the tank's roof plates. Vent sizing

Because the API 650 tank cannot have any pressure accumulation, vent sizing may be approached by working backward from the design pressure.

For example, if such a tank is to be operated at 2 inches water column and has a design pressure of 15 inches of water column, then 15 inches of water column may also be selected as the relieving pressure of the emergency vent valve at the required relieving capacity. If the set pressure for the emergency vent valve is 10 inches water column, then we want to ensure that the relieving pressure of the PV vent valve for normal venting is well below this, say at 7 inches of water column, so as not to trip the emergency vent valve during normal operations. We may then use the pressure-capacity curves available from vent valve manufacturers to select venting that, at a set pressure of 4 inches of water column (i.e., adequately above the operating pressure) and a relieving pressure of 7 inches of water column, will provide the required relieving capacity. This example is illustrated in Figure 6.

Keep in mind that, for blanketed tanks, it is important to ensure that vent set points and overpressure are properly coordinated with the blanketing valves that supply the inert gas.

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Figure 6: Example of tank pressure and vent settings for normal and emergency venting.

Typical vent types

There are many different kinds of vent devices that perform essentially the same function. Two basic categories are reclosing and non-reclosing devices (see Sidebar 2).

• Reclosing devices include pressure relief valves that are either direct-acting or pilot-operated. Direct-acting reclosing valves are either weight-loaded or spring-loaded. Weight-loaded direct-acting vents (also called weighted-pallet vents) open gradually in proportion to the increase in pressure, or modulating action. Weight-loaded vents require 70 to 100 percent overpressure to open fully. Weightloaded vents do not close leak-tight. Also, they are not included in the ASME Boiler and Pressure

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Vessel Code [8]. Spring-loaded direct-acting vents may open either gradually (modulating action) or rapidly (snap or pop action).

Pilot-operated reclosing vents may open gradually or rapidly. API 2000 indicates that the typical minimum set pressure for these vents is 2 inches of water column. However, a review of manufacturers' literature shows minimum set pressures of 3 to 4 inches of water column.

• Non-reclosing pressure relief vents do not reclose unless they are manually reset. These vents include breaking or buckling pin devices that open rapidly. An example of this technology is Protectoseal's Pin-Tech emergency vent, which employs a machined, straight metal pin that holds an o-ringed piston in a cylinder to hold the vent closed. The amount of axial force needed to buckle a pin is a constant as defined by Euler's Law. When the pressure in the tank reaches the vent set point, the pin buckles and the piston pops out and allows the vent to open. Afterwards, the vent must be manually reset by installing a new pin. Figure 7 is an exposed view of an emergency vent using this technology.

Figure 7: Exposed view of an emergency vent using the breaking or buckling pin technology. Courtesy of Protectoseal. Leak-tightness standard

A design concern for blanketed tanks, or for any tank that is part of a closed-vent system for collecting vapors, is that vent valves for these tanks must be leak-tight when closed (particularly when subject to EPA regulations). Typical weighted-pallet type vents, even if advertised as achieving leak rates of less than 0.5 standard cubic feet per hour, will generally not meet the EPA standard of having no detectable leaks (i.e., vapor concentration at the vent valve of less than 500 ppm). Vents that will meet EPA's leak-tightness standard may only be available with set pressures higher than the tank design would have otherwise called for. The higher set pressure may result in a corresponding increase in the design pressure for the tank. Minimum set pressure points for some of the different types of pressure relief devices are shown in Figure 8.

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Figure 8: Minimum set pressure points for selected vent devices.

Vent inspection

Each type of venting device is subject to its own failure modes and rates, so any program aimed at inspecting them must take their differences into account. For example, inspection of PV vents is far more undefined and nebulous than inspection of pressure relieving devices on pressure vessels. There is no code, law or standard on how to effectively test or inspect PV vents to insure that they are maintained in proper working order. A few suggestions are in order with regard to maintaining the integrity of these venting devices.

To illustrate basic inspection principles that apply to the various devices, let's focus on weightedpallet devices. These devices are very simple, which limits the number of failure modes that must be considered. Inspection should include a review of the working components of the vent to ensure that the pallet assemblies are clean and free to move properly. Sealing surfaces of the pallets and the

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seats are especially important to inspect, in order to maintain good sealing performance. When considering an inspection program, it is important to consider the whole tank and the risks—look at the whole picture. The following scenarios will help you see why.

PV vent valve on asphalt tank.

In this situation, the vent valve can fail by sticking due to build up of asphaltic materials on the seat. When this happens, the valve will stick either open or closed. If it sticks open, it is in violation of air pollution control requirements. If it sticks closed, excessive external pressure (vacuum) can cause the tank to collapse. At worst, inflowing air could cause ignition of pyrophoric materials and an internal explosion. For this reason, it is highly recommended that asphalt tanks have frangible roof designs whenever possible. The owner must decide how frequently to check and clean the parts for these devices. Some facilities inspect them monthly, which seems to work for many asphalt tanks.

PV vent valve on sulfur tank.

A similar but more demanding service is for sulfur tanks. Experience shows that even steam-traced PV vents are likely to plug and cause problems. The solution is to use steam-jacketed vent valves and inspect them frequently.

PV vent valve on gasoline tank.

For clean services, such as a gasoline tank, many companies never inspect the valves. Most of the time, this has not caused problems, but the devices sometimes stick. Most manufacturers recommend checking the devices at least annually. Sticking can be very dangerous in some cases, because the PV vent valve also functions as a flame arrester. If the valves in a clean service are not properly sized, the seats can wear rapidly. Inspections should include checking for excessive wear.

How often should you inspect PV valves? There is no simple answer. Each facility operator should review these issues on a tank-by-tank basis and establish a reasonable inspection schedule.

Confused air regulation concepts

In the area of emissions from tank venting systems, both the regulatory and the vent manufacturing communities frequently misconstrue some basic principles. The following observations are made to foster a better understanding of these principles.

• When a tank is NOT subject to EPA emissions control regulations, there is no regulatory requirement for the tank vent to be leak-tight, nor is the vent subject to the inspection provisions of the air rules. This would apply to most low-vapor-pressure stocks, such as diesel, lubricants and jet fuels. Venting is required only for preventing such hazards as overpressure of the tank or collapse by vacuum. In our opinion, compliance with API 2000 is the preferable way to address these hazards, as discussed earlier. Weighted-pallet type vents, although not leak-tight, are a suitable selection for such tanks. Air regulators should not be inspecting the vents of tanks that are not subject to emissions controls.

• When a tank IS subject to the EPA emissions control requirements and the emissions are controlled by routing them to a control system, pressure from normal operations should be relieved through the

closed-vent system and not to the atmosphere. This requires that the set pressure of the emergency vent be adequately above the internal pressure range of the tank during normal operations. The vent must close leak-tight, (i.e., not exceed the 500 ppm vapor concentration threshold specified by EPA). Typical weighted-pallet type PV vent valves cannot meet this requirement. Vent manufacturers should not be recommending weighted-pallet type vents for tanks that are subject to emissions controls. In this regard, some vendor literature promises vents at least as tight as 1 SCFH or tighter, but, as we discussed earlier, this is still not leak-tight. There is no substantial benefit to "an almost leak-tight vent" from a regulatory compliance perspective.

Recommended tank venting specifications

The following are our recommendations to tank owners for specifying venting systems for fixed-roof tanks (no floating roof) storing product with a flash point below 100° F.

• Specify that a frangible roof be provided if possible. Ensure that the manufacturer advises you whether the roof can be made frangible, or if it is impossible or unfeasible. Ask for documentation, calculations and details that support the product they are supplying.

• Specify both normal and emergency vents from a single manufacturer and require all relevant information, including set pressure points, full open pressure-flow points and whether the vent valves automatically reclose or have to be manually reset after opening.

• Specify that the tank manufacturer shall provide the vents (to insure that the design of the tank is compatible with the set and relieving pressures of the vents). Ask them to provide the tank design pressure, the set pressure of the PV valve, the relieving pressure of the PV valve (which should not exceed the design pressure of the tank), the set pressure of the emergency vent valve (if so equipped) or the calculated pressure at which the frangible roof will fail.

• Specify a set pressure for normal venting (above the maximum normal operating pressure, if an internal pressure is to be maintained).

• Specify that emergency venting devices shall be provided in accordance with API 2000 (even if the tank has a frangible roof, which is an acceptable option under API 2000).

• Specify a set pressure for emergency venting (which may be at or above the relieving pressure of the normal vents, so as to preclude opening of the emergency vents under normal conditions; or, if emergency vents are self-closing, they could be in the same pressure range as the normal vents, providing additional capacity in that range).

• Specify the tank design pressure (it must be sufficiently higher than the emergency vent set pressure to allow the vents to open).

• Be a stickler for details if the tank is blanketed and ask for a pressure versus set point and operating pressure diagram that includes the design pressure and failure pressure of the tank to ensure that the blanketing system will operate as intended.

• Specify average and maximum pump-in and pump-out rates and the use of API 2000 for determining required flow capacities for both normal and emergency venting,

• Specify whether the vents must close leak-tight in accordance with EPA regulations.

• Specify a sound program of inspection that is commensurate with the site- and tank-specific conditions and risks.

For fixed-roof tanks storing products with a flash point above 100 F, the above recommendations apply. In addition, the purchaser should specify whether or not open vents are allowed (open vents would correspond to a set pressure of zero).

REFERENCES

[1] American Petroleum Institute, API Standard 650, Welded Steel Tanks for Oil Storage, 10th edition, Washington, DC, 1998.

[2] American Petroleum Institute, API Standard 2000, Venting Atmospheric and Low-Pressure Storage Tanks, 5th edition, Washington, DC, 1998.

[3] National Fire Protection Association, NFPA 325, Guide to Fire Hazard Properties of Flammable Liquids, Gases, and Volatile Solids, Quincy, MA, 1994.

[4] National Fire Protection Association, NFPA 68, Guide for Venting Deflagrations, Quincy, MA, 1998.

[5] National Fire Protection Association, NFPA 69, Standard on Explosion Prevention Systems, Quincy, MA, 1997.

[6] National Fire Protection Association, NFPA 30, Flammable and Combustible Liquids Code, Quincy, MA, 1996.

[7] American Petroleum Institute, API Standard 620, Design and Construction of Large, Low-Pressure Storage Tanks, 9th edition, Washington, DC, 1996.

[8] American Society of Mechanical Engineers, ASME Boiler and Pressure Vessel Code, Section VIII, "Rules for Construction of Pressure Vessels," New York, NY, 1998.

[9] Welding Research Council Bulletin 410, Evaluation of Design Criteria for Storage Tanks with Frangible Roof Joints, April 1996.

GLOSSARY

Accumulation: A pressure increase above the tank's design pressure or maximum allowable working pressure (MAWP).

Blanketed tank: A tank having a blanket made of inert gas (e.g., nitrogen) that occupies the vapor space of a fixed-roof tank or an internal floating-roof tank. Breaking or buckling pin: A thin bar or rod that holds the seat of the vent cover tightly closed against the opening until the internal pressure causes it to buckle, allowing the cover to move away from the opening.

Deflagration: Combustion that propagates at a velocity less than the speed of sound in the vapor space inside a tank.

Design pressure: Maximum allowable working pressure (MAWP) of a tank.

Direct-acting reclosing valve: Weight-loaded or springloaded valves intended for atmospheric tank applications.

Emergency venting: Venting to relieve the internal tank pressure caused by an external fire in the vicinity of the tank.

External floating roof: Roof that floats on the surface of the liquid in a tank, with no fixed roof above it.

Failure pressure: The pressure (computed by the rules in API 650 Appendix F) at which a frangible roof will fail by buckling of the shell-to-roof junction.

Fixed roof tank: A tank with a fixed roof above a free liquid surface (i.e., the tank has a fixed roof but no floating roof).

Flame arrester: A screen-like device designed to prevent the passage of a flame—burning outside the tank—from propagating into the tank's vapor space. Flash point: The minimum temperature at which liquid generates sufficient vapor to form an ignitable mixture with air; thus a measure of the liquid's combustibility. Flow capacity: The capacity of a relief device to relieve pressure. Required flow capacity is the capacity required to prevent overpressure or vacuum in a tank

under the most severe operating conditions. Frangible roof: A tank roof with a weak roof-to-shell connection that fails more easily than the rest of the tank under excessive internal pressure. Gas blanket: See blanketed tank.

Gravity-operated vent: A vent device that uses the weight of the pallet or cover to close the vent opening. Internal floating roof: Roof that floats on the surface of the liquid in a tank, but is covered by a fixed roof that is vented freely to the atmosphere.

Landed floating roof: A floating roof that has come to rest on the tank bottom.

Leg-actuated vent: Vent through the deck of a floating roof that opens when the roof is landed, allowing free flow of air into or out of the space under the floating roof.

Liquid movement: The flow of product into or out of a tank.

Maximum allowable working pressure: The design pressure of a tank (MAWP).

Non-reclosing device: Vents that do not reclose unless they are manually reset. These include rupture disks, buckling pin devices and any other device that must be manually reset.

Normal venting: Venting that relieves pressure caused by movement of liquid into or out of a tank or by thermal breathing.

Operating pressure: The normal limits of pressure inside the tank below the setting of any pressure-vacuum vent settings.

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