

**Fire Code Requirements for Venting of Flammable and Combustible Liquid Storage Tanks:
Common Questions and Answers
By Jeff Shapiro, PE, FSFPE**

Vent openings are required by fire codes to limit internal pressure and vacuum conditions that might threaten the structural integrity of tanks used for storing flammable or combustible liquids. Such pressure changes may occur for a variety of reasons; however, fire code requirements focus on two, product transfer (the introduction or removal of liquid) and fire exposure.

The two predominant model fire codes in the United States are the *International Fire Code (IFC)*, published by the International Code Council (ICC) and *NFPA 1*, published by the National Fire Protection Association (NFPA). Both of these codes contain regulations that govern the storage of flammable and combustible liquids. In the case of NFPA 1, the regulations are copied from NFPA's *Flammable and Combustible Liquids Code*, NFPA 30, and in the case of the IFC, the regulations are developed by the ICC but tend to be consistent with NFPA codes, which in turn rely heavily on nationally recognized standards that govern tank construction and tank venting including:

- ANSI/UL 142, *Standard for Steel Aboveground Tanks for Flammable and Combustible Liquids*
- ANSI/UL 58, *Standard for Steel Underground Tanks for Flammable and Combustible Liquids*
- API Standard 650, *Welded Steel Tanks for Oil Storage*
- API Standard 2000, *Venting Atmospheric and Low-Pressure Storage Tanks*

Tank venting is a complex subject that relies on the expertise of tank and vent manufacturers, testing laboratories, mechanical engineers who may be charged with designing vent piping extensions, product specialists who must be familiar with the properties of stored liquids, and the local authority having jurisdiction who is charged with interpretation and enforcement of code requirements. Accordingly, the answers offered in this article are general in nature and should not be used in the absence of qualified experts responsible for overseeing the design and installation of tank vents.

With this background in mind, the following is a collection of commonly asked questions and answers associated with fire code requirements for venting of flammable and combustible liquid storage tanks.

Question 1: Fire codes reference two types of venting, "normal" and "emergency." What is the difference between "normal" and "emergency" venting?

Answer: Normal venting refers to a tank opening that is provided primarily to relieve excess pressure caused by liquid filling a tank and to relieve vacuum that results from liquid being removed from a tank. Normal venting also allows equalization of interior and exterior pressures associated with atmospheric temperature and pressure changes. Emergency venting refers to a tank opening designed to relieve excess pressure caused by a fire exposure to the outside of a tank.

The amount of pressure that must be relieved by normal and emergency vent openings and any venting devices attached thereto, such as spring loaded or weighted caps, can be calculated and must be balanced against a tank's design pressure limits. Normal vents tend to be relatively small in diameter since the volume of air or vapor that must be exchanged to prevent over- or under-pressure due to liquid transfer and environmental factors tends to be small. Although the required vent flow may be calculated, it is typically permissible without calculation to size the vent not less than the greater of 1¼ inches in diameter or the size of the largest fill/withdrawal connection (unless multiple filling/withdrawal connections are provided).

Emergency vents are larger because they must release vapor generated when a tank is engulfed in a pool fire, which is a much larger quantity.

Tanks may, in some cases, be required to accommodate additional venting capacity to handle pressure generated by reactive liquids, heated liquid storage or other unique circumstances, and these considerations are beyond the scope of fire code requirements. API 2000 should be consulted in such cases, and a custom vent design by a qualified engineer may be necessary.

Question 2: Must normal and emergency vents be separate, or may they be combined?

Answer: Fire codes do not require normal and emergency vents to be separate. Provided that the required venting capacity can be met by a single opening or device, only one vent is required. Economics and environmental concerns, however, tend to drive the use of separate devices.

To reduce the risk of igniting escaping vapor and/or reduce the release of vapors that may harm the environment to the atmosphere, many liquids are not permitted by fire codes or environmental regulations to be exposed to the atmosphere through an open vent. In such cases, vents must be equipped with a normally-closed venting device.

Because normal vents must “breathe” in both directions, a pressure-vacuum venting device is needed for a normally-closed vent, which will be expensive in a size large enough to handle emergency vent flows. The more economical solution is to use a small pressure-vacuum venting device on the normal vent and use a pressure-only device on the emergency vent.

Question 3: Is an emergency vent opening or vent device required on all aboveground tanks?

Answer: No. Certain tanks are permitted to have no venting device or to use alternative means of relieving overpressure. Specifically, NFPA 30 does not require tanks storing liquids with flashpoints at or above 200-degrees Fahrenheit (Class IIIB liquids) to have emergency vents when they exceed 12,000 gallons capacity and are not located in an area that might be subject to a pool fire from Class I or Class II liquids stored elsewhere.

NFPA 30 also permits the use of a weak roof-to-shell seam on vertical tanks in lieu of a vent opening. Such seams are designed to fail prior to the remainder of the tank shell when an overpressure condition occurs, allowing excess pressure to be relieved without a significant loss of liquid. Nevertheless, the permissible use of this type of tank design has been restricted in recent years because of concerns that increased internal pressure might fail a bottom seam on some tanks before failing the weak seam.

Question 4: Are multiple normal and emergency vents required for tanks that have multiple compartments or integral secondary containment?

Answer: Yes. Each enclosed space in a tank assembly must be treated separately with respect to venting because any enclosed could individually be subject to an overpressure condition.

Question 5: Is an emergency vent required for underground tanks?

Answer: No. Fire codes only require emergency vents for tanks that are subject to an exposure fire. Buried tanks are inherently protected from an exposure fire.

Question 6: Is it permissible to remove an underground tank and reinstall it aboveground if an emergency vent is added?

Answer: No. The tank construction requirements for underground and aboveground tanks are different, and the lack of an emergency vent is only one differentiating aspect of the design criteria.

Even if an emergency vent is retrofitted onto a steel underground tank, it is still not permissible to re-use the tank aboveground because underground steel tanks are constructed in accordance with UL 58 and aboveground steel tanks must be constructed in accordance with UL 142, which is not an equivalent design standard. Likewise, nonmetallic underground tanks are not designed for use aboveground, and fire codes via reference to NFPA 30 have numerous restrictions on the use of any nonmetallic tank for aboveground storage of flammable and combustible liquids, regardless of whether such tanks are designed for aboveground use.

For these reasons, NFPA 30, Chapter 21 specifically prohibits re-use of underground tanks in aboveground locations and vice versa.

Question 7: Where tanks are installed inside of a building, are there any special requirements related to vent installation?

Answer: Many, and they're changing. Generally, codes require vents for tanks containing flammable and combustible liquids that are installed in buildings, including storage tanks, day tanks on pumps and generators, etc., to be extended to discharge outside. Such a requirement is contained in NFPA 30 Chapters 22 and 27 and in Chapter 34 of the IFC. While this may seem rather straightforward, it isn't.

With respect to normal venting, vent flows for tanks in buildings tend to be low enough that extending a vent pipe can be done without causing excessive backpressure. Care must be taken to ensure that there are no low points that could accumulate liquid, which could come from condensation inside the pipe or from unintended sources, or other obstructions. Any blockage of the pipe could result in excessive backpressure or vacuum inside of the tank. Because the vent pipe must be arranged to generally drain back to the tank's vent opening, provisions must also be made to prevent accumulation of any liquid on top of a venting device, which could impede operation.

With respect to emergency vents, similar precautions against obstruction are needed, but the situation becomes far more serious. UL 142 specifies the minimum diameter for an emergency vent based on a maximum permissible nipple length (pipe connecting the tank shell to the emergency vent opening or vent device) of one foot. When an emergency vent opening must be extended to the building exterior, the additional length through which vapor must flow to escape the tank will lead to excessive back-pressure on the tank if the vent pipe diameter is inadequate. In a worst-case scenario of a fire engulfing a tank with a large surface area, vent flows would be enormous and backpressure from an under-sized vent pipe could cause the tank to rupture.

In addition to the pipe diameter, fittings used to make turns are also a concern because they too are a factor in backpressure calculation.

An early calculation procedure for determining the needed vent size for an extension of vent piping was published in Crane Technical Paper No. 410 in 1957. Other procedures and/or computer programs to execute the calculations may now be available, but the Crane procedure is still valid.

The bottom line with respect to extending emergency vent piping for indoor tanks is to perform the required calculations to ensure that the vent diameter will be adequate to allow enough vapor to release without exceeding the structural design limits for the tank. To accomplish this, expect that the vent diameter may become very large, even for short pipe runs, if the tank has a large surface area/storage volume.

A couple options that may be considered per NFPA 30 Chapter 22 to reduce the vent flow rate and associated pipe diameters are 1) Insulating the tank with a fire-resistive insulating material, 2) Providing an approved water spray system that will wet the tank shell in the event of a fire, 3) Providing a drainage system to remotely drain spilled liquid and minimize the energy of a spill fire. Another option that would allow smaller vent piping and increased back pressure is to use a pressure vessel for liquid storage.

Finally, a new option will appear in the 2012 edition of the IFC. Code Change F204-09/10 modified Section 5704.2.7.4 (previously Section 2704.2.7.4 in the 2009 edition) to allow emergency vents on tanks storing liquids with flashpoints at or above 100-degrees Fahrenheit to discharge inside the building if the tanks qualify as "protected tanks" in accordance with UL2085. Among other enhanced safety features, such tanks are highly insulated and are tested to survive a 2-hour fire exposure with limited temperature increase on stored liquids, which dramatically reduces vapor production inside of the tank.

Question 8: How can an inspector determine whether the size of an emergency venting device is adequate for a particular UL142 compliant aboveground steel tank?

Answer: UL142, Section 48 requires that the nameplate on aboveground tanks specify the required vent flow for emergency venting. Likewise, commercial emergency venting devices are required by NFPA 30, Chapter 22 to be marked with the rated flow capacity.

To verify that an emergency venting device is adequately sized, an inspector must verify that: 1) The flow rate on the venting device is equal to or greater than the minimum vent flow rate specified on the tank nameplate, and 2) The nipple connecting the tank to the venting device is equal to or greater than the size of the required vent opening and does not exceed one foot in length. UL142 only contemplates a maximum nipple length of one foot, so if a longer nipple is attached to the tank, the vent flow must be calculated by an engineer or other qualified specialist as described above for tanks in buildings.

Question 9: Is it permissible to manifold multiple vents into a single vent pipe?

Answer: Not generally, IFC Chapter 34 and NFPA 30 Chapters 22 and 27 only permit vents to be manifolded for special purposes, such as vapor recovery, vapor conservation and air pollution control. This would preclude manifolding of vents for simple convenience or cost efficiency.

Where manifolded vents are used for special cases, the codes specify minimum criteria to be considered, and for aboveground tanks, the design must contemplate a simultaneous fire exposure of all tanks. This will yield emergency vent flows that are so large that required pipe sizes would be impractical under normal circumstances.

Question 10: What are the testing requirements for normal and emergency vents that bear the UL listing mark?

Answer: UL listed venting devices (and various other tank appurtenances) will indicate that they are listed in accordance with UL 142. However, it is interesting to note that UL 142 is devoid of testing criteria to be used in evaluating these devices. Accordingly, when one sees a UL listing mark on a manufactured venting device, there is no way to readily know what tests that device was subjected to in order to earn its listing. Has the device been subjected to operational cycling, corrosion testing (important for tanks located near the ocean), freeze/thaw cycles, fire exposure...? No published standard documents the minimum requirements.

Instead, for these devices, UL uses unpublished (non-consensus) guidelines that are developed by UL staff, perhaps with selected outside input. The only way to find out what tests were done on a particular device is to ask the device manufacturer for a copy of the UL listing report, which should provide this information.

Access to detailed testing requirements is becoming even more important as alternative fuels that contain alcohol continue to increase in popularity. For tanks containing fuels with significant alcohol content, vent seals must be resistant to alcohol vapors because a flame traveling past a failed seal into a tank's vapor space poses a fire or explosion risk if the vapors in the space are in the flammable range, certainly a possibility with fuels containing alcohol. However, don't assume that UL specifically evaluates pressure-vacuum (P-V) venting devices with respect to their ability to perform as flame arresters...normally, they don't, even though fire codes recognize P-V vents in lieu of flame arresters on flammable and combustible liquid storage tanks. Designers and inspectors need consider whether reviewing the listing report for a particular valve installation is necessary to ensure compatibility of the valve with stored liquids.

UL is beginning the process of developing a standard that will hopefully, at some point, provide published criteria detailing the testing requirements for vents and other tank appurtenances. Given that some of these devices are essential to safety and that they are installed on many tanks, this seems to be an appropriate step. The time frame for completion of that project has not been formally established.