Flame Arresters for Vents of Tanks Storing Petroleum Products

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American Petroleum Institute
1220 L Street, Northwest
Washington, D.C. 20005

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Safety and Fire Protection Department

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SECTION 1—INTRODUCTION

1.1 In addition to connections for liquid entry and withdrawal, every atmospheric cone-roof tank requires a vent that allows escape or entry of air and/or vapors to avoid development of pressure or vacuum conditions sufficient to damage the tank during liquid transfer or changes in ambient conditions.

1.2 NFPA 30, *Flammable and Combustible Liquids Code*[1] lists the requirements for tank vents in which flammable and combustible liquids are stored; API Standard 2000, *Venting Atmospheric and Low-Pressure Storage Tanks*[2] and NFPA 30 cover the size and venting capacity to accommodate both normal and emergency conditions of the tanks. Devices that are normally closed, except when venting under pressure or vacuum conditions, are often called pressure-vacuum valves. Such valves are normally required for flammable liquids (see NFPA 30, paragraph 2–2.46). Under certain circumstances, flame arresters listed by the Underwriters' Laboratories[3] or approved by the Factory Mutual Engineering and Research Corporation[4] are used in conjunction with or in lieu of a pressure-vacuum valve.

1.3 The publications cited above are considered standards for good practice, and the law requires adherence to them in many jurisdictions.

[1] National Fire Protection Association, Batterymarch Park, Quincy, Massachusetts 02269.
[2] American Petroleum Institute, 1220 L Street, N.W., Washington, D.C. 20005.
[3] Underwriters' Laboratories, 333 Pfingston Road, Northbrook, Illinois 60062.
[4] Factory Mutual Engineering and Research Corporation, 1151 Boston Providence Turnpike, Norwood, Massachusetts 02062.

SECTION 2—SCOPE

This publication covers flame arresters on vents for steel tanks operating essentially at atmospheric pressure, as defined in API Standard 650, *Welded Steel Tanks for Oil Storage*

SECTION 3—BACKGROUND

3.1 In the early history of the petroleum industry, when storage tanks were constructed of wood or of wrought iron with wooden roofs, there were spectacular losses from tank fires. Lightning or other ignition sources that ignited vapors in the tank or escaping from the tank usually caused the tank fires. The combustible nature of wooden roofs contributed to the start and magnitude of the fires.

3.2 The losses caused by fires and the evaporation of crude oil and gasoline in wooden-roof tanks contributed to the development and use of riveted steel-roof tanks. The tightness of the riveted steel-roof tanks led to the need for controlled tank venting. The use of a valve that remains tightly closed during periods when the tank internal pressure is within specified limits but that promptly opens when pressure or vacuum exceeds those limits can reduce fire losses. This valve, initially known as a breather valve is now called a conservation vent or a pressure-vacuum (PV) valve.

3.3 As steel-roof tanks began to replace wooden ones, it was noted that lightning-caused fires continued to occur in tanks with wooden roofs, but tanks with steel roofs were virtually immune to lightning-caused fires. Steel-roof tanks were selected for the storage of volatile stocks, and such tanks were usually equipped with pressure-vacuum valves as a measure to reduce evaporation loss. Through a 1925 API committee report, the petroleum industry learned that the combination of a tight steel roof and a pressure-vacuum valve gave virtually complete protection against lightning-caused fires; the use of this combination in the ensuing years has confirmed this report.

SECTION 4—FLAME ARRESTERS

4.1 The term *flame arrester* is usually used to describe some device or form of construction that will allow free passage of a gas or gaseous mixture but will interrupt or prevent the passage of flame. Effective and reliable arresting devices are designed for many specific situations. The metal screen in the Davy safety lamp and the tiny passages in the sintered metal powder device in a combustible gas indicator are two examples of arresting devices.

4.2 Arresters have been made incorporating small metal tubes, drilled holes, or passages between interleaved corrugated and flat sheets of metal for use on tanks storing gasoline and similar flammable liquids. Such devices have been tested and listed as acceptable by the Underwriters' Laboratories or approved by the Factory Mutual Engineering and Research Corporation; in every case the listing is based on tests made with mixtures of gasoline vapor and air of maximum explosiveness, with prescribed limitations on the manner of installation. For example, a pipe extension downstream from the arrester that is longer than the extension used in the test invalidates the listing (see Underwriters' Laboratories *Gas and Oil Equipment Directory* and the *Factory Mutual Approval Guide*). For other vapors or gases and for different manners of installation, there is no assurance that the arrester will be effective.

4.3 Problems in the use and maintenance of tank flame arresters occur from a number of causes such as the following:

1. The tank vapor must pass through the arrester's narrow passages causing a friction loss that may reduce the flow capacity below that of an open pipe of a pressure-vacuum valve of comparable size. Thus, the pressure drop must be considered when a flame arrester is selected.

2. The narrow passages invite clogging from dust or other airborne debris, and a rigorous maintenance program is necessary to avoid the possibility of damage to the tank roof.

3. The water bottoms of certain petroleum tanks produce high-humidity in the vapor space that causes ice to accumulate and clog the arrester in freezing weather, which jeopardizes the tank. To remedy this situation, apply heat to the arrester or remove the arrester bank. The latter procedure would, of course, nullify the protection for which the arrester was installed.

4. The need for periodic inspecting and cleaning afford opportunities for errors in reassembly, possibly making the arrester incapable of stopping flame.

5. A listed flame arrester is not reliable indefinitely, even in perfect conditions. Although the 1.9-volume-percent mixture of gasoline vapor and air employed in the Underwriters' Laboratories tests is the mixture most likely to flash through a narrow passage, evidence exists that a richer mixture can produce heat damage and may render the device incapable of preventing flame propagation.

4.4 These limitations are recognized in NFPA 30 (see paragraph 2–2.47) and in the paragraphs introducing the products on the Underwriters' Laboratory *Gas and Oil Equipment Directory* and the *Factory Mutual Approval Guide*.

SECTION 5—PRESSURE-VACUUM VALVES AS A SUBSTITUTE FOR FLAME ARRESTERS

5.1 NFPA 30 (see paragraph 2–2.4.6) recognizes that a pressure-vacuum valve is an alternative to a flame arrester under certain circumstances. This recognition is based on tests started in 1920, supplemented by many years of experience.

5.2 Even in mixtures of maximum flammability, flame cannot pass back through an opening if the efflux velocity exceeds some critical value. Tests made with mixtures of gasoline components and air issuing from openings typical of tank vents have demonstrated that the critical velocity is approximately 10 feet per second. In a valve set to close when the upstream pressure falls below approximately ¾ inch of water, the velocity of flow across the pallet-seat area exceeds twice the critical velocity; therefore, flame cannot pass from the low-pressure to the high-pressure side. The flame was snuffed out when the valve closed upon reduction of the upstream pressure to test and confirm this condition.

5.3 Tests have also shown that under some circumstances a long-burning flame at the valve outlet could damage the valve sufficiently to interfere with its closing. Under such circumstances, flashback may occur when the flow rate falls below the critical velocity, if a flammable mixture exists inside the tank.

SECTION 6—SUMMARY

6.1 The desire to protect a tank vent from flashback is based on a fear of the simultaneous occurrence of an ignition source in the vicinity of the vent and the release of a mixture capable of transmitting flame.

6.2 Ignition sources such as open flames usually are, and certainly can be, excluded from the vicinity of tank vents. Falling brands, unless actually flaming, are not an ignition source for petroleum vapors. Lightning is a potential ignition source, as demonstrated by the occasional ignition of vent stacks that release vapor continuously. However, such stacks are usually a much more attractive target for lightning than a tank vent.

6.3 The availability of a mixture capable of producing flashback must be considered. Stocks stored at temperatures below the flash point do not produce ignitable mixtures in the vapor space. Crude oil and gasolines generally produce mixtures too rich to transmit flame. Expelled vapor, if ignited, will burn as a torch until its flow ceases, at which time the fire will go out. If a tank containing such stocks were to inbreathe a substantial volume of air, it is possible that the diluted mixture could fall within the flammable range. Such a condition, however, is likely to be brief. There are, of course, a few stocks that produce a mixture within the flammable range under normal atmospheric conditions. These stocks are the exceptions and may warrant special consideration.

6.4 The conditions under which a tank can exhale must be examined. Whether as a result of filling or ambient condition change, this exhaling period is unlikely to exist more than half the time.

6.5 Flashback through an open tank vent can only result from the coincidental occurrence of two unlikely events—efflux of a mixture of the right composition, and the presence of an ignition source, such as lightning at the right time and place. The records support the belief that the probability of this coincidence is very low.

6.6 Most companies have accepted the premise that a tight steel roof and a pressure-vacuum valve are all the protection that is required and that the negligible additional protection afforded by flame arresters does not warrant their installation in addition to a pressure-vacuum valve. API Standard 2000 (see 1.6) states that a flame arrester is not considered necessary for use in conjunction with a pressure-vacuum valve.

SECTION 7—CONCLUSION

There is no supportable basis for requiring that an outdoor aboveground tank provided with a pressure-vacuum valve must also be equipped with a flame arrester. The use of flame arresters is discouraged unless the user is able to institute the maintenance necessary to ensure that the required venting capacity is maintained.