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Proposed Standard Specification for Anti-Flashback Burner (This test protocol was used to develop Paradox's AFB's)

1. Scope

1.1. This proposed standard provides the minimum requirements for designing, constructing, performing, and testing anti-flashback burners used as end-of-line burners in open and enclosed vapor destruction devices for marine loading applications.

2. Intent

2.1. This standard is intended for anti-flashback burners protecting systems containing flammable or combustible liquid vapors with a flashpoint that does not exceed 60°C. The test media defined in 14.1.1 can be used except where arresters protect systems handling vapors with a maximum experimental safe gap (MESG) below 0.9 millimeters. Anti-flashback burners protecting such systems must be tested with appropriate media (the same vapor or a media having an MESG no greater than the vapor). Various gases and their respective MESG are listed in Attachment 1.

3. Applicable Documents

3.1. ASTM Standards (1)F722 Welded Joints for Shipboard Piping Systems; F1155 Standard Practice for Selection and Application of Piping System Materials

3.2. ANSI Standards (2) B16.5 Pipe Flanges and Flanged Fittings.

3.3. Other Documents

3.3.1. ASME Boiler and Pressure Vessel Code (2) section VIII, Division 1, Pressure Vessels; Section IX, Welding and Brazing Qualifications.

3.3.2. International Maritime Organization, Maritime Safety Committee (3) MSC/Circ. 373/Rev. 1--Revised Standards for the Design, Testing, and Locating of Devices to Prevent the Passage of Flame into Cargo Tanks in Tankers.

3.3.3. International Electrotechnical Commission (4) Publication 79.1--Electrical Apparatus for Explosive Gas Atmospheres.

3.3.4. American Society for Testing and Materials (ASTM), 100 Barr Harbor Dr., West Conshohocken, PA 19428-2959.

3.3.5. Available from the American Society of Mechanical Engineers International, Three Park Avenue, New York, NY 10016-5990.

3.3.6. Available from the International Maritime Organization, 4 Albert Embankment, London SEl 7SR, England.

3.3.7. Available from the International Electrotechnical Commission, one rue de Varembe, Geneva, Switzerland

3.3.8. Detonation & Deflagration Flame Arresters by Stanley Grossel

3.3.9. Development of testing procedures and acceptance criteria for AFBs in MVCSs SwRI 1.19.2001 SwRI Project No. 01-02828

3.3.10. Paradox IP Anti-Flashback Burner Report, by Dwight Brooker.

3.3.11. The Dangers Involved With Using 316L SS for Element CANMET 1992

4. Terminology

4.1. Anti-flashback burner— A combined burner/deflagration arrester end-of-line device to prevent the passage of flame from a vapor destruction device built following a specified performance standard. Its stabilized flame/deflagration arresting element matrix is founded on the quenching principle.

4.2. Flame speed--The speed at which a flame propagates along a pipe or other system.

4.3. Flame Passage--The transmission of a flame through an anti-flashback burner.

4.4. Gasoline Vapors--A non-leaded petroleum distillate consisting of aliphatic hydrocarbon compounds with a boiling range approximating 65°C/75°C.

4.5. Vapor Destruction Device—An open or enclosed combustion device that destroys cargo vapor through incineration.

4.6. Endurance burn or stabilized flame--

4.7. $\Delta P/P_o$ to add….

4.8. More to be added…

5. Classification

(Reserved)

6. Ordering Information

6.1. Orders for anti-flashback burners under this specification shall include the following information as applicable:

6.1.1. Nominal pipe size and connection type, i.e., flanged or threaded.

6.1.2. The NEC or IEC Gas Group vapor to be protected and the corresponding MESG and maximum flow rate.

6.1.2.1. If the vapor is a composition of multiple gases, the MESG of the composition should be calculated using a form of the Le Chatelier relationship $SGmix = \frac{1}{\sum_i \left(\frac{x1}{MESGi}\right)}$ Or similar.

6.1.2.2. When calculating flow rate when the vapor is a composition of multiple gases, the specific gravity of the composition vapor should be calculated using the formula $M_a = y_i \sum y_j M_i$ Or a similar method.

6.1.2.3. Anticipated ambient air temperature range.

6.1.2.4. Purchaser's inspection requirements (see section 10.1).

6.1.2.5. Description of Installation.

6.1.2.6. Description of Installation.

6.1.2.7. Materials of construction (see section 7).

6.1.2.8. Minimum flow rate and the expected duration of the minimum flow rate.

6.1.2.9. Maximum Pressure drop the system is designed to handle.

7. Materials

7.1. The anti-flashback burner parts or bolting used shall be constructed of materials listed in ASTM F 1155 (incorporated by reference, see Sec. 154.106) or section VIII, Division 1 of the ASME Boiler and Pressure Vessel Code.

7.2. Burners, elements, gaskets, and seals (if any) must be of materials resistant to seawater attack and the protected system's liquids and vapors. (see section 6.1.3).

7.3. Nonmetallic materials, other than gaskets and seals, shall be able to withstand predicted pressure and temperature when used as components of the anti-flashback burner.

7.4. Nonmetallic gaskets and seals shall be non-combustible and suitable for the service intended.

7.5. Bolting materials other than Section 7.1 shall equal those listed in Table 1 of ANSI B16.5.

7.6. Galvanic corrosion shall be a consideration in the selection of materials.

7.7. All other components shall be constructed of materials suitable for the service intended.

8. ***Other Requirements***

8.1. Anti-flashback burner housings shall be gas-tight to prevent the escape of vapors before exiting the burner tip—the burner tip discharges into the combustion zone of the vapor destruction device.

8.2. Anti-flashback burner's elements shall fit in the housing to ensure tightness of metal-to-metal contacts so that flame cannot pass between the element matrix and the housing.

8.3. Housings and elements shall be substantially constructed and designed for the mechanical and other loads intended during service. In addition, they shall be capable of withstanding the maximum and minimum pressures and temperatures to which the device is exposed under both normal and the specified fire test conditions in section 14.

8.4. Threaded or flanged pipe connections shall comply with the applicable B16 standards in ASTM F 1155 (incorporated by reference; see Sec. 154.106). Welded joints shall comply with ASTM F 722 (incorporated by reference; see Sec. 154.106).

8.5. All flat joints of the housing shall be machined true and provide for a joint having adequate metal-to-metal contact.

8.6. Where welded construction is used, welded joint design details, welding, and non-destructive testing shall follow section VIII, Division 1, Subsection B of the ASME Code and ASTM F 722 (incorporated by reference, see Sec. 154.106). Welders and weld procedures are to be qualified per section IX of the ASME Code.

8.7. The design of the anti-flashback burner shall allow for ease of Inspection and removal for replacement, cleaning, or repair without removing the vapor collection system piping immediately upstream of the vapor destruction unit.

8.8. Anti-flashback burner shall allow for efficient drainage of condensate without impairing their efficiency to prevent the passage of flame.

8.9. All fastenings are to be protected against loosening.

8.10. Anti-flashback burners shall be designed and constructed to minimize the effect of fouling under normal operating conditions.

8.11. Anti-flashback burners shall be capable of operating over the full range of ambient air temperatures anticipated.

8.12. Anti-flashback burners shall be constructed to direct the efflux vertically upward.

8.13. Anti-flashback burners shall be of first-class workmanship and free from imperfections that may affect their intended purpose.

8.14. Anti-flashback burners shall not use "straight threads" without a backup nut when used as a connection in place of a flange. (Tapered Pipe Threads are preferred).

9. ***Protocol***

9.1. Tests shall be conducted or witnessed by a creditable independent laboratory. In choosing a laboratory, the manufacturer accepts that it is a qualified independent laboratory by determining that it has (or has access to) the apparatus, facilities, personnel, and calibrated instruments necessary to Test Anti-flashback burners per this standard.

9.2. A test report shall be prepared by the laboratory, which shall include:

9.2.1. Detailed drawings of the anti-flashback burner and its components (including a parts list identifying the construction materials).

9.2.2. Types of tests conducted and results obtained.

9.2.3. Types of NEC or IEC Gas Groups for which the anti-flashback burner is approved (see section 6.1.2).

9.2.4. Drawings of the test rig.

9.2.5. Record all labels/markings on the tested anti-flashback burners, such as model, size, and serial number.

9.2.6. A report number.

9.2.7. Each style and size of anti-flashback burner shall be tested. A change of design or construction that may affect the corrosion resistance, endurance burn, or flashback capabilities of the anti-flashback burners shall be considered a change of model for this paragraph.

9.2.8. The anti-flashback burners shall have the exact dimensions, configuration, and the most unfavorable clearances expected in production units.

9.2.9. Performance characteristics, as declared by the manufacturer, such as flow rates, pressure, operating sensitivity, flow resistance, and velocity, shall be demonstrated by appropriate tests.

9.2.10. Anti-flashback burners shall be tested for endurance burn and deflagration protection following the test procedures in section 14.

9.2.11. After all tests, the device shall be disassembled and examined, and no part shall be damaged or show permanent deformation.

10. Inspection

10.1.1. The manufacturer shall afford the Purchaser's inspector all necessary facilities to ensure the material is furnished following this standard. All examinations and inspections shall be made at the place of manufacture unless otherwise agreed upon.

10.1.2. Each finished anti-flashback burner shall be visually and dimensionally checked to ensure that the device corresponds to this standard, is certified per section 11, and is marked following section 12. Particular attention shall be given to checking the proper fit-up of joints (see sections 8.5 and 8.6)

11. Certification

11.1. Manufacturer's certification that an anti-flashback burner has been constructed per this standard shall be provided in an instruction manual. The manual shall include as applicable:

11.2. Installation instructions and a description of all configurations tested (reference paragraph 9.2.4.1 and 9.2.4.2). Installation instructions to include manufacturer's recommended limitations based on all configurations tested.

11.3. Operating instructions.
11.4. Maintenance requirements.
11.5. Instructions on how to determine when anti-flashback burners cleaning is required and the method of cleaning.
11.6. Copy of test report (see section 9.1.1).
11.7. Flow test data, including flow rate and pressure drop.
11.8. The ambient air temperature range over which the device will effectively operate.

12. Marking

12.1. Each anti-flashback burner shall be permanently marked indicating:
12.1.1. Manufacturer's name or trademark.
12.1.2. Style, type, model, or other manufacturer's designation for the anti-flashback burners
12.1.3. Size of the inlet and outlet, type of connection, i.e., flanged or threaded.
12.1.4. Direction of flow through the anti-flashback burners
12.1.5. laboratory and report number.
12.1.6. Lowest MESG of gases for which the anti-flashback burners are suitable.
12.1.7. Ambient air operating temperature range.
12.1.8. Burn time at/and lowest flow rate as tested.
12.1.9. ASTM designation of this standard.

13. Quality Assurance

13.1. Anti-flashback burners shall be designed, manufactured, and tested to ensure they meet the characteristics of the unit tested following this standard.
13.2. The manufacturer shall maintain the quality of the anti-flashback burners designed, tested, and marked per this standard. At no time shall an anti-flashback burner be sold with this standard designation that does not meet the requirements herein.

14. Test Procedures for Anti-flashback burners

14.1. Media/Air Mixtures
14.1.1. For vapors from flammable or combustible liquids with a MESG greater than or equal to 0.9 mm, technical grade propane may be used for the deflagration test in Section 14.3.
14.1.2. Gasoline vapor or hexane may be used for the endurance burn test in Section 14.2. For vapors with an MESG less than 0.9 mm, the specific vapor (or a gas with an MESG less than or equal to the MESG of the vapor) must be used as the test medium in all section 14 tests.
14.1.3. Test media vapors shall be mixed with air to form a stoichiometric mixture.
14.2. Endurance Burn Test Procedure
14.2.1. An endurance burning test shall be carried out as follows:
14.2.2. The test rig shall consist of an apparatus producing a stoichiometric mixture, a small tank with a diaphragm, a prototype of the anti-flashback burners, and a firing source close to the test device (see Figure 1).
14.2.3. The anti-flashback burners shall be installed so that the mixture emission is vertically upwards, or installed in the position for which it is designed, and which will cause the most severe heating of the device under the prescribed endurance burn conditions. In this position, the mixture shall be ignited.
14.2.4. Endurance burn test shall start by using a stoichiometric mixture with air with the aid of a pilot flame or a spark igniter

at the outlet. The flammable mixture may be re-ignited as necessary during the endurance burn.

14.2.5. Multiple Temperature measurements will be performed simultaneously; #1 on the surface of the burner element half way between the center and its edge. #2 @ one-third of the element length from the surface drilled into the housing and one inch into the element. #3 @ two-thirds of the element length from the surface drilled into the housing one inch into the element. #4 Temperatures measured on the protected side to record a failure (typically, this position will not see any deviation until just before failure). Using multiple thermocouples between the protected and unprotected sides will allow the tester to accurately predict when a failure is imminent and visually see the migration of the flame through the matrix of the AFB when adjusting flows and mixtures. When the stabilized flame enters the element channels, the temperature on the surface will drop. Without these measurements, the operator may wrongfully interpret and increase the flow rate to raise the surface temperature, which will cool the element and delay or prevent the failure of AFB if repeated.

14.2.6. By varying the flow rate of the initial stoichiometric mixture, by leaning or enriching the mixture, the anti-flashback burners shall be heated by a stable flame on the surface of the burner element until the highest obtainable temperature is reached on the ignited side. (See 14.3.2 note for other sizes to be tested).

14.2.7. The flow rate will be lowered until the flame enters the element channels and migrates toward the protected side. This is done to find the lowest flow rate conditions, resulting in the shortest failure time. The fuel/air mixture and flow rate at the shortest time to failure are recorded.

14.3. Due to the known fact that a new flame arrester element will have a shorter burn time than a previously burned unit, a second new untested AFB is used to repeat the burn test using the recorded shortest time to failure air/fuel mixture and flow rate data derived from the previous test. The unit is then allowed to burn without adjustments until failure.

14.4. The time to failure at the flow rate is recorded. Note: there is no failing of this test, only data to be put on the label and published literature showing the time to failure at the lowest tested flow rate and caution that any flow rate lower will have a reduced time to fail. *FYI, an AFB with the longest burn time to failure at the lowest possible flow rate is a superior choice.*

14.5. (note for other sizes to be tested) To save time in seeking this flow rate when testing other sizes, it has been observed that by calculating flow rate per free flow element surface area, correlating the same flow rate and gas mixtures into the area of the other sizes can narrow the time and some cases be used directly to test the other sizes. (rewording needed)

15. Deflagration Test Procedure (I do not believe that deflagration tests are needed since it is a burner, if it is decided that it should be the following is proposed.)

15.1. Anti-flashback burners shall be installed at one end of a pipe of the same diameter as the outlet of the anti-flashback burners. A temporary flange or other suitable connection must be

added to the outlet end (burner tip end) to a busting disk or plastic bag. The test pipe shall be capable, by change in its length or configuration, of developing deflagrations of various sub-sonic flame speeds and $\Delta P/P_o$ from 0.0 to 10.0 as measured on the side of the pipe where ignition occurs (run-up side). The test piping arrangements on the inlet side of the anti-flashback burners (the side which is not ignited). The inlet side pipe diameter shall be equal to that on the run-up side. The inlet side pipe shall be at least 10 pipe diameters long with a plastic bag over the free end. (Alternate end-of-pipe closures are also acceptable, provided they quickly give way during the test, and the closure allows the required gas concentration to be maintained throughout the test piping arrangement.) The entire pipe shall be filled with a stoichiometric mixture of the test gas and air to a test pressure corresponding to or greater than the upper limit of the device's maximum operating pressure (see 11.1.7). To obtain this test pressure, a device such as a bursting disc may be fitted on the open end of the device in place of the plastic bag. The concentration of the mixture should be verified by appropriate testing of the gas composition. The vapor/air mixture shall then be ignited.

15.2. Explosion pressures within the pipe shall be measured by a high-frequency transducer situated in the test pipe no more than 2 inches from the run-up side of the housing of the anti-flashback burners

15.3. A series of tests shall be conducted to determine the test pipe length and configuration that results in deflagrations where $\Delta P/P_o$ was 0.0 to 10.0. (These tests may also be carried out using a single length of pipe with igniters spaced at varying distances from the arrester.) The flame explosion pressures and test pipe configurations shall be recorded for these tests. During testing, the device shall demonstrate its ability to withstand five deflagrations where $\Delta P/P_o$ was less than 1 and five deflagrations where $\Delta P/P_o$ was greater than 1 but less than 10. Initiation of deflagrations shall be at several locations to generate a range for $\Delta P/P_o$. No evidence of flame passage shall occur during these tests. The explosion pressures for each of these tests shall be recorded.

15.4. A device that successfully passes the tests of 14.3.4 shall be considered to be unidirectional (suitable for arresting a deflagration advancing only from the direction as tested).

(1) Available from the American Society for Testing and Materials (ASTM), 100 Barr Harbor Dr., West Conshohocken, PA 19428-2959.

(2) Available from the American Society of Mechanical Engineers International, Three Park Avenue, New York, NY 10016-5990.

(3) Available from the International Maritime Organization, 4 Albert Embankment, London SE1 7SR, England.

(4) Available from the International Electrotechnical Commission, 1 rue de Varembe, Geneva, Switzerland.

(5) See IEC Publication 79-1.

(6) Some data are available for the estimation of flame speeds in horizontal pipes without anti-flashback burners s. Some data indicate that the presence of small obstacles, fittings or bends in the test pipe can accelerate the flame speeds appreciably.

(7) Other pressure and/or flame speed measuring techniques may be used if effective.

Attachment 1

Inflammable gas or vapor	Experimental maximum safe gap	
	Mm	in.
Methane	1.170	0.046
Blast furnace gas	1.193	0.047
Propane	0.965	0.038
Butane	1.066	0.042
Pentane	1.016	0.040
Hexane	0.965	0.038
Heptane	0.965	0.038
Iso-octane	1.040	0.041
Decane	1.016	0.040
Benzene	0.99	0.039
Xylene	1.066	0.042
Cyclohexane	0.94	0.037
Acetone	1.016	0.040
Ethylene	0.71	0.028
Methyl-ethyl-ketone	1.016	0.040
Carbon monoxide	0.915	0.036
Methyl-acetate	0.990	0.039
Ethyl-acetate	1.04	0.041
Propyl-acetate	1.04	0.041
Butyl-acetate	1.016	0.040
Amyl-acetate	0.99	0.039
Methyl alcohol	0.915	0.036
Ethyl alcohol	1.016	0.040
Iso-butyl-alcohol	0.965	0.038
Butyl-alcohol (Normal)	0.94	0.037
Amyl-alcohol	0.99	0.039
Ethyl-ether	0.864	0.034
Coal gas (H_2 57%)	0.482	0.019
Acetylene	≤0.025	≤0.001
Carbon disulphide	0.203	0.008
Hydrogen	0.102	0.004
Blue water gas (H_2 53% CO 47%)	0.203	0.008
Ethyl nitrate	≤0.025	≤0.001
Ammonia	3.33	0.133
Ethylene oxide	0.65	0.026
Ethyl nitrite	0.922	0.038