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June 12, 2023

VIA ELECTRONIC MAIL

Ms. Alberta Mills
Office of the Secretary
U.S. Consumer Product Safety Commission
4330 East-West Highway
Bethesda, MD 20814-4408

Re: Notice of revision to ASTM F3429/F3429M Standard Specification for Performance of Flame Mitigation Devices Installed in Disposable and Pre-Filled Flammable Liquid Containers

Dear Ms. Mills:

On January 13, 2023, the U.S. Consumer Product Safety Commission published a determination in the Federal Register under the Portable Fuel Container Safety Act of 2020 (PFCSA) (15 U.S.C. 2056d) that ASTM F3429/F3429M-20 *Standard Specification for Performance of Flame Mitigation Devices Installed in Disposable and Pre-Filled Flammable Liquid Containers* is a mandatory consumer product safety rule that impedes the propagation of flames into pre-filled portable fuel containers covered by the standard. 88 Fed. Reg. 2,206. Section (b)(5) of the PFCSA requires ASTM to notify the Commission after the final approval of the revision of a standard regarding any voluntary standards previously determined by the Commission to be meet the requirements of the PFCSA as a mandatory consumer product safety rule.

We are writing to officially notify the CPSC that ASTM has published a revised 2023 version of ASTM F3429/F3429M *Standard Specification for Performance of Flame Mitigation Devices Installed in Disposable and Pre-Filled Flammable Liquid Containers*. We are enclosing a redlined document highlighting the specific technical changes between the 2020 and 2023 versions to help facilitate review by the CPSC Staff.

If you or your staff have any questions about the specific revisions or would like to discuss any issues related to this request, you may contact me or Molly Lynyak (610-832-9743 or mlynyak@astm.org) at any time. ASTM International looks forward to continuing to work with the CPSC to help ensure the safety of consumer products.

Sincerely,

Katharine E. Morgan
President, ASTM International

Attachment

cc: Jacqueline Campbell – CPSC Voluntary Standards Coordinator
Scott Ayers – CPSC Project Manager the Portable Fuel Container Safety Act of 2020
Jarrod Kuhn – ASTM F15.72 Pre-Filled Containers of Flammable and Combustible Liquids Subcommittee Chair
Donald Mays – Chairman, ASTM Committee F15 on Consumer Products

Designation: ~~F3429/F3429M – 20~~ F3429/F3429M – 23

Standard Specification for Performance of Flame Mitigation Devices Installed in Disposable and Pre-Filled Flammable Liquid Containers[1]

This standard is issued under the fixed designation F3429/F3429M; the number immediately following the designation indicates the year of original adoption or, in the case of revision, the year of last revision. A number in parentheses indicates the year of last reapproval. A superscript epsilon (ε) indicates an editorial change since the last revision or reapproval.

1. Scope

1.1 This specification establishes performance requirements for the performance of flame mitigation devices (FMDs) installed in disposable and pre-filled liquid containers, intended for consumer use where the liquid flashpoint is below 60 ºC [140 ºF].

1.1.1 Uses of disposable and pre-filled flammable liquid containers include but are not limited to fuels, fire starters, and additives for internal combustion engines.

1.1.2 An FMD that complies with this specification minimizes the potential of flame jetting or container rupture from occurring.

1.1.3 Containers without a significant area reduction at the container opening are not covered because there is no hazard of a flame jet or container rupture because an internal pressure rise does not result from an internal ignition. (See Appendix X1.)

1.2 This specification does not apply to the following containers:

1.2.1 Containers greater than 20 L [5.3 gal] or smaller than 100 mL [3.4 oz] in volume.

1.2.2 Containers intended for beverages.

1.2.3 Portable fuel containers as defined in Specification F852/F852M.

1.2.4 One-time use portable emergency fuel containers for use by consumers as defined in Specification F2874.

1.2.5 Containers not intended to be open to ambient conditions such as those for liquefied petroleum gas.

~~1.3 This specification does not address hazards caused by fire and explosion nor hazards from vapors external to the container when the fuel in the container does not ignite. Further, this specification does not consider scenarios where confinement, obstructions, or preheating cause flame acceleration prior to the flame front reaching the interior of the container.~~

1.3 The values stated in either SI units or inch-pound units are to be regarded separately as standard. The values stated in each system are not necessarily exact equivalents; therefore, to ensure conformance with the standard, each system shall be used independently of the other, and values from the two systems shall not be combined.

[1] This specification is under the jurisdiction of ASTM Committee F15 on Consumer Products and is the direct responsibility of Subcommittee F15.72 on ~~Torch Fuels~~Pre-Filled Containers of Flammable and Combustible Liquids.

Current edition approved ~~Aug. 1, 2020~~May 1, 2023. Published ~~September 2020~~May 2023. Originally approved in 2020. Last previous edition approved in 2020 as F3429/F3429M – 20. DOI: ~~10.1520/F3429_F3429M-20.~~10.1520/F3429_F3429M-23.

1.4 *This standard does not purport to address all of the safety concerns, if any, associated with its use. It is the responsibility of the user of this standard to establish appropriate safety, health, and environmental practices and determine the applicability of regulatory limitations prior to use.* Information on specific hazards associated with the test methods in this specification is shown in Section 4.4.

1.5 This specification does not address hazards caused by fire and explosion nor hazards from vapors external to the container when the fuel in the container does not ignite. Further, this specification does not consider scenarios where confinement, obstructions, or preheating cause flame acceleration prior to the flame front reaching the interior of the container.

1.6 This standard is used to measure and describe the response of materials, products, or assemblies to heat and flame under controlled conditions, but does not by itself incorporate all factors required for fire-hazard or fire-risk assessment of the materials, products, or assemblies under actual fire conditions.

1.7 Fire testing is inherently hazardous. Adequate safeguards for personnel and property shall be employed in conducting these tests.

1.8 *This international standard was developed in accordance with internationally recognized principles on standardization established in the Decision on Principles for the Development of International Standards, Guides and Recommendations issued by the World Trade Organization Technical Barriers to Trade (TBT) Committee.*

2. Referenced Documents

2.1 *ASTM Standards:*[2]

D3828 Test Methods for Flash Point by Small Scale Closed Cup Tester
D4359 Test Method for Determining Whether a Material Is a Liquid or a Solid
F852/F852M Specification for Portable Gasoline, Kerosene, and Diesel Containers for Consumer Use
F2874 Specification for One Time Use Portable Emergency Fuel Containers (PEFC) for Use by Consumers
~~F3326 Specification for Flame Mitigation Devices on Portable Fuel Containers~~

2.2 *NFPA Standards:*[3]

NFPA 68 Standard on Explosion Protection by Deflagration Venting
NFPA 497 Recommended Practice for the Classification of Flammable Liquids, Gasses, or Vapors and of Hazardous (Classified) Locations for Electrical Installations in Chemical Process Areas

3. Terminology

3.1 *Definitions:*

3.1.1 *disposable and pre-filled flammable liquid container, n*—a vessel, which includes a closure for storage or dispensing pre-filled with flammable liquids, that is intended and designed to be poured and discarded or recycled (and not re-filled) after the flammable liquids are fully consumed in one or multiple uses.

3.1.1.1 *Discussion—*
In this specification, "container" means "disposable and pre-filled flammable liquid fuel container."

3.1.2 *equivalence ratio, n*—the ratio of fuel concentration in the actual fuel-air mixture divided by the fuel concentration in a stoichiometric mixture.

3.1.3 *flame jetting, n*—phenomenon where an external ignition source causes a sudden ignition within a liquid container that directionally propels burning vapor and liquid from the mouth of the container.

3.1.3.1 *Discussion—*
Flame jetting requires the burning vapor and liquid to travel a lengthy distance from the container, relative to the intended use and application. Often, flame jetting will occur when pouring from the container; in these situations flame jetting occurs only when the burning liquid and vapor are propelled reasonably beyond the pouring target. The presence of a small flame in the immediate vicinity of the mouth of the container is not considered flame jetting.

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[2] For referenced ASTM standards, visit the ASTM website, www.astm.org, or contact ASTM Customer Service at service@astm.org. For *Annual Book of ASTM Standards* volume information, refer to the standard's Document Summary page on the ASTM website.

[3] Available from National Fire Protection Association (NFPA), 1 Batterymarch Park, Quincy, MA 02169-7471, http://www.nfpa.org.

3.1.4 *flame mitigation device (FMD), n*—a device or feature attached to, installed in, or otherwise integral to, a container that is expected to inhibit the propagation of an external flame into the container.

3.1.4.1 *Discussion*—
A flame arrester is a type of FMD that prevents the propagation of flame through quenching, or removal of heat from the flame. Other examples of FMDs include, but are not limited to, expanded metal mesh, screens, bladders, pinhole restrictors, and pumps.

3.1.5 *fundamental burning velocity, n*—the velocity of a laminar flame under stated conditions of composition, temperature, and pressure through a mixture of unburnt fuel and oxidizer gases.

3.1.6 *maximum experimental safe gap (MESG), n*—a standardized measurement of how easily a gas flame will pass through a narrow gap bordered by heat absorbing metal.

3.1.6.1 *Discussion*—
Industry practice is to report MESG in millimeters (mm), therefore MESG is only reported in millimeters (mm) in this specification.

3.1.7 *removable spout, n*—a device included with the container that is intended and allows for the consumer can easily attach, remove, and reattach without the use of tools.

3.1.7.1 *Discussion*—
While a removable spout is not required in order to pour liquid from a container, the spout will allow, when attached, flammable liquid to pass through it.

4. Significance and Use and Limitations

4.1 These test methods are intended to provide a challenge as severe as possible to FMDs made of polymers or other materials that have the potential to swell, melt, or self-close in some other fashion when exposed to direct flame impingement.

4.2 The endurance flame test required by 5.2 and described in Section 8 is intended to challenge the performance of such FMDs when exposed to sustained thermal exposures.

4.3 The flashback flame test required by 5.3 and described in Section 9 does not necessarily provide the most severe test to such FMDs. It is intended to challenge the performance of such FMDs.

4.4 *Hazards:*

4.4.1 The test methods in Sections 8 and 9 require exposure to open flames and pre-mixed flammable gases. Consider and address the inherent dangers of testing with open flames and the storage, handling, and transport of flammable gases.

4.4.2 Utilize appropriate personal protective equipment (PPE) as necessary. Appropriate PPE will potentially include gloves, glasses, safety shields, and respiratory equipment, as necessary to protect from exposure to flames, heat, smoke, and combustion products.

4.4.3 The test methods require controlled pre-mixing of flammable gas and air.

4.4.3.1 Control and port the gases separately from the supply to the container under test. Mix the flammable gas and air as close as possible to the inlet to the container to limit the potential for supply line flashback.

4.4.3.2 Use an inline flame arrester placed in the pre-mixed flow path to protect from potential flashback.

(1) Use caution when selecting an inline flame arrester to be certain that it provides sufficient protection for this application. Inline flame arresters intended for protection of gases with lower maximum experimental safe gap (MESG) than the test gas are sufficient for this purpose.

4.4.4 Separate the operator from the test apparatus by a rigid wall, window, or other separation.

4.4.5 The pre-mixed flammable gases will flow for an extended duration prior to ignition. Conduct the test in an area with sufficient ventilation to remove all flammable gases from the area while limiting direct air movement around the opening to the container. Compare the calculations of total gas flow rate made in accordance with Section 7 to the volume of the test area and the volumetric flow rate of the exhaust system to prevent hazardous buildup of flammable gases.

4.4.6 Internal ignition of the pre-mixed gases occurs if a flame penetrates a container. A means to vent the internal ignition is required in 6.1.1.4 with the intention of preventing any hazardous rupture or failure of the container. It is possible that flames will project from such means. Do not locate instrumentation or operators within the direct projection of any such means.

5. Requirements

5.1 *General Requirements:*

5.1.1 Confirm that the contents of the container are liquid at ambient conditions. For viscous substances, use Test Method D4359 or equivalent to determine if the contents of the container are liquid. If the contents are not liquid, this specification does not apply.

5.1.2 Determine if the liquid is flammable. For this specification, a liquid is flammable if the flashpoint is below 60 °C [140 °F]. If the flash point of the liquid is not provided, use Test Methods D3828, or equivalent, to determine if the liquid has a flash point below 60 °C [140 °F]. If the liquid has a flash point at or above 60 °C [140 °F], this specification does not apply.

5.1.3 For the purposes of this specification, a valid test shall be a test conducted on an exemplar or production container, following each step in the applicable test method (Section 8 or Section 9) where no testing or environmental situation arises that would question the results of that test. Any test that is determined to be invalid requires a repeat of the test with a new test specimen.

5.2 *Determine the Test Gas:*

5.2.1 The MESG of the liquid fuel stored within the container shall be used to determine the test gas.

5.2.2 When the liquid is a mixture of multiple chemical constituents, the liquid shall be classified by the chemical constituent with the smallest value of MESG.

5.2.3 For liquids with a MESG greater than or equal to 0.89 mm, ethylene shall be the test gas.

NOTE 1—Ethylene has a MESG of 0.65 mm, as determined in accordance with NFPA 497.

5.2.4 For liquids with a MESG less than 0.89 mm, the test gas shall be a gas with a MESG at least 0.24 mm less than the determined liquid MESG.

NOTE 2—NFPA 497 contains a list of MESGs for many flammable liquids. Table 1 lists some common liquids used in consumer products and their MESG values.

5.3 When tested in accordance with the endurance test in Section 8, using the test gas identified in 5.2, there shall be no internal ignitions in any valid test.

5.3.1 If the container is provided with a removable spout, there shall be no internal ignitions in any valid test when the container is separately tested both with the spout attached and with the spout removed.

5.4 When tested in accordance with the flashback flame test in Section 9, using the test gas identified in 5.2, there shall be no internal ignitions in any valid test.

TABLE 1 MESG of Class I Group D Flammable Liquids

Liquid Fuel	MESG (mm)
Ethanol	0.89
Methanol	0.92
n-Heptane	0.94
Ethyl Acetate	0.99
Isopropanol	1.00
Acetone	1.02

5.4.1 If the container is provided with a removable spout, there shall be no internal ignitions in any valid test when the container is separately tested both with the spout attached and with the spout removed.

5.5 Functional test of the container. (Reserved, see Appendix X2.)

5.6 ~~Permanency~~Retention test of the FMD on the container (Reserved, see Appendix X3.)

5.7 A container found acceptable for one flammable liquid shall also be acceptable for other flammable liquids with a MESG no less than 0.89 mm, if tested with ethylene. Alternatively, if the container has been tested with a test gas other than ethylene, it shall be acceptable for other flammable liquids with a MESG no less than that of the liquid considered in 5.2.4.

5.8 A container with the same FMD, and its attachment to the container opening, as a container which has met the requirements of this specification shall be considered as compliant with this specification.

6. General Specimen Preparation and Test Apparatus

6.1 *Specimen Preparation:*

6.1.1 Prepare each container as follows:

6.1.1.1 Create a sealed penetration for the influx of pre-mixed flammable gas that is at least 100 mm [4 in.] from the container opening. In order to prevent explosions in the test gas supply, protect the pre-mixed flammable gas outlet from flashback by using an appropriately sized flame arrester or comparable device. Exhaust all gas through the container opening(s). Seal all other vents or openings.

NOTE 3—For containers less than 100 mm [4 in.], see 6.1.1.5 for enlarging the container.

6.1.1.2 Insert instrumentation to determine ignition into the container (5.3). Do not insert instrumentation through the container opening. Locate instrumentation no closer than 50 mm [2 in.] from the container opening.

6.1.1.3 If the FMD fills the container volume, such as an expanded metal mesh type FMD, insert all the instrumentation and gas supply into the FMD such that the void space behind the FMD is no greater than 10 % of the volume of the FMD. If the FMD does not fill the entire container volume, locate the instrumentation in the void space.

6.1.1.4 Provide a means for venting a container ignition.

NOTE 4—When using SI units, one or more sealed explosion vents with a total area, in square centimeters, equal to or greater than the container ignitable volume, in liters, multiplied by 15, has been shown to be acceptable. [When using inch-pound units, one or more sealed explosion vents with a total area, in square inches, equal to or greater than the container ignitable volume, in gallons, multiplied by 8.8, has been shown to be acceptable.]

6.1.1.5 ~~If the container geometry presents difficulty for instrumentation,~~ It is acceptable to remove a bottom portion of the container, leaving the FMD and shoulder of the container intact. Mount the container to a rigid metal or plastic base, creating a test container. ~~Do not reduce the test container volume or width. It is acceptable to increase the test container volume and width above the original container volume or width.~~ Seal all penetrations and joints with an appropriate adhesive.

(1) If the FMD fills the container volume, such as an expanded metal mesh type FMD, keep all dimensions of the FMD and the container constant between the original container and the test container.

6.1.2 Seal the container opening under test and pressurize the container to a minimum of 1.1 times the absolute atmospheric pressure (~111 kPa [16.2 psi] absolute) prior to testing. Verify that the pressure loss is no greater than 0.01 times the absolute atmospheric pressure (~1.0 kPa [0.15 psi]) after 5 min.

6.1.3 Measure and record the size and location of any openings in the FMD. Calculate and record the total open area at the opening of the container and the test container volume.

6.2 *Test Apparatus:*

6.2.1 Mount the container securely such that the center of the opening is projected at an angle of 45° ~~± 2° below the horizontal.~~ to 60° below the horizontal, as required to orient the impinging flame directly on the FMD.

6.2.2 *Flammable Gas and Air Delivery:*

6.2.2.1 Select the required flammable test gas in accordance with 5.2. Use a minimum of 99.5 % purity for the test gas.

6.2.2.2 Use compressed air with an inline dryer or bottled air with a certified oxygen content of between 20.4 % and 21.4 %, by volume, for the flow control and measurement apparatus.

6.2.2.3 Electronically control and record the mass flow rates of the flammable test gas and air with minimum resolution of no greater than 2 % of the combined flammable mixture flowrate, as determined by Section 7.

6.2.2.4 Mount an open tube burner below the container under test. Use non-mixed test gas for the burner. Have a means of adjusting the flow rate to the burner based on visible flame height.

6.2.2.5 Provide a means of remotely igniting the flow of flammable gas such as a spark igniter or other electronic igniter.

6.2.3 *Instrumentation:*

6.2.3.1 Record data at no less than 1 Hz using a data acquisition system, except record pressure at no less than 50 Hz.

6.2.3.2 Connect all instrumentation, including thermocouples, used to the data acquisition system.

6.2.4 Ensure that a means is present to prevent flashback from the container to the supply of pre-mixed gases. See 4.4.3.2.

7. Gas Flow Calculation

7.1 Calculate the flow rates of air and flammable gas based on the container opening area and the required stoichiometry of the mixture, as shown below.

7.2 Determine the container opening area, A_o.

7.2.1 Ensure that the FMD constrictions in the container mouth are accounted for. For complex FMDs, the container opening area can be calculated by multiplying the container mouth area by the ratio of the free (open) volume within the FMD to the total volume of the FMD.

7.3 Determine the fundamental burning velocity of the test gas, v_1. NFPA 68 lists fundamental burning velocities for a number of gases. For ethylene, use a fundamental burning velocity of 0.80 m/s [31.5 in./s].

7.4 Calculate the combined flow rate of air and fuel, $\dot{V}_T$, by using:

$$\dot{V}_T = 1.125(A_0)(V_1) \quad (1)$$

7.4.1 Do not exceed a combined flow rate, V_T, of 815 SCCM.

7.5 Calculate the volume ratio of the fuel in the total flow, based on stoichiometry.

7.5.1 Use a slightly rich equivalence ratio equal to 1.05 times the stoichiometric ratio.

7.5.2 For ethylene use a volume ratio of 0.0735 of the total flow with the balance being air; this results in an equivalence ratio 1.05 times the stoichiometric ratio.

7.5.3 Multiply the calculated ratio by $\dot{V}_T$ to determine the volumetric flow rate of the test gas.

7.5.4 Multiply one minus this calculated ratio by $\dot{V}_T$ to determine the volumetric flow rate of air. The combined volumetric flow rate of the test gas and air will equal $\dot{V}_T$.

8. Endurance Test Method to Assess FMD Performance

8.1 *Scope of the Test Method:*

8.1.1 This test method evaluates a FMD installed in a container such that it ensures the external flame will not ignite the headspace inside a container during the described test.

8.2 *Specimen Preparation:*

8.2.1 Prepare no fewer than six (6) new, unused, empty containers representative of the finished product according to 6.1.

8.3 *Test Apparatus:*

8.3.1 Prepare the test containers according to the procedure in 6.2.

8.3.2 A general representation of the setup of the container for this test method, is provided in Fig. 1.

8.4 *Test Procedure:*

8.4.1 Connect the supply of air and of test gas to the container.

8.4.2 Calculate the flow rates of air and of flammable gas, in accordance with Section 7.

8.4.3 Verify that all connections are sealed and that the premixed gases do not leak from the container from any location other than the opening under test.

8.4.4 Provide an external exposure diffusion flame with a flame height of 50 mm ± 20 mm [2.0 in. ± 0.75 in.], by using the test gas placed under the container opening as indicated in Fig. 1. Position the tip of this flame at the bottom edge of the container opening.

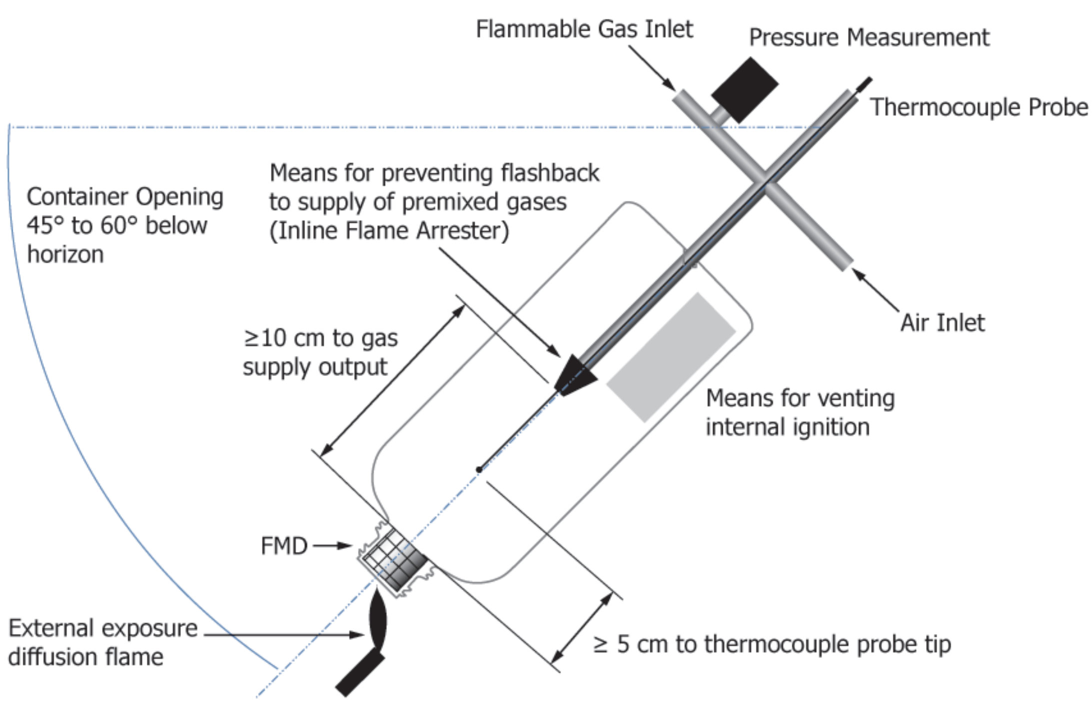

FIG. 1 Example Setup of Container for Endurance Test Method, Using a Thermocouple Probe and Pressure Measurement

8.4.5 Develop and maintain a steady flow of pre-mixed air and gas, at the appropriate air/gas ratio (in accordance with Section 7), through the container for a minimum of four test container volume air changes. To ensure adequate mixing, do not exceed one (1) container volume change per minute. Reduce the combined flow rate as needed while maintaining the fuel to air ratio.

8.4.6 At the end of the required air changes in the container, initiate a flow of flammable gas through the open tube burner and then activate the remote igniter. Adjust the flame to a 50 mm ± 20 mm [2.0 in. ± 0.75 in.] height, which just initiates contact with the container opening.

8.4.7 Sustain the external ignition source and the flow of pre-mixed gas for a minimum period of 30 s.

8.4.8 At the end of the minimum 30 s pre-mixed gas flow period, immediately shut off the flow of pre-mixed gas through the test container.

8.4.9 Sustain the external flame exposure for 5 s after stopping the flow of pre-mixed gas.

8.4.10 Throughout the test, observe whether an internal ignition occurs. If an internal ignition is clearly observed at any point during the test, immediately stop the flow of gases and end the test.

8.4.11 If the test has been completed and no internal ignition has been observed before the end of test, determine whether internal ignition has occurred, in accordance with Section 10.

8.4.12 Repeat the steps in 8.4.1 through 8.4.12 for each separate container opening.

8.5 Repeat the test in accordance with 8.4 on no fewer than six total samples for each opening in the container.

8.6 If the container has a removable spout, test each of the six total samples with and without the removable spout attached.

8.7 Report the test as a failure if, at any time during the test, internal ignition has occurred in a test that was a valid test.

8.8 If no failures have occurred, report the test as a pass.

8.9 *Precision and Bias:*

8.9.1 The precision of this test method has not been determined.

8.9.2 This test method has no bias because the results are expressed purely in terms of this test method.

9. Flashback Flame Test Method to Assess FMD Performance

9.1 *Scope of the Test Method:*

9.1.1 This test method evaluates a FMD installed in a container such that it ensures the external flame will not ignite the headspace inside a container during the described test.

9.2 *Specimen Preparation:*

9.2.1 Prepare no fewer than six (6) new, unused, empty containers representative of the finished product according to 6.1.

9.3 *Test Apparatus:*

9.3.1 Prepare the test containers according to the procedure in 6.2.

9.3.2 Attach to the container opening a tube made of low-density polyethylene (LDPE). The LDPE tube shall have a thickness of 0.076 mm ± 0.013 mm [0.003 in. ± 0.0005 in.], a length of 300 mm ± 100 mm [12 in. ± 4 in.], and a width of between 2 and 5 times the maximum width or outside diameter of the container opening. If a removable spout is used in the test, attach the LDPE tube to the removable spout.

9.3.2.1 If the tube cannot be sealed around the container neck or top, it is acceptable to modify the external surface of the container neck to allow for a sealed connection. Do not modify the container opening or the FMD from the as-built design.

9.3.2.2 Seal the end of the tube using a press heat sealer or other appropriate method.

9.3.2.3 Create a small gas release hole at the end of the tube away from the FMD that allows both the tube to inflate and flow through the tube.

9.3.3 A general representation of the setup of the container for this test method, is provided in Fig. 2.

9.4 *Test Procedure:*

9.4.1 Connect air and test gas supply to the container.

9.4.2 Calculate the flow rates of air and flammable gas in accordance with Section 7.

9.4.3 Verify that all connections are sealed and that the premixed gases do not leak from anywhere except the hole at the end of the tube.

9.4.4 Provide an external exposure diffusion flame with a flame height of 50 mm ± 20 mm [2.0 in. ± 0.75 in.] using the test gas below the tube. Position the tip of this flame below the bottom edge of the end of the tube opposite the container.

9.4.5 Maintain a steady flow of pre-mixed air and gas, at the appropriate air/gas ratio, through the container and tube for a minimum of four air changes, using the sum of the container and tube volumes.

9.4.5.1 It is acceptable to increase the flow rate of the pre-mixed air and gas, at the appropriate air/gas ratio, to reduce the time required to achieve the required four air changes. However the flow rate may not exceed one (1) container volume change per minute.

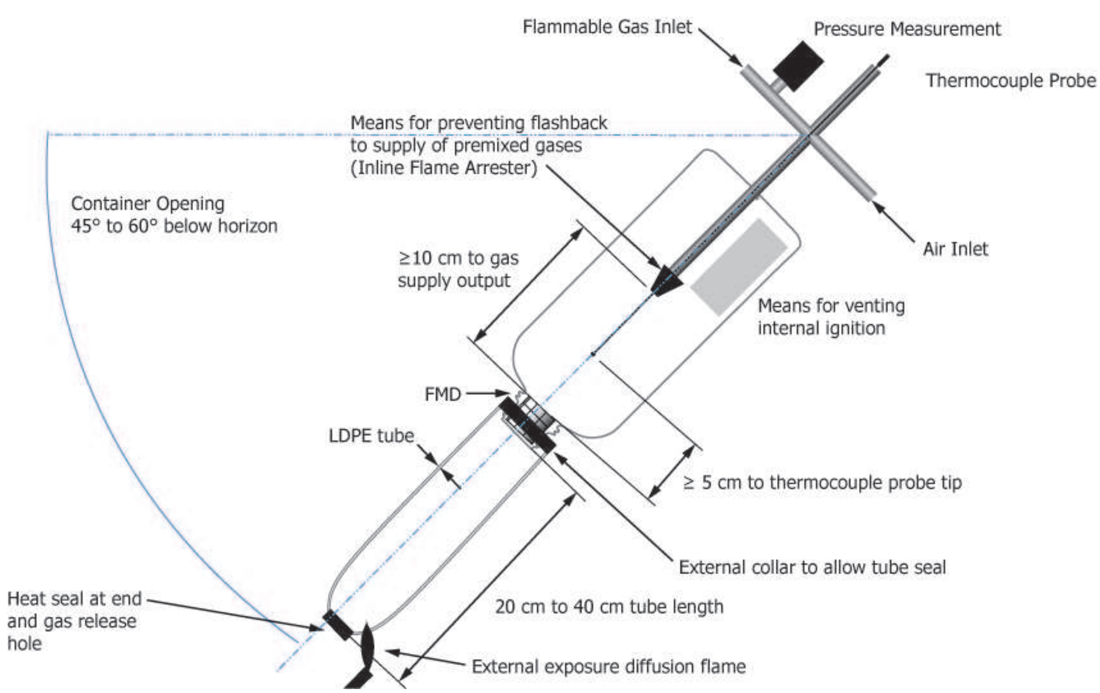

FIG. 2 Example Setup of Container for Flashback Flame Test Method, Using Thermocouple Probe and Pressure Measurement

9.4.6 Confirm that the tube is inflated by verifying that its weight is supported by its internal pressure and that the tube does not sag below the ~~45°~~ downward angle of the container.

9.4.7 At the end of the required air changes in the container and tube, stop the flow of premixed air/gas through the system.

9.4.8 Ignite the external exposure diffusion flame using a remote igniter before depressurization of the tube occurs. A sudden flame needs to ignite in the tube, which would then flash back to the container without pressurization or flame acceleration.

9.4.9 Throughout the test, observe whether ignition occurs. If an internal ignition is clearly observed at any point during the test, immediately stop the flow of gases and end the test.

9.4.10 Turn off the gas flow to the open tube burner.

9.4.11 If the test has been completed and no internal ignition has been observed before the end of test, determine whether internal ignition has occurred, in accordance with Section 10.

9.5 Repeat the steps in 9.4.1 through 9.4.11 for each separate container opening.

9.6 If the container has a removable spout, test each of the six total samples with and without the removable spout attached.

9.7 Report the test as a failure if, at any time during the test, internal ignition has occurred in a test that was a valid test.

9.8 If no failures have occurred, report the test as a pass.

9.9 *Precision and Bias:*

9.9.1 The precision of this test method has not been determined.

9.9.2 This test method has no bias because the results are expressed purely in terms of this test method.

10. Requirements to Determine Ignition within the Container

10.1 There shall be only three acceptable methods to determine whether ignition has occurred within the container: (*a*) a measured temperature rise (determined with a thermocouple); (*b*) a measured pressure rise; and (*c*) visual evidence obtained from a video camera.

NOTE 5—The temperature rise with the thermocouple is the preferred method if the FMD is a flame arrestor.

10.2 In order to determine whether ignition has occurred via measurement of temperature rise, use a single, open bead, 24-gauge Type K Inconel-sheathed thermocouple, with a 2.2 °C [4 ºF] tolerance, through a sealed penetration. It is acceptable to pass the thermocouple through the gas supply tube. A temperature rise of greater than 50 °C [90 °F] in less than 3 s shall be considered a failure.

10.3 In order to determine whether ignition has occurred via measurement of pressure rise, use an appropriate pressure measurement device which records data at a rate not less than 50 Hz. A pressure increase of greater than 3.5 kPa [0.5 psi] shall be considered a failure.

10.4 In order to determine whether ignition has occurred by using a video camera, use either a visible light video camera, at no less than 200 fps, an infrared video camera, at no less than 30 fps, or both. The camera technology shall be verified, prior to use in a test, to ensure that it is capable of accurately determining through the container wall whether internal ignition has occurred. If the camera is unable to determine whether internal ignition has occurred, a view port shall be provided for the camera, prior to testing.

NOTE 6—It is likely that video cameras may not be suitable for some FMD technologies.

10.5 The means for venting from 6.1.1.4 shall not be used to determine that an internal ignition did not occur. An internal ignition will not necessarily activate the means for venting.

10.6 When multiple methods prescribed in 10.1 are used to determine internal ignition, the test result shall be considered a failure, if at least one of the methods prescribed in 10.1 results in the observation of an internal ignition.

10.7 A test operator shall not be permitted to determine a test to be a pass without using evidence from one of the methods prescribed in 10.1.

10.8 A test operator shall be permitted to determine a test to be a fail without using evidence from one of the methods prescribed in 10.1, if an observable ignition has occurred.

11. Keywords

11.1 disposable flammable liquid container; flame mitigation device

APPENDIXES

(Nonmandatory Information)

X1. APPLICABILITY OF TEST METHODOLOGY

X1.1 The test methodology is specifically applicable to FMD that operate as flame arresters utilizing the principle of quenching to remove heat from a flame and prevent propagation into the container.

X1.2 Applicable containers include disposable (that is, non-refillable) consumer products that contain a flammable liquid intended to be used as a fuel. Such fuels include, but are not limited to, gelled or liquid fireplace fuels, pre-mixed fuels for small engines, and fire starter fuels.

X1.3 This methodology also applies to containers that are squeezable and fuels that are sufficiently viscous so as to require squeezing for application. Developmental testing has indicated that the effects of squeezing disposable flammable liquid containers result in reverse or suction flow of hot combustion gases and flame impingement at the FMD surface. This increase in heat transfer to quenching FMD reduces the hole sizes needed to pass the test by 3 % to 5 % for the surrogate gases evaluated. The frequency of internal ignition is increased by suction, and the six (6) repeat tests are intended to sufficiently capture this increased propensity for internal ignition.

X1.4 The test methodology may be applicable to some flammable liquid containers, except those specifically identified as out of scope in 1.2, such as containers for flammable liquids not intended to be used as fuels, or for combustible liquids. This may include acetone, isopropyl or rubbing alcohol, or other consumer pharmaceutical products; laboratory chemicals; or cleaning products. (See 1.1 through 1.1.3.)

X2. FUNCTIONAL TEST

X2.1 The intent of the functional test or of the flow out requirement is to ensure that the flow of liquid out of the container is adequate for the intended use of the product. Adding a FMD to an existing product without changing the container's design may result in a pouring flow rate reduction. Depending on the pouring flow rate reduction level, consumers may tamper with the FMD to obtain a flow rate that they believe is acceptable. Tampering with a FMD may nullify its effectiveness. Manufacturers should ensure that the flow of liquid out of the container is suitable for the intended use of the product. (See reserved 5.5.)

X3. ~~PERMANENCY~~RETENTION TEST

X3.1 The intent of the ~~permanency~~retention test is to ensure that the FMD cannot be easily removed without the use of tools. Frequently, the FMD is a flame arrestor at the mouth of the container. Consumers may not be familiar with flame arrestors and may not know if the flame arrestor is intended to be removed. ~~The manufacturer should ensure that a FMD is installed in such a manner that a consumer cannot easily remove the FMD without the use of tools. Specification F3326 requires that the FMD in a portable fuel container resist a push and pull force of 67 N [15 lb.].~~ (See reserved 5.6.)