Designation: E3082 – 17

Standard Test Methods for Determining the Effectiveness of Fire Retardant Treatments for Natural Christmas Trees[1]

This standard is issued under the fixed designation E3082; 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 fire-test-response standard provides a two-step testing process for determining the effectiveness of surface applied treatments for natural Christmas trees to improve fire test response.

1.2 The purpose of these test methods is to:

1.2.1 Utilize a detached branch test (Method 1) to screen potential surface-applied fire retardant products and to determine their effectiveness in limiting the spread of flame and the continuation of flaming by comparing the burning characteristics of treated and untreated small Christmas tree branches subjected to a small open Bunsen-burner type flame ignition source, and

1.2.2 Use whole natural Christmas trees (Method 2) to determine the effectiveness of surface applied fire retardants found to be effective in the detached branch test (Method 1) through comparison of heat release rate contribution of treated trees as compared to untreated trees when subjected to an open flame ignition source.

1.3 The values stated in inch-pound units are to be regarded as standard. The values given in parentheses are mathematical conversions to SI units that are provided for information only and are not considered standard.

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 and health practices and determine the applicability of regulatory limitations prior to use.*

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

1.6 The text of this standard references notes and footnotes which provide explanatory material. These notes and footnotes (excluding those in tables and figures) shall not be considered as requirements of the standard.

1.7 *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]

E176 Terminology of Fire Standards

D1835 Specification for Liquefied Petroleum (LP) Gases

D5025 Specification for Laboratory Burner Used for Small-Scale Burning Tests on Plastic Materials

E2067 Practice for Full-Scale Oxygen Consumption Calorimetry Fire Tests

2.2 *California Regulations:*[3]

California Code of Regulations, Title 19, Chapter 8, Article 3 Registration and Labeling of Chemicals

2.3 *NFPA Standards:*[4]

NFPA 1 Fire Code

NFPA 289 Standard Method of Fire Test for Individual Fuel Packages

2.4 *UL Standards:*[5]

UL 1975 Standard for Fire Tests for Foamed Plastics Used for Decorative Purposes

UL 2358 Outline for Fire Tests of Pre-lit Artificial Seasonal Use Tress and Other Seasonal Decorative Items

2.5 *Gas Processors Association Standard:*[6]

GPA 2140 Liquefied Petroleum Gas Specifications and Test Method

[1] These test methods are under the jurisdiction of ASTM Committee E05 on Fire Standards and are the direct responsibility of Subcommittee E05.15 on Furnishings and Contents.

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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 State of California Department of Industrial Relations.

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

[5] Available from Underwriters Laboratories (UL), 2600 N.W. Lake Rd., Camas, WA 98607-8542, http://www.ul.com.

[6] Available from Gas Processors Association (GPA), 66 American Plaza, Suite 700, Tulsa, OK 74135, http://www.gpaglobal.org.

3. Terminology

3.1 *Definitions*—For definitions of terms used in these test methods refer to Terminology E176.

3.2 *Definitions of Terms Specific to This Standard:*

3.2.1 *distal end*—the apex or tip of the tree branch.

3.2.2 *Christmas trees—for the purpose of this standard*, a natural tree product intended to be decorated or displayed in a manner associated with the Christmas, or other holiday season of the year.

4. Significance and Use

4.1 In past research experiments, some surface applied fire retardant chemicals improved the fire performance characteristics of natural Christmas trees, whereas other retardants were not effective, or adversely affected tree quality or burning characteristics. These methods are intended to provide a two-step process to determine the effectiveness of surface applied treatments to natural Christmas trees.

4.2 The fire performance of natural trees is highly variable and varies from species to species. Test results from these methods do not intend to provide data for judgment on the absolute fire performance of any natural or treated natural tree, but rather provide a means for comparing the fire performance of treated versus untreated trees.

4.3 These test methods do not take into account the influence of decorations that are added to the tree.

4.4 For Test Method 1, only Fraser fir [*Abies fraseri* (Pursh) Poi.] trees are tested. Although this is one of the most commonly used Christmas trees in the United States, it is possible that results for other tree species will differ from the results for this species.

4.5 For Test Method 2, Large Scale Fire Test, it is important that the treated and untreated tree specimens be evaluated consistently and as simultaneously as possible for adequate comparative results.

4.6 The performance of the treatment will vary depending on the uniformity of the application of the treatment. This quality of application is not determined by these test methods.

Method 1 – Small Scale Detached Branch Fire Tests

5. Test Method

5.1 *Test Specimens*—For each test, specimen branches shall be selected from five 8 to 15 ft (2.4 to 4.6 m) tall non-sheared Fraser fir [*Abies fraseri* (Pursh) Poir.] trees grown at a single location, during November or December. Trees shall be healthy, with no visible pest or disease problems. Branches shall have no cones nor evidence that cones were present. Nine 2-year-old specimen branches, each 18 to 24 in. (457 to 610 mm) long, and of similar diameter and foliage density, shall be cut from the distal ends of branches in the upper half of each tree specimen (Fig. 1). Bundle together branches from each tree, labeled to indicate the tree (1 to 5) they were harvested from, and place them in a 4 to 5 gal (15 to 19 L) plastic bucket containing sufficient water to cover the bases of the branches for transport to the conditioning room.

FIG. 1 Example of Open-grown Tree with a Circled Typical 2-yr-old Distal Branch Specimen

5.2 *Assignment of Branches to Specific Treatments*—Given that moisture content is the single most important factor relating to the flammability of conifer foliage, conduct the small scale branch fire test 1, 7, 14, and 21 days after treatment of branches to ensure that potential fire retardants are effective over a range of moisture contents. Assign a single branch from each tree randomly to each of the 8 treatment groups (Table 1 and 2). Place a small aluminum or paper tag on each branch, and label it with the assigned treatment codes. The use of color-coded tags, one color for each burn test schedule number will make it easier to identify groups of branches that need to be removed from the racks on any given testing date. Use the 9th branch from each tree to determine the initial moisture content of the specimens upon arrival of the branches at the conditioning room.

5.3 *Conditioning*—All specimen branches shall be stored in racks or hung from a wire in a lighted room maintained at 68 ± 5°C (20 ± 3°C) and at a relative humidity of 45 ± 5 % (Fig. 2). Branches shall be spaced far enough apart so that they are not touching each other to promote uniform drying and to facilitate making assessments of the effects of the fire retardant or needle retention and quality. (See Note 1).

NOTE 1—If cone containers are used, it is recommended that they be spaced further apart than in the photo in Fig. 2.

TABLE 1 Fire Test Schedule

Fire Test Schedule Number	Days of Conditioning after Treatment	Number of Branches	
		Non-treated Control (NTC)	Treated (T)
1	1 day	5	5
2	7 days	5	5
3	14 days	5	5
4	21 days	5	5

FIG. 2 Example of Branches Displayed in Cone Containers

5.4 *Moisture Content*—The percent moisture content (MC) of each branch shall be determined as described in 5.4.1 just prior to the fire test. Determine the moisture content of specimens from a single branch from each tree as soon as feasible after arrival at the conditioning room to determine the initial MC of the branches (See Fig. 3).

5.4.1 Moisture content shall be determined by weighing a current-season shoot removed from each branch to the nearest 0.1 g. Place each shoot in a labeled paper envelope, staple the envelope closed, and dry all shoots for 3 days at 150 to 160°F (65 to 71°C). Determine the dry weight of each shoot by immediately weighing the dried shoot after removal of the envelope from the oven. The moisture content shall be calculated as follows:

$$MC = (Mass_{wet} - Mass_{dry})/(Mass_{dry}) \times 100 \quad (1)$$

where:

$Mass_{wet}$ = mass of the specimen before drying.
$Mass_{dry}$ = mass of the specimen after drying.

5.5 *Application of Treatment*—The treatment shall then be applied to the 20 "T" labeled branch specimens prior to set up in the conditioning room. Use colored flagging to tag all of the branches at the time of labeling in order to make it easier to identify the branches to be treated. The treatment shall be applied at the manufacturer's application rate and in accordance with the manufacturer's application instructions. Following treatment, all branches shall be stored in the conditioning environment described in 5.2 until the fire test.

5.6 *Burner*—A laboratory type burner having a tube with a length of 4 ± ¼ in. (102 ± 6.4 mm) and an inside diameter of ⅜ in. (9.5 mm). The barrel is not to be equipped with an end. The burner wing tip shall have a slit 2 in. (51 mm) in length by 0.05 in. (1.3 mm) width, for the burner. The burner shall be in compliance with Specification D5025.

FIG. 3 A 2-year-old Branch Specimen with Arrows Showing a Pair of Current-Season Shoots to be used for Moisture Content and Fire Tests

5.7 *Test Apparatus*—Arrange the gas burner, box, racks, ruler, and test specimen under a fume hood as shown in Fig. 4.

5.8 *Test Procedure:*

5.8.1 Prior to each fire test, note the condition of each branch to be tested (such as discoloration, accelerated needle loss, or the presence of stiff needles). If significant needle loss has occurred, the branch will no longer be suitable for use in the fire test.

5.8.2 Arrange the bas burner such that the tip of the burner is ¾ in. (19 mm) below the level of the sheet metal box, with the air supply off, and gas adjusted to give a luminous flame 1-1½ in. (38-mm) long.

5.8.3 Within 30 min of taking the specimens from the conditioning environment, cut a 6 to 8 in. (152 to 203 mm) long current season shoot from the branch specimen (Fig. 4) and clip the specimen into the sliding rack so that the tip of the specimen is touching the top surface of the sheet metal box.

5.8.4 Slide the specimen to the test position over the flame. After a 12-s exposure, slide the specimen out of the flame.

5.8.5 If the specimen is flaming, wait until it has extinguished, then move the specimen against the ruler.

5.9 *Data Report:*

5.9.1 Report the following:

5.9.1.1 Date and location of specimen collections.

5.9.1.2 Approximate age of trees (in years/months).

5.9.1.3 Labeling system (see example in Table 2).

5.9.1.4 Temperature, relative humidity, and light level of conditioning room.

5.9.1.5 The condition of the branch prior to the flame test (note issues such as discoloration, accelerated needle loss, or stiff needles).

5.9.1.6 Moisture content of each branch at the time of testing (in %).

5.9.1.7 Duration of flaming after removing from flame (after-flame, in seconds).

5.9.1.8 If there was flame spread after removal of the specimen from the flame and how far the flame spread (in inches).

5.9.1.9 Total length of the test specimen (in inches).

5.9.1.10 Flame spread length (in inches).

5.9.1.11 A plot of the average moisture content versus average flaming time and average moisture content and average percent of specimen flame spread from the test data comparing treated and control specimens.

5.9.1.12 A bar graph showing the number of "NTC" and "T" specimens that passed the fire tests (Section 6) at each test interval.

5.9.1.13 Photograph of specimen following the fire test.

6. Conditions of Acceptance

6.1 Specimens shall meet all of the criteria in 6.1 through 6.6 in order to be considered to have passed the test.

6.2 Specimens shall cease burning, without any additional fire spread when the specimen is removed from the flame.

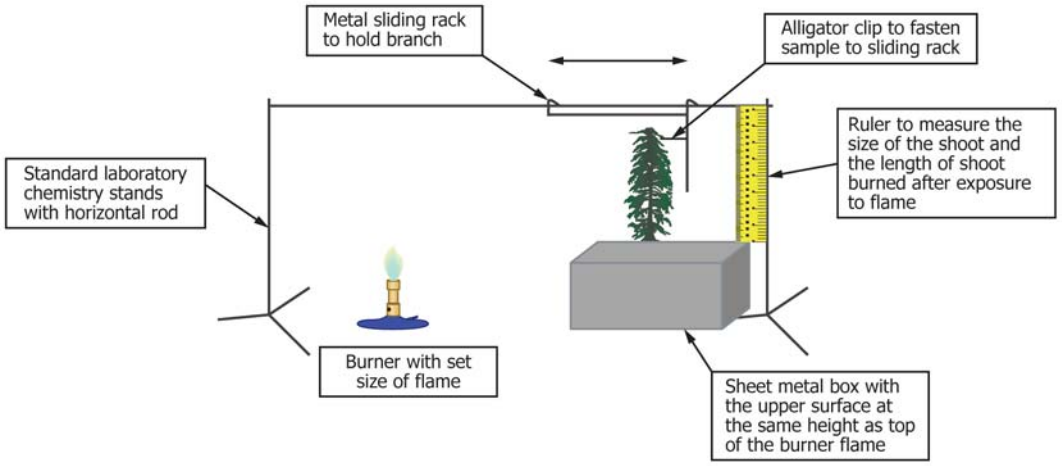

FIG. 4 Simple Apparatus to Test the Flammability of Conifer Branches

TABLE 2 Example of Tag Labels for Branches from Each Tree

Branch	Tree 1	Tree 2	Tree 3	Tree 4	Tree 5
1	1-1-NTC[A]	1-2-NTC	1-3-NTC	1-4-NTC	1-5-NTC
2	1-1-T	1-2-T	1-3-T	1-4-T	1-5-T
3	2-1-NTC	2-2-NTC	2-3-NTC	2-4-NTC	2-5-NTC
4	2-1-T	2-2-T	2-3-T	2-4-T	2-5-T
5	3-1-NTC	3-2-NTC	3-3-NTC	3-4-NTC	3-5-NTC
6	3-1-T	3-2-T	3-3-T	3-4-T	3-5-T
7	4-1-NTC	4-2-NTC	4-3-NTC	4-4-NTC	4-5-NTC
8	4-1-T	4-2-T	4-3-T	4-4-T	4-5-T
9	Initial	Initial	Initial	Initial	Initial
	MC-1	MC-2	MC-3	MC-4	MC-5

[A]Tagging code: X (fire test schedule No.); Y (tree No.); Z (non-treated control or treated). Place a small aluminum or paper tag on each branch, and label it with the assigned treatment.

6.3 Specimens shall cease spreading flame after the specimen is removed from the flame.

6.4 Specimens shall spread flame not more than 1 in. (25 mm) from the area in contact with the flame.

6.5 Specimens shall have after-flaming that does not exceed 10 s once the source of flame is removed.

6.6 No treatment is permitted to induce obvious deterioration in quality (such as discoloration and accelerated needle loss) when compared to the NTC.

Method 2 – Large Scale Fire Tests

7. Test Methods

7.1 *Test Specimens*—For each treatment to be evaluated, two sets of two natural Fraser fir [*Abies fraseri* (Pursch) Poir] trees of the same tree age, and shape are to be cut and selected for tests. Each tree shall be approximately 6 to 7 ft (1.8 to 2.1 m) tall.

7.2 *Conditioning and Treatment*

7.2.1 All tree are to be conditioned indoors at 70 ± 5°F (21 ± 3°C) and at a relative humidity of 50 ± 5 %. The trees are to remain in the conditioning area for at least 2 weeks, and no more than 4 weeks, until ready to receive the fire retardant treatment. During this pre-conditioning period, the trees shall be well-watered (checked daily and water added as needed, but no less frequently than twice per week).

7.2.2 Following the pre-conditioning, the treatment shall be applied to one set of trees (two trees) at the manufacturer's application rate and in accordance with the manufacturer's application instructions. The remaining set of trees (two trees) is to remain untreated.

7.2.3 All trees are then conditioned again indoors at 70 ± 5°F (21 ± 3°C) and at a relative humidity of 20 ± 5 %. The trees are to remain in the conditioning area for 14 days, and no more than 17 days, until ready for test. During this conditioning period, the trees are not to be watered.

7.3 *Equipment and Instrumentation*

7.3.1 For the determination of peak heat release rate and total heat released of the natural tree specimens in accordance with Practice E2067 or with NFPA 289, the test equipment and instrumentation shall consist of:

7.3.1.1 A 20 kW ignition source from a sand burner in accordance with 7.3.2,

7.3.1.2 A collection hood and exhaust duct,

7.3.1.3 Velocity and temperature measuring instruments,

7.3.1.4 Gas sampling and oxygen analysis instruments,

7.3.1.5 A data acquisition system, and

7.3.1.6 Photographic and video equipment.

7.3.2 The ignition source shall be a propane gas burner having nominal inside dimensions of 12 by 12 by 4 in. ± ¼ in. (305 by 305 by 102 mm ± 76 mm). The burner is to be constructed of nominal ¼-in. (6.4-mm) steel with a nominal ½-in. (12.7-mm) diameter steel gas inlet pipe. A minimum 4-in. (102-mm) layer of white Ottawa silica sand shall be used to provide the horizontal surface through which the gas is supplied. The pipe is to extend into the burner 5 in. (127 mm) nominal and a 6 in. (152 mm) nominal metal diffuser plate is to be positioned over the outlet of the gas pipe. A fine mesh

metal screen is to be placed on top of the diffuser plate. The burner field is to be filled with silica sand.

7.3.3 The canopy collection hood and exhaust duct, velocity measuring instruments, and gas sampling and analysis equipment shall be as described in Practice E2067 or in NFPA 289.

7.3.4 *Data Acquisition*—Use a digital data acquisition system to collect and record oxygen analyzer measurements, pressure gauge measurements, and temperatures. The speed and capacity of the data system shall be sufficient to collect the data every 2 s or less.

7.3.5 *Photographic and Video Equiment*—Photographs before, during, and after the tests, or video, or both, shall be used to record the test specimen performance.

7.4 *Pretest Calibration of Equipment*—Calibration of the rate of heat release measurement equipment is to follow generally accepted practices for oxygen consumption calorimetry using either Practice E2067 or NFPA 289.

7.5 *Test Procedure*

7.5.1 Within 30 min of removal of the tree from the conditioning environment, each tree shall be tested to determine peak heat release rate and total heat released in accordance with Practice E2067 or NFPA 289, using a 20 kW rise and decay ignition source for a test duration of 5 min. Measurements are made only for peak heat release rate and total heat released.

7.5.2 Prior to the start of the test, the ambient air at the mid-height entrance to the fire test area shall have a velocity of less than 0.5 m/s (100 ft/min) in any direction, as measured at a horizontal distance of 1 ± 0.1 m (3.3 ± 0.3 ft) from the center of the hood.

7.5.3 The test specimen is to be placed below the center of the exhaust hood.

7.5.4 The ignition source shall be placed 4 in. (0.10 m) below the bottom branches and positioned such that the burner is beneath the highest concentration of tree branches and needles.

7.5.5 The gas to be supplied to the burner is to be either: *(a)* Special Duty Propane, as defined in Specification D1835, or *(b)* HD-5 Propane as defined in the Standard for Liquefied Petroleum Gas Specifications and Test Methods, GPA Standard 2140, or *(c)* CP-Grade Propane. This gas has a nominal heating value of 2500 Btu (thermochemical) per cubic foot [93.1 MJ/m^3 or 22.2 kilocalories (thermochemical) per cubic meter]. To start the test, the propane gas burner is to be controlled linearly from zero to 29.8 standard cubic feet per hour (234 cm^3/s) to provide a peak flame which produces a theoretical net heat output of 20 kW at 2-½ min, and then linear decay to 0 kW at 5 min. Burner controls shall be provided for automatic shutoff of the gas supply if flameout occurs. The burner shall be ignited by a pilot burner or a remotely controlled spark igniter. The digital data acquisition equipment is to be started simultaneously.

7.5.6 Photographic or video recordings, or both, shall be made throughout each test.

7.5.7 In addition to measurements of peak heat release rate and total heat released in 7.5.1, visual observations are also to be recorded for time to ignition, flame height, lateral flame involvement, and other events regarding the burning specimen.

7.5.8 The test is to be conducted, and data collected, for 5 min at which time the gas burner is to be shut off. Data are to be collected until flaming or other signs of combustion cease. Visual observations of the specimen after the test are to be recorded.

7.6 *Heat Release Calculations*—The heat release rate and total heat released shall be calculated following generally accepted practices for large-scale heat release measurement using oxygen consumption calorimetry using either Practice E2067 or NFPA 289.

8. Conditions of Acceptance

8.1 The treatment or coating system shall reduce or maintain the peak heat release rate to 100 kW or less.

9. Report

9.1 The information in this section shall be reported for Methods 1 and 2, as applicable. This data is permitted to be used to judge the effectiveness of fire retardant treatments.

9.2 Description of the tree specimens or tree branch specimens selected for testing and description of the treatment for both Methods 1 and 2.

9.3 Documentation of how and when the test specimens were prepared and details of the application of the treatments for both Methods 1 and 2.

9.4 *For Method 1*—A statement as to whether the Conditions of Acceptance in Section 6 are met.

9.5 *For Method 2*—The following shall be reported:

9.5.1 Maximum (peak) heat release rate, HRR, for both the treated and untreated trees over the 5 min test duration (kW),

9.5.2 Total heat released for both the treated and untreated trees, (MJ),

9.6 The following information shall also be reported:

9.6.1 Date of test,

9.6.2 Description of the specimen being tested,

9.6.3 Details of specimen preparation,

9.6.4 Plotted graph of HRR (kW) versus time (s),

9.6.5 Recorded visual observations during or after the test, or both, and

9.6.6 Time to reach maximum (peak) HRR (s).

10. Keywords

10.1 Christmas tree; natural; peak heat release; total heat release; treatment

APPENDIX

X1. COMMENTARY

X1.1 Introduction

X1.1.1 This commentary is provided so the user of the Test Methods has the background information, including literature references, on the development, use, and special considerations of these test methods.

X1.1.2 NFPA 1 contains an example of acceptable fire performance for the individual decorative vegetation item to exhibit a maximum heat release rate of 100 kW when tested in accordance with UL1975 or NFPA 289, using the 20-kW ignition source.

X1.1.3 UL Outline of Investigation 2358 contains requirements for artificial seasonal trees to exhibit *(1)* a maximum heat release rate of 100 kW, *(2)* total heat release rate does not exceed 15 MJ during the first 10 min of the test, and *(3)* the specimen shall not lose structural integrity such as tipping, falling, or loss of branches during the test when subjected to an ignition fire source exposure of a 5-min growth and decay that peaks at 20 kW.

X1.2 Development of Methods

X1.2.1 Test Method 1, entitled "Small Scale Fire Test" was developed based on California Code of Regulations, Title 19, Chapter 8, Article 3, "Registration and labeling of Chemicals," Section 1264.3, "Christmas Trees."

X1.2.2 Test Method 2, entitled "Large Scale Fire Test" was developed based on NFPA 289 and UL Outline of Investigation 2358, "Outline of Investigation for Fire Tests of Pre-lit Artificial Seasonal Use Trees and Other Seasonal Decorative Items."