



# Reducing the Fire Hazard of Pre-Lit Artificial Christmas Trees



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# Overview

As the holiday season approaches, consumers and businesses alike will decide whether to decorate using live, natural Christmas trees or pre-lit artificial ones. According to National Fire Protection Association (NFPA) statistics, Christmas trees of all types present a safety risk during the holiday season. There is a strong, wellknown safety message that a live tree must be kept well-watered to reduce the risk of a fire. Unfortunately, the fire safety message is not as clear for a pre-lit artificial tree. Understanding key safety concerns for pre-lit artificial trees is equally important because these trees can also be a significant source of fuel if ignited.

When it comes to artificial trees, shoppers may be misled by the tree packaging or advertisements that identify the tree or tree materials as “flame retardant.” These claims infer a certain level of fire performance and can give consumers a false sense of safety. Indeed, artificial trees can contribute to rapid fire growth in a room in a manner like that of a dried-out natural tree.

As the popularity of pre-lit Christmas trees has grown and the size of these trees has continued to increase, it was necessary to review and adjust safety requirements to address the increased fire fuel load of the materials used to manufacture pre-lit trees. Underwriters Laboratories has conducted research and developed fire performance testing requirements for pre-lit artificial trees exceeding 30 inches in height. Testing requirements gauge the tree’s compliance to standards and other measurements, thereby limiting its

contribution to the growth of fire and increasing the time available to consumers to escape. Testing has shown that the peak heat release rate (HRR) of freshly harvested natural Christmas trees, or those that are well-watered, yield a peak heat release rate of approximately 100 kilowatts (kW).<sup>1</sup>

The objective is to have a pre-lit artificial tree that performs comparably with a freshly harvested natural Christmas tree. This UL white paper reviews Underwriters Laboratories research that led to the development of performance testing criteria for pre-lit artificial trees. It also describes the testing required for certification to UL 2358, Outline of Investigation for Fire Tests of Pre-Lit Artificial Seasonal Use Trees and Other Seasonal Decorative Items.

# A brief history of Christmas trees



The Christmas tree tradition in the United States reportedly dates back to the 18th and 19th centuries, when immigrants from Germany, England and other European countries transitioned holiday traditions from their native homelands to their adopted country.<sup>2</sup> By the 1960s, manufacturers had begun producing artificial Christmas trees that offered consumers greater shopping convenience, reduced clean-up and minimal maintenance.

The initial silver aluminum trees popular in the early 1960s soon gave way to more natural looking trees with green plastic needles and branches composed of 100% polyvinylchloride (PVC) materials and other various petrochemicalbased materials.

## Early safety research regarding pre-lit artificial Christmas trees

Despite their widespread use, Christmas trees, both natural and artificial, pose a special safety and building property risk during the holiday season. According to statistics reported by the National Fire Protection Association (NFPA), “Between 2013-2017, U.S. fire departments responded to an average 160 home fires that started with Christmas trees per year. These fires caused an average of three deaths, 15 injuries, and \$10 million in direct property damage annually.”<sup>3</sup>

The fire and safety risks posed by artificial and pre-lit artificial trees have been researched by Underwriters Laboratories and others for more than 50 years. Underwriters Laboratories’ first involvement dates to the 1960s, when it issued a Classification Report to the American Tree and Wreath Company based on an evaluation of the fire potential of the products used in the company’s artificial Christmas trees.

At that time, artificial Christmas trees were evaluated by visual observation of flame extension above the height of the tree. However, fire protection engineering suggests that the heat released from a burning tree is a better indicator of its potential contribution to home structure fires. Today, the measure of a burning object’s HRR is recognized as a primary factor in assessing its potential fire hazard.

A product or group of products with a lower HRR produces less energy, lengthening the time before a fire can lead to flashover<sup>4</sup> and providing valuable extra minutes for consumers to safely escape from a burning residence or building structure. In the late 1990s, Underwriters Laboratories conducted research to develop baseline heat release data on both natural and artificial Christmas trees. In that research, peak HRRs for 6-foot tall artificial trees ranged



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from 50 to almost 700 kW, varying with tree size, density and other design characteristics. When lights were added to these trees, a significant increase in peak HRRs was observed, adding between 150 to 350 kW to the peak HRR of the tree. One pre-lit artificial tree tested exhibited a peak HRR of almost 1,100 kW.<sup>5</sup>

This means that a single stand-alone tree within a test room compartment, if ignited, would quickly drive the compartment to flashover and prevent safe egress. Comparatively, a known peak HRR of well-watered natural trees, without decorations, that does not pose a significant fire concern is 100 kW.

## The research behind UL 2358

As major U.S. retailers expressed interest in a safety certification program expressly for pre-lit artificial Christmas trees, Underwriters Laboratories launched an investigation to develop test protocols to determine the fire performance of pre-lit artificial Christmas trees. A report on the findings of that investigation was published in November 2009.<sup>6</sup>

Following the fire safety approach described in NFPA 550, Guide to the Fire Safety Concepts Tree, and the risk

assessment guide prepared by the Fire Protection Research Foundation, Underwriters Laboratories' investigation evaluated samples of pre-lit, undecorated, artificial Christmas trees of various types that were available to consumers. Sample trees were initially chosen based on fuel load and potential for ignition, flame propagation and development of rapid heat generation. Other sample variables included weight, height, number of lights, number of needle grouping tips, and needle and material types.

Testing was conducted to determine the potential for fire when the tree was the first item ignited, such as in situations in which an electrical short or small open flame, e.g., from a candle, exposes a tree component to localized heating. Testing was also conducted to assess the potential for fire when the tree was the second item ignited, such as in situations in which wrapped gift packages placed under the tree catch fire. Finally, since most pre-lit artificial trees offer consumers a variety of branch configuration options, and are eventually decorated to individual consumer taste, testing was conducted to assess the influence of different branch arrangements on a tree's fire performance as well as the impact of decorations.



It is important to note that the Fire Code of the National Fire Protection Association (NFPA 1) requires that artificial Christmas trees and other artificial vegetation be labeled or otherwise identified as “fire retardant,” and that “one example of acceptable fire retardance is for the individual item to exhibit a maximum heat release rate of 100kW.”<sup>7</sup> The International Fire Code of the International Code Council (ICC) also mandates that “artificial decorative vegetation item(s) shall ... have a maximum heat release rate of 100kW.”<sup>8</sup> Therefore, the maximum total heat release prescribed in UL 2358 is aligned with the limit explicitly defined in the leading U.S. and international fire safety codes



## Changes to UL 2358

Since the original investigations that led to the development of UL 2358, Underwriters Laboratories has conducted additional research using natural and pre-lit artificial Christmas trees. Specifically, research was used to determine the influence of ignition sources of various magnitudes on fresh (watered) and dried (un-watered) natural and artificial pre-lit Christmas trees. The following ignition sources were examined:

- Downward burning rate test/needle flame (UL 588, the Standard for Seasonal and Holiday Decorative Products)
- 20 kW propane fueled sand burner – 15 minutes (NFPA 289)
- 1 pound of shredded paper (UL Subject U411)
- Wood crib (UL 1975, the Standard for Standard for Fire Tests for Foamed Plastics Used for Decorative Purposes, and NFPA 1)
- 20 kW propane fueled sand burner – growth and decay for 5 minutes

Based on the data obtained from this research, and from data gathered during the testing of pre-lit artificial trees submitted for evaluation, the 20 kW ignition source remains the most viable ignition source challenge, but with some significant qualifications. Consequently, UL 2358 was revised in 2013 as follows.

- UL 2358’s language specific to the test equipment and procedures is now consistent with other oxygen consumption calorimetry standards and practices.
- The constant 20 kW fire source exposure was updated to fire exposure of growth and decay. This change better represents the growth and decay fire challenge exhibited by various first items that may become ignited underneath a pre-lit tree.
- The test ignition source application duration was reduced from 15 minutes to five minutes. Research showed that both natural and artificial trees reacted to the fire challenge within five minutes and, in most cases, were fully involved well within the first five minutes of testing.
- The number of samples tested was reduced to three from five. The most adverse testing location is now demonstrated through test evaluations and research, alleviating the need for two of the previously required samples.

In addition to these changes, a reference to UL 2358’s fire requirements were added to UL 588 to bring consistency to the flammability testing of all seasonal holiday and decorative products.



In evaluating the testing results, researchers reaffirmed the importance of the peak HRR in comparing the relative safety of various sample trees and configurations. The results also indicated that small open flame sources, such as those intended to simulate a flame from a candle, were generally not sufficient to ignite and sustain burning of a tree to create a fire hazard. However, larger ignition sources, such as those representative of a burning package under the tree, could be the source of a significant fire hazard.

As a result of this investigation, researchers proposed that a certification program for pre-lit artificial Christmas trees should establish a peak HRR of not more than 100 kW, with a total heat release rate of not more than 15 megajoules (MJ). These numbers are similar to the performance of a fresh and watered live Christmas tree and are significantly lower than the heat required to cause a flash over condition. These numbers were also based on the assumption that a consumer would add additional decorations to a pre-lit artificial tree.

Further, the report proposed that fire performance testing should involve the use of an open flame with a 20 kW ignition heat source, positioned so that the flame has a direct impact on the greatest concentration of combustible tree components. A 20 kW ignition source produces a flame similar to crumpled newspaper ignited in the bottom of a small wastebasket. The ignition source represents a small localized fire under or around a tree significant enough to initiate fire involvement. Both proposals were ultimately adopted in UL 2358.

## Fire performance criteria in UL 2358

The overall intent of the fire performance criteria found in UL 2358 is to limit the extent to which a pre-lit artificial Christmas tree contributes to a flashover fire condition and reduce the potential for a building structural fire. The key provisions of the UL 2358 include:

- **Test specimens (Section 6)** — Samples are submitted for testing for each family of products. A product family consists of a group of products with design and component features that could be expected to produce similar results when subjected to the fire performance tests. Such design and component features could include base materials, maximum needle and branch density, overall shape and height, and lamp density.
- **Testing procedure (Section 7)** — An ignition source is placed below the bottom branches of the sample in a worst case position of greatest material concentration. Multiple tests are conducted. If any of the tests produces results not in accordance with the performance criteria, the testing is discontinued, and the results reported.
- **Heat release calculations (Section 8)** — The measurement of the HRR and the total heat released during each test follows the procedure detailed in ASTM E2067, Standard Practice for Full-Scale Oxygen Consumption Calorimetry Fire Test. Section 8 of UL 2358 provides the detailed formulas for calculating the HRR and total heat released during testing.
- **Acceptance criteria (Section 10)** — For each of the samples tested, the peak HRR cannot exceed 100 kW and the maximum total heat released cannot exceed 15 MJ. In addition, the sample cannot lose its structural integrity as a result of the test.



## Recommendations for manufacturers

Conducting the testing to the fire performance requirements of UL 2358 is comprehensive and sample selection can be a complex process. Samples submitted for testing must be representative of the range of available product configurations and account for variations in a tree's weight, height, number of lights and various types of needles and materials.

For these reasons, manufacturers and suppliers of pre-lit artificial Christmas trees seeking to certify their products to the requirements of UL 2358 are encouraged to begin the product evaluation process as early as possible to be confident that a certified product is available for the Christmas holiday season. UL can assist manufacturers in their efforts to address the anticipated challenges of meeting the fire performance requirements and speed the product evaluation process.

## The benefits of UL 2358 Certification

Subsequent to the updating of UL 2358 in 2013, manufacturer submittals of pre-lit artificial Christmas trees for testing and certification have increased significantly. As a result, several tree designs have now earned UL certification and are eligible to bear the UL Mark. In addition, pre-lit artificial trees certified to UL 588 and UL 2358 are Certified under UL's category for Pre-Lit Artificial Christmas Trees and Wreaths, DGYT. Retailers and consumers can search for Certified pre-lit artificial Christmas trees at UL's Product iQ™ online directory at <https://productiq.ULprospector.com/en>.

For artificial tree manufacturers, certification to UL 2358 helps to differentiate their products from those that have not been certified, giving them an important advantage in a competitive market. National retailers have also derived benefits from sourcing prelit artificial Christmas trees that have been certified to UL 2358, since it supports their efforts to provide their customers with compliant products. Finally, UL 2358-certified pre-lit artificial Christmas trees gives consumers added assurance that their purchase has been tested and found compliant with rigorous safety standards.



Retailers and consumers can search for Certified pre-lit artificial Christmas trees at UL's Product iQ™ online directory at [productiq.ULprospector.com/en](https://productiq.ULprospector.com/en).





## Summary and conclusion

Underwriters Laboratories has been at the forefront of research and testing of artificial Christmas trees. In recent years, the focus on pre-lit artificial trees has been one aspect of an overall investigation into the changing nature of the modern housing fire. The typical housing environment has changed drastically toward more synthetic materials, and this has been identified as a contributing factor to decreased time for occupants to escape in fire scenarios.

Underwriters Laboratories' research has demonstrated that artificial trees, including pre-lit artificial trees, can be a significant contributor to rapid fire growth in a room. The publication of UL 2358 and the introduction of fire performance criteria for pre-lit artificial Christmas trees are important parts of UL's overall effort to decrease these fire safety risks.

UL's safety certification program for pre-lit artificial Christmas trees is an important tool that allows manufacturers and retailers to provide consumers with clear, objective information on the safety of their products. Certifying pre-lit artificial trees to the requirements of UL 2358 and UL 588 ultimately helps consumers choose safer products and increases overall safety.

**For more information about UL's fire safety research and UL's certification services for pre-lit artificial Christmas trees, please contact Anthony Tassone at [anthony.t.tassone@ul.com](mailto:anthony.t.tassone@ul.com).**



## Endnotes

1. Data based on a freshly harvested natural pine tree, and a well-watered natural fir tree after four weeks of indoor aging. From “Report of Research on Burning Characteristics of Natural and Artificial Christmas Trees in Room Fires,” Underwriters Laboratories, March 1, 1999
2. “The Chronological History of the Christmas Tree,” The Christmas Archives. Web. 1 April 2016. [www.christmasarchives.com/trees.php](http://www.christmasarchives.com/trees.php).
3. National Fire Protection Association. Web. 15 September 2020. <https://www.nfpa.org/Public-Education/Fire-causes-andrisks/Seasonal-fire-causes/Winter-holidays/Holiday-fires-by-the-numbers>
4. Flashover is generally defined as that moment when the fire within a compartment rapidly transitions to a state of total surface involvement. A conservative (minimum) HRR necessary to cause flashover in a standardized test compartment is approximately 1000 kW.
5. “Report of Research on Burning Characteristics of Natural and Artificial Christmas Trees in Room Fires,” See Note 1.
6. “Flammability of Pre-Lit Artificial Christmas Trees,” UL Corporate Research Report, November 12, 2009.
7. “NFPA 1: Fire Code,” National Fire Protection Association, 2015. Web. 15 September 2020. <http://www.nfpa.org/codes-andstandards/document-information-pages?mode=code&code=1>.
8. “2018 International Fire Code,” International Code Council. Web. 15 September 2020. <http://www.iccsafe.org/codes-techsupport/codes/2015-i-codes/ifc/>



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