UL 2335

STANDARD FOR SAFETY

Fire Tests of Storage Pallets

UL Standard for Safety for Fire Tests of Storage Pallets, UL 2335

Second Edition, Dated July 28, 2010

Summary of Topics

This revision of ANSI/UL 2335 is being issued to update the title page to reflect reaffirmation of ANSI approval.

Text that has been changed in any manner or impacted by UL's electronic publishing system is marked with a vertical line in the margin. Changes in requirements are marked with a vertical line in the margin and are followed by an effective date note indicating the date of publication or the date on which the changed requirement becomes effective.

The revisions are substantially in accordance with Proposal(s) on this subject dated June 30, 2017.

The following table lists the future effective dates with the corresponding reference.

Future Effective Date	Reference
March 26, 2014	Paragraphs 7.1, 7.2, 7.3 and 7.4

JULY 28, 2010
(Title Page Reprinted: August 17, 2017)

ANSI/UL 2335-2012 (R2017)

UL 2335

Standard for Fire Tests of Storage Pallets

First Edition – June, 2001

Second Edition

July 28, 2010

This ANSI/UL Standard for Safety consists of the Second Edition including revisions through August 17, 2017.

The most recent designation of ANSI/UL 2335 as a Reaffirmed American National Standard (ANS) occurred on August 17, 2017. ANSI approval for a standard does not include the Cover Page, Transmittal Pages, and Title Page.

Comments or proposals for revisions on any part of the Standard may be submitted to UL at any time. Proposals should be submitted via a Proposal Request in UL's On-Line Collaborative Standards Development System (CSDS) at https://csds.ul.com.

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INTRODUCTION

1 Scope

1.1 This standard includes test methods and requirements to investigate the fire growth performance of pallets in idle storage, and when storing commodities in palletized and rack storage arrangements, by sprinkler systems installed in accordance with the Standard for the Installation of Sprinkler Systems, NFPA 13.

1.2 Variations from the construction or conditions tested are capable of substantially changing the performance characteristics of the pallets.

1.3 This standard does not include test methods and requirements to investigate other performance characteristics such as:

a) Fire growth characteristics when pallets are not protected by sprinkler systems,

b) Risks associated with materials used in the pallet construction or the products of combustion and

c) Physical strength characteristics of the pallets including those during a fire condition.

2 General

2.1 Units of measurement

2.1.1 Values stated without parentheses are the requirement. Values in parentheses are explanatory or approximate information.

2.2 Undated references

2.2.1 Any undated reference to a code or standard appearing in the requirements of this standard shall be interpreted as referring to the latest edition of that code or standard.

2.3 Requirements

2.3.1 Two types of tests are required by this standard, idle pallet storage tests and commodity storage tests. The Idle Pallet Storage Test, Section 3, with either a 2 x 3 or a 2 x 7 pallet array, identified herein as Method A or Method B respectively, is used to determine the potential fire hazard for the storage of idle pallets. The Commodity Storage Test, Section 4, is used to determine that the commodity classification rank of a warehouse commodity is not increased when the tested pallets are used in place of conventional wood pallets.

PERFORMANCE

3 Idle Pallet Storage Test

3.1 Test set-up

3.1.1 The tests are to be conducted in a room with minimum dimensions of 100 feet by 100 feet (30.5 meters by 30.5 meters). During the test all doors and windows in the room are to be closed. At the start of the test the room temperature shall not be less than 10°C (50°F) nor more than 32°C (90°F). The room shall have a smooth, flat, unbounded ceiling located 30 ±0.17 ft (9.1 ±0.05 m) above the floor.

3.1.2 Pallet array is to be arranged as follows:

a) Method A; Six stacks of pallets 12 ±0.25 ft (3.6 ±0.08 m) high in a 2 x 3 array are to be used for this test. The middle of the 2 x 3 array is to be centered between four sprinklers. See Figure 3.1.

b) Method B; Fourteen stacks of pallets 12 ±0.25 ft (3.6 ±0.08 m) high in a 2 x 7 array are to be used for this test. The middle of the 2 x 7 array is to be centered between four sprinklers. See Figure 3.2.

Figure 3.1
Test set-up - Method A

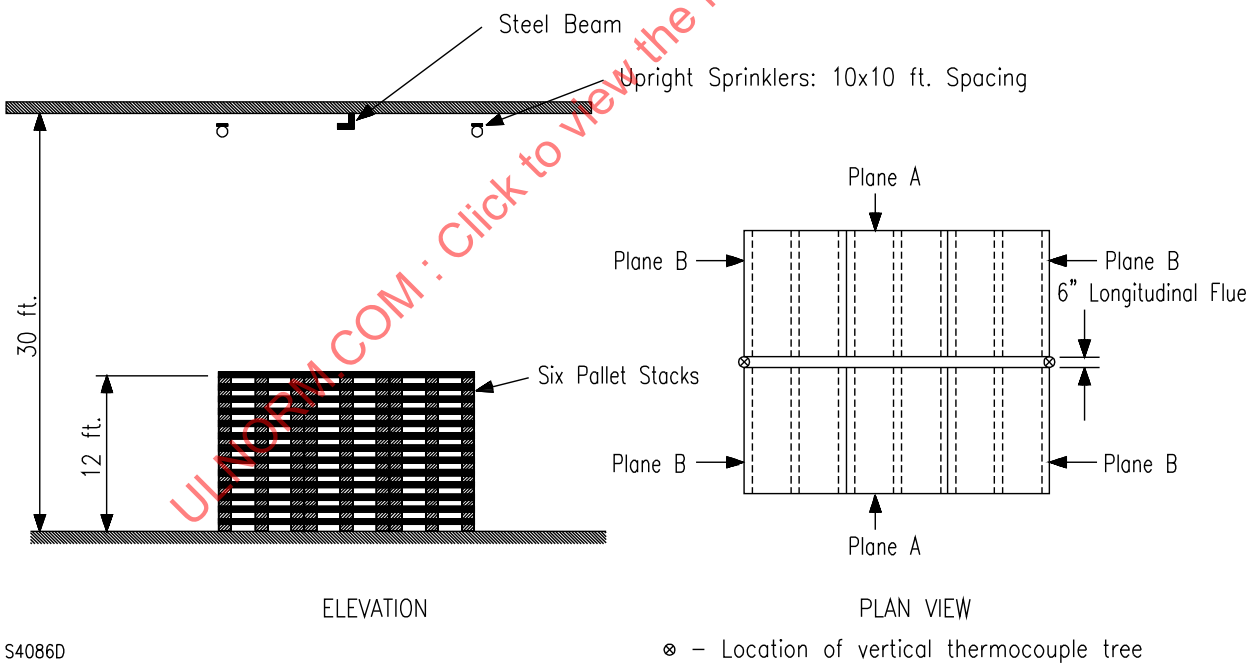
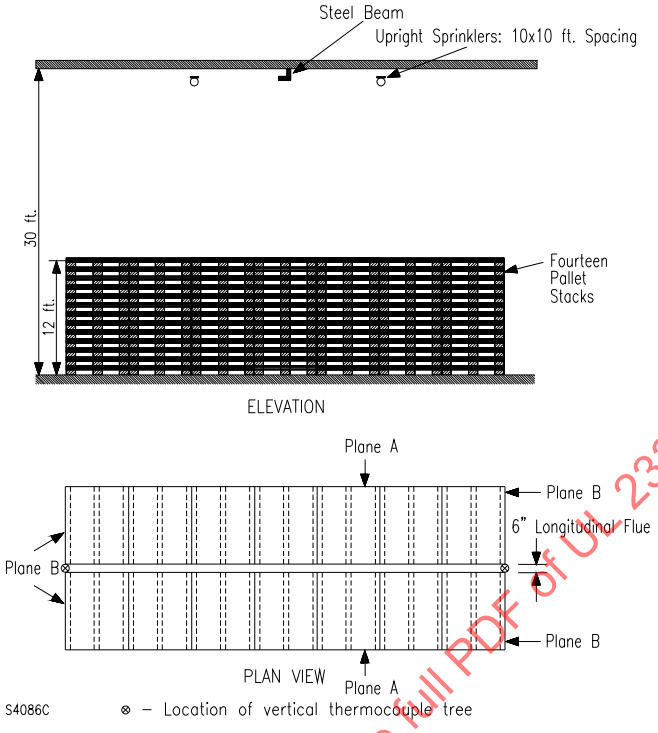


Figure 3.2
Test set-up – Method B



3.1.3 A nominal 4-foot (1.2-meter) length of 2 x 2 x 0.25 inch (50 x 50 x 6 mm) steel angle beam shall be mounted adjacent to the ceiling directly above the center of the pallet array. Five equally spaced Type K, or equivalent, thermocouples shall be embedded in the steel angle beam to measure its temperature.

3.1.4 Instrumentation shall be present to record sprinkler activation, water pressure, water flow rate and steel angle beam temperatures at a minimum scan rate of once every second. Due to the possibility of vision being obscured by the smoke generated during this test, an infrared camera shall be used to visually evaluate the flame propagation during the test. The infrared camera output shall be recorded.

3.2 Sprinkler system

3.2.1 A wet-pipe automatic sprinkler system consisting of a minimum of 36 sprinklers shall be positioned below the ceiling. The sprinkler system shall be connected to a water supply system capable of maintaining the specified water pressure and flow rate for the 36 sprinklers.

3.2.2 Each activated sprinkler shall have a water discharge density of 0.6 ±0.03 gpm/ft^2 (24.2 ±1.2 lpm/m^2).

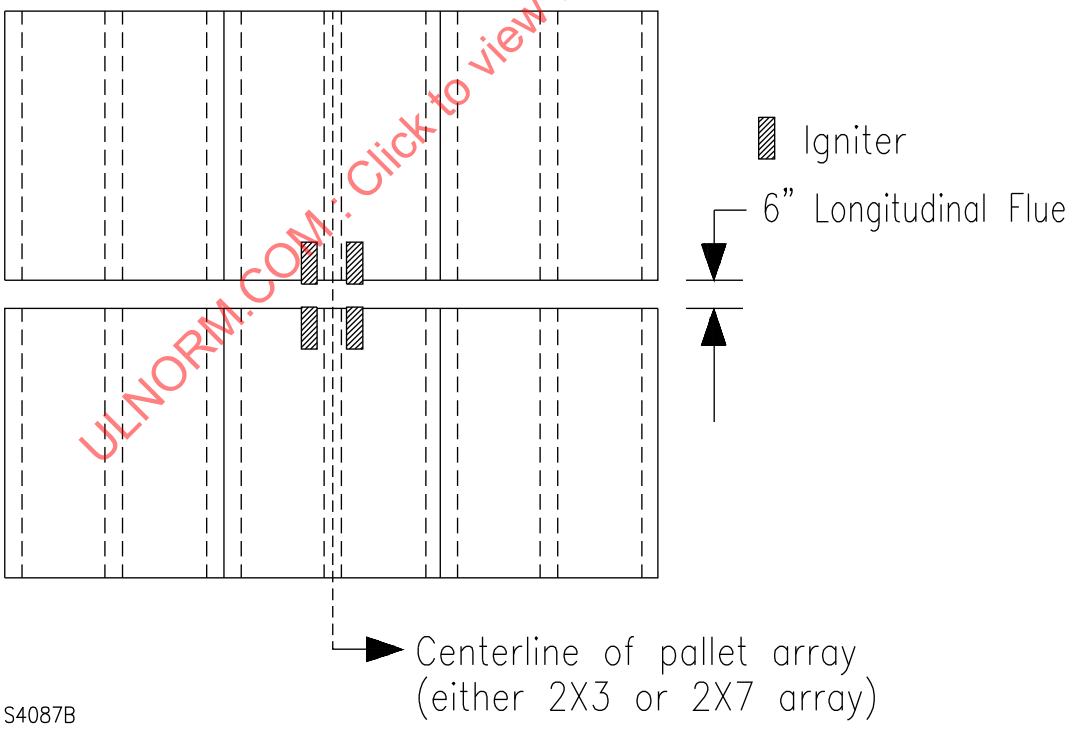
3.2.3 The sprinklers used for this test shall be in accordance with the Standard for Automatic Sprinklers for Fire-Protection, UL 199. The sprinklers shall be upright style with a rated temperature of 165°F (72°C). The sprinklers shall have a nominal discharge coefficient of 11.2 gpm/(psig$^{0.5}$). The sprinklers shall have a response time index (RTI) between 234 and 277 ft$^{0.5}$sec$^{0.5}$ when determined in accordance with the Standard for Early-Suppression Fast-Response Sprinklers, UL 1767.

3.2.4 The sprinklers shall be installed on a nominal 10 x 10 ft (3 x 3 m) spacing with their deflectors 3.0 ±1.0 inches (7.6 ±1.3 cm) below the ceiling.

3.3 Test procedure

3.3.1 Four igniters shall be positioned in the center of the array inside the bottom pallets as shown in Figure 3.2.

Figure 3.3
Igniter placement



3.3.2 Each igniter shall be constructed from a nominal 3-inch (76-mm) diameter by a nominal 6-inch (152-mm) long cellulosic bundle soaked with 8 ±0.125 fluid ounces (236 ±4 ml) of gasoline and wrapped in a polyethylene bag.

3.3.3 A minimum of 10 seconds of data is to be recorded prior to the ignition of the igniters.

3.3.4 As the sprinklers are activated the sprinkler system shall provide 60 ±3 gallons/min (227 ±11 L/min) of water to each activated sprinkler.

3.3.5 Flame propagation during the test is to be observed and the times at which the flame breaches any side of the array for a duration of 30 continuous seconds are to be recorded as referenced in Table 5.1.

3.3.6 A thermocouple tree shall be positioned at each end of the pallet array, perpendicular to the longitudinal flue space, as shown in Figure 3.1 and Figure 3.2. The thermocouple tree is to incorporate a minimum of twelve equally spaced, 0.0625 inch (1.5875 mm) diameter, inconel sheathed type K thermocouples along the vertical 12-ft. tall pallet stack arrangement.

3.3.7 The test is to be terminated when one of the following conditions occurs:

a) The fire is extinguished (see 3.3.8),

b) The total time elapsed from the ignition of the igniters reaches 30 minutes,

c) More than 6 sprinklers are activated, or

d) The average temperature on the 4-foot steel angle beam exceeds 200°F (93°C) for more than one minute.

3.3.8 In situations where the igniters fail to create a fire large enough to activate at least one sprinkler, the number of igniters shall be doubled and the test procedure repeated until at least one sprinkler is activated.

3.4 Calculations

3.4.1 The average steel angle beam temperature at any time, t, shall be calculated using the following formula:

$$T_{avg,t} = \frac{T_{1t} + T_{2t} + T_{3t} + T_{4t} + T_{5t}}{T_N}$$

in which:

$T_{avg,t}$ is the average temperature at any time, t, and

T_{1t}, T_{2t}, T_{3t}, T_{4t}, and T_{5t} are the temperatures measured by the five thermocouples (see 3.1.3) at any time, t. The number of temperature values in the numerator shall be permitted to be reduced if less than five thermocouples are functional. See 3.4.3, and

T_N is the number of temperature values in the numerator.

3.4.1 revised September 26, 2012

3.4.2 Based upon a 1-second scan interval, the running 60-second average temperature for the test shall be calculated as follows:

$$T_{60\,avg} = \frac{1}{60} \sum_{i=n}^{i=n+59} T_{avg,t,i}$$

in which:

T_{60avg} is the 60-second average and

n is the scan number (n=1,2,3,...etc.)

3.4.2 revised September 26, 2012

3.4.3 The maximum steel angle beam temperature is the maximum value of T_{60avg} during the test. If a thermocouple provides erroneous temperature measurements, the average temperature as referenced in 3.4.2 shall be permitted to be calculated using at least three functional thermocouples.

3.4.3 revised September 26, 2012

4 Commodity Storage Test

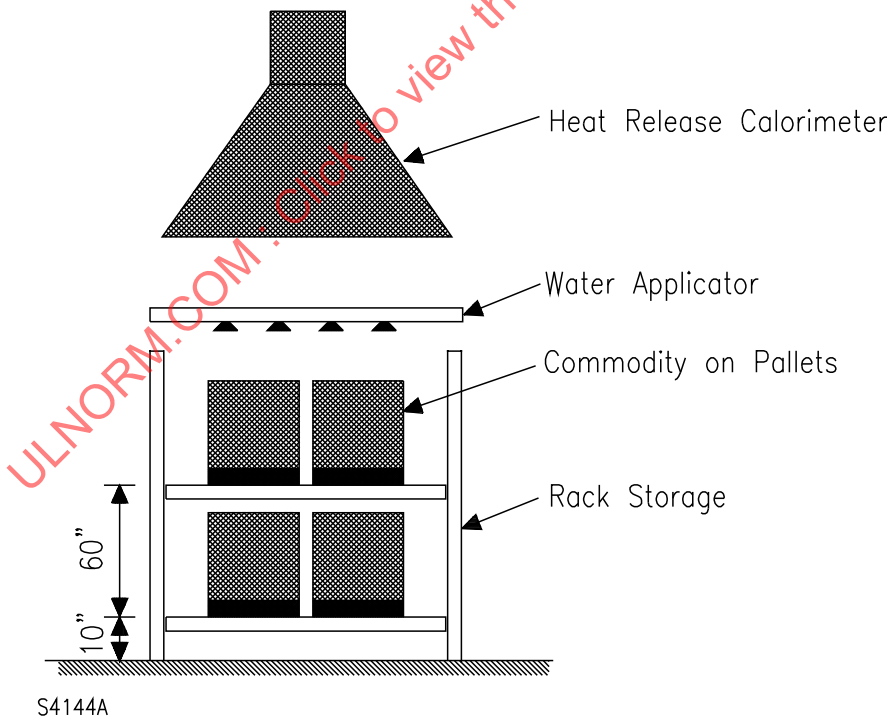
4.1 Test set-up

4.1.1 During the tests all doors and windows in the room shall be closed and the room otherwise controlled as necessary to prevent outside wind and weather conditions from influencing the test results. Tests are not to be conducted when the room temperature is less than 10°C (50°F) or more than 32°C (90°F).

4.1.2 The Commodity Storage Test shall be conducted using eight pallets of corrugated cartoned test commodity placed on the subject pallets and arranged in a 2 by 2 by 2 storage arrangement. The beams of the storage rack are adjusted so that the top of the lower beam is 10 ±1.0 inches (25.4 ±1.27 cm) from the floor, and the distance between the tops of the upper and lower beams is 60 ±1.0 inches (152 ±1.27 cm). The commodity is to be placed on the pallets so that there is a 6 ±0.25 inch (15.24 ±0.64 cm) flue space in each direction. See Figure 4.1. Each test commodity shall consist of double tri-wall corrugated cardboard cartons with five-sided (bottom open) steel stiffeners as referenced for Class II commodity described in the Standard for Automatic Sprinklers for Fire-Protection Service, UL 199. The moisture content of the cardboard boxes as measured in representative samples shall be 8 ±3 percent. For pallets that contain some wood components, the moisture content of the wood components, as measured in representative samples, shall not exceed 12 percent.

4.1.2 revised September 26, 2012

Figure 4.1
Commodity storage test set-up



4.1.3 As shown in Figure 4.1, the pallet loads of test commodity shall be centered under a heat release rate calorimeter consisting of a nominal 25 foot (7.6 m) diameter collection hood connected to an exhaust systems capable of drawing a nominal 60,000 CFM (28,317 L/second) from the test room. The heat release calorimeter shall be equipped with instrumentation to measure both convective and total heat release rates.

4.1.3 revised September 26, 2012

4.1.4 The commodities shall be placed on the pallets such that the sides of the commodity are flush with the sides of the pallets in the flue spaces between the pallets. See Figure 4.1.

4.1.4 revised September 26, 2012

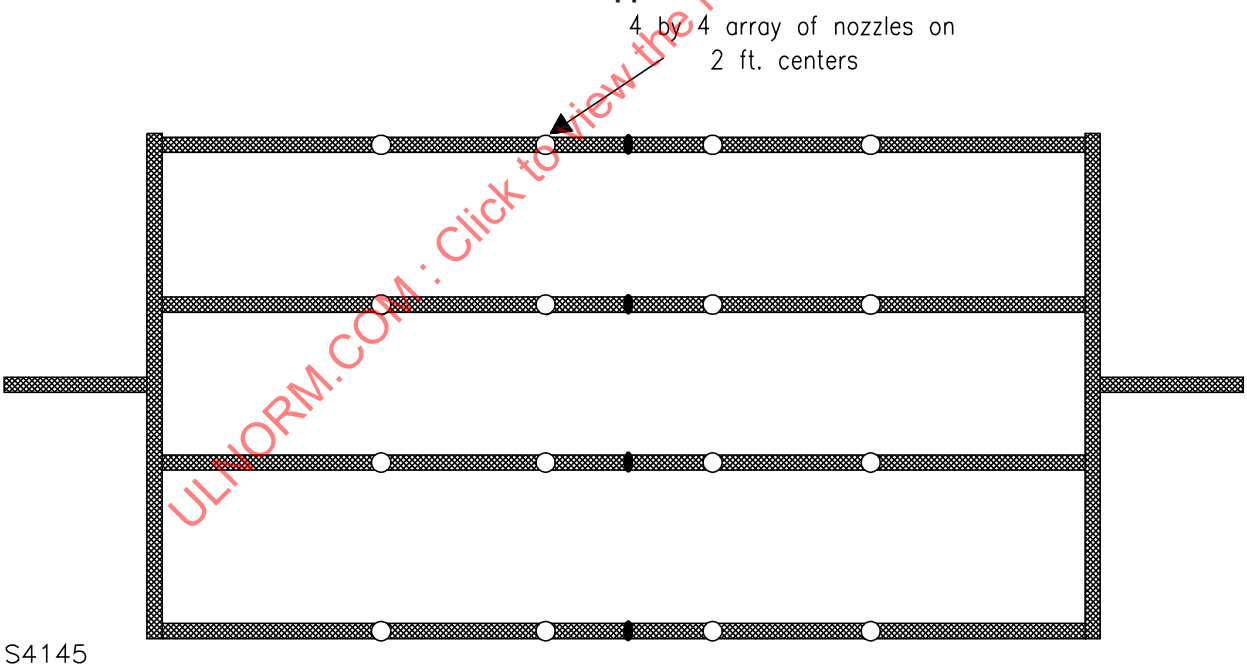
4.2 Water applicator

4.2.1 The nozzles in a water applicator shall be installed nominally 12 inches above the top of the commodity and provide a uniform water distribution over an 8 by 8-foot (2.4 by 2.4-meter) area at the top of the commodity.

4.2.2 The water applicator shall consist of four parallel insulated steel or stainless steel pipes with four spray nozzles along each pipe. See Figure 4.2.

4.2.2 revised September 26, 2012

Figure 4.2
Water applicator



4.3 Heat release rate

4.3.1 Total heat release rate

4.3.1.1 The total heat release rate shall be measured by a measurement system consisting of a paramagnetic oxygen analyzer, velocity probe, and a Type K thermocouple or equivalent. The instrumentation shall be located in the exhaust duct of the heat release rate calorimeter at a location that minimizes the influence of bends or exhaust devices.

4.3.1.2 The heat release rate measurement system shall be calibrated using an atomized heptane diffusion burner. The calibration shall be performed using flows of 1, 2, 3 and 4 gpm (3.8, 7.6, 11.4 and 15.2 l/min) of heptane. A burner constructed with Model F -80 -30, 70 degree PLP nozzles manufactured by Monarch Nozzle Co. has been found to be acceptable.

4.3.1.2 revised September 26, 2012

4.3.1.3 Calculate the heat release rate at each of the flows as follows:

$$HRR_t = 16.54 \times 10^3 V_e \frac{298}{T_e} A \frac{0.2095 - X_{02}}{1.076 - 1.36 X_{02}}$$

in which:

HRR_t is the total heat release rate (kW),

16.54 x 10^3 is kJ of energy per m^3 of oxygen consumed at 298K,

V_e is the exhaust velocity (m/s),

T_e is the temperature at the location where exhaust velocity is measured (K),

A is the exhaust duct area (m^2),

0.2095 is the ambient oxygen concentration,

X_{02} is the measured oxygen concentration,

1.076 is the chemical expansion factor for heptane, and

1.36 is the ratio of combustion products formed from burning heptane and oxygen consumption.

4.3.2 Convective heat release rate

4.3.2.1 The convective heat release rate shall be measured using thermopile, a velocity probe, and a Type K thermocouple, or equivalent, located in the exhaust system of the exhaust duct.

4.3.2.2 The convective heat release rate shall be calculated using the following equation:

$$HRR_c = V_e A \frac{353.22}{T_e} \int_{T_o}^{T} C_p dT$$

in which:

HRR_c is the convective heat release rate (kW),

A is the exhaust duct area (m^2),

V_e is the exhaust velocity (m/s),

T_e is the temperature at the location where exhaust velocity is measured (K),

$353.22/T_e$ is the density of air at the velocity measurement location (kg/m^3)

T_o is the ambient temperature (K) in the test room,

T is the thermopile temperature (K),

C_p is specific heat of air (kJ/kg-K), given as $C_p=A_0+A_1T+A_2T^2+A_3T^3$,

in which:

A_0 = 0.9950,

A_1 = -5.29933E-05,

A_2 = 3.21022E-07,

A_3 = -1.22004E-10, and

$$\int_{T_o}^{T} C_p\,dT = A_0(T - T_o) + A_1/2\,(T^2 - T_o^2) + A_2/3\,(T^3 - T_o^3) + A_3/4\,(T^4 - T_o^4)$$

4.4 Water application fire model

4.4.1 A validated fire model that predicts sprinkler response under a smooth, flat, horizontal ceiling for commodities stored in racks having heat release characteristics described in Appendix A is to be used to indicate when the water applicator is activated. The fire model uses the convective heat release rate and the parameters in Table 4.1 to determine sprinkler activation time.

4.4.1 revised September 26, 2012

Table 4.1
Values for determination of sprinkler activation time

Description	Value
Sprinkler activation time	286°F (141°C)
Sprinkler RTI	500 (ft-sec)$^{1/2}$ [276.1 (m-sec)$^{1/2}$]
Distance of heat responsive element below ceiling	7 inches (17.8 cm)
Radial distance of sprinkler to center of fire	7.1 ft (10 x 10 ft. sprinkler spacing) [2.2 m (3 x 3 m sprinkler spacing)]
Distance of ceiling to top of commodity	10 ft (3 m)
Number of storage tiers	2

4.5 Test procedure

4.5.1 Three commodity storage tests are to be conducted using a water discharge density of 0.11, 0.21, and 0.31 gpm/ft^2(4.5, 8.6, and 12.6 mm/min) respectively, applied to the top surface of the commodity.

4.5.2 Four igniters shall be placed on the bottom racks and each igniter shall be adjacent to one of the four pallets. Each igniter shall be constructed from a nominal 3-inch (76-mm) diameter by 3-inch (76-mm) long cellulosic bundle soaked with 4 ±0.125 fluid ounces (118 ±4 ml) of gasoline and wrapped in a polyethylene bag.

4.5.3 Instrumentation shall be present to record the water flow and the total and convective heat release rates at a minimum scan rate of 2 seconds.

4.5.4 A minimum of 10 seconds of data shall be recorded prior to ignition of the igniters.

4.5.5 The igniters shall be lit and the total and convective heat release rates shall be recorded. When the validated fire model indicates the sprinkler heat responsive element temperature exceeds 286°F (141°C) water shall be discharged through the water applicator at the water discharge density specified in 4.5.1.

4.5.5 revised September 26, 2012

4.5.6 The test is to be terminated when one of the following conditions occurs:

a) One or more cardboard box assemblies falls onto the floor outside the rack storage array during the 30 minutes of the most severe burning or

b) The total time elapsed from the ignition of the igniters reaches 30 minutes, unless at 30 minutes there is an indication of an increase in the heat release rate. In this case the test shall be continued until the data shows that the heat release rate is continuously decreasing.

4.5.6 revised September 26, 2012

4.6 Calculations

4.6.1 Calculate the heat release rates as in Section 4.5.

4.6.2 Determine the heat release parameters using the information in Table 4.2.

Table 4.2
Description of parameters

Parameter	Description
V1	Maximum one minute average of the total heat release rate
V2	Maximum one minute average of the convective heat release rate
V3	Effective convective heat release rate, defined as the average convective heat release rate measured over the five minutes of the most intense fire
V4	Convective Energy, the total convective energy measured over the ten minutes of most severe burning

4.6.3 The rank for each of the parameters shall be determined using the tables provided in Appendix A.

4.6.3 revised September 26, 2012

4.6.4 Calculate the mean unit rank (rounded to not less than the nearest 0.01 unit) for each test as an average of the rank of the heat release parameters as follows:

Mean Unit Rank = $[r(V_1)+r(V_2)+r(V_3)+r(V_4)]/4$

in which:

$r(V_1)$ is the rank of heat release rate parameter i (i=1,2,3,4).

4.6.4 revised September 26, 2012

4.6.5 Calculate the average of the three mean unit ranks calculated in 4.6.4 to determine the Classification rank which shall be rounded to the nearest 0.25 unit.

4.6.5 revised September 26, 2012

ACCEPTANCE CRITERIA

5 General

5.1 The pallets shall meet all of the criteria in Table 5.1.

Table 5.1
Acceptance criteria

Table 5.1 revised September 26, 2012

Test	Description	Acceptance criteria			
		Method A (2 x 3 array)		Method B (2 x 7 array)	
Idle Pallet Storage Test	Number of activated sprinklers	6 or less		6 or less	
	Steel angle temperature	Maximum 1 minute average to be less than 200°F (93°C)		Maximum 1 minute average to be less than 200°F (93°C)	
	Time for 30 seconds of continuous flame breach at any side of the array after ignition.	Vertical Plane A, see Figure 3.1	Vertical Plane B, see Figure 3.1	Vertical Plane A, see Figure 3.2	Vertical Plane B, see Figure 3.2
		Greater than 7 minutes	Greater than 7 minutes[a]	Greater than 7 minutes	Greater than 30 minutes[a](test duration)
Commodity storage test	Commodity classification	The Classification rank shall not be greater than 2.25. No individual test shall have a mean unit rank greater than 3.25.			
	Stack stability	One or more of the cardboard box assemblies shall not fall onto the floor outside the rack storage array during the 10 minutes of most severe burning.			
[a] In addition to flame spread for entire vertical plane B, temperatures measured at the vertical end plane of the longitudinal flue space shall be less than 1112°F (600°C) for the duration specified (see 3.3.6).					

REPORT

6 General

6.1 The report shall include the following:

a) Description of the product being tested,

b) Number of sprinklers activated during the Idle Pallet Test,

c) The maximum steel angle beam temperature (T_{60avg}) measured during the Idle Pallet Test as determined by 3.4.1 and 3.4.3,

d) The time at which the flame had spread to the end of the array in the Idle Pallet test,

e) If test commodity fell outside the rack storage array, the number of cardboard box assemblies that fell onto the floor outside the array during the 10 minutes of most severe burning (see stack stability criteria in Table 5.1) and

f) The mean unit rank for each of the three commodity storage (see 4.6.4)tests and the Classification Rank (see 4.6.5).

6.1 revised September 26, 2012