UL 2431

STANDARD FOR SAFETY

Durability of Fire Resistive Coatings and Materials

UL Standard for Safety for Durability of Fire Resistive Coatings and Materials, UL 2431

Second Edition, Dated October 15, 2014

Summary of Topics

This revision of ANSI/UL 2431 dated January 30, 2025 includes changes in requirements for Irradiance Levels for Lamps in Table 5.3.

Text that has been changed in any manner or impacted by ULSE's electronic publishing system is marked with a vertical line in the margin.

These revised requirements are substantially in accordance with Proposal(s) on this subject dated November 1, 2024.

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UL 2431

Standard for Safety for Durability of Fire Resistive Coatings and Materials

The first edition was titled “Standard for Safety for Durability of Spray-Applied Fire Resistive Coatings

First Edition –August, 2007

Second Edition

October 15, 2014

This ANSI/UL Standard for Safety consists of the Second Edition including revisions through January 30, 2025.

The most recent designation of ANSI/UL 2431 as an American National Standard (ANSI) occurred on January 30, 2025. 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 ULSE at any time. Proposals should be submitted via a Proposal Request in the Collaborative Standards Development System (CSDS) at https://csds.ul.com.

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INTRODUCTION

1 Scope

1.1 This standard is intended to provide a means to measure the ability of fire resistive materials to retain their fire resistive properties after being subjected to various conditioning environments. The fire resistive performance is determined by measuring temperatures of steel tubes, wide flange sections and plates protected by the materials.

1.2 Various types of conditioning environments are described. The conditioning environments include air erosion, a combination of wet, freeze and dry cycling, humidity, impact resistance, industrial atmosphere, salt spray, temperature stability, ultraviolet light, and vibration.

1.3 Two fire exposures are defined, a normal temperature rise fire and a rapid temperature rise fire. The normal temperature rise fire is intended to represent a fully developed interior building fire. The rapid temperature rise fire is intended to represent a hydrocarbon pool fire.

1.4 The conditioning environments and fire exposure tests are not intended to be representative of all exposure and fire conditions. With respect to fire exposure, conditions vary with changes in the amount, nature, and distribution of fire loading: ventilation; compartment size and configuration; and heat conducting and dissipating characteristics of the compartment in which the fire resistive material is installed.

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.

3 Glossary

3.1 For the purpose of this Standard the following definitions apply.

3.2 CONDITIONING ENVIRONMENT – Exposures intended to simulate conditions potentially experienced by protective coating systems after application to steel surfaces.

3.3 CONDITIONED INTERIOR SPACE – Interior locations where the relative humidity and the temperature are controlled according to the manufacturer’s recommendations. The maximum recommended relative humidity is not to be more than 75 percent during the application and curing of the fire resistive material.

3.4 CONDITIONING SAMPLE(S) – A maximum of two test samples that is to be or has been subjected to the conditioning environment as specified in Conditioning Environments, Section 5.

3.5 CONTROL SAMPLE – A prepared sample intended to provide a performance comparison benchmark with a test sample; unlike a test sample, a control sample is not subjected to any identified conditioning environment, such as temperature stability, humidity, air erosion or the like.

3.6 FIRE RESISTIVE MATERIAL – Any material intended to extend the fire resistance rating of bare structural steel. These materials include, but are not limited to, spray-applied fire resistive materials (SFRM's) and paint type coatings such as mastic and intumescent coatings.

3.7 PROTECTIVE COATING SYSTEM – All materials added to the steel section such as a primer, insulating coating, reinforcement mesh and surface sealer required for fire resistive performance.

3.8 LIMITING TEMPERATURE TIME – The time period in minutes determined by the first occurrence steel sample(s) reaching 1000°F (538°C) as measured by the four thermocouples on the tube, wide flange or steel plate sample, or the time when one thermocouple reaches a temperature of 1200°F (649°C). The average thickness of fire resistive material on each steel sample used to determine the reference period is to be within 10 percent of the standard deviation as determined from the population consisting of the average fire resistive material thickness calculated for each sample used in the investigation.

3.9 SAMPLE SET – The minimum number of samples required for evaluation of a specific conditioning exposure.

Note: For example, a sample set for a II-A-3 condition (Indoor, Exposed Non-Controlled Temperature and Humidity Environment) will consist of ≥ 2 control samples, ≥ 2 temperature stability samples, ≥ 2 UV samples, ≥ 2 High Humidity samples, ≥ 2 Air Erosion samples, ≥ 2 Impact samples and ≥ 2 Vibration samples.

3.10 STRUCTURAL STEEL SECTION – A steel member used for the application of the protective coating material under investigation. These sections may consist of steel tubes (hollow structural steel), wide flange or plate configurations.

3.11 TARGET DENSITY – The density of the SFRM or other protective coating system selected for evaluation on application to the steel section.

3.12 TARGET THICKNESS – A thickness of the protective coating system selected for evaluation on application to the steel section. The thickness of protective coating system shall be sufficient such that the average temperature of the control sample reaches 1000°F (538°C) in not less than 60 minutes as measured by the four thermocouples within the steel sample. The maximum temperature at the time when the average temperature is 1000°F (538°C) shall not be greater than 1200°F (649°C).

3.13 UNCONDITIONED INTERIOR SPACE – Interior locations where conditions do not meet requirements for conditioned interior space.

PERFORMANCE

4 General

4.1 General

4.1.1 The steel section used for the conditioning sample(s) and the control sample(s) for a specific conditioning environment shall be the same size.

4.2 Steel tube sections

4.2.1 Each steel tube section shall be a 6 x 6 x 3/16 inches hollow structural section as described in the Manual of Steel Construction, published by AISC. The tube sample shall consist of a 24 inches (610 mm) long steel section with a 0.25 inch (6.4 mm) thick steel plate at each end. Each steel tube section and both steel plates shall be coated with the protective coating system under investigation. The area of the steel plates shall be sufficient to provide resistance to the expansion of the protective coating system applied on the steel section. The ends of the specimen, including the means for restraint, are to be given sufficient thermal insulation to prevent appreciable direct heat transfer through the ends of the column.

4.2.2 Wide flange sections

4.2.2.1 Wide flange steel sections shall consist of a 24 inches (610 mm) long steel section with a 0.25 inch (6.4 mm) thick steel plate at each end. Each wide flange section and both steel plates shall be prepared with the protective coating system under investigation. The area of the steel plates shall be sufficient to provide resistance to the expansion of the protective coating system applied on the steel section. The ends of the specimen, including the means for restraint, are to be given sufficient thermal insulation to prevent appreciable direct heat transfer through the ends of the column.

4.2.3 Steel Plates

4.2.3.1 Steel plates of minimum size 8-inch x 8-inch (200 mm x 200 mm) with a nominal thickness of 3/16-inch (5 mm) shall be used while conducting the combined Temperature stability, UV & High humidity environmental exposure specified in Classification Categories I-A and I-B in Table 5.2, and the UV environmental exposure as specified in Classification Category II-A-3 in Table 5.3. A maximum of 0.5-inches (12.7 mm) of the steel plate edges shall be treated with an anti-corrosion material. Where necessary, reinforcement shall be used to ensure bond of the material to the steel plate.

4.2.4 Thermocouples

4.2.4.1 Each steel tube and wide flange section shall include a set of four thermocouples of the same gauge and response time. Such thermocouples shall be a maximum 14 gauge and minimum 18 gauge of Type K and fusion welded at the end to be in contact with the test specimen.

4.2.4.2 Each steel plate section shall include a set of four thermocouples of the same gauge and response time. A thermocouple assembly may be used in lieu of the thermocouple specified in 4.2.4.1. Each thermocouple assembly shall consist of thermocouple wires having a diameter of not more than 0.03 inch with each thermocouple wire brazed to the center of the face of a copper disk 0.5 inch in diameter and 0.01 inch thick. Each thermocouple or thermocouple assembly for steel plates shall be located under a minimum 2 x 2 inch pad as specified in Appendix A and secured to the surface of the specimen at the required position. The thermocouples for all steel samples shall be located as shown in Figure 4.1 – Figure 4.3.

4.2.4.3 *Deleted*

4.2.4.4 *Deleted*

Figure 4.1

Steel tube sample – thermocouple locations

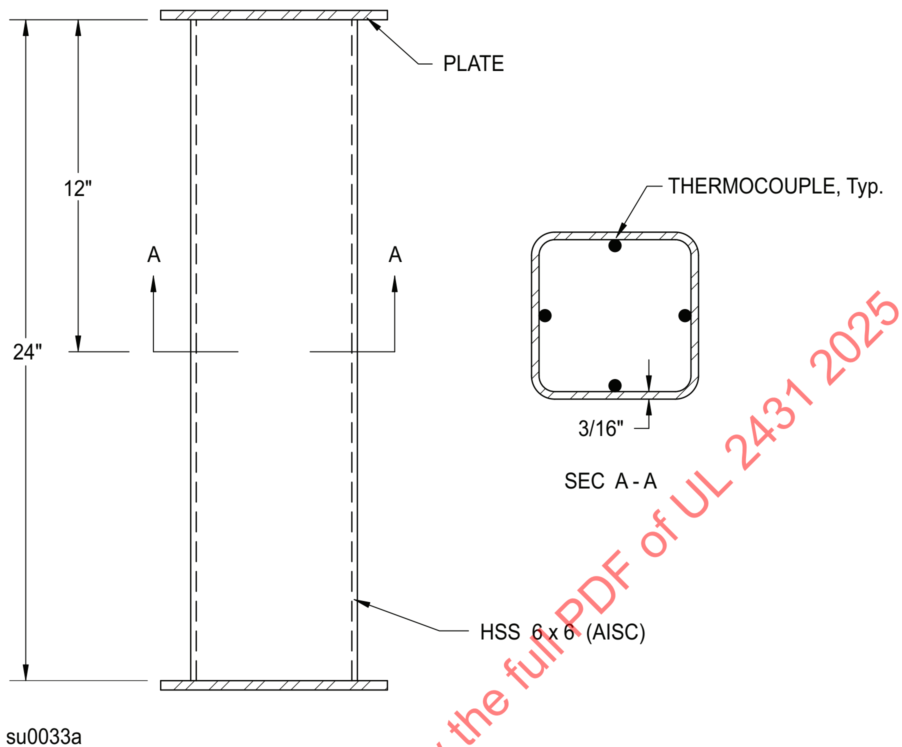


Figure 4.2

Steel wide flange sample – thermocouple locations

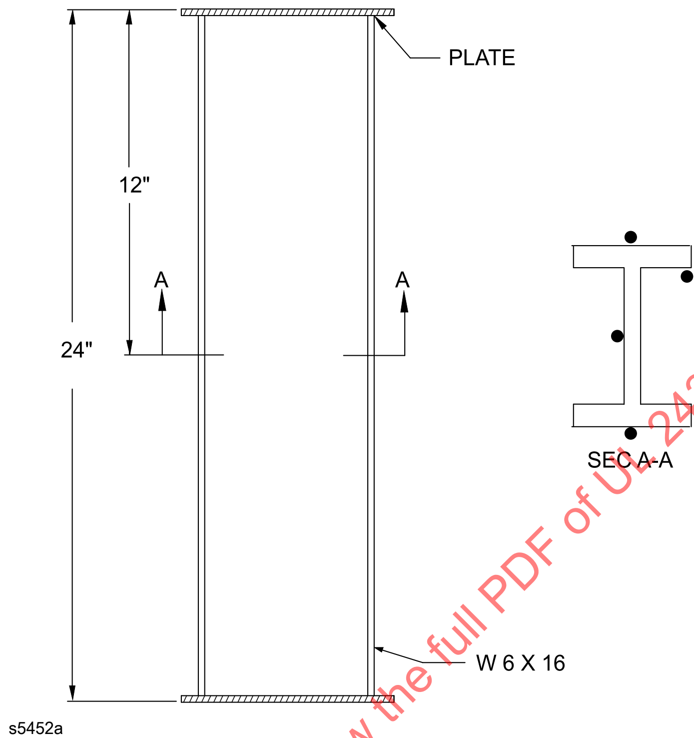
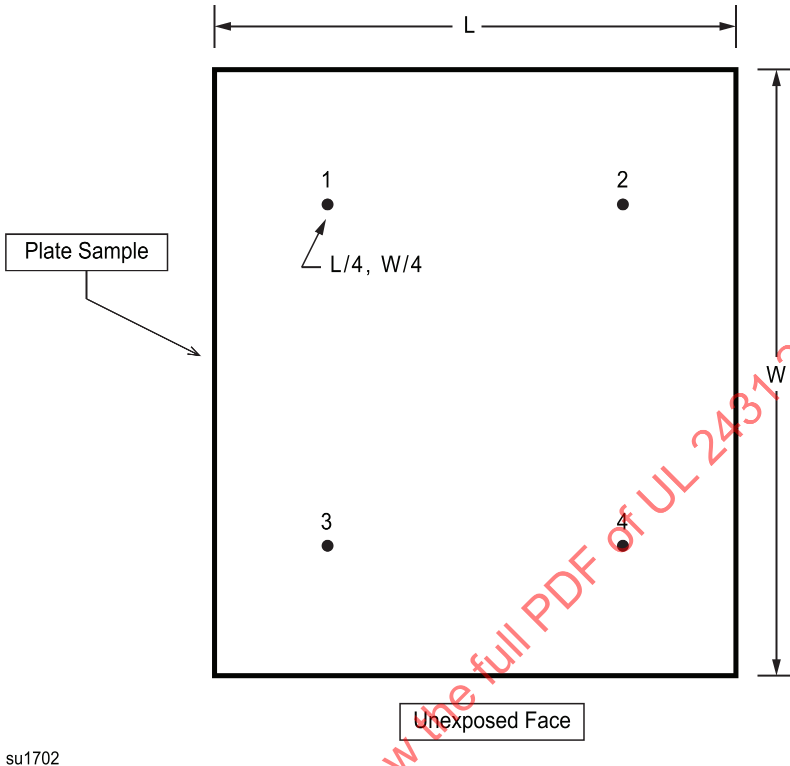


Figure 4.3

Steel plate sample – thermocouple locations



4.2.5 Thickness

4.2.5.1 The thickness of the protective coating system on each tube or wide flange sample shall be determined by measurements made at the locations shown on Figure 4.4 through Figure 4.6. The thickness of the protective coating system on the steel plate sample shall be determined by 10 measurements made at the locations shown on Figure 4.6.

Figure 4.4

Steel tube sample – location of thickness measurements

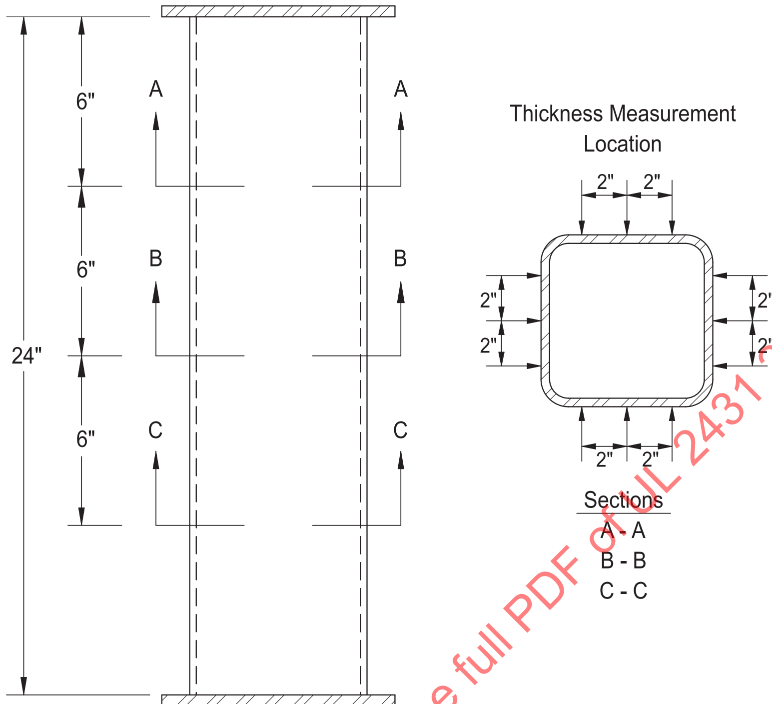


Figure 4.5

Steel wide flange sample – location of thickness measurements

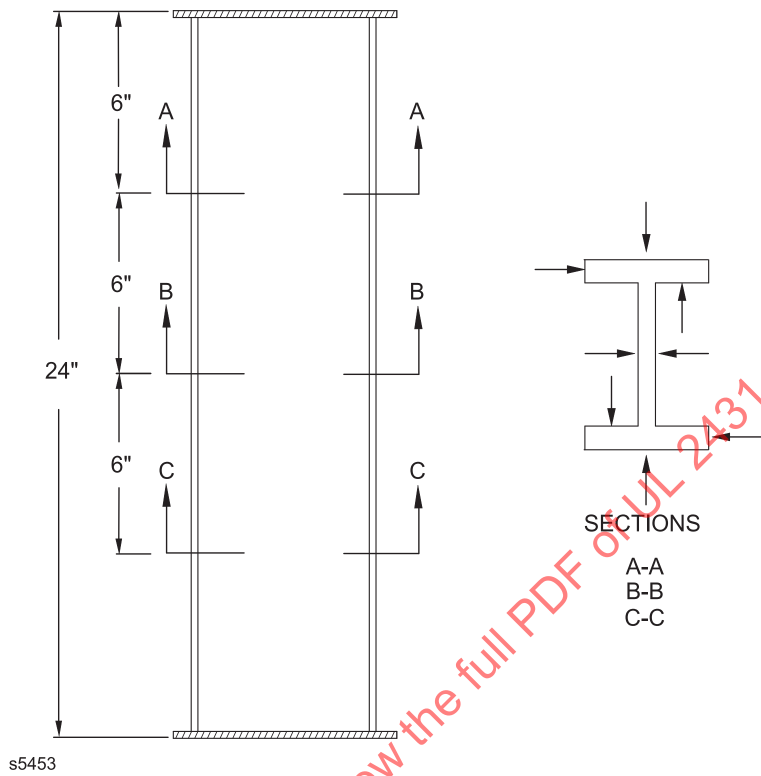
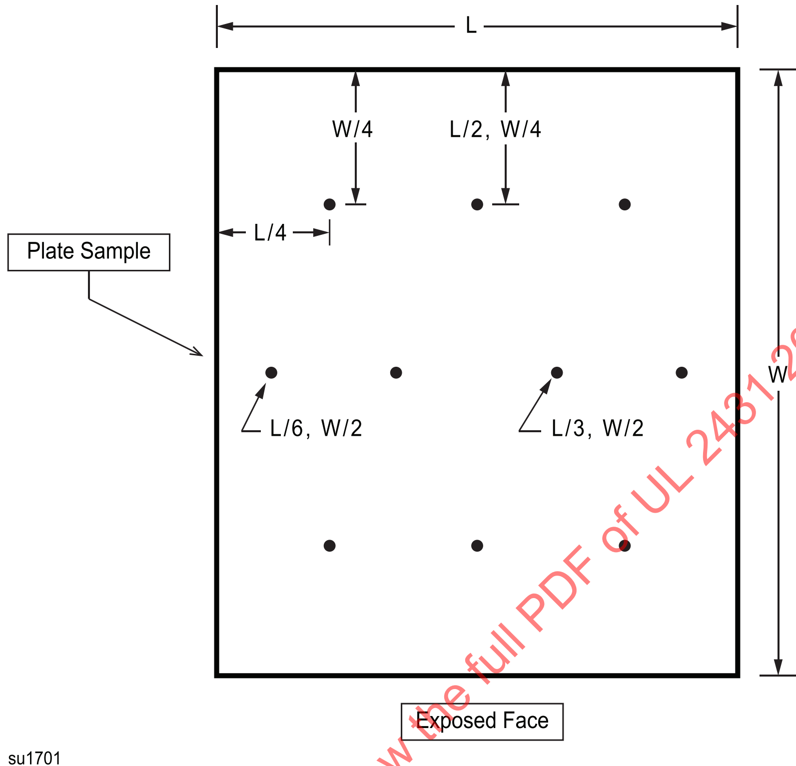


Figure 4.6

Steel plate sample – location of thickness measurements



4.2.5.2 The device used to measure the thickness of the SFRM shall comply with the requirements in the Standard Test Method for Thickness and Density of Sprayed Fire-Resistive Material (SFRM) Applied to Structural Members, ASTM E605.

4.2.5.3 The device used to measure the thickness of a paint coating type of fire resistive material shall comply with the requirements for Type 2 gauge in the Standard Practice for Nondestructive Measurement of Dry Film Thickness of Nonmagnetic Coatings Applied to Ferrous Metals and Nonmagnetic, Nonconductive Coatings Applied to Non-Ferrous Metals, ASTM D7091.

4.2.5.4 The coating thickness of the protective coating system at all locations on a sample shall be within ± 20 percent of the average thickness.

4.2.5.5 The average protective coating system thickness of the samples shall be within ±5 percent of each other.

4.2.5.6 Samples shall be corrected for A/P, W/D and thickness variations within the sample set, where A is the cross-sectional area of a tube section, W is the weight per linear foot of a wide flange section and P is the heated perimeter of steel section in accordance with Section 11.3.3.

4.3 Protective coating system

4.3.1 SFRM type

4.3.1.1 For each target thickness of SFRM, the density of the SFRM shall be determined in accordance with 4.3.1.2 – 4.3.1.4.

4.3.1.2 The protective coating shall be applied to three 0.06 in (1.5 mm) thick, 16 by 16 in (406 by 406 mm) bare or galvanized steel plates for each application day. The protective coating system applied to the density plates shall be mixed and applied in the same manner to the product applied to the test samples.

4.3.1.3 The density shall be determined by following the procedure described in the Standard Test Method for Thickness and Density of Sprayed Fire-Resistive Material Applied to Structural Members, ASTM E605.

4.3.1.4 Each density measurement of the protective coating system shall be within ±15 percent of the target density.

4.3.2 Paint type

4.3.2.1 For paint type coatings, determine the percent solids in accordance with the Standard Test Method for Volatile Content of Coatings, ASTM D2369. Each solids measurement of the protective coating system shall be within ±3 percent of the target solids content.

4.3.3 Other type

4.3.3.1 For other type coatings the physical and chemical properties of the coatings materials shall be measured and documented by the testing laboratory.

5 Conditioning Environments

5.1 General

5.1.1 Table 5.1 identifies the classification categories for fire resistive materials and the related applications.

Table 5.1
Fire resistive material classification categories

Classification category	Application
I-A	Outdoor, Heavy Industrial
I-B	Outdoor, General Use
II-A-1	Indoor, Concealed, Controlled Temperature and Humidity Environment
II-A-2	Indoor, Concealed, Elevator Shafts
II-A-3	Indoor, Exposed Non-Controlled Temperature and Humidity Environment

5.1.2 Table 5.2 and Table 5.3 specify the exposure type and exposure details for each classification category. A fire resistive material is to be subjected to the exposures specified for the classification category the material is seeking. A fire resistive material test sample is to be subjected to one exposure prior to a fire test. A test sample is to be tested for each exposure specified.

Table 5.2
Outdoor location exposures

Exposure	Classification category I-A	Classification category I-B
Temperature stability, UV & High humidity	In accordance with the procedures specified in the Standard Practice for Fluorescent UV-Condensation Exposures of Paint and Related Coatings, ASTM D4587, for 5000 h (8 h UV at 158°F ±5°F (70 ±2.8°C), 4 h condensation at 122°F ±5°F (50 ±2.8°C))	In accordance with the procedures specified in the Standard Practice for Fluorescent UV-Condensation Exposures of Paint and Related Coatings, ASTM D4587, for 5000 h (8 h UV at 158°F ±5°F (70 ±2.8°C), 4 h condensation at 122°F ±5°F (50 ±2.8°C))
Air erosion	In accordance with the procedures specified in the Standard Test Method for Air Erosion of Sprayed Fire-Resistive Materials (SFRMs) Applied to Structural Members, ASTM E859, at a speed of 60 mph (96.6 km/h).	In accordance with the procedures specified in the Standard Test Method for Air Erosion of Sprayed Fire-Resistive Materials (SFRMs) Applied to Structural Members, ASTM E859, at a speed of 60 mph (96.6 km/h).
Salt spray	In accordance with the procedures specified in the Standard Practice for Operating Salt Spray (Fog) Apparatus, ASTM B117.	In accordance with the procedures specified in the Standard Practice for Operating Salt Spray (Fog) Apparatus, ASTM B117.
Combination wet/freeze/dry cycling	A cycle consisting of the equivalent of rainfall at the rate of 0.7 in/h (0.005 mm/s) of water for 72 h, followed by a temperature of minus 40 ±5°F (minus 40 ±2.8°C) for 24 h, and then a dry atmosphere of 140 ±5°F (60 ±2.8°C) for 72 h. This cycle is to be repeated twelve times.	A cycle consisting of the equivalent of rainfall at the rate of 0.7 in/h (0.005 mm/s) of water for 72 h, followed by a temperature of minus 40 ±5°F (minus 40 ±2.8°C) for 24 h, and then a dry atmosphere of 140 ±5°F (60 ±2.8°C) for 72 h. This cycle is to be repeated twelve times.
Industrial atmosphere CO_2/SO_2	The sulfur dioxide (SO_2) content and carbon dioxide (CO_2) content of an industrial atmosphere may be simulated by exposing the samples for 30 days to an amount of SO_2 equivalent to 1 percent of the volume of the test chamber, and an equal volume of CO_2. The test chamber is to be maintained at 95 ±3°F (35 ±1.7°C) and a small amount of water is to be maintained at the bottom of the chamber.	–
Specific chemical exposure (optional)	Samples may be sprayed with reagent grade solvents at 70 ±5°F (21 ±2.8°C). Typical solvents are acetone and toluene. The solvent spray exposure is to be applied with a paint spray gun until the entire surface area of the sample is completely covered with solvent that is not absorbed by the protective coating and excess solvent runs off the sample. An exposure cycle is to consist of application of the solvent, drying of the sample for 6 h, application of the solvent and drying of the sample for 18 h. The exposure cycle shall be repeated five times.	–
High impact resistance	2 in (50.8 mm) steel ball dropped from 20 ft (6.1 m) distance through 3 inch (76.2 mm) diameter pipe	2 in (50.8 mm) steel ball dropped from 20 ft (6.1 m) distance through 3 inch (76.2 mm) diameter pipe
Vibration	See Table 5.5. Frequency shall be 10 – 60 Hz (5 min exposure at each 2 Hz increment) plus 2 h exposure at the maximum resonance or at 60 Hz should no resonance be observed during the variable frequency test.	See Table 5.5. Frequency shall be 10 – 60 Hz (5 minutes exposure at each 2 Hz increment) plus 2 h exposure at the maximum resonance or at 60 Hz should no resonance be observed during the variable frequency test.

Table 5.3
Indoor location exposures

Exposure	Classification category II-A-1	Classification category II-A-2	Classification category II-A-3
Temperature stability	2000 h at 120°F (49°C)	2000 h at 120°F (49°C)	In accordance with the procedures specified in the Standard Practice for Operating Fluorescent Ultraviolet (UV) Lamp Apparatus for Exposure of Materials, ASTM G154, for 2000 h with UVA-351 lamps at 120°F (49°C). The irradiance level of the lamps is 0.76 W / (m^2 x nm).
UV	–	–	
High humidity	10 days at 97 – 100 percent and 96°F ±3°F (36 ±1.7°C)	180 days at 97 – 100 percent and 96°F ±3°F (36 ±1.7°C)	180 days at 97 – 100 percent and 96°F ±3°F (36 ±1.7°C)
Air erosion	In accordance with the procedures specified in the Standard Test Method for Air Erosion of Sprayed Fire-Resistive Materials (SFRMs) Applied to Structural Members, ASTM E859, at a speed of 12.5 mph (20.1 km/h)	In accordance with the procedures specified in the Standard Test Method for Air Erosion of Sprayed Fire-Resistive Materials (SFRMs) Applied to Structural Members, ASTM E859, at a speed of 29 mph (46.6 km/h)	In accordance with the procedures specified in the Standard Test Method for Air Erosion of Sprayed Fire-Resistive Materials (SFRMs) Applied to Structural Members, ASTM E859, at a speed of 12.5 mph (20.1 km/h)
Impact resistance	1.25 inches (31.8 mm) steel ball dropped from 12 ft (3.6 m) distance through 2 inch (50.8 mm) diameter pipe	1.25 inches (31.8 mm) steel ball dropped from 12 ft (3.6 m) distance through 2 inch (50.8 mm) diameter pipe	1.75 inches (44.5 mm) steel ball dropped from 17 ft (5.2 m) distance through 3 inch (76.2 mm) diameter pipe
Vibration	See Table 5.5. Frequency shall be 10 – 18 Hz exposure (5 minutes exposure at each 2 Hz increment) plus 1 h exposure at 18 Hz	See Table 5.5. Frequency shall be 10 – 40 Hz exposure (5 minutes exposure at each 2 Hz increment) plus 1.5 h exposure at 40 Hz	See Table 5.5. Frequency shall be 10 – 40 Hz (5 minutes exposure at each 2 Hz increment) plus 1.5 h exposure at the maximum resonance or at 40 Hz should no resonance be observed during the variable frequency test.

5.2 Temperature stability

5.2.1 The test sample is to be placed in a circulating air-oven for the time and temperatures specified in the applicable classification category of the fire resistive material. See Table 5.2 and Table 5.3.

5.3 Air erosion

5.3.1 The test sample is to be subjected to air erosion resulting from the exposure as specified in the applicable classification category of the fire resistive material. See Table 5.2 and Table 5.3.

5.4 Combination wet, freeze, and dry cycling

5.4.1 The test sample is to be cycled between a water exposure, freezing temperatures and a heated dry atmosphere as specified in the applicable classification category of the fire resistive material. Prior to the test sample being exposed to the freeze cycle the test sample is to be tested in the wet condition, without returning it to equilibrium moisture content. See Table 5.2.

5.5 Humidity

5.5.1 The test sample is to be placed in a chamber with a humidity of 97 – 100 percent at 96 ±3°F (35 ±1.5°C) for the duration specified in the applicable classification category of the fire resistive material. See Table 5.3.

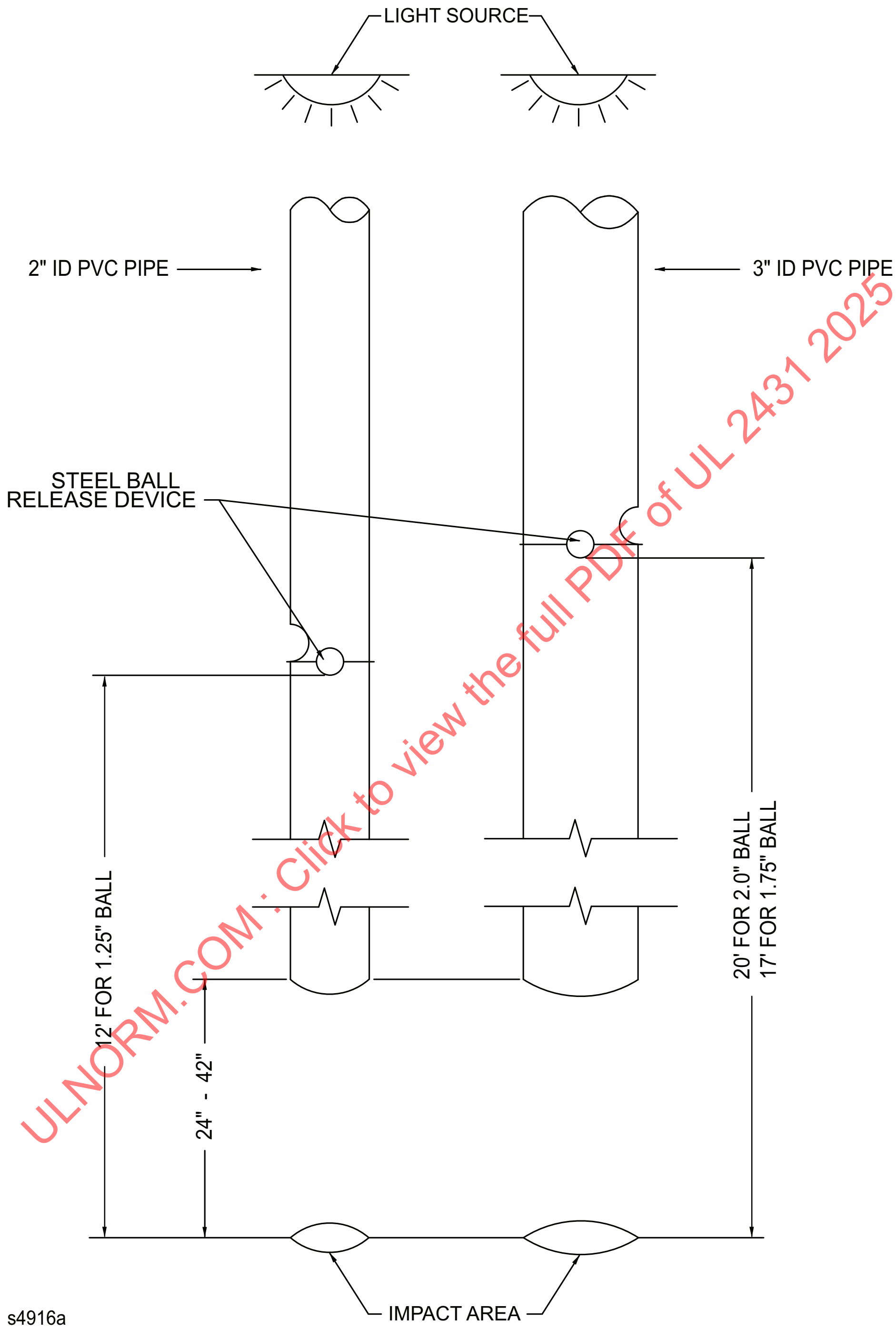
5.6 Impact resistance

5.6.1 The test sample is to be subjected to impact loads. The impact loads are to be applied by dropping a steel ball onto the test sample at two locations on each face. The drop height mass and diameter of the steel ball is to be as specified in the applicable classification category of the fire resistive material. See 5.6.2 – 5.6.4 for additional test details. See Table 5.2 and Table 5.3.

5.6.2 The test apparatus is shown on Figure 5.1. The test apparatus is to consist of lengths of 2 inches (50.8 mm) diameter (ID) and 3 inches (76.2 mm) diameter (ID) pipe secured vertically over the test specimen. Drop positions are to be located to provide for the release of the steel ball down the centerline of the pipe from the drop heights specified for each size (diameter) of steel ball. The 2 inches (50.8 mm) diameter pipe is to be used for the 1.25 inches (31.8 mm) balls. The 3 inches (76.2 mm) diameter pipe is to be used for the 1.75 and 2.00 inches (44.5 and 50.8 mm) steel balls.

Figure 5.1

Impact test apparatus



Notes:

The length of the pipe is not critical. Ball must be able to drop straight.

1 inch = 25.4 mm

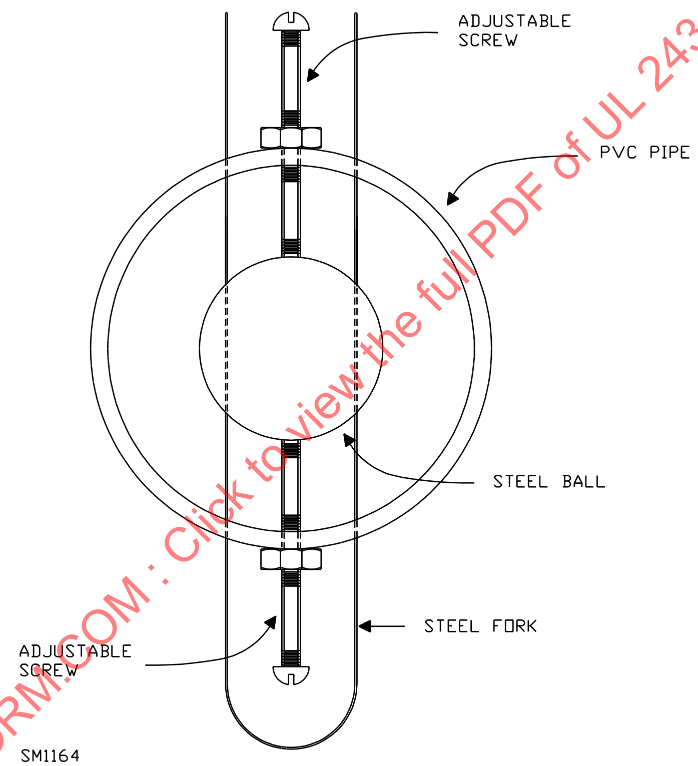
1 ft = 0.305 m

5.6.3 The steel balls (chrome or stainless) are to be 1.25 ±0.01 inches (31.8 ±0.25 mm), 1.75 ±0.01 inches (44.5 ±0.25 mm), and 2.00 ±0.01 inches (50.8 ±0.25 mm) inches diameter, weighing 0.28 ±0.01 lb (126.9 ±4.5 g), 0.79 ±0.04 lb (358.2 ±18 g) and 1.15 ±0.04 lb (521.4 ±18 g), respectively, with a Rockwell C hardness of 57 to 66.

5.6.4 The release device is to be designed so as to assure a straight drop down to the sample surface. A sketch of an acceptable device is shown in Figure 5.2. Release is achieved by sliding the fork from the pipe, thereby allowing the ball to fall between the adjustable screws down the centerline of the pipe. Other release devices are acceptable when the objective of assuring a straight drop of the steel ball to the sample surface is met.

Figure 5.2

Release device for impact test apparatus



5.6.5 The size of the steel ball and the drop height of the ball are to be as specified in Table 5.4.

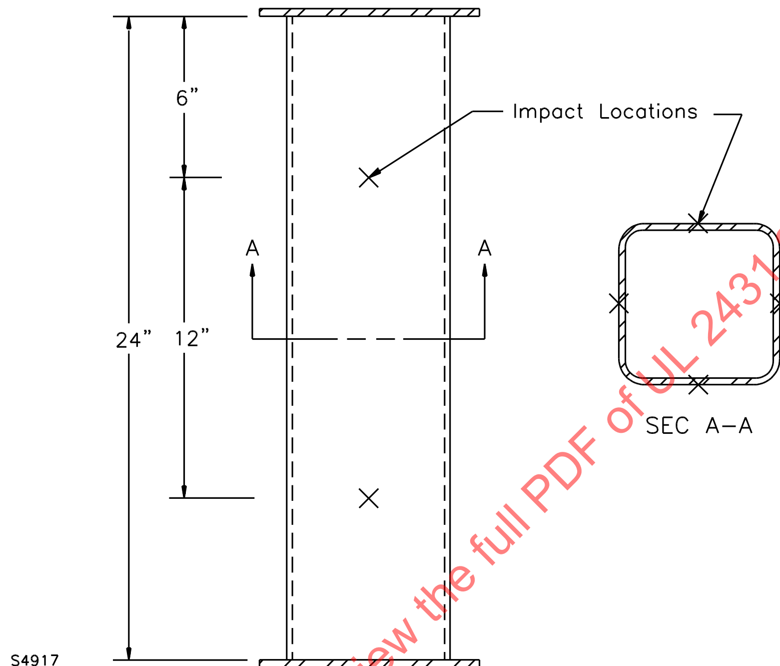
Table 5.4
Drop height and kinetic energy

Steel ball diameter		Distance		Kinetic energy	
in	(mm)	ft	(mm)	ft-lb	J
1.25	(31.8)	12.0	(3700)	3.36	4.56
1.75	(44.5)	17.0	(5200)	13.43	18.21
2.00	(50.8)	20.0	(6100)	23.00	31.19

5.6.6 An impact exposure is to consist of dropping one size of steel ball at the eight locations specified in Figure 5.3. The impact test is to be conducted in a room at a temperature of 70 ±5°F (21.1 ±2.8°C).

Figure 5.3

Steel tube sample – Impact test locations



Note: 1 in = 25.4 mm

5.7 Industrial atmosphere

5.7.1 The test sample is to be exposed to a CO_2/SO_2 atmosphere as specified in the applicable classification category of the fire resistive material. See Table 5.2.

5.7.2 The test sample is to be exposed to any optional chemical exposure desired for evaluation.

5.8 Salt spray

5.8.1 The test sample is to be exposed to a salt spray atmosphere for a minimum of 90 days as specified in the applicable classification category of the fire resistive material. See Table 5.2.

5.9 Ultraviolet light

5.9.1 Two levels of ultraviolet light exposure are specified. One level is to be used for fire resistive materials intended for indoor use and the other level is to be used for fire resistive materials intended for outdoor applications. See Table 5.2 and Table 5.3.

5.10 Vibration

5.10.1 The test sample is to be subjected to a variable frequency test and an endurance test in each of the three rectilinear orientation axes, horizontal, lateral and vertical. Both the variable frequency test and the endurance test are to be completed in one plane of vibration before the test sample is moved to another plane. See Table 5.2 and Table 5.3.

5.10.2 For the variable frequency test, the test sample is to be vibrated at frequencies specified in Table 5.2 and Table 5.3 at discrete frequency intervals of 2 Hz. For each frequency, the table displacements shall be as specified in Table 5.5. The vibration is to be maintained for 5 minutes at each frequency. During the variable frequency test, determine the frequency that produces maximum resonance.

Table 5.5
Vibration exposure

Frequency of vibration	Table displacement		Amplitude	
Hz	in	(mm)	in	(mm)
10 – 18	0.060 ±0.006	(1.52 ±0.15)	0.030 ±0.003	(0.76 ±0.08)
20 – 38	0.040 ±0.004	(1.0 ±0.1)	0.020 ±0.002	(0.51 ±0.05)
40 – 60	0.020 ±0.002	(0.51 ±0.05)	0.010 ±0.001	(0.25 ±0.03)

5.10.3 Resonance is defined as the maximum magnification of the applied vibration.

6 Fire Test

6.1 The test equipment and test sample are to be protected from any condition of wind or weather that influences the test results. The test sample at the beginning of the test is to be within the range of 50 to 90°F (10 to 32°C). The test sample is not to be tested until it has reached a defined equilibrium (i.e. constant weight) with an ambient atmosphere of 50 percent relative humidity at 73°F (23°C) unless otherwise specified (see 5.4.1).

6.2 Accelerated conditioning to achieve constant weight of the test assembly is not prohibited provided the method does not alter the properties of component materials. It is the responsibility of the laboratory conducting the test to avoid procedures that will significantly alter the structural or fire resistance characteristics of the test sample.

6.3 Observations of the test assembly are to be made throughout the fire test. All significant observations, such as deformation, cracking, development of openings, and burning of the test sample are to be recorded.

6.4 The temperatures in the furnace chamber and on the test sample are to be read at intervals not exceeding 1 minute throughout the fire test.

7 Test Furnace

7.1 The furnace chamber is to be designed to provide uniform heating to all surfaces of the protective coating system.

8 Time-Temperature Curves

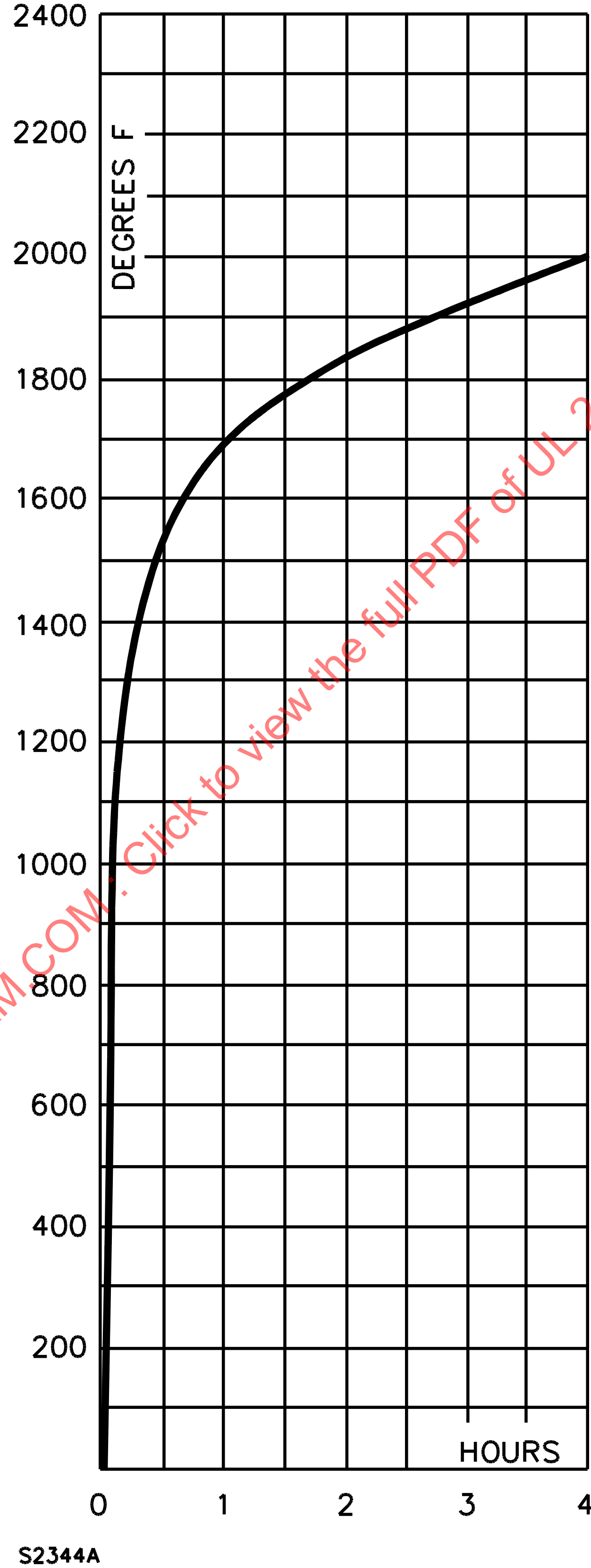
8.1 Normal temperature rise curve

8.1.1 The temperature in the test furnace is to follow the standard time-temperature curve shown in Figure 8.1 when the temperatures are to represent a normal temperature rise fire. For a more precise definition of the normal temperature rise curve, see Appendix A, Standard Normal Temperature Rise Time-Temperature Curve for the Control of Fire Tests. The points on the curve that determine its character are:

Temperature °F (°C)	Time (minutes)
50 to 90 (10 to 32)	0
1000 (538)	5
1300 (704)	10
1550 (843)	30
1700 (927)	60
1792 (978)	90
1850 (1010)	120
1925 (1052)	180

Figure 8.1

Time-temperature curve



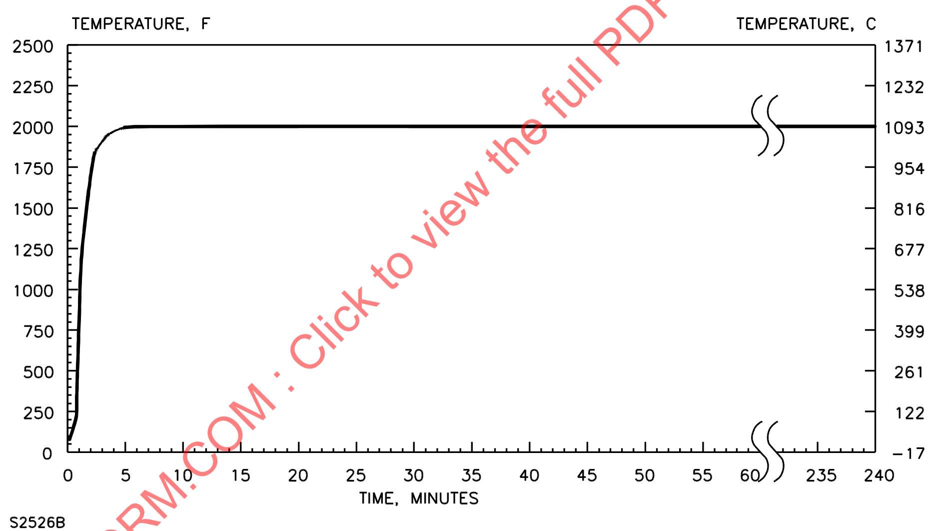
8.2 Rapid temperature rise curve

8.2.1 The temperature in the test furnace is to follow the time-temperature curve shown in Figure 8.2 when the temperatures are to represent a rapid temperature rise fire. The points on the curve that determine its character are:

Temperature °F (°C)	Time (minutes)
50 to 90 (10 to 32)	0
2000 (1093)	5
2000 (1093)	180

Figure 8.2

Time-temperature curve



9 Furnace Temperature

9.1 General

9.1.1 When a single test sample is evaluated in the furnace, there is to be a minimum of two furnace control thermocouples, each located at the mid-height of the sample, but no closer to the ceiling or floor of the furnace than 24 in (610 mm).

9.1.2 When multiple test samples are evaluated in the furnace, there is to be a minimum of two furnace control thermocouples located at the mid-height of each sample, adjacent to two faces. See the Figure 9.1 for an example of a large number of test items (squares) in a single furnace.