



Standard Guide for Extension of Data From Fire Resistance Tests Conducted in Accordance with ASTM E 119¹

This standard is issued under the fixed designation E 2032; 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 guide covers the extension of fire ~~endurance results~~ resistance ratings obtained from fire tests performed in accordance with Test Method E 119 to constructions that have not been tested. Test Method E 119 evaluates the duration for which test specimens will contain a fire, retain their standard integrity, or both during a predetermined test exposure.

1.2 This guide is based on principles involving the extension of test data using simple considerations. The acceptance of these principles and their application is based substantially on an analogous worst case proposition.

1.3 These principles are only applicable to temperature conditions represented by the standard time-temperature curve described in Test Method E 119. Test Method E 119 is a fire-test-response standard.

1.4 The types of building constructions which are the subject of this guide are categorized as follows: beams; floor and roof assemblies; columns; and walls and partitions. Floor and roof assemblies include such assemblies with ceiling protective membranes.

1.5 The extension of test data using numerical calculations based on empirical data or theoretical models is not covered in this guide.

1.6 This guide does not cover the substitution of one proprietary material for another proprietary material, or materials for which fire test data are not presently available.

1.7 This guide does not purport to be comprehensive in its treatment of non-proprietary modifications of tested constructions. Engineering evaluation or tests are recommended for assessing modifications not specifically covered in this guide.

1.8 The values given in SI units are regarded as standard.

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

1.10 *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.*

2. Referenced Documents

2.1 *ASTM Standards:*²

C 168 Terminology Relating to Thermal Insulation

C 553 Specification for Mineral Fiber Blanket Thermal Insulation for Commercial and Industrial Applications

C 612 Specification for Mineral Fiber Block and Board Thermal Insulation

E 119 Test Methods for Fire Tests of Building Construction and Materials

E 176 Terminology of Fire Standards

E 631 Terminology of Building Constructions

E 1264 Classification for Acoustical Ceiling Products

E 1513 Practice for Application of Sprayed Fire-Resistive Materials (SFRMs)

3. Terminology

3.1 *Definitions:*

3.1.1 For definitions used in this guide, refer to Terminologies E 176, C 168, and E 631.

¹ This standard guide is under the jurisdiction of ASTM Committee E05 on Fire Standards and is the direct responsibility of Subcommittee E05.11 on Fire Resistance. Current edition approved ~~Oct. March 1, 2007-2008~~. Published ~~October-2007-April 2008~~. Originally approved in 1999. Last previous edition approved in 2007 as E 2032-07a.

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.

3.1.2 *fire endurance, n*—a measure of the elapsed time during which a material or assemblage continues to exhibit fire resistance

3.1.3 *fire resistance, n*—the property of a material or assemblage to withstand fire or give protection from it.

3.1.3.1 *Discussion*—In this guide, it is characterized by the ability to confine a fire and continue to perform a given structural function.

3.1.4 *mineral fiber insulation, n*—insulation composed principally of fibers manufactured from rock, slag, or glass processed from molten state into fibrous form to comprise flexible batts or blankets, rigid or semi-rigid blocks and boards, or loose fill insulations, with or without binder.

3.1.4.1 *Discussion*—Mineral fiber blanket thermal insulations and mineral fiber block and board thermal insulations are classified into various types based upon the maximum use temperature, which can range from 204°C (400°F) to 982°C (1800°F), and the apparent thermal conductivity (See Specifications C 553 and C 612).

3.1.5 *unit weight, n*—as applied to concrete, weight per unit volume.

3.2 *Definitions of Terms Specific to This Standard:*

3.2.1 *acoustical ceiling panel, n*—a form of a prefabricated sound absorbing ceiling element used with exposed suspension systems (see Specification E 1264).

3.2.2 *acoustical ceiling tile, n*—a form of a prefabricated sound absorbing ceiling element used with concealed or semi-exposed suspension systems, stapling, or adhesive bonding (see Specification E 1264).

3.2.3 *beams, n*—all horizontally oriented structural members employed in building construction and known variously as beams, joists, or girders.

3.2.4 *ceiling protective membrane, n*—a ceiling membrane attached to or suspended from the structural members of the floor or ceiling assembly, usually by hanger wire or threaded rods, consisting of a grid suspension system with lay-in ceiling panels or a grid of steel furring channels to which the ceiling membrane is directly attached, intended to provide fire protection, acoustical and or aesthetic enhancements, or both.

3.2.5 *composite, n*—as applied to loadbearing elements, an interaction between structural components which is to be taken into account in the evaluation of load capacity.

3.2.6 *design load, n*—the intended maximum design load condition allowed by design under appropriate nationally recognized structural design criteria.

3.2.7 *directly applied fire resistive coating, n*—materials that are normally sprayed onto substrates to provide fire-resistive protection of the substrates.

3.2.7.1 *Discussion*—These coatings are called sprayed fire-resistive materials in Standard Practice E 1513 and related standards.

3.2.8 *equivalent thickness, n*—the calculated solid thickness of concrete or masonry for purposes of determining fire resistance ratings of barrier elements on the basis of heat transmission end-point criteria.

3.2.9 *insulation, n*—a material that is normally added to an assembly to provide resistance to heat flow for purpose of energy conservation.

3.2.9.1 *Discussion*—Insulation materials are also used to improve sound control or improve fire resistance.

3.2.10 *lightweight aggregate concrete, n*—concrete made with aggregates of expanded clay, shale, slag, or slate or sintered fly ash, and weighing 1360 to 1840 kg/m³ (85 to 115 pcf).

3.2.11 *material, generic, n*—is one for which a nationally recognized Standard Specification exists.

3.2.12 *material proprietary, n*—is one whose fire performance characteristics are determined in consideration of a formulation or process of production that is proprietary.

3.2.13 *non-composite, n*—as applied to loadbearing elements, structural interaction between contiguous elements is assumed not to exist in the evaluation of load capacity.

3.2.14 *sand-lightweight concrete, n*—concrete made with a combination of expanded clay, shale, slag, or slate or sintered fly ash and natural sand and generally weighing between 1680 and 1920 kg/m³ (105 to 120 pcf).

3.2.15 *specified load, n*—as applied to loadbearing elements, the test load applied to the element in a Test Method E 119 test.

3.2.15.1 *Discussion*—In Test Method E 119 testing, the specified load is generally the design load (see 3.2.6).

3.2.16 *test specimen, n*—the specific construction assembly that was tested in accordance with Test Method E 119.

3.2.17 *transfer, n*—the process of substituting a loadbearing element from one test specimen for the loadbearing element in another test specimen, or utilizing a loadbearing element from one test specimen for use in another test specimen that does not include a loadbearing element.

3.2.18 *ultimate capacity, n*—as applied to loadbearing elements, the actual maximum load carrying capacity of an element based on properties specific to the material constituting the element.

4. Significance and Use

4.1 The methods and procedures set forth in this guide relate to the extension of the fire ~~endurance results~~ resistance ratings obtained from particular fire tested specimens to constructions that have not been tested.

4.2 Users of this guide must have knowledge and understanding of the provisions of Test Method E 119 including those pertaining to conditions of acceptance.

4.3 In order to apply some of the principles described in this guide, reference to the original fire test report will be necessary.

4.4 In Test Method E 119, the specimens are subjected to specific laboratory fire test exposure conditions. Substitution of

different test conditions or changes in the end use conditions have the ability to change the measured fire-test-response characteristics. Therefore, the extensions of data are valid only for the fire test exposure conditions described in Test Method E 119,.

5. General Principles

5.1 The same criteria or conditions of acceptance as set out in the Test Method E 119 and followed in the establishment of the fire ~~endurance classification~~ resistance rating of the original test specimen shall be used in the evaluation of the effect of the modification or substitution of components in a test specimen.

5.1.1 The criteria or conditions of acceptance for the evaluation of modified test specimens shall likewise be in accordance with the appropriate sections of Test Method E 119.

5.2 Statements in this guide only indicate whether a change in the construction either “can reduce” or “does not reduce” the fire endurance. resistance rating.

5.3 Limitations:

5.3.1 The extension of fire ~~endurance data~~ resistance ratings is valid only for changes to the tested specimen that fall within normal and reasonable limits of standard construction practices.

5.3.2 Statements are valid only if the identified changes are the only changes in the construction or properties of the components.

5.3.3 It is possible that multiple changes have a different cumulative effect than that of individual changes applied separately.

5.3.4 Unless otherwise indicated, statements are only valid if the change identified does not change the specified load.

5.3.4.1 Provisions in this guide involving the ratio of specified load to design load assume that the safety factor (ratio of ultimate capacity to design load) inherent in the design procedure is constant.

5.3.4.2 Increasing the ratio of the maximum applied load (specified load, dead plus live load) to the design load of an element beyond that realized in the test specimen can reduce the fire ~~endurance. resistance rating.~~

5.3.5 Provisions in this guide pertaining to concrete only apply to concrete with a compressive strength of 55.1 MPa (8000 psi) or less.

5.4 Restrained/Unrestrained Specimens :

5.4.1 The fire ~~endurance~~ resistance rating of a beam, floor, or roof test specimen is related to either a restrained or unrestrained condition, or both. A restrained condition in a fire test is considered to be one in which the displacement or rotation due to fire induced thermal expansion of a load bearing element is resisted by forces external to the element. An unrestrained condition in a fire test is one in which the load bearing element is free to expand and rotate at its supports or is not subject to substantial thermal expansion and its resulting restraining forces.

5.4.2 Ratings of restrained beam, floor, or roof test specimens are intended for application to elements which are considered to be suitable for use in restrained building construction where the surrounding or supporting structure is capable of resisting substantial thermal expansion throughout the range of anticipated elevated fire conditions.

5.4.3 Ratings of unrestrained beam, floor or roof test specimens are intended for application to elements which are considered to be suitable for use in unrestrained and restrained building construction where the surrounding or supporting structure is or is not capable of resisting substantial thermal expansion throughout the range of anticipated elevated fire conditions.

5.4.3.1 The application of unrestrained classified beams, floors or roofs for use in building constructions with end restraint does not reduce the fire ~~endurance. resistance rating.~~

NOTE 1—See Appendix X3 “Guide for Determining Conditions of Restraint for Floor and Roof Assemblies and for Individual Beams” in Test Method E 119 for assistance in determining the conditions of thermal restraint applicable to floor and roof constructions and individual beams in actual building construction.

5.5 Composite and Non-Composite Design:

5.5.1 Fire ~~endurance classifications~~ resistance ratings of beams and floors or roofs tested with composite design between the beam and the floor or roof is not reduced in actual building constructions designed for either composite or non-composite action.

5.5.2 Conversely, fire ~~endurance classifications~~ resistance ratings of beams and floors or roofs tested in non-composite design shall be limited to building constructions designed for non-composite action.

6. Principles Pertaining to Heat Transfer Characteristics of Concrete

6.1 The provisions in this section are applicable only as they affect the transfer of heat through concrete. Considerations involving structural fire ~~endurance~~ resistance are addressed in other sections.

6.2 For concrete test specimens where temperature rise on the unexposed surface of a concrete slab (wall, floor, or roof) is the governing criterion, the following modifications do not reduce the fire ~~endurance~~ resistance rating of the assembly:

6.2.1 Decrease in concrete unit weight;

6.2.2 Substitution of sanded light-weight aggregate concrete or light-weight aggregate concrete for normal weight concrete; also, substitution of carbonate aggregate for siliceous aggregate for either the coarse or the fine aggregate used in the concrete;

6.2.3 Decrease in the nominal maximum size of coarse aggregate within a given concrete aggregate type;

6.2.4 Increase or decrease in the compressive strength of the concrete;

6.2.5 Change in the type of portland cement, flyash or admixtures used in the concrete;

6.2.6 Changes in the type or amount of reinforcement;

6.2.7 Increase in the equivalent thickness of the slab for a given type of aggregate concrete; and

6.2.8 Change in slab design or restraint conditions, provided the equivalent thickness of slab does not decrease.

6.2.9 In slabs or constructions incorporating joints other than construction joints, changes in joint design provided that the substituted joint design has been tested in a Test Method E 119 test and met the required fire ~~endurance~~-resistance rating.

6.2.10 For slabs containing hollow cores or air cavities, filling of cores or voids with non-combustible insulation material;

6.3 For temperature rise to be the governing criteria, it is assumed that the structural design requirements of the slab are met and adequate cover protection is provided to the steel reinforcement (prestressing and reinforcing bars).

7. Principles Pertaining to Protective Finish Systems

7.1 *Directly Applied Fire Resistive Coatings:*

7.1.1 The following modifications to directly applied fire resistive coatings can reduce the fire ~~endurance~~-resistance rating:

7.1.1.1 A decrease in thickness;

7.1.1.2 A change in a critical aspect of the coating such as composition, formulation, density, etc. or system (use of adhesive, sealer or top coat; mechanical retention; etc); and

7.1.1.3 A change in the nature of the substrate (composition, orientation, shape, etc.) or condition (surface texture, surface finish, contamination, etc.).

7.1.2 Except for intumescent coatings, the following modifications to directly applied fire resistive coatings, do not reduce the fire ~~endurance~~-resistance rating:

7.1.2.1 An increase in thickness;

7.1.2.2 A change in a non-critical aspect of the coating such as color, compatible decorative or protective oversprays, texture, etc; and

7.1.2.3 The use of mechanical retention systems (metal lath, steel studs and disks, etc.) to satisfy concerns about substrate changes.

7.2 *Cover Protection for Steel Columns:*

7.2.1 For steel column protections that are not required by design to carry any of the column load, the alternative test and conditions of acceptance specified under “Alternative Test of Protection for Structural Steel Columns” in Test Method E 119, are applicable (See 11.1.2).

7.2.2 Concrete membrane protection systems- where membrane protection consists of monolithic concrete (column spaces filled), concrete masonry units or precast reinforced concrete units (column spaces not filled), the following modifications do not reduce the fire ~~endurance~~-resistance rating of the column:

7.2.2.1 Substitution of carbonate aggregate for siliceous aggregate for either the coarse or the fine aggregate used in concrete;

7.2.2.2 Substitution of lightweight concrete for sand-lightweight concrete;

7.2.2.3 Substitution of sand-lightweight concrete or lightweight concrete for normal-weight concrete;

7.2.2.4 Decrease in nominal maximum size of coarse aggregate within a given aggregate type concrete;

7.2.2.5 Change in the type of portland cement, flyash or admixtures used in the concrete;

7.2.2.6 Change in compressive strength of the concrete;

7.2.2.7 Increase in thickness of the membrane protection; and

7.2.2.8 Where column spaces are not filled, increases or decreases in the air space between the column and the column cover.

7.3 *Fire Resistive Protective Membranes :*

7.3.1 ~~Ceiling protective membranes are generally of three types:~~

7.3.1 Ceiling protective membranes used as part of fire resistance rated floor/ceiling or roof/ceiling assemblies are generally of three types:

7.3.1.1 Lay-in, acoustical or gypsum, panels supported by an exposed steel grid system;

7.3.1.2 Fitted, acoustic, tiles supported by a concealed steel grid system; or

7.3.1.3 Mechanically fastened gypsum boards screw attached to furring channels or screw or nail attached directly to the underside of the structural members.

7.3.2 *Effects of Fasteners*—The following changes relating to fasteners (such as screws, nails, bolts, etc.) can reduce the fire ~~endurance of protective membranes~~-resistance rating by reducing the stability of the membrane.

7.3.2.1 A decrease in length or a change in shaft diameter of fasteners;

7.3.2.2 An increase in the spacing between fasteners; or

7.3.2.3 A reduction in the distance between the edge of a panel and the location of a peripheral fastener when that distance in the tested specimen is less than 25 mm (1 in.).

7.3.3 The substitution of unbacked joints for joints backed can reduce the fire ~~endurance~~-resistance rating.

7.3.4 The use of furring channels as a substitute for the direct attachment of the membrane to joists does not reduce the ~~endurance~~-resistance rating provided that:

7.3.4.1 The joist spacing is not increased and the furring channels are spaced apart a distance no greater than the joist spacing;

7.3.4.2 The spacing of fasteners used to connect the membrane to the furring channels is not increased; and

7.3.4.3 Provisions are made using procedures proven to be effective by prior Test Method E 119 fire tests to reduce furring

channel spacing and provide additional furring channel(s) at butt joints between ceiling panels ends to reduce fire induced stresses at these joints.

7.3.5 The substitution of resilient furring channels for “top hat” or “non-resilient” furring channels or vice versa does not reduce the fire ~~endurance~~; resistance rating.

7.3.6 Increasing the depth of the space between the underside of the floor, beam or roof deck and the protective ceiling membrane does not reduce the fire ~~endurance~~; resistance rating.

7.3.6.1 A decrease in this depth can reduce the fire ~~endurance~~; resistance rating.

7.3.7 *Suspended or Lay-In Acoustical Ceiling Panels and Fitted Type Acoustical Ceiling Tiles:*

7.3.7.1 A change in the composition or density of the panels or tiles can reduce the fire ~~endurance~~; resistance rating.

7.3.7.2 A decrease in the area of individual panels, resulting in an increase in the area of exposed steel, can reduce the fire ~~endurance~~; resistance rating due to a reduction in insulative performance.

7.3.7.3 An increase in the area of individual panels, resulting in a reduction of the area of exposed steel, does not reduce the fire ~~endurance~~; resistance rating provided the stability of the larger panel and supporting steel grid system has been validated by a Test Method E 119 test for the duration required and under the anticipated ceiling deflection conditions.

7.3.7.4 An increase in thickness of the panel or tile does not reduce the fire ~~endurance~~; resistance rating.

7.3.8 *Mechanically Fastened Gypsum Board*—The following changes in dimension or physical characteristic of a gypsum board used in a mechanically fastened ceiling application can reduce the fire ~~endurance~~; resistance rating:

7.3.8.1 A decrease in length or width due to an increase in the length of joint per unit area of ceiling; or

7.3.8.2 A change in the composition or density.

7.3.9 The following changes in dimension or physical characteristic of a gypsum board used in a mechanically fastened ceiling application do not reduce the fire ~~endurance~~; resistance rating:

7.3.9.1 An increase in thickness;

7.3.9.2 An increase in length or width provided that the spacings between fasteners are not increased and the spacings between fasteners and the edge or ends of the board are not decreased;

7.3.10 *Penetrations of Membranes:*

7.3.10.1 For test specimens employing a membrane penetrated by light fixtures or air-handling services, changes in the area or construction of the penetrating items can reduce the fire ~~endurance~~; resistance rating.

7.3.10.2 An increase in the individual and aggregate area of light fixtures or air-handling services penetrating the membrane can reduce the fire ~~endurance~~; resistance rating. A decrease of these areas does not reduce the fire ~~endurance~~; resistance rating.

7.3.10.3 Substitution of light fixtures that employ casings, framing, screws, or fasteners of materials having a melting point of less than 1000°C (1835°F) can reduce the fire ~~endurance~~; resistance rating;

7.3.10.4 Substitution of light fixtures that do not permit the ready attachment of the prescribed suspension wires to the perimeter grid without the introduction of rotational stresses in that grid can reduce the fire ~~endurance~~; resistance rating.

7.3.10.5 For test specimens employing a suspended membrane penetrated by surface mounted air supply or return devices, the use of lay-in air supply or return devices of the same overall area does not reduce the fire ~~endurance~~; resistance rating, provided that:

7.3.10.6 The lay-in devices are of welded or riveted steel construction;

7.3.10.7 Suspension wires are provided for the steel framing members at each corner of the lay-in device; and

7.3.10.8 Thermal protection is provided to the back of the lay-in device that has demonstrated an equivalent performance to that of the tested system.

8. Principles Pertaining to Thermal Insulation of Walls and Floors

8.1 The addition of thermal insulation in a concealed space within a specimen tested without insulation is regulated by the following:

8.1.1 It is expected that elements of the construction between the insulation and the exposing fire will experience a more rapid temperature rise. Where this effect reduces the stability of the element, the net effect can reduce the fire ~~endurance~~; resistance rating;

8.1.2 If insulation were incorporated in a concealed space within a test specimen, the substitution of a different type, thickness or density, or the relocation of the insulation can reduce the fire ~~endurance~~; resistance rating; and

8.1.3 It is expected that elements of the construction between mineral fiber insulation and the unexposed surface will experience a lower rate of temperature rise while the test specimen and the insulation remain intact. This effect does not reduce the fire ~~endurance~~; resistance rating.

8.2 *Insulation in Floor/Roof Assemblies :*

8.2.1 Where the elements of the construction between the insulation and the exposing fire are required to support the weight of the backloaded insulation, the load imposed on the ceiling protective membrane and its suspension system by excessively high levels of insulation can result in a loss of stability and can reduce the fire ~~endurance~~; resistance rating.

8.2.2 Except as provided in 8.2.3, the addition of insulation to the top surface of a test specimen supported by structural steel elements can reduce the fire ~~endurance~~; resistance rating by virtue of heat entrapment causing increased temperatures in the supporting elements. The insulation referred to in this Section is limited to products of the following types: glass fiber, vermiculite,

perlite, wood fiber, mineral fiber produced from rock or slag and phenolic foam.

8.2.3 *Steel Deck Roof Construction* :

8.2.3.1 The addition of identical insulation to the top surface of a steel deck roof tested with over 100 mm (4 in.) of insulation does not reduce the fire ~~endurance~~-resistance rating.

8.2.3.2 In order to increase the thickness of insulation without reducing the fire ~~endurance~~-resistance rating of a test specimen incorporating 100 mm (4 in.) or less of insulation applied directly on top of a steel deck, it is necessary to include a layer of 12.7 mm (0.5 in.) or thicker type X gypsum board, or equivalent heat sink, between the insulation and the steel deck.

8.3 *Insulation in Wall Assemblies* :

8.3.1 An increase in thickness of the mineral fiber insulation does not reduce the fire ~~endurance~~-resistance rating.

9. Principles Pertaining to Fire Resistance Rating of Beams

9.1 *Conditions of Acceptance*—Individual fire resistance ratings for beams are determined in accordance with the following:

9.1.1 A restrained beam rating is obtained based on the procedure specified under “Tests of Loaded Restrained Beams” in Test Method E 119 and the conditions of acceptance of that section.

9.1.2 Procedures for obtaining an unrestrained beam rating include:

9.1.2.1 Test as a beam using the procedures specified under “Tests of Loaded Restrained Beams” in Test Method E 119 and the conditions of acceptance in the section entitled “Alternative Classification Procedure for Loaded Beams”, and

9.1.2.2 Test as part of floor or roof assembly using the procedures specified under “Tests of Floors and Roofs” in Test Method E 119 and the conditions of acceptance in the section entitled “Alternative Classification Procedure for Loaded Beams”.

9.1.3 A rating is also obtained for steel beams based on the procedure specified under “Alternative Test of Protection for Solid Steel Beams and Girders” in Test Method E 119 and the conditions of acceptance of that section.

9.1.4 An individual restrained beam rating cannot be obtained from a tested floor or roof specimen.

9.2 *Substitution or Transfer*—The process of substituting a beam from one test specimen for the beam in another test specimen, or transferring a beam from one test specimen for use in another test specimen that does not include a beam shall be regulated by the following:

9.2.1 When tested separately as beams and assigned a rating based on “Tests of Loaded Restrained Beams” of Test Method E 119 (see 9.1.1), it is permitted to transfer provided that:

9.2.1.1 The unrestrained beam rating of the substitute beam is equal to or greater than the unrestrained beam rating of the beam being replaced;

9.2.1.2 The restrained beam rating of the substitute beam is equal to or greater than the restrained assembly rating of the roof into which the beam is to be utilized; and

9.2.1.3 The rating of the substitute beam is at least equal to the rating of the requirement.

9.2.2 When tested as part of a floor and assigned a rating based on “Tests of Floors and Roofs” of Test Method E 119, it is permitted to transfer the beam provided that:

9.2.2.1 The unrestrained beam rating of the substitute beam is equal to or greater than the unrestrained beam rating of the beam being replaced;

9.2.2.2 The restrained assembly rating of the floor or roof in which the substitute beam was tested is equal to or greater than the restrained assembly rating of the floor or roof assembly in which the beam is to be utilized; and

9.2.2.3 The unrestrained rating of the substitute beam is at least equal to the rating of the requirement.

9.2.3 The load deflection (at full specified load of tested specimen) of the construction into which the beam is being substituted or transferred shall be equal to or less than that of the specimen in which it was tested;

9.2.4 The capacity for heat dissipation from the beam in the construction into which it is being substituted or transferred shall be equal to or greater than that of the specimen in which it was tested; and

9.2.5 The capacity for heat transfer to the beam in the construction into which it is being substituted or transferred shall be equal to or less than that in the specimen in which it was tested.

9.2.6 The substitution of steel beams having the same geometric shapes and a greater W/D ratio (ratio of weight to heated perimeter) than that of the tested beam does not reduce the fire resistance rating. Conversely, the substitution of steel beams having a dissimilar geometric shape or a lesser W/D ratio can reduce the fire resistance rating.

9.3 It is possible to increase or decrease the span of beams without reducing the fire resistance rating provided that the structural design requirements arising from the span changes are satisfied and the resulting loading stresses (bending and shear) do not exceed the corresponding stresses of the fire tested design.

9.4 Spacing of beams is governed by provisions of Section 10 and by the following:

9.4.1 Except as noted in Section 10 changes in the spacing of beams tested with spacing greater than 1.2 m (4-ft) on center do not reduce the fire resistance rating provided that:

9.4.1.1 The structural design requirements arising from the spacing changes are satisfied and that the resulting loading stresses (bending and shear) of both the beam and any deck/slab do not exceed the corresponding stresses of the fire tested design; and

9.4.1.2 Provisions for support of the ceiling membrane are maintained, when the function of that membrane is to provide fire resistance.

9.4.2 Except as noted in Section 10, changes in the spacing of beams from, that of the tested specimen with spacing less than