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EDITION

FDS[®]

FIRE DESIGN SPECIFICATION
FOR WOOD CONSTRUCTION[®]



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AMERICAN
WOOD
COUNCIL

Updates and Errata

While every precaution has been taken to ensure the accuracy of this document, errors may have occurred during development.

Updates or Errata are posted to the American Wood Council website at www.awc.org.

Technical inquiries may be addressed to info@awc.org.

On behalf of the industry it represents, AWC is committed to ensuring a resilient, safe, and sustainable built environment. To achieve these objectives, AWC contributes to the development of sound public policies, codes, and regulations which allow for the appropriate and responsible manufacture and use of wood products. We support the utilization of wood products by developing and disseminating consensus standards, comprehensive technical guidelines, and tools for wood design and construction, as well as providing education regarding their application.

FOREWORD

This Specification is for use in designing wood buildings. Its use is intended to complement and not supersede any provision of the applicable building code.

Since 2001, the *National Design Specification® for Wood Construction* (NDS®) has contained provisions in Chapter 16 for design of fire exposed wood members to meet code-required structural fire-resistance ratings based on a standardized ASTM E119 time-temperature exposure. The NDS Chapter 16 provisions apply to exposed timber members of sawn lumber, glued-laminated softwood timber, laminated veneer lumber, parallel strand lumber, laminated strand lumber, and cross-laminated timber. Additional calculation procedures have been developed to address the added fire resistance and thermal benefits of protection using additional wood, gypsum panel products, and some types of insulation. These additional calculation provisions have been developed to provide standardized methods of calculating thermal separation and burn-through requirements as required in ASTM E119 and as provided in AWC's *Technical Report 10: Calculating the Fire Resistance of Exposed and Protected Wood Members* (TR10). The existing design provisions in NDS Chapter 16 and the new protection provisions contained within TR10 have been incorporated in this Specification.

In developing the provisions of this Specification, the most reliable data available from laboratory tests and experience with structures in service have been carefully analyzed and evaluated for the purpose of providing, in convenient form, a national standard of practice. AWC invites and welcomes comments, inquiries, suggestions, and new data relative to the provisions of this document.

It is intended that this Specification be used in conjunction with competent engineering design, accurate fabrication, and adequate supervision of construction. AWC does not assume any responsibility for errors or omissions in the document, nor for engineering designs, plans, or construction prepared from it. Those using this standard assume all liability arising from its use. The design of engineered structures is within the scope of expertise of licensed engineers, architects, or other licensed professionals for applications to a particular structure.

American Wood Council

AWC Fire Design Specification for Wood Construction

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Supplement to the AWC Fire Design Specification

Supplement A: Flame Spread Performance of Wood Products Used for Interior Finish

Supplement B: Fire-Resistance-Rated Wood-Frame Wall and Floor-Ceiling Assemblies

CHAPTER 1: GENERAL REQUIREMENTS FOR FIRE DESIGN

1.1 General

1.1.1 Scope

This standard establishes fire design provisions that apply to all structural members, assemblies, and connections designed using the ANSI/AWC *National Design Specification (NDS) for Wood Construction*, unless otherwise noted.

1.1.2 Design Methods

Design methods in this standard shall be based on the provisions of this document and the fire exposure and acceptance criteria specified in the reference standards in each section.

1.1.3 Type of Construction

For the purpose of this Standard, any reference to the Type of Construction is linked to the fire-resistance ratings, materials, and detailing requirements of the applicable building code.

1.2 Terminology

APPROVED. Acceptable to the authority having jurisdiction.

ASSEMBLY. For the purpose of this standard, a system that combines wood structural members and other materials to create portions of buildings such as walls, floors, and roofs.

BURN-THROUGH. The passage of hot gases or flames between or through members or assemblies which are intended to provide thermal separation.

BURN-THROUGH TIME. The period of time before burn-through occurs during an ASTM E119 fire resistance test or as determined using design methods in Chapter 3 which are based on ASTM E119 tests.

COMBUSTIBLE MATERIALS. Materials that ignite and burn when exposed to fire.

CONNECTION. For the purpose of this standard, wood-to-wood, wood-to-metal, or wood-to-concrete connections designed using the *National Design Specification for Wood Construction* (see 1.1.1).

CROSS-LAMINATED TIMBER (CLT). A prefabricated engineered wood product consisting of at least three layers of sawn lumber or structural composite lumber where the adjacent layers are cross-oriented and bonded with structural adhesive to form a solid wood panel.

DOUBLE-STUD WALL. Framing method where two stud wall frames are set next to each other on common plates.

DOUBLE WALL. Framing method where two walls are set next to each other.

DRAFTSTOPPING. Material or construction installed to restrict the movement of air and hot gases between concealed spaces within floor-ceiling assemblies and within an attic.

EXTERIOR WALL. A loadbearing or non-loadbearing wall that is used as enclosing wall for a building, and that has a slope of 60 degrees or greater relative to the horizontal plane, and which has specific requirements for continuity and opening protection.

EXTERIOR WALL COVERING. A material, member, or assembly applied on the exterior side of exterior walls for aesthetics, as a weather-resisting barrier, or as insulation (e.g. cladding, siding, exterior insulation and finish systems, architectural trim and embellishments such as cornices, soffits, facias, gutters and leaders).

FIRE AREA. The aggregate floor area which is used to determine requirements for a fire protection system and which is enclosed and bounded by exterior walls, fire walls, fire barriers, or horizontal assemblies of a building, including areas of the building not provided with surrounding walls that are within the horizontal projection of the adjacent roof or floor above.

FIRE BARRIER. An interior fire-resistance-rated wall that is used to separate interior building areas according to hazards associated with function, for means of egress protection or, for purposes of building compartmentalization into fire areas, and which has specific requirements for continuity and opening protection.

FIRE PARTITION. An interior fire-resistance-rated wall that is used to separate interior spaces according to hazard associated with function, and which has specific requirements for continuity and opening protection.

FIRE PROTECTION SYSTEM. Approved devices, equipment and systems or combinations of systems used to detect a fire, activate an alarm, extinguish, or control a fire; control or manage smoke and products of a fire; or any combination thereof.

FIRE RESISTANCE. The ability of a material, member, or assembly to perform its structural function or to slow or prevent the passage of excessive heat, hot gases, or flames during fire exposure.

FIRE-RESISTANCE-RATED. Having a fire-resistance rating assigned based on ASTM E119 or ANSI/UL 263 fire resistance testing or as determined using design methods in Chapter 3.

FIRE-RESISTANCE RATING (FRR). The period of time a material, member, or assembly performs its structural function and, where required, prevents the passage of excessive heat, hot gases, or flames during an ASTM E119 or ANSI/UL 263 fire resistance test or as determined using design methods in Chapter 3.

FIRE RETARDANT-TREATED WOOD (FRTW). Wood products that are treated with chemicals to reduce surface-burning characteristics and resist propagation of fire.

FIRE SEPARATION DISTANCE (FSD). The minimum perpendicular distance measured from the building exterior wall to the closer of:

- a. the closest interior lot line; or
- b. the centerline of a street, an alley or public right-of-way; or
- c. an imaginary line between two buildings on the same lot.

FIRE WALL. A fire-resistance rated wall that is used to provide total separation between adjacent or attached buildings, which extends vertically from the foundation to the roof or beyond, extends horizontally between or beyond exterior walls, and which has specific requirements for opening and penetration protection.

FIREBLOCKING. Material or construction installed to restrict the passage of flames within and between concealed spaces.

FIRESTOPPING. Material, device, or system that is used to prevent the spread of fire for a specified period of time.

- **Fire-Resistant Joint System.** An assemblage of materials and/or devices that is designed, tested, and approved to resist passage of fire through design joints between fire-resistance-rated assemblies.
- **Membrane-Penetration Firestop System.** An assemblage of materials and/or devices that is designed, tested, and approved to resist passage of fire through an opening in a membrane of a fire-resistance-rated assembly.

- **Through-Penetration Firestop System.** An assemblage of materials and/or devices that is designed, tested, and approved to resist passage of fire through an opening in a fire-resistance-rated assembly.

GLUED LUMBER. A product that is manufactured by end-gluing, edge-gluing, or face-gluing pieces of sawn lumber.

GYPSONUM PANEL PRODUCTS. A family of sheet products consisting of a noncombustible core primarily of gypsum, includes Glass Mat Gypsum Panel and Gypsum Board. Both product lines are available as fire-rated (Type X).

- **Gypsum Board.** A line of sheet products consisting of a noncombustible core primarily of gypsum and manufactured with paper facers. Gypsum board includes gypsum wallboard, gypsum sheathing board, gypsum backing board, exterior gypsum soffit board, gypsum ceiling board, gypsum lath, and gypsum base for veneer plaster.
- **Glass Mat Gypsum Panel.** A gypsum panel product with glass mat facers.
- **Gypsum Sheathing.** A gypsum board or glass mat gypsum panel product intended as a backing for exterior surface materials.

HEAVY TIMBER (HT). Wood members or assemblies of wood members of minimum dimensions based on application (see Section 1.5).

HORIZONTAL ASSEMBLY. A fire-resistance-rated floor or roof assembly in which penetrations and openings are restricted or required to be protected.

INTERIOR FINISH. The exposed surfaces of the interior of a room including the surfaces of interior walls, partitions, ceilings and floors.

INTERIOR FLOOR FINISH. The exposed floor surfaces of buildings.

- **Interior Floor Coverings.** Loose-laid interior floor finish materials, such as carpet and vinyl, that are used to cover floors, including other interior floor finishes.

JOINT. An opening between fire-resistance-rated assemblies designed to allow independent movement of the building in any plane caused by thermal, seismic, wind, or other loading condition.

MECHANICALLY-LAMINATED TIMBER (MLT). A structural assembly of lumber members set on edge, in contact with adjacent pieces, and attached with mechanical fasteners. Nail-laminated timber (NLT) and mechanically-laminated decking are common types of mechanically-laminated timber.

MEMBER. For the purpose of this standard, an element or interconnected elements used to transfer loads through the structure or to provide support for attached non-structural elements, such as insulation and finish materials. A wood member may consist of one element (e.g., solid beam, column, or panel) or multiple elements (e.g., truss, built-up beam, or built-up column).

MINERAL FIBER INSULATION. Insulation type including fiberglass insulation and mineral wool insulation.

- **Fiberglass insulation (glass wool or fibrous glass)** - Insulation composed of synthetic vitreous fibers made by melting predominately silica sand and other inorganic materials, and then physically forming the melted materials into fibers.
- **Mineral wool insulation** - Insulation composed of synthetic vitreous fibers made by melting predominately igneous rock or furnace slag, and other inorganic materials, and then physically forming the melted materials into fibers.

NONCOMBUSTIBLE MATERIALS. Materials that do not ignite or burn when exposed to fire, and composite materials having a core of material(s) that does not ignite or burn when exposed to fire and a finish of combustible material that meets certain performance requirements(e.g. Type X gypsum wallboard).

PARTICLEBOARD. A generic term for a panel primarily composed of cellulosic materials (usually wood), generally in the form of discrete pieces or particles, as distinguished from fibers. The cellulosic material is combined with synthetic resin or other suitable bonding system by a process in which the interparticle bond is created by the bonding system under heat and pressure.

PLATFORM CONSTRUCTION. Construction where the floor structure is supported by exterior and interior bearing walls below and supports exterior and interior bearing walls above.

PROJECTION. Construction that extends beyond an exterior wall such as cornices, eave overhangs, and exterior balconies.

PROTECTION. Materials used to increase the fire resistance of members, assemblies, and connections.

- **COVER.** A sacrificial layer of a material, such as wood or a gypsum panel product, that is used to protect one or more surfaces of an underlying member and/or connection from direct fire exposure for a specified time (e.g. wood boards or gypsum panel products directly attached to a wood beam).
- **MEMBRANE.** A sacrificial layer typically composed of panels, such as wood structural panels or gypsum panels, that protects an assembly from direct fire exposure for a specified time (e.g. gypsum wallboard ceiling used to protect a floor-ceiling assembly).

SAWN LUMBER. A product that is manufactured from trees by sawing wood logs.

SMOKE BARRIER. A building element such as a wall, floor, ceiling, or other continuous membrane or assembly, either vertical or horizontal, that is designed and constructed to restrict the movement of smoke.

SMOKE PARTITION. A wall assembly that extends from the top of the foundation or floor below to the underside of the floor or roof sheathing, deck, or slab above or to the underside of the ceiling above where the ceiling membrane is constructed to limit the movement of smoke.

STAGGERED-STUD WALL. Framing method that places adjacent studs on opposite sides of wide top and bottom plates to prevent the membranes on each side of the wall from being attached to common studs.

STRUCTURAL COMPOSITE LUMBER (SCL). A group of engineered wood structural products that are bonded with an exterior adhesive. Types of structural composite lumber covered under this designation in this standard are:

- **Laminated veneer lumber (LVL)** - A composite of wood veneer sheet elements in which the wood veneer thicknesses do not exceed 0.25" and the wood fiber is primarily oriented along the length of the member.
- **Parallel strand lumber (PSL)** – A composite of wood strand elements in which the least dimension of the strands does not exceed 0.25", the average length of the strands is a minimum of 300 times the least dimension, and the wood fibers are primarily oriented along the length of the member.
- **Laminated strand lumber (LSL)** - A composite of wood strand elements in which the least dimension of the strands does not exceed 0.10", the average length of the strands is a minimum of 150 times the least dimension, and the wood fibers are primarily oriented along the length of the member.
- **Oriented strand lumber (OSL)** - A composite of wood strand elements in which the least dimension of the strands does not exceed 0.10", the average length of the strands is a minimum of 75 times the least dimension, and the wood fibers are primarily oriented along the length of the member.

STRUCTURAL FIRE-RESISTANCE TIME. The period of time a material, member, or assembly performs its structural function during an ASTM E119 or ANSI/UL 263 fire resistance test or as determined using design methods in Chapter 3.

STRUCTURAL GLUED LAMINATED TIMBER (Glulam or GLT). An engineered, stress rated product of a timber laminating plant, comprising assemblies of specially selected and prepared wood laminations bonded together with adhesives. The grain of all laminations is approximately parallel longitudinally. The separate laminations do not exceed 2" in net thickness and are permitted to be composed of:

- one piece
- pieces joined end-to-end to form any length
- pieces placed or glued edge-to-edge to make wider ones
- pieces bent to curved form during gluing

THERMAL SEPARATION TIME. The period of time a material, member, or assembly prevents transmission of excessive heat during an ASTM E119 or ANSI/UL 263 fire resistance test or as determined using design methods in Chapter 3.

TYPE OF CONSTRUCTION (TOC). Classification system used in building codes to establish permitted materials, fire-resistance ratings, and to set detailing requirements for building elements and assemblies.

WOOD I-JOIST (prefabricated wood I-joist). A structural member composed of sawn or structural composite lumber flanges and wood structural panel webs bonded together with exterior exposure adhesives, forming an “I” cross-sectional shape.

WOOD STRUCTURAL PANEL (WSP). A panel manufactured from veneers; or wood strands or wafers; or a combination of veneer and wood strands or wafers; bonded together with waterproof synthetic resins or other suitable bonding systems. Types of wood structural panels covered under this designation in this standard are:

- **Plywood** - A wood structural panel composed of plies of wood veneer arranged in cross-aligned layers. The plies are bonded with an adhesive that cures on application of heat and pressure.
- **Oriented strand board (OSB)** –A mat-formed wood structural panel product composed of thin rectangular wood strands or wafers arranged in oriented layers and bonded with waterproof adhesive.
- **Composite panels** –A wood structural panel composed of wood veneer and reconstituted wood-based material bonded together with a waterproof adhesive.

WOOD TRUSS. Engineered frames constructed of wood structural components (and possibly other materials) joined together in triangular shapes using metal connector plates, timber connectors, plywood gussets, or by other means.

1.3 Notation

Except where otherwise noted, the symbols used in this Specification have the following meanings:

C_D	= ASD load duration factor
F_b	= reference bending design value, psi
F_{bE}	= critical buckling design value for a bending member, psi
F_c	= reference compression parallel to grain design value, psi
F_{cE}	= critical buckling design value for a compression member, psi
$F_{c\perp}$	= reference compression perpendicular to grain design value, psi
F_t	= reference tension parallel to grain design value, psi
F_v	= reference shear design value, psi
K_F	= LRFD format conversion factor
a_{char}	= char depth, in.
a_{eff}	= effective char depth, in.
d_p	= thickness of the protective layer of wood, in.
h_{lam}	= thickness of a CLT lamination where all laminations are of equal thickness, in.
$h_{lam,i}$	= thickness of individual lamination where lamination thicknesses vary, in.
n_{lam}	= number of CLT laminations fully charred
t	= exposure time to standardized time-temperature curve from ASTM E119, hr
t_{gl}	= time for char front to reach glued interface where all laminations are of equal thickness, hr
$t_{gl,i}$	= time for char front to reach glued interface where lamination thicknesses vary, hr
t_p	= protection time (minutes)
w_D	= member or assembly dead load
w_S	= member or assembly superimposed load for use in ASTM E119 testing or ASD design
w_T	= member or assembly total load for use in ASTM E119 testing or ASD design
w_{T-LRFD}	= member or assembly total load for strength (LRFD) design
β_t	= non-linear char rate constant, in./hr ^{0.813}
β_n	= nominal char rate constant, in./hr
λ	= LRFD time effect factor
ϕ	= LRFD resistance factor

1.4 Materials Standards

The provisions of this standard are not intended to prevent the use of any material or method of construction not specifically prescribed herein, where it is demonstrated by experience, modeling, or testing by an approved agency, that a product or procedure provides equivalent or greater fire safety. Alternative materials and methods shall be subject to approval by the authority having jurisdiction.

1.4.1 Wood Products

Sawn lumber, glued lumber, structural glued laminated timber, prefabricated wood I-joists, structural composite lumber, prefabricated wood trusses, and panel and siding products, shall conform to the applicable standards or grading rules, including marking requirements specified in 1.4.1.1 through 1.4.1.10. Secondary bondlines for structural wood products glued to make larger cross sections shall be made using adhesives that have the heat resistance and durability that meets the minimum requirements for the material being glued or, alternatively, ANSI 405 *Standard for Adhesives for Use in Structural Glued Laminated Timber*.

1.4.1.1 *Sawn Lumber*: Sawn lumber used for load-bearing purposes shall meet the provisions of U.S. Department of Commerce Voluntary Product Standard 20 (PS 20) *American Softwood Lumber Standard*. Each piece shall be identified by the grademark of a lumber grading or inspection agency accredited by the American Lumber Standards Committee (ALSC). The grademark shall include an easily distinguishable mark or insignia of the accredited agency in accordance with the requirements of PS 20.

1.4.1.2 *Glued Lumber*. Glued lumber used for load-bearing purposes shall meet the provisions of PS 20. Each piece shall be identified by the grademark of a lumber grading or inspection agency accredited by ALSC. The grademark shall include an easily distinguishable mark or insignia of the agency in accordance with the requirements of PS 20 and the ALSC *Glued Lumber Policy*. The grademark shall include an indication that glued joint integrity is subject to quality control by the accredited agency.

1.4.1.2.1 End-jointed (finger-jointed) lumber used in fire-resistance-rated assemblies shall be manufactured with heat-resistant adhesives (HRA) meeting the requirements of the American Lumber Standard Committee *Glued Lumber Policy* or with adhesives complying with ANSI 405 *Standard for Adhesives for Use in Structural Glued Laminated Timber*. The grademark shall include the designation “Heat-Resistant Adhesive” or “HRA” or “Adhesives Meet ANSI 405”.

1.4.1.2.2 Face-glued and Edge-glued lumber used in fire-resistance-rated assemblies shall be manufactured with adhesives complying with ANSI 405 *Standard for Adhesives for Use in Structural Glued Laminated Timber*. The grademark shall include the designation “Adhesives Meet ANSI 405.”

1.4.1.3 *Structural Glued Laminated Timber*: Structural glued laminated timber shall meet the provisions of ANSI A190.1 *Structural Glued Laminated Timber*. Each piece shall be identified with the trademark of an accredited inspection agency in accordance with the requirements of ANSI A190.1.

1.4.1.4 *Prefabricated Wood I-Joists*: Prefabricated wood I-joists shall meet the provisions of ASTM D5055 *Standard Specification for Establishing and Monitoring Structural Capacities of Prefabricated Wood I-Joists*. Each piece shall be identified with the trademark of an accredited inspection agency in accordance with the requirements in ASTM D5055.

1.4.1.5 *Structural Composite Lumber*: Structural composite lumber used in applications covered by this standard shall meet the provisions of ASTM D5456 *Standard Specification for Evaluation of Structural Composite Lumber Products*. Each piece shall be identified with the trademark of an accredited inspection agency in accordance with the requirements in ASTM D5456.

1.4.1.6 *Prefabricated Wood Trusses*: Prefabricated wood trusses used in applications covered by this standard

shall meet the provisions set forth in ANSI/TPI 1 *National Design Standard for Metal Plate Connected Wood Truss Construction*, the truss design drawings, or the manufacturer's code evaluation report.

1.4.1.7 *Plywood*: Plywood shall meet the provisions of U.S. Department of Commerce Voluntary Product Standard 1 (PS 1) *Structural Plywood*, U.S. Department of Commerce Voluntary Product Standard 2 (PS 2) *Performance Standard for Wood Structural Panels*, or applicable code evaluation reports. Each panel shall be identified for grade, bond classification, and Performance Category by the trademarks of an approved testing and grading agency. The Performance Category value shall be used as the "nominal panel thickness" whenever referenced in this standard.

1.4.1.8 *Oriented-Strand Board (OSB)*: Oriented-strand board shall meet the provisions of PS 2 or applicable code evaluation reports. Each panel shall be identified for grade, bond classification, and Performance Category by the trademarks of an approved testing and grading agency. The Performance Category value shall be used as the "nominal panel thickness" whenever referenced in this standard.

1.4.1.9 *Particleboard*: Particleboard shall meet the provisions of ANSI A208.1 *Particleboard Standard* and any additional requirements as set forth in the manufacturer's code evaluation report.

1.4.1.10 *Cross-Laminated Timber*: Cross-laminated timber shall meet the requirements of ANSI/APA PRG 320.

1.4.2 Gypsum Panel Products

Gypsum board shall conform to ASTM C1396 *Standard Specification for Gypsum Board*. Glass mat gypsum panels used as an exterior substrate for a weather barrier shall conform to ASTM C1177 *Standard Specification for Glass Mat Gypsum Substrate for Use as Sheathing*. Glass mat gypsum panels not used as an exterior substrate for a weather barrier shall conform to ASTM C1658 *Standard Specification for Glass Mat Gypsum Panels*. Gypsum panel products shall be installed as specified in 1.4.2.1 through 1.4.2.2.

1.4.2.1 *Gypsum Panel Installation*: Regular and Type X gypsum panel products shall be installed in accordance with the provisions of this standard. Where installation requirements for a specific application are not provided in this standard, the gypsum panel products shall be installed in accordance with ASTM C840 *Standard Specification for Application and Finishing of Gypsum Board*.

1.4.2.2 *Gypsum Sheathing Installation*: Regular and Type X gypsum sheathing shall be installed in accordance with the provisions of this standard. Where installation requirements for a specific application are not provided in this standard, the gypsum sheathing shall be installed in accordance with ASTM C1280 *Standard Specification for Application of Exterior Gypsum Panel Products for Use as Sheathing*.

1.4.3 Insulation

Mineral fiber insulation, including fiberglass or mineral wool, shall conform to the standards specified in 1.4.3.1 for batts or blankets and 1.4.3.2 for loose-fill insulation.

1.4.3.1 *Batts or Blankets*: Mineral fiber thermal insulation batts or blankets shall meet the provisions of ASTM C665 *Standard Specification for Mineral-Fiber Blanket Thermal Insulation for Light Frame Construction and Manufactured Housing*.

1.4.3.2 *Loose-Fill*: Mineral fiber loose-fill thermal insulation shall meet the provisions of ASTM C764 *Standard Specification for Mineral Fiber Loose-Fill Thermal Insulation*.

1.4.4 Fasteners

Fasteners shall conform to the standards specified in 1.4.4.1 through 1.4.4.4.

1.4.4.1 *Bolts*: Bolts shall comply with ANSI/ASME B18.2.1 *Square and Hex Bolts and Screws (Inch Series)*.

1.4.4.2 *Lag Screws*: Lag screws or lag bolts shall comply with ANSI/ ASME B18.2.1 *Square and Hex Bolts and Screws (Inch Series)*.

1.4.4.3 *Screws*: Wood screws shall comply with ANSI/ASME B18.6.1 *Wood Screws (Inch Series)*. Screws used to attach gypsum panel products shall comply with ASTM C1002 *Standard Specification for Steel Self-Piercing Tapping Screws for Application of Gypsum Panel Products or Metal Plaster Bases to Wood Studs or Steel Studs*.

1.4.4.4 *Nails*: Nails shall comply with ASTM F1667 *Standard Specification for Driven Fasteners: Nails, Spikes, and Staples*.

1.4.5 Metal Parts

Metal parts shall be designed in accordance with the applicable code-recognized design procedures. Connections between wood members and metal parts shall be designed in accordance with the NDS and the appropriate code-referenced standard for metal parts.

1.4.6 Concrete or Masonry Parts

Concrete or masonry parts shall be designed in accordance with the applicable code-recognized design procedures. Connections between wood members and concrete or masonry parts shall be designed in accordance with the NDS and the appropriate code-referenced standard for concrete or masonry.

1.5 Heavy Timber

1.5.1 Heavy Timber framing members shall consist of sawn lumber, structural glued laminated timber, glued lumber, or structural composite lumber with configurations and minimum sizes as specified in Tables 1.5.1 and 1.5.4.

1.5.2 Heavy Timber roof decks, floor decks, and walls shall consist of sawn lumber, structural glued laminated timber, glued lumber, structural composite lumber, wood structural panels, or cross-laminated timber with configurations and minimum sizes as specified in Tables 1.5.2 and 1.5.4.

1.5.3 Heavy Timber floor decks constructed of lumber decking or mechanically laminated decking shall be topped with one of the materials listed in Table 1.5.3.

Table 1.5.1 Minimum Nominal Sizes¹ for Heavy Timber Framing Members

Building Element	Heavy Timber Framing Member Configurations	Minimum Size
Roof framing	<ul style="list-style-type: none"> Wood arches from the floor line or grade, not supporting floors: <ul style="list-style-type: none"> Lower half of the height Upper half of the height 	6x8 ¹ 6x6 ¹
	<ul style="list-style-type: none"> Wood arches from the top of walls, not supporting floors 	4x6 ¹
	<ul style="list-style-type: none"> Wood beams and girders 	4x6 ¹
	<ul style="list-style-type: none"> Wood trusses² 	4x6 ¹
	<ul style="list-style-type: none"> Wood framing members protected by approved automatic sprinklers under the roof deck 	3x6 ¹
Floor framing	<ul style="list-style-type: none"> Wood beams and girders 	6x10 ¹
	<ul style="list-style-type: none"> Wood arches supporting floors 	8x8 ¹
	<ul style="list-style-type: none"> Wood trusses 	8x8 ¹
Columns	<ul style="list-style-type: none"> Wood columns: <ul style="list-style-type: none"> Supporting floor loads Supporting only roof and ceiling loads 	8x8 ¹ 6x8 ¹

¹ See Table 1.5.4 for minimum dimensions of sawn lumber or glued lumber; structural glued laminated timber; and LSL, LVL, or PSL that correspond to these heavy timber nominal sizes.

² Spaced members shall be permitted, where composed of two or more members that are not less than 3x6. The intervening spaces between the 3-inch (nominal) spaced members shall be either entirely filled with blocking or the spaces shall be tightly enclosed by a continuous wood cover plate of 2-inch (nominal) minimum thickness, attached to the fire-exposed edge(s) of the 3-inch (nominal) spaced members. Splice plates shall be not less than 3x6.

Table 1.5.2 Minimum Sizes for Heavy Timber Roof Decks, Floor Decks and Walls

Building Element	Heavy Timber Panel Configuration	Minimum Size
Roof Decks	• Wood structural panels	1-1/8 in., nominal thickness ²
	• Lumber decking, laid flat and splined or T&G	2x3 ¹
	• Mechanically-laminated decking, set on edge and fastened to adjacent pieces	2x3 ¹
	• CLT, laid flat and splined, lap-spliced, or T&G	3 in., actual thickness ²
Floor Decks	• Lumber decking ³ , laid flat and splined or T&G	3x4 ¹
	• Mechanically-laminated decking ³ , set on edge and fastened to adjacent pieces	2x4 ¹
	• CLT, laid flat and splined, lap-spliced, or T&G	4 in., actual thickness ²
Exterior Walls	• Mechanically laminated decking, assembled and fastened with wide faces in contact and installed with the length of the wood decking members oriented either vertically or horizontally to form a solid wood wall	2x4 ¹
	• CLT	4 in., actual thickness ²
Interior Walls & Partitions	• Wood planks, laid flat and splined or T&G	2 layers 1x4, nominal size
	• Mechanically laminated decking, assembled and fastened with wide faces in contact and installed with the length of the wood decking members oriented either vertically or horizontally to form a solid wood wall	2x4 ¹
	• CLT	3 in., actual thickness ²

¹ See Table 1.5.4 for minimum dimensions of sawn lumber or glued lumber; structural glued laminated timber; and LSL, LVL, or PSL that correspond to these heavy timber nominal sizes.

² "Thickness" refers to cross-sectional dimension perpendicular to fire-exposed face.

³ Floor decks constructed with lumber decking or mechanically laminated decking shall be topped with one of the topping materials listed in Table 1.5.3.

Table 1.5.3 Topping for Heavy Timber Floor Decks

Topping Material	Minimum Size
Tongue-and-groove wood plank flooring, laid crosswise or diagonally	1x3, nominal size
Wood structural panels	15/32 in., nominal thickness
Particleboard panels	1/2 in., actual thickness
Concrete or gypsum concrete topping	0.75 in. thickness

Table 1.5.4 Heavy Timber Nominal Sizes and Minimum Dimensions

Heavy Timber Nominal Size	Sawn Lumber or Glued Lumber ¹ Minimum Dimensions		Structural Glued-Laminated Timber Minimum Dimensions		LSL, LVL, or PSL Minimum Dimensions	
	Narrow Face (inches)	Wide Face (inches)	Narrow Face (inches)	Wide Face (inches)	Narrow Face (inches)	Wide Face (inches)
Framing Members						
8x8	7-1/4	7-1/4	6-3/4	8-1/4	7	7-1/2
6x10	5-1/2	9-1/4	5	10-1/2	5-1/4	9-1/2
6x8	5-1/2	7-1/4	5	8-1/4	5-1/4	7-1/2
6x6	5-1/2	5-1/2	5	6	5-1/4	5-1/2
4x6	3-1/2	5-1/2	3	6-7/8	3-1/2	5-1/2
3x6	2-1/2	5-1/2	2-1/2	5-1/2	2-1/2	5-1/2
Lumber Decking Members						
3x4	2-1/2	3-1/2	2-1/2	3-1/2	2-1/2	3-1/2
2x4	1-1/2	3-1/2	--	--	1-1/2	3-1/2
2x3	1-1/2	2-1/2	--	--	1-1/2	2-1/2

¹ Glued lumber meeting the requirements of ALSC Glued Lumber Policy.

1.6 Material Combustibility

Use of materials shall be in accordance with this section and the applicable building code requirements for the Type of Construction.

1.6.1 Noncombustible Materials

1.6.1.1 Material required to be noncombustible shall be tested in accordance with ASTM E136 or ASTM E2652 and meet the ASTM E136 requirements to be classified as noncombustible. A material shall not be classified as a noncombustible material if it is subject to an increase in combustibility or flame spread beyond the limitations herein established through the effects of age, moisture, or other atmospheric conditions.

1.6.1.2 Composite material that has a base layer of noncombustible material, as determined in accordance with 1.6.1.1, and a surface layer of not more than 0.125 inches thick that has a flame spread index not greater than 50 as determined in accordance with ASTM E84 or UL 723, shall be acceptable as noncombustible materials.

1.6.1.3 Material not meeting the requirements of 1.6.1.1 or 1.6.1.2 shall be deemed as combustible material and meet the requirements of 1.6.2.

1.6.2 Combustible Materials

1.6.2.1 Where combustible materials are permitted, they shall comply with the requirements in Chapter 2.

1.7 Fire-Resistance-Rated Wood Members and Assemblies

The required fire-resistance ratings for wood members and assemblies shall be in accordance with this section and the applicable building code requirements for the Type of Construction.

1.7.1 Fire-Resistance-Rated Construction

Fire-resistance ratings for wood members and assemblies shall be established in accordance with Chapter 3.

1.7.2 Continuity of Fire-Resistance Rating

The fire-resistance-rating of a fire-resistance-rated assembly shall be maintained for the full extent of the assembly, as determined in Chapter 3, according to the continuity requirements of the applicable building code and detailing requirements at intersections in 1.7.8.

1.7.3 Supporting Construction

Construction that supports gravity loads from fire-resistance-rated building elements or assemblies shall have a fire-resistance rating that is equal to or greater than the required fire-resistance rating of the supported building elements or assemblies, except as permitted in this chapter and by the applicable building code.

1.7.3.1 *Platform construction.* In platform construction where a floor-ceiling assembly supports gravity loads from a wall, portions of the floor-ceiling construction that support the wall shall provide at least the same fire-resistance rating as required for the wall. Where a floor-ceiling assembly supports an exterior wall, the material requirements of the floor-ceiling assembly shall be in accordance with requirements for interior building elements for the Type of Construction, including portions of the floor-ceiling construction that support gravity loads from the exterior wall.

1.7.4 Column protection

Wood columns required to have a fire-resistance rating shall be designed in accordance with Chapter 3.

1.7.4.1 A wood column shall meet its required fire-resistance rating for the entire height of the column without consideration of protection from ceiling membranes.

1.7.4.2 Where a wood column is located within a wall assembly, protection provided to the wall assembly that also protects the column, shall be permitted to be included in the design of the wood column.

1.7.4.3 Vertical wood members, such as wood columns (including built-up columns) and boundary elements, located entirely within a loadbearing wood stud wall assembly shall be considered to have the fire-resistance rating of the wall assembly without additional protection where the wood member has cross-section dimensions that are equal to or greater than cross-section dimensions of the wood studs.

1.7.5 Beam protection

Wood beams required to have a fire-resistance rating shall be designed in accordance with Chapter 3.

1.7.5.1 A wood beam shall meet its required fire-resistance rating for the entire span of the beam. For multi-span beams where individual spans have different required fire-resistance ratings, the maximum required fire-resistance rating shall be provided for all spans.

Exception: For multi-span beams where individual spans have different required fire-resistance ratings, and where failure of any individual span would not decrease the fire resistance ratings of the remaining spans, the fire-

resistance rating required for each individual span shall be provided.

1.7.5.2 Where a wood beam supports gravity loads from more than two floors, more than one floor and one roof, or a wall more than two stories high, the wood beam shall achieve its required fire-resistance rating without consideration of protection from ceiling membranes.

1.7.5.3 Where a wood beam supports gravity loads from two floors or less, one floor and one roof, or walls not more than two stories high, ceiling membranes that also provide protection to the beam shall be permitted to be included in the design of the beam.

1.7.5.4 Horizontal wood members, such as wood beams (including built-up beams), and boundary elements located entirely within a wood joist floor-ceiling or roof-ceiling assembly and that support gravity loads from one floor or one roof only shall be considered to have the fire-resistance rating of the floor-ceiling or roof-ceiling assembly without additional protection where the wood member has cross-sectional dimensions that are equal to or greater than cross-section dimensions of the wood joists.

1.7.6 Truss protection

The fire-resistance rating of wood trusses and wood truss assemblies shall be established based on tests or approved calculations that consider the fire performance of the wood trusses, including connections such as chord splices and web-to-chord connections. Approval shall be based on tests or analyses that demonstrate the fire-resistance of the truss or assembly meets the required fire resistance.

1.7.6.1 A wood truss shall meet its required fire-resistance rating for the entire length of the truss.

1.7.6.2 Where a wood truss supports gravity loads from more than two floors, more than one floor and one roof, or a wall more than two stories high, the wood truss shall achieve its required fire-resistance rating without consideration of protection from ceiling membranes.

1.7.6.3 Where a wood truss supports gravity loads from two floors or less, one floor and one roof, or walls not more than two stories high, ceiling membranes that also provide protection to the truss shall be permitted to be included in the design of the truss.

1.7.7 Protection of Connections

Where a wood member is required to have a fire-resistance rating, structural connections of that member shall be protected from fire exposure for the time corresponding to the required fire resistance rating of the wood member. Protection of the structural connection shall be established by test or designed in accordance with 3.9. Intersections of fire-resistance-rated assemblies shall be in accordance with 1.7.8.

Exception: Structural connections tested as part of a fire-resistance-rated assembly shall be considered to have the fire-resistance rating of the assembly without additional protection.

1.7.8 Joints and Intersections between Fire-Resistance-Rated Assemblies

Where required by the applicable building code, intersections of fire-resistance-rated assemblies shall be detailed to prevent burn-through before the required thermal separation time is reached (see Section 3.6). Where use of a fire-resistant joint system is required at joints between fire-resistance-rated assemblies, the fire-resistant joint system shall be in accordance with Section 2.5.1.3. Where a membrane is used to protect a fire-resistance-rated assembly, the edges of the membrane shall be protected in accordance with Section 1.7.8.1. Fireblocking shall be installed at intersections of concealed spaces in accordance with Section 2.5.2.

1.7.8.1 *Edges of membranes.* Edges of membranes shall be detailed to prevent fire from circumventing the

membrane protection and compromising the protected assembly. Installation of gypsum panels in accordance with 1.7.8.1.1 and 1.7.8.1.2 shall be deemed to satisfy this requirement.

1.7.8.1.1 Where a gypsum panel ceiling membrane intersects a gypsum panel wall membrane, the gypsum panel ceiling membrane shall be installed prior to the gypsum panel wall membrane to ensure that the gypsum panel ceiling membrane extends past the gypsum panel wall membrane.

1.7.8.1.2 Where a gypsum panel wall membrane intersects at a wall-to-wall intersection, the gypsum panel membrane on the wall with a greater fire-resistance rating shall be installed prior to the gypsum panel membrane on the wall with a lesser fire-resistance rating. For fire-resistance-rated wood-frame walls, the edges of gypsum wall panel membranes at wall-to-wall intersections shall be attached to and fully supported by vertical framing equal in size to the wood studs or larger.

1.7.8.2 *Wood members entering concrete or masonry fire walls.* Where wood structural members are embedded in a concrete or masonry fire wall from opposite sides of the fire wall, there shall be at least 4 inches between the embedded member ends. Where wood members frame into hollow walls or walls of hollow units, the hollow space shall be filled with non-combustible materials that are approved for use as fireblocking and shall fill the full thickness of the wall for a distance not less than 4 inches above, below, and between the embedded ends of members.

1.7.9 Limitations and Protection of Openings

Limitations and protection of openings and penetrations in fire-resistance-rated assemblies shall be in accordance with the applicable building code.

CHAPTER 2: IGNITION AND FLAMMABILITY

2.1 General

Chapter 2 specifies ignition and flammability requirements for wood products and provides reference test standards to be used to show compliance with these requirements.

2.2 Ignition Resistance

Where ignition resistance of combustible exterior wall coverings is regulated, materials shall be tested in accordance with NFPA 268 and shall not exhibit sustained flaming when exposed to an incident radiant heat flux of 12.5 kW/m².

Exception: Testing is not required for wood or wood-based products used as exterior wall coverings.

2.3 Flame Spread Performance of Wood Products

2.3.1 Interior wall and ceiling finish materials

2.3.1.1 Where interior wall and ceiling finishes are required to be tested for flame spread and smoke development, materials used in these applications shall be tested in accordance with ASTM E84 or UL723 and shall be classified in accordance with their reported flame spread index (FSI) and smoke developed index (SDI) as indicated by Table 2.3.1.

Table 2.3.1. Material Classification

Class	FSI Range	SDI Range
A	0-25	0-450
B	30-75	0-450
C	80-200	0-450

EXCEPTION: Wood materials tested in accordance with NFPA 286 and complying with the following requirements shall be considered to meet the requirements of Class A:

1. During the 40-kW exposure, flames shall not spread to the ceiling.
2. Flames shall not spread to the outer extremity of the sample on any wall or ceiling.
3. Flashover, as defined in NFPA 286, shall not occur.
4. The peak heat release rate throughout the test shall not exceed 800 kW.
5. The total smoke released throughout the test shall not exceed 1,000 m².

2.3.1.2 As an alternative to 2.3.1.1, the FSI and SDI values and the associated material classifications listed in Supplement A1 shall be permitted to be used for sawn lumber and products manufactured from sawn lumber, such as structural glued laminated timber and cross-laminated timber, of the species tested, and the FSI values and material classifications listed in Supplement A2 shall be permitted to be used for oriented strand board (OSB), hardwood and softwood plywood, particleboard, and medium density fiberboard (MDF) of the listed thicknesses.

2.3.2 Interior floor finish materials

Where interior floor finish are required to be classified for fire performance, these materials shall be tested in accordance with ASTM E648 or NFPA 253 and shall meet the requirements of Class I (0.45 watts/cm² or greater) or Class II (0.22 watts/cm² or greater) in accordance with the applicable building code.

2.3.3 Fire retardant-treated wood

Fire retardant-treated wood (FRTW) shall meet the conditions of classification specified in ASTM E2768. FRTW shall be impregnated with chemicals by a pressure process or other means during manufacture. Where FRTW is used in locations that are damp, wet, or exposed to weather, it shall meet the conditions of classification specified in ASTM E2768 after accelerated weathering in accordance with ASTM D2898 and shall be identified and labeled “exterior”. FRTW not labeled “exterior” shall demonstrate a maximum 28% moisture content when tested in accordance with ASTM D3201 at 92% relative humidity.

2.3.3.1 Design values: Design values and treatment adjustment factors for FRTW shall consider both the immediate effects of treatment chemicals and re-drying, and the long-term effects of elevated temperature and humidity on wood properties. Treatment adjustment factors shall consider the wood species and the climatological location where FRTW will be used. All adjustment factors applicable to untreated wood from the NDS shall also apply to FRTW.

2.3.3.1.1 Softwood plywood: Design values for fire-retardant-treated softwood plywood shall be determined based on published design values for untreated softwood plywood determined in accordance with PS 1 or PS 2, with treatment adjustment factors determined and published by the fire-retardant-treatment manufacturer in accordance with ASTM D5516 and ASTM D6305.

2.3.3.1.2 Sawn Lumber: Design values for fire-retardant-treated sawn lumber shall be determined based on the design values for untreated sawn lumber published by lumber rules writing agencies accredited by the American Lumber Standard Committee under PS 20, with treatment adjustment factors determined and published by the fire retardant-treatment manufacturer in accordance with ASTM D5664 and ASTM D6841.

2.3.3.1.3 Laminated Veneer Lumber (LVL): Reference design values and treatment adjustment factors for fire-retardant-treated LVL shall be determined and published by the fire retardant-treated LVL manufacturer in accordance with ASTM D8223.

2.3.4 Wood-based Products with Fire-Retardant Coatings

Approved wood-based products with fire-retardant coatings used as interior wall and ceiling finish materials shall be classified in accordance with ASTM E84 or UL723 as required in 2.3.1. Approved wood-based products with fire-retardant coatings used as an alternative to FRTW shall meet the conditions of classification specified in ASTM E2768. A wood-based product with fire-retardant coating shall be used in approved end-use environmental conditions. The effects of fire-retardant coatings on strength and stiffness shall be evaluated in the approval process and accounted for in design.

2.4 Vertical and Lateral Flame Propagation

2.4.1 Exterior Wall Coverings

Where combustible exterior wall coverings are permitted by the Type of Construction and the ignition resistance of the exterior wall covering is regulated, wood or wood-based materials used as wall coverings shall meet the requirements of Sections 2.2, 2.3.3, and this section.

2.4.1.1 Coverage area: Exterior wall coverings of wood or wood-based materials shall not exceed 10% of the exterior wall surface when the fire separation distance is 5 feet or less.

Exception: Where the exterior wall covering is constructed of fire-retardant-treated wood suitable for exterior use, there is no limit of the coverage area.

2.4.1.2 Coverage height: Exterior wall coverings of wood or wood-based materials shall not exceed 40 feet in height above grade.

Exception: Where the exterior wall covering is constructed of fire-retardant-treated wood (FRTW) suitable for exterior use, the exterior wall covering shall not exceed 60 feet in height above grade. Where FRTW exterior wall coverings are used above 40 feet, the exterior wall shall be tested in accordance with and shall comply with the acceptance criteria of NFPA 285.

2.4.1.3 Fireblocking: Where exterior wall coverings or other exterior architectural elements are of wood construction or installed over wood furring or wood, fireblocking meeting the requirements of 2.5.2 shall be installed within concealed spaces between the exterior wall coverings and the exterior walls. The distance between the back of the exterior wall covering and the exterior wall shall not exceed 1-5/8 inches. Fireblocking shall be installed at maximum intervals of 20 feet in either dimension so that there will be no concealed space exceeding 100 square feet between fireblocking. Exterior trim need not be considered as part of the 20-foot interval if the exterior trim sections are separated by at least 4 inches and the ends are closed.

Exception: Fireblocking shall not be required where the exterior wall covering has been tested without the fireblocking and complies with NFPA 285, and the exterior wall covering is installed as tested.

2.4.1.4 Top of exterior walls: exterior wall coverings of wood or wood-based materials shall not extend beyond the top of exterior walls.

2.4.1.5 Wood veneers: Wood veneers used as part of the exterior wall covering shall meet the requirements of this section.

2.4.1.5.1 Wood veneer thickness: Wood veneers shall be not less than 1-inch (nominal) lumber (3/4-inch thickness), 7/16-inch exterior hardboard siding, or 3/8-inch exterior-type wood structural panels or particleboard.

2.4.1.5.2 Wood veneer shall be attached to a noncombustible backing or furred from a noncombustible sheathing.

2.4.1.5.3 Where open or spaced wood veneers are installed without concealed spaces, the wood veneers shall not project more than 24 inches from the exterior wall.

2.4.2 Building Projections

Balconies and similar appendages of wood construction, and projections of wood or wood-based materials extending to less than five feet from a property line or a line used to establish fire separation distance, shall be in accordance with the applicable building code.

2.5 Firestopping, Fireblocking and Draftstopping

2.5.1 Firestopping

2.5.1.1 Membrane-penetration firestop system: Where an approved membrane-penetration firestop system is required to protect a membrane penetration in a fire-resistance-rated assembly, the assembly shall be permitted to be designed in accordance with Chapter 3, and the firestop system shall have an F and T rating not less than the fire-resistance-rating of the fire-resistance-rated assembly when tested in accordance with ASTM E814 or UL1479 with a minimum positive pressure differential of 0.01 in. of water.

2.5.1.2 Through-penetration firestop system: Where an approved through-penetration firestop system is required to protect a penetration through a fire-resistance-rated assembly, the assembly shall be permitted to be designed in accordance with Chapter 3, and the firestop system shall have an F and T rating not less than the fire-resistance-rating of the fire-resistance-rated assembly when tested in accordance with ASTM E814 or UL 1479 with a minimum positive pressure differential of 0.01 in. of water.

2.5.1.3 Fire-resistant joint system: Where an approved fire-resistant joint system is required for a designed joint between fire-resistance rated assemblies, the assemblies shall be permitted to be designed in accordance with Chapter 3 and the fire-resistance joint system shall be tested in accordance with ASTM E1966 or UL 2079.

2.5.2 Fireblocking

In wood construction, fireblocking shall be installed to restrict the passage of flames within and between concealed spaces constructed using exposed combustible materials. Fireblocking materials shall be in accordance with 2.5.2.1. Fireblocking shall be installed in the locations specified in 2.5.2.2 through 2.5.2.5 and as specified by the applicable building code. The integrity of fireblocking shall be maintained permanently. If the fireblocking is removed to allow temporary access or construction, it shall be replaced immediately after access or construction is completed.

2.5.2.1 Fireblocking materials: The following materials shall be permitted for fireblocking:

1. One layer of 2-inch (nominal) lumber, (1½-inch thickness).
2. One layer of minimum 1⅛-inch thick structural composite lumber.
3. One layer of minimum 1⅛-inch thick engineered wood rim board.
4. Two layers of 1-inch (nominal) lumber, (¾-inch thickness); abutting ends and edges in adjacent layers spaced at least 2 inches apart.
5. One layer of 23/32-inch wood structural panels with all panel edges backed by 23/32-inch wood structural panels, wood framing, or wood blocking.
6. One layer of 3/4-inch particleboard with all panel edges backed by 3/4-inch particleboard, wood framing, or wood blocking.
7. One layer of 1/2-inch gypsum panel product; with all panel edges backed by wood framing or wood blocking.
8. One layer of 1/4-inch cement-based millboard; with all panel edges backed by wood framing or wood blocking.
9. Batts or blankets of minimum 2.5 pcf mineral wool filling the entire cross section of the wall cavity, installed to be securely retained in place, and tightly packed around piping, conduit, or similar obstructions.
10. Wood members and wood protection materials designed in accordance with Chapter 3 to limit the passage of flames for at least 15 minutes.

2.5.2.2 Concealed wall cavities: Concealed spaces of stud walls and partitions, which include furred spaces and spaces within double walls, double-stud walls, and staggered stud walls, shall have fireblocking in accordance with 2.5.2.2.1 and 2.5.2.2.2.

2.5.2.2.1 Horizontal intervals: Fireblocking shall be provided for the full height of the cavity, at horizontal intervals not exceeding 10 feet.

Exception: Fireblocking is not required where batts or blankets of mineral wool, fiberglass or other approved nonrigid materials are installed such that they prevent the movement of hot air and gases and will remain in place.

2.5.2.2.2 Vertical intervals: Fireblocking shall be installed at the ceiling and floor levels for the full length of the wall.

2.5.2.3 Intersection of concealed spaces: Fireblocking shall be provided at intersections between concealed spaces within wall assemblies and concealed spaces within floor/ceiling and roof/ceiling assemblies, and at intersections between concealed spaces in other locations such as occur at soffits, drop ceilings, and cove ceilings.

2.5.2.4 Stairways: Fireblocking shall be provided in concealed spaces between stair stringers at the top and bottom of the stair run.

2.5.2.5 Concealed sleeper spaces: Where wood sleepers are used for laying wood flooring on masonry or concrete fire-resistance-rated floors, the concealed space between the floor and the underside of the wood flooring shall meet one of the following:

1. The concealed space between the floor slab and the underside of the wood flooring shall be filled with an approved material to resist the free passage of flame and products of combustion; or,
2. Fireblocking shall be installed to limit open spaces under the flooring to no more than 100 square feet and also beneath permanent partitions to prevent fire spread between adjoining rooms.

2.5.3 Draftstopping

In wood construction, draftstopping shall be installed to subdivide large areas and restrict the movement of air and hot gases between combustible concealed spaces within floor-ceiling assemblies, and within attic spaces. Draftstopping materials shall be in accordance with 2.5.3.1. The integrity of draftstopping shall be maintained permanently. If the draftstopping is removed to allow temporary access or construction, it shall be replaced immediately after access or construction is completed.

2.5.3.1 Draftstopping materials: The following materials shall be permitted for draftstopping:

1. 1/2-inch gypsum panel product
2. 3/8-inch wood structural panel
3. 3/8-inch particleboard
4. 1-inch (nominal) lumber, (3/4-inch thickness)
5. cement fiberboard
6. batts or blankets of mineral wool or glass fiber insulation, adequately supported

2.5.3.2 Draftstopping in floors: Draftstopping shall be installed to divide concealed spaces within floor/ceiling assemblies constructed using wood or wood-based materials so that horizontal areas of concealed spaces do not exceed 1,000 square feet.

Exception: Buildings equipped throughout with an automatic sprinkler system.

2.5.3.3 Draftstopping in attics: Draftstopping shall be installed to divide attic spaces constructed using wood or wood-based materials such that horizontal areas do not exceed 3,000 square feet. Separate ventilation shall be provided for each attic space.

Exception: Buildings equipped throughout with an automatic sprinkler system.

CHAPTER 3: FIRE RESISTANCE

3.1 General

3.1.1 Scope

Chapter 3 establishes fire resistance design provisions that apply to all wood structural members, assemblies, and connections designed using the *National Design Specification® (NDS®) for Wood Construction*.

3.1.2 Fire Exposure

The provisions of Chapter 3 are based on the standard fire exposure and acceptance criteria specified in ASTM E119 or UL 263. Design fire scenarios, used to conduct performance-based designs, are outside the scope of this standard.

3.1.3 Fire-Resistance Rating

The fire-resistance rating of a member or assembly shall be based on the fire exposure and acceptance criteria specified in ASTM E119 or UL 263. Fire-resistance ratings shall be permitted to be determined using fire tests, calculations as prescribed herein, or engineering analyses based on comparison with fire tests of similar members or assemblies. Where a member or assembly is required to prevent passage of fire, the fire-resistance rating of that member or assembly shall be the least of the structural fire resistance time, the thermal separation time, and the burn-through time. Where a member or assembly is not required to prevent passage of fire, the fire-resistance rating of that member or assembly shall be the structural fire resistance time.

3.1.3.1 Design requirements: Each wood member or connection shall be designed in accordance with NDS for all loads prescribed by the applicable building code. In addition, where required to be fire-resistance-rated, the wood member, assembly or connection shall be designed to support its design dead load plus any applied live, roof live, or snow loads for the required fire resistance time based on the ASTM E119 or UL 263 fire exposure.

3.1.3.2 Reference design values: Reference design values and specific design provisions applicable to wood members, assemblies, and connections shall be in accordance with the NDS and this standard. Application of adjustment factors to reference design values and use with reduced cross-sections shall be in accordance with 3.2.5.

3.1.3.3 Test loads: Where the fire-resistance rating is determined by testing, the total load (w_T) to be used in ASTM E119 or UL 263 fire resistance testing shall simulate a maximum design load unless limited design criteria are specified, and a corresponding reduced load is applied and reported. The total load (w_T) shall include the superimposed load (w_S) to be applied throughout a fire resistance test combined with the member or assembly dead load (w_D).

3.1.3.3.1 For wood-frame walls, the superimposed load (w_S) shall be determined in accordance with ASTM D6513.

3.1.3.3.2 For wood-frame floor-ceiling assemblies, the superimposed load (w_S) shall be determined in accordance with ASTM D7746.

3.1.3.3.3 For other members and assemblies, the maximum design load shall be determined based on the reference design value determined in accordance with the NDS multiplied by all applicable adjustment factors, except for C_D , K_F , ϕ , and λ . The superimposed load (w_S) shall be calculated as the total load (w_T) minus the member or assembly dead load (w_D):

$$w_S = w_T - w_D \quad (3.1-1)$$

3.1.3.3.4 The total load (w_T) shall be reported as a percentage of the maximum design load for the member, assembly, or connection.

3.1.3.4 *Design loads*: Where the fire-resistance rating is determined by calculation in accordance with the provisions of this Chapter, the design load used for calculating the fire-resistance time shall be determined in accordance with the NDS and this section.

3.1.3.4.1 *Allowable Stress Design (ASD)*: Where required to be fire-resistance-rated, the total load (w_T) to be used to calculate the fire resistance time for a member, assembly, or a connection designed using ASD methods shall be the design dead load (w_D) plus the design gravity live loads (w_L), including applicable occupancy live load, roof live load, and snow load, supported by the member or assembly.

$$w_T = w_D + w_L \quad (3.1-2)$$

3.1.3.4.2 *Strength Design (LRFD)*: Where a member, assembly, or a connection is designed using LRFD methods, the total load (w_{T-LRFD}) to be used to calculate the fire resistance time shall be calculated as follows:

$$w_{T-LRFD} = \frac{1.5(w_D + w_L)^2}{1.2w_D + 1.6w_L} \quad (3.1-3)$$

3.2 Calculation of Structural Fire Resistance of Exposed Wood Members

Design provisions for exposed wood members herein are limited to structural fire resistance calculations not exceeding 2 hours. Wood members or assemblies protected with one or more of the protection options in 3.3 shall be permitted to exceed the 2-hour limitation on calculated fire resistance per this section, however, the calculated contribution of the wood members to the structural fire resistance shall not exceed 2 hours.

3.2.1 Char Rate of Exposed Wood Members

The non-linear char rate to be used in this procedure shall be estimated from published nominal 1-hour char rate data using the following equation:

$$\beta_t t^{0.813} = \beta_n t \quad (\text{at } t = 1 \text{ hr}) \quad (\text{Equation 3.2-1})$$

Where:

- β_t = Non-linear char rate constant (in./hr^{0.813}), adjusted for exposure time, t
- β_n = Nominal char rate constant (in./hr), linear char rate based on 1-hour exposure
- t = Exposure time (hr)

3.2.1.1 *Standard Char Rate*: A nominal char rate, β_n , of 1.5 in./hr shall be applicable for sawn lumber, structural glued laminated softwood timber, laminated veneer lumber, parallel strand lumber, laminated strand lumber, and cross-laminated timber.

3.2.2 Char Depth, a_{char}

3.2.2.1 For sawn lumber, structural glued laminated timber, laminated veneer lumber, parallel strand lumber, and laminated strand lumber, the char depth, a_{char} , for each exposed surface shall be calculated as:

$$a_{\text{char}} = \beta_t t^{0.813} \quad (\text{Equation 3.2-2})$$

3.2.2.2 For cross-laminated timber, the time required to reach the glue line for each lamination shall be calculated as:

$$t_{gl,i} = \left(\frac{h_{lam,i}}{\beta_t} \right)^{1.23} \quad (\text{Equation 3.2-3})$$

Where:

$$\begin{aligned} t_{gl,i} &= \text{time to char through lamination } i \text{ (hr)} \\ h_{lam,i} &= \text{thickness of lamination } i \text{ (in.)} \end{aligned}$$

The number of laminations fully charred through, n_{lam} , shall be calculated by subtracting the sum of times to char through each fully charred lamination, $t_{gl,i}$, from the total exposure time, t . The value of n_{lam} shall be the maximum integer value in which the following equation is true:

$$t - \sum_{i=1}^{n_{lam}} t_{gl,i} \geq 0 \quad (\text{Equation 3.2-4})$$

Where:

$$n_{lam} = \text{number of laminations fully charred (truncated integer)}$$

The values of $t_{gl,i}$ and n_{lam} determined in the Equations 3.2-3 and 3.2-4, respectively, shall be used to calculate the char depth, a_{char} :

$$a_{char} = \sum_{i=1}^{n_{lam}} h_{lam,i} + \beta_t \left(t - \sum_{i=1}^{n_{lam}} t_{gl,i} \right)^{0.813} \quad (\text{Equation 3.2-5a})$$

Alternately, for cross-laminated timber manufactured with laminations of equal thickness, h_{lam} , the char depth, a_{char} , shall be permitted to be calculated using the time to char through one lamination, t_{gl} , and the following equation:

$$a_{char} = n_{lam} \cdot h_{lam} + \beta_t \left(t - (n_{lam} \cdot t_{gl}) \right)^{0.813} \quad (\text{Equation 3.2-5b})$$

Where:

$$t_{gl} = \left(\frac{h_{lam}}{\beta_t} \right)^{1.23} \quad (\text{Equation 3.2-6})$$

$$n_{lam} = \frac{t}{t_{gl}} \quad (\text{Equation 3.2-7})$$

3.2.3 Effective Char Depth, a_{eff}

For structural calculations, section properties shall be calculated using standard equations for area, section modulus and moment of inertia using reduced cross-sectional dimensions to account for charring and the effects of elevated temperature. Except as provided in 3.2.3.3 for specific bearing conditions, the dimensions are reduced by the effective char depth, a_{eff} , for each surface exposed to fire, where:

$$a_{eff} = 1.2 a_{char} \quad (\text{Equation 3.2-8a})$$

3.2.3.1 For sawn lumber and timbers, structural glued laminated timber, laminated veneer lumber (LVL), parallel strand lumber (PSL), and laminated strand lumber (LSL), assuming a nominal char rate, $\beta_n = 1.5$ in./hr, the char depth, a_{char} , and effective char depth, a_{eff} , are provided in Table 3.2.3.1.

Table 3.2.3.1 Char Depth and Effective Char Depth
(for $\beta_n = 1.5$ inches/hour)

Required Fire-Resistance Rating (hr)	Char Depth, a_{char} (in.)	Effective Char Depth, a_{eff} (in.)
1-Hour	1.5	1.8
1½-Hour	2.1	2.5
2-Hour	2.6	3.2

3.2.3.2 For cross-laminated timber, reduced section properties shall be calculated using equations provided by the cross-laminated timber manufacturer based on the actual layup used in the manufacturing process. For cross-laminated timber manufactured with laminations of equal thickness and assuming a nominal char rate, β_n , of 1.5 in./hr, the char depth, a_{char} , and effective char depth, a_{eff} , are provided for each exposed surface in Table 3.2.3.2:

Table 3.2.3.2 Effective Char Depth (for CLT with $\beta_n=1.5$ inches/hour)

Required Fire-Resistance Rating (hr)	Lamination Thickness, h_{lam} (in.)								
	5/8	3/4	7/8	1	1-1/4	1-3/8	1-1/2	1-3/4	2
	Char Depth, a_{char} (in.)								
1-Hour	1.8	1.8	1.7	1.7	1.7	1.6	1.5	1.5	1.5
1½-Hour	2.8	2.7	2.6	2.5	2.4	2.4	2.4	2.3	2.2
2-Hour	3.7	3.6	3.4	3.4	3.2	3.2	3.0	3.0	3.0
	Effective Char Depth, a_{eff} (in.)								
	1-Hour	2.2	2.2	2.1	2.0	2.0	1.9	1.8	1.8
	1½-Hour	3.4	3.2	3.1	3.0	2.9	2.8	2.8	2.6
2-Hour	4.4	4.3	4.1	4.0	3.9	3.8	3.6	3.6	3.6

Alternatively, for CLT layups in Annex A of APA PRG 320, the cross-laminated timber is permitted to be designed using properties for one of the tabulated CLT layups in Annex A where the number of laminations does not exceed the number of uncharred laminations remaining after the effective char depth, from Table 3.2.3.2, has been removed.

3.2.3.3 Effective Char Depth for Bearing. The dimensions of the perpendicular-to-grain bearing area shall be reduced by the effective char depth for bearing, $a_{eff(bearing)}$, as follows:

1. Where an adhesive or sealant meeting ASTM C920 or ASTM D3498 is applied at the contact surfaces extending from exposed edges to a minimum depth of a_{char} into the bearing interface.

$$a_{eff(bearing)} = 1.5 a_{char} \quad (\text{Equation 3.2-8b})$$

2. For all other bearing conditions.

$$a_{eff(bearing)} = 2.0 a_{char} \quad (\text{Equation 3.2-8c})$$

3.2.4 Char Penetration at Intersections and Abutting Edges

Intersections and abutting edges of exposed wood members shall be designed in accordance with 3.2.4.1 through 3.2.4.3 based on the proximity of the adjacent members.

3.2.4.1 For a gap between exposed wood members greater than 1/8-inch, wood surfaces within the gap shall be assumed to be fully exposed to fire for the full depth of the gap.

3.2.4.2 For intersections and abutting edges of exposed wood members that are in contact, the char front shall be assumed to penetrate between wood members a distance equal to $2a_{\text{char}}$ (see Figure 3-1).

Exception: Char penetration between contact surfaces at bearing locations shall be taken as a_{char} where an adhesive or sealant meeting ASTM C920 or ASTM D3498 is applied at the contact surfaces extending from exposed edges to a minimum depth of a_{char} into the bearing interface.

3.2.4.3 For a gap between exposed wood members less than or equal to 1/8 inch in service, the char front shall be assumed to penetrate between wood members a distance equal to $2a_{\text{char}}$ (see Figure 3-1), provided that air flow through the gap does not occur. Air flow through the gap is permitted to be neglected where one of the following occurs:

1. A Fire Resistant Joint System in accordance with 2.5.1.3 is used to firestop the intersection.
2. The intersection is detailed to prevent burn-through in accordance 3.6.
3. Draftstopping material as listed in 2.5.3.1, excluding fiberglass and mineral wool batts, is installed on the unexposed side of the assembly.
4. Adhesives or sealants meeting ASTM C920 or ASTM D3498 are applied in the gap on the unexposed side of the assembly.
5. The intersection occurs entirely within a single compartment such that the gap does not provide for air passage between compartments.

If air flow through the gap cannot be neglected, wood surfaces within the gap shall be assumed to be fully exposed to fire for the full depth of the gap.

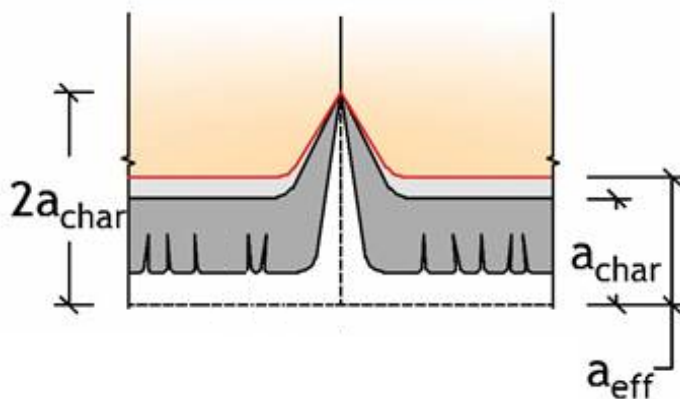


Figure 3-1. Char penetration at abutting wood members that are unbonded

3.2.5 Member Strength

For sawn lumber, structural glued laminated softwood timber, laminated veneer lumber, parallel strand lumber, laminated strand lumber, and cross-laminated timber, the average member strength shall be approximated by multiplying reference design values (F_b , F_{bE} , F_t , F_v , F_c , F_{cE} , $F_{c\perp}$) by the adjustment factors specified in Table 3.2.5. All design values and cross-sectional properties shall be adjusted prior to structural calculations, including structural interaction equations, in the NDS provisions.

Table 3.2.5 Adjustment Factors for Fire Design^{1,2}

			ASD or LRFD						
			Design Stress to Member Strength Factor, K	Size Factor ³	Volume Factor ³	Flat Use Factor ³	Repetitive Member Factor	Beam Stability Factor ⁴	Column Stability Factor ⁴
Bending Strength	F_b	x	2.85	C_F	C_V	C_{fu}	C_r	C_L	-
Beam Buckling Strength	F_{bE}	x	2.03	-	-	-	-	-	-
Tensile Strength	F_t	x	2.85	C_F	-	-	-	-	-
Shear Strength	F_v	x	2.75	-	-	-	-	-	-
Compressive Strength	F_c	x	2.58	C_F	-	-	-	-	C_P
Column Buckling Strength	F_{cE}	x	2.03	-	-	-	-	-	-
Bearing Strength	$F_{c\perp}$	x	1.67						

1. See NDS for applicability of adjustment factors for specific products.

2. Member strengths shall not be adjusted for C_D , C_M , nor C_t since these adjustments are addressed in the design stress to member strength factor.

3. Factor shall be based on initial cross-section dimensions.

4. Factor shall be based on reduced cross-section dimensions.

3.2.6 Design of Members

Induced stresses calculated using the design loads determined in 3.1.3.4 and the reduced section properties determined in 3.2.3 shall not exceed the member strength determined in 3.2.5.

3.2.6.1 Special Provisions for Lumber Decking: Lumber decking shall consist of tongue-and-groove (T&G) planks or mechanically-laminated dimension lumber set on edge and nailed to the adjacent pieces. Mechanically-laminated decking shall be designed as an assembly of wood beams partially exposed on the sides due to shrinkage and char contraction and fully exposed on the bottom face. Abutting edges of exposed lumber decking shall be designed in accordance with 3.2.4.

Exceptions:

1. Single and double tongue- and-groove (T&G) decking shall be permitted to be designed as an assembly of wood beams fully exposed only on the bottom face.

2. For mechanically-laminated decking the effects of partial exposure on the sides of the individual decking laminations shall be permitted to be designed assuming wood surfaces between laminations have an effective char depth that is 33% of the char depth for the fully exposed wood on the bottom face, extending for the full depth of the decking.

3.2.6.2 *Special Provisions for Structural Glued Laminated Timber Beams:* For structural glued laminated timber bending members that are required to have a fire-resistance rating and are manufactured with multiple lamination grades throughout the depth, the following additional layup requirements shall apply in addition to any requirements of the structural design:

1. For structural glued laminated timber bending members required to have a fire resistance rating of up to 1 hour, the beam shall be manufactured to the specified layup except that:
 - a. For unbalanced beams with the top of the beam not exposed to fire, a nominal 2-inch core lamination shall be removed, and an additional nominal 2-inch outer tension lamination shall be placed adjacent to the outer tension lamination as shown in Figure 3-2.
 - b. For unbalanced beams with the top of the beam exposed to fire, two nominal 2-inch core laminations shall be removed, and an additional nominal 2-inch outer tension lamination and an additional nominal 2-inch outer compression lamination shall be placed adjacent to the outer tension lamination and the outer compression lamination, respectively, as shown in Figure 3-3.
 - c. For balanced beams with the top of the beam not exposed to fire, a nominal 2-inch core lamination shall be removed, and an additional nominal 2-inch outer tension lamination shall be placed adjacent to the outer tension lamination at the bottom of the beam as shown in Figure 3-2.
 - d. For balanced beams with the top of the beam exposed to fire, two nominal 2-inch core laminations shall be removed, and an additional nominal 2-inch outer tension lamination shall be placed adjacent to the outer tension lamination at the top and bottom of the beam as shown in Figure 3-3.
2. For structural glued laminated timber bending members required to have a fire resistance rating of greater than 1 hour and up to 2 hours, the beam shall be manufactured to the specified layup except that:
 - a. For unbalanced beams with the top of the beam not exposed to fire, two nominal 2-inch core laminations shall be removed, and two additional nominal 2-inch outer tension laminations shall be placed adjacent to the outer tension lamination as shown in Figure 3-2.
 - b. For unbalanced beams with the top of the beam exposed to fire, four nominal 2-inch core laminations shall be removed, and two additional nominal 2-inch outer tension laminations and two additional nominal 2-inch outer compression laminations shall be placed adjacent to the outer tension lamination and the outer compression lamination, respectively, as shown in Figure 3-3.
 - c. For balanced beams with the top of the beam not exposed to fire, two nominal 2-inch core laminations shall be removed, and two additional nominal 2-inch outer tension laminations shall be placed adjacent to the outer tension lamination at the bottom of the beam, as shown in Figure 3-2.
 - d. For balanced beams with the top of the beam exposed to fire, four nominal 2-inch core laminations shall be removed, and two additional nominal 2-inch outer tension laminations shall be placed adjacent to the outer tension lamination at the top and bottom of the beam as shown in Figure 3-3.

TOP OF BEAM NOT EXPOSED TO FIRE

Unbalanced Layout			Balanced Layout		
Outer Compression	Outer Compression	Outer Compression	Outer Tension	Outer Tension	Outer Tension
Inner Compression	Inner Compression	Inner Compression	Inner Tension	Inner Tension	Inner Tension
Inner Compression	Inner Compression	Inner Compression	Inner Tension	Inner Tension	Inner Tension
Core	Core	Core	Core	Core	Core
Core	Core	Core	Core	Core	Core
Core	Core	Core	Core	Core	Core
Core	Core	Core	Core	Core	Core
Core	Core	Inner Tension	Core	Core	Inner Tension
Core	Inner Tension	Inner Tension	Core	Inner Tension	Inner Tension
Inner Tension	Inner Tension	Additional Outer Tension	Inner Tension	Inner Tension	Additional Outer Tension
Inner Tension	Additional Outer Tension	Additional Outer Tension	Inner Tension	Additional Outer Tension	Additional Outer Tension
Outer Tension	Outer Tension	Outer Tension	Outer Tension	Outer Tension	Outer Tension
Unrated	One Hour	Two Hour	Unrated	One Hour	Two Hour

Figure 3-2 Top of Beam Not Exposed to Fire

TOP OF BEAM EXPOSED TO FIRE

Unbalanced Layout			Balanced Layout		
Outer Compression	Outer Compression	Outer Compression	Outer Tension	Outer Tension	Outer Tension
Inner Compression	Additional Outer Compression	Additional Outer Compression	Inner Tension	Additional Outer Tension	Additional Outer Tension
Inner Compression	Inner Compression	Additional Outer Compression	Inner Tension	Inner Tension	Additional Outer Tension
Core	Inner Compression	Inner Compression	Core	Inner Tension	Inner Tension
Core	Core	Inner Compression	Core	Core	Inner Tension
Core	Core	Core	Core	Core	Core
Core	Core	Core	Core	Core	Core
Core	Core	Inner Tension	Core	Core	Inner Tension
Core	Inner Tension	Inner Tension	Core	Inner Tension	Inner Tension
Inner Tension	Inner Tension	Additional Outer Tension	Inner Tension	Inner Tension	Additional Outer Tension
Inner Tension	Additional Outer Tension	Additional Outer Tension	Inner Tension	Additional Outer Tension	Additional Outer Tension
Outer Tension	Outer Tension	Outer Tension	Outer Tension	Outer Tension	Outer Tension
Unrated	One Hour	Two Hour	Unrated	One Hour	Two Hour

Figure 3-3 Top of Beam Exposed to Fire

3.3 Protection of Structural Wood Members and Assemblies

Where protective materials are used to increase the fire resistance of structural wood members, the structural fire resistance times of protected wood members shall be permitted to be calculated in accordance with 3.2, except with delayed onset of charring of each protected surface. The protection time, t_p , from the protective material shall be determined either by testing or using assigned values and calculations in accordance with this section. The protection times assigned in 3.3.1 through 3.3.3 shall be permitted to be used to estimate the delayed onset of charring of each protected surface. Where all surfaces of the structural wood member are protected with the same protection system, such as one or more protective membranes, the protection times of the protection system are directly additive with the structural fire resistance times of the structural wood members calculated in 3.2.

3.3.1 Protection by Wood

Wood cover shall be permitted as protection to increase fire resistance of structural wood members and assemblies.

3.3.1.1 *Wood cover in contact with protected member*: The protection time, t_p , provided by each layer of wood cover that is in contact with either the protected member or another underlying layer of protection shall be calculated as:

$$t_p = 60 \left(\frac{d_p}{\beta_t} \right)^{1.23} \text{ minutes} \quad (\text{Equation 3.3-1})$$

Where:

d_p = thickness of the protective layer of wood (in.)
 β_t = non-linear char rate constant (in./hr^{0.813})

For a nominal char rate of 1.5 in./hr, the non-linear char rate constant is calculated as $\beta_t = 1.5 \text{ in./hr}^{0.813}$, and the protection time associated with a protective wood membrane of a thickness, d , shall be calculated as follows:

$$t_p = 60 \left(\frac{d_p}{1.5} \right)^{1.23} \text{ minutes} \quad (\text{Equation 3.3-2})$$

3.3.1.2 *Wood cover not in contact with protected member*: The protection time, t_p , provided by a layer of wood cover that is not in contact with the protected member or another underlying layer of protection shall be calculated as follows:

$$t_p = \left[60 \left(\frac{d_p - 0.6}{1.5} \right)^{1.23} + 17 \right] \text{ minutes for } d_p \geq 0.6 \text{ inches} \quad (\text{Equation 3.4-1a})$$

$$t_p = 60 \left(\frac{d_p}{2.1} \right) \text{ minutes for } d_p < 0.6 \text{ inches} \quad (\text{Equation 3.4-1b})$$

3.3.1.3 *Wood membrane*: Where wood cover is used as a membrane to protect the entire wood member or assembly, the protection time calculated in 3.3.1.1 or 3.3.1.2 shall be the added protection time.

3.3.1.4 *Fasteners attaching wood protection*: Each layer of the wood cover shall be attached with fasteners of sufficient length to penetrate the protected wood member or underlying layers of wood cover, for a total depth of at least one inch. Fasteners attaching wood protection shall not be required to be protected.

3.3.1.5 *Intersections and abutting edges of exposed wood cover*: Intersections and abutting edges between wood members and wood cover or between wood cover elements shall be designed in accordance with 3.2.4. Additional protection shall be provided at gaps, as necessary, to ensure that the wood cover provides the required protection.

3.3.2 Protection by Type X Gypsum Panel Products

Fire-rated gypsum panel products (Type X) shall be permitted as protection to increase fire resistance of wood members and assemblies.

3.3.2.1 *Gypsum panel cover*: Where used to increase fire resistance of wood members, the protection time, t_p , provided by each layer of Type X gypsum panel cover that is in contact with either the protected member or another underlying layer of protection shall be as provided in Table 3.3.2.1.

3.3.2.2 *Gypsum panel membrane*: Where Type X gypsum panels are used as a membrane to protect the entire wood member or assembly, the protection time, t_p , provided by each layer of Type X gypsum panels shall be in accordance with Table 3.3.2.1.

Table 3.3.2.1 Fire Resistance Time for Type X Gypsum Panel Products

Protection Description ¹	Gypsum Panel Cover of Members ^{2, 3}	Gypsum Panel Membrane Protection of Members & Assemblies ^{4, 5, 6, 7}		Protection Time, t_p (minutes)
	Maximum Fastener Spacing (inches)	Maximum Framing Spacing (inches)	Maximum Fastener Spacing (inches)	
1/2-inch Type X Gypsum Panel Product	12	16 24	12 8	30 ⁸
5/8-inch Type X Gypsum Panel Product	12	16 24	12 8	40 ⁹

¹ Each gypsum panel layer shall be attached with fasteners of sufficient length to penetrate the wood member at least 1 inch or be attached to steel channels capable of supporting the weight of the gypsum panel.

² Where multiple layers of gypsum panels are required, all adjoining panel edges shall be offset at least 16 inches from those of the adjacent underlying layer and attached with fasteners offset at least 4 inches in both orthogonal directions from the fasteners in all underlying layers.

³ Gypsum panel cover attached to wood members shall be installed such that gypsum panel cover at outside corners overlaps by at least the thickness of the gypsum panel. For gypsum panel cover attached to horizontal wood members (e.g. wood beams), side layers are installed first, followed by the bottom layer(s) to ensure that the edges of the side layers are covered.

⁴ Panel edges of the gypsum panel membrane face layer shall be taped and finished with joint compound, and fastener heads shall be covered with joint compound.

⁵ Where multiple layers of gypsum panels are required, adjoining panel edges occurring over framing shall be staggered at least one framing spacing from those of the adjacent underlying layer and attached to framing with fasteners offset at least 4 inches from the fasteners in all underlying layers. Unbacked adjoining panel edges shall be offset by at least 12 inches from those of the adjacent underlying layer.

⁶ At wall-to-ceiling intersections, the gypsum panel membrane shall be installed such that the ceiling gypsum panel membrane is installed first, followed by the wall gypsum panel membrane to ensure that the ceiling gypsum panel membrane is supported by each layer of the wall gypsum panel membrane.

⁷ At wall-to-wall intersections, each layer of the gypsum panel membrane shall be installed such that the gypsum panel membrane on the wall with a greater fire resistance rating is installed first, followed by the gypsum panel membrane on the intersecting wall.

⁸ For wood-frame walls with studs spaced 16 inches on center or less, the protection time, t_p , for 1/2" Type X gypsum panel, with 2-1/4" Type S drywall screws spaced at 7 inches on center or less, shall be permitted to be increased to 33 minutes for a single layer or a base layer of 1/2" Type X gypsum panel. Additional layers of 1/2" Type X gypsum panel are limited to 30 minutes/layer.

⁹ For wood-frame walls with studs spaced 24 inches on center or less, the protection time, t_p , for 5/8" Type X gypsum panel, with 2-1/4" Type S drywall screws spaced at 7 inches on center or less, shall be permitted to be increased to 48 minutes for a single layer or a base layer of 5/8" Type X gypsum panel. Additional layers of 5/8" Type X gypsum panel are limited to 40 minutes/layer.

3.3.2.3 Fasteners attaching gypsum panel products: Each Type X gypsum panel layer shall be attached with fasteners of sufficient length to penetrate the wood member at least 1 inch or be attached to steel channels capable of supporting the weight of the gypsum panel. Fasteners attaching gypsum panel shall not be required to be protected.

3.3.2.4 Gypsum panel product contraction: Where Type X gypsum panel contraction will cause gaps to form at edges of gypsum panels that are initially considered to be in contact, ignition of combustible materials directly behind the gaps shall be assumed to occur at the time assigned to that Type X gypsum panel layer, determined in 3.3.2.1 or 3.3.2.2, multiplied by 0.50. Additional protection shall be provided at the gaps, as necessary, to ensure that the Type X gypsum panel provides the required protection.

3.3.3 Protection by Insulation

Mineral wool and fiberglass insulation shall be permitted as protection to increase fire resistance of wood members and assemblies.

3.3.3.1 Insulation cover: Where used to increase fire resistance of wood members or assemblies, the protection time, t_p , provided by mineral wool or fiberglass insulation batts of the specified minimum thickness and density or R-value, shall be as provided in Table 3.3.3.1. Protection times specified in Table 3.3.3.1 shall not be additive with each other and shall not be increased for additional insulation thickness, density, or R-value.

3.3.3.2 Insulation as part of a membrane: Where mineral wool or fiberglass insulation batts are used as part of a membrane to protect the entire wood member or assembly, the protection time calculated in 3.3.3.1 shall be the added protection time. Protection times specified in Table 3.3.3.1 shall not be additive with each other and shall not be increased for additional insulation thickness, density, or R-value.

Table 3.3.3.1 Fire Resistance Time for Protected Wood Surfaces

Insulation Description	Minimum Thickness (inches)	Protection Time, t_p , (minutes)
Mineral wool batts (minimum nominal density: 2.5 pcf)	3.5	19
	1.5	17
Fiberglass batts (minimum R-13)	3.5	3

3.4 Calculation of Structural Fire Resistance Time of Protected Wood Members and Assemblies

The structural fire resistance time for protected wood members and assemblies shall be permitted to be calculated in accordance with 3.2, accounting for delayed charring on each protected surface in accordance with 3.3. Wood members or assemblies protected with one or more of the protection options in 3.3 shall be permitted to exceed the 2-hour limitation on calculated fire resistance for exposed wood members in 3.2, however, the calculated contribution of the wood members to the structural fire resistance shall not exceed 2 hours.

3.5 Calculation of Thermal Separation Time

The calculated thermal separation time provided by a assembly shall be equal to the sum of the times assigned to the protective membranes on both the fire-exposed side of the assembly and the unexposed side of the assembly,

and additional contribution by other protective components such as insulation. Where the calculated thermal separation time for a structural assembly exceeds the structural fire resistance time, the thermal separation time shall be limited to the structural fire resistance time.

3.5.1 Thermal Separation Time provided by Wood Layers

3.5.1.1 *Wood cover or membranes*: The contribution of wood layers to the thermal separation time shall be equal to the sum of protection times assigned to each layer, determined in 3.3.1, except where a single layer of wood is used to provide thermal separation or where the final layer on the unexposed side of the thermal separation is wood, the time assigned to that wood layer, as determined in 3.3.1, shall be multiplied by 0.85.

3.5.1.2 *Intersections and abutting edges of exposed wood cover*: Intersections and abutting edges between wood members and wood cover or between wood cover elements shall be designed in accordance with 3.2.4. Where char penetration will cause gaps to form between wood members or wood cover that are initially considered to be in contact, additional protection shall be provided, as necessary, to ensure that wood members or wood cover provide the required thermal separation time.

3.5.2 Thermal Separation Time provided by Type X Gypsum Panel Products

3.5.2.1 *Gypsum panel cover or membranes*: The contribution of Type X gypsum panel layers to the thermal separation time shall be equal to the sum of protection times assigned to each layer, determined in 3.3.2, except where a single layer of Type X gypsum panel is used to provide thermal separation or where the final layer on the unexposed side of the thermal separation is Type X gypsum panel, the time assigned to that Type X gypsum panel layer, determined in 3.3.2, shall be multiplied by 0.50.

3.5.2.2 *Gypsum panel product contraction*: Where Type X gypsum panel contraction will cause gaps to form between adjoining gypsum panels that are initially considered to be in contact, ignition of combustible materials directly behind the gaps shall be assumed to occur at the time assigned to that Type X gypsum panel layer, determined in 3.3.2, multiplied by 0.50; however, the effect on the thermal separation time, estimated in 3.5.2.1, shall be permitted to be ignored.

3.5.3 Thermal Separation Time provided by Insulation

3.5.3.1 *Insulation protection time*: Where insulation is used to provide a portion of the thermal separation, the protection time, t_p , determined in 3.3.3, shall be permitted to be added. Protection times specified in Table 3.3.3.1 shall not be additive with each other and shall not be increased for additional insulation thickness, density, or R-value.

3.6 Calculation of Burn-Through Time

Where thermal separation is required, detailing shall be provided to prevent burn-through before the required thermal separation time is reached. Determination of burn-through time shall account for the effects of char penetration between wood members or wood cover in accordance with 3.5.1.2, and for the effects of Type X gypsum panel product contraction in accordance with 3.5.2.2.

3.7 Tested Fire-resistance-rated Assemblies

Assemblies tested in accordance with ASTM E119 or UL 263 are provided in Supplement B. Supplement B1 and B2 provides a listing of reported wall assemblies meeting specified 1-hr and 2-hr fire-resistance ratings,

respectively. Supplement B3 and B4 provides a listing of reported floor/ceiling and roof/ceiling assemblies meeting specified 1-hr and 2-hr fire-resistance ratings, respectively.

3.8 Component Additive Method for Assemblies

The fire-resistance ratings of wall assemblies, floor/ceiling assemblies, and roof/ceiling assemblies shall be permitted to be calculated using the provisions of this section which are based on ASTM E119 or UL 263 test data. The fire-resistance rating shall be the minimum time determined from the structural fire resistance time calculated in 3.8.1 and the thermal separation time calculated in 3.8.2.

3.8.1 Calculating the Structural Fire Resistance Time

The structural fire resistance time of an assembly shall be equal to the sum of the structural fire resistance times assigned to the members in 3.8.1.1 and the protection times assigned to the protective membrane on the fire-exposed side in accordance with 3.8.1.2. The membrane on the unexposed side shall not be included in determining the structural fire resistance time of the assembly.

3.8.1.1 *Fire Resistance Times for Wood Members in Assemblies:* The structural fire resistance times for wood members in common assemblies are provided in 3.8.1.1.1 through 3.8.1.1.3.

3.8.1.1.1 *Sawn Lumber, LVL, PSL, or LSL Studs:* The structural fire resistance times for sawn lumber or LVL, PSL, or LSL studs in Table 3.8.1.1.1 shall be permitted for use with the component additive method of this section provided that the stress ratio for the studs does not exceed the tabulated value.

Table 3.8.1.1.1 Structural Fire Resistance Times Assigned to Sawn Lumber or LVL, PSL, or LSL Studs

Stud Size	Maximum Bearing	Maximum Axial Compression		Assigned Fire Resistance Time for Studs (minutes)		
	Stress Ratio ¹	Stress Ratio ^{2,3}		No Insulation	Mineral Wool ⁴ (Min. 2.5 pcf)	Fiberglass ⁴ (Min. R-13)
	(f _c / F _{c⊥} ')	(f _c /F _c ')				
		K _e =1.0 ²	K _e =0.7 ³			
2x4	78%	100%	54%	10	23	12
	61%	78%	42%	12	26	14
2x6	100%	61%	42%	14	30	16

¹ The maximum Bearing Stress Ratio limits the allowable load on 2x6 studs as a result of the calculated compression perpendicular-to-grain stress, F_{c⊥}.

² The maximum Axial Compression Stress Ratio for K_e=1.0 limits the allowable load on 2x4 studs as a result of the calculated compression parallel-to-grain stress, F_c, assuming concentric loading and pinned-end reactions at each end of studs.

³ The Axial Compression Stress Ratio for K_e=0.7 is the basis of the calculated fire resistance times and is based on the calculated compression parallel-to-grain stress, F_c, assuming concentric loading and square-end bearing reactions at each end of studs.

⁴ Cavity between studs shall be filled completely with insulation.

3.8.1.1.2 *Sawn Lumber, LVL, PSL, or LSL Joists*: The structural fire resistance times for sawn lumber or LVL, PSL, or LSL joists in Table 3.8.1.1.2 shall be permitted for use with the component additive method of this section, provided that the stress ratio for the joists does not exceed the tabulated value.

Table 3.8.1.1.2 Structural Fire Resistance Times Assigned to Sawn Lumber or SCL Joists^{1, 2, 3}
(Protected Surface on Top Edge)

	ASD Stress Ratio ⁴	2x6	2x8	2x10	2x12	Additional LVL, PSL, or LSL Sizes			
		1½"x5½"	1½"x7¼"	1½"x9¼"	1½"x11¼"	1½"x9½"	1½"x11⅝"	1¾"x9½"	1¾"x11⅝"
		Structural Fire Resistance Time for Joists (minutes)							
No Insulation	0.5	15.1	15.3	15.5	15.6	15.5	15.7	18.6	18.8
	0.6	14.1	14.4	14.6	14.7	14.6	14.8	17.5	17.7
	0.7	13.2	13.5	13.7	13.8	13.7	13.9	16.4	16.7
	0.8	12.3	12.6	12.8	13.0	12.9	13.0	15.4	15.6
	0.9	11.4	11.8	12.0	12.1	12.0	12.2	14.3	14.6
	1.0	10.6	10.9	11.2	11.3	11.2	11.4	13.3	13.6
Fiberglass Batt Insulation (min. R-13)	0.5	17.9	18.2	18.4	18.6	18.4	18.6	21.5	21.7
	0.6	16.9	17.2	17.5	17.6	17.5	17.7	20.4	20.6
	0.7	15.9	16.3	16.6	16.7	16.6	16.8	19.3	19.5
	0.8	15.0	15.4	15.7	15.9	15.7	15.9	18.2	18.5
	0.9	14.1	14.5	14.8	15.0	14.8	15.0	17.1	17.4
	1.0	13.3	13.7	14.0	14.2	14.0	14.2	16.1	16.4
Mineral Wool Batt (min. 1.5" thick, 2.5 pcf)	0.5	30.9	31.6	31.9	32.2	32.0	32.2	34.9	35.3
	0.6	29.8	30.5	30.9	31.2	31.0	31.3	33.7	34.1
	0.7	28.7	29.5	29.9	30.2	30.0	30.3	32.5	33.0
	0.8	27.6	28.5	29.0	29.3	29.0	29.4	31.3	31.8
	0.9	26.6	27.5	28.0	28.4	28.1	28.5	30.2	30.7
	1.0	25.7	26.5	27.1	27.5	27.2	27.6	29.1	29.7

¹ Values are applicable to joists that are continuously laterally supported such that $C_L = 1.0$.

² Interpolation shall be permitted.

³ Glulam joists of the sizes listed for sawn lumber or SCL joists shall be permitted for use with the component additive method and utilize the tabulated fire resistance times assigned for the ASD stress ratios.

⁴ Stress ratio is for f_b/F_b' . For cases where f_v/F_v' controls the design, the tabulated fire resistance time for the given stress ratio is slightly conservative.

3.8.1.1.3 *Wood I-Joists*: The structural fire resistance time assigned to a wood I-joist, based on the lesser of the structural fire resistance times assigned to the flange in Table 3.8.1.1.3a and the web in Table 3.8.1.1.3b, shall be permitted for use with the component additive method of this section. Alternatively, I-joist fire resistance times shall be permitted to be assumed as zero for the analysis.

Table 3.8.1.1.3a Structural Fire Resistance Times Assigned to Wood I-joist Flanges ¹

Insulation Description and Location	ASD Stress Ratio ²	I-joists – Flange Dimensions (width x depth)							
		1-1/2" x 1-5/16"	1-1/2" x 1-1/2"	1-3/4" x 1-1/8"	1-3/4" x 1-1/4"	1-3/4" x 1-5/16"	2-5/16" x 1-1/8"	2-5/16" x 1-1/4"	3-1/2" x 1-1/2"
		Time (minutes) ³							
<i>All flange surfaces exposed, no insulation</i>	0.5	9.6	10.5	9.0	9.9	10.3	9.7	10.8	14.2
	0.6	8.8	9.6	8.3	9.1	9.5	9.0	10.0	13.2
	0.7	8.1	8.8	7.7	8.4	8.7	8.3	9.2	12.2
	0.8	7.4	8.1	7.0	7.7	8.0	7.7	8.5	11.3
	0.9	6.8	7.4	6.5	7.1	7.3	7.1	7.8	10.5
	1.0	6.2	6.8	5.9	6.5	6.7	6.5	7.2	9.6
<i>Bottom and sides of flange exposed, top protected with fiberglass insulation (min. 3.5 in., R13)</i>	0.5	10.4	11.2	10.1	10.9	11.3	11.0	12.0	15.5
	0.6	9.6	10.3	9.4	10.1	10.4	10.2	11.2	14.4
	0.7	8.9	9.6	8.7	9.4	9.7	9.5	10.4	13.5
	0.8	8.2	8.8	8.1	8.7	8.9	8.9	9.6	12.5
	0.9	7.6	8.2	7.5	8.0	8.3	8.3	9.0	11.7
	1.0	7.1	7.5	7.0	7.4	7.7	7.7	8.3	10.8
<i>Bottom and sides of flange exposed, top protected with mineral wool insulation (min. 1.5 in., 2.5 pcf)</i>	0.5	13.3	13.8	14.5	15.1	15.4	17.2	17.8	21.8
	0.6	12.3	12.7	13.3	13.9	14.1	16.1	17.0	20.7
	0.7	11.3	11.8	12.2	12.8	13.0	14.7	15.7	19.7
	0.8	10.5	10.9	11.2	11.7	12.0	13.5	14.4	18.7
	0.9	9.6	10.0	10.3	10.8	11.0	12.4	13.2	17.9
	1.0	8.8	9.2	9.4	9.9	10.1	11.3	12.1	17.1
<i>Bottom exposed, top and sides of flange protected with fiberglass insulation (min. 3.5 in., R13)</i>	0.5	10.0	10.8	9.7	10.4	10.8	10.6	11.5	14.8
	0.6	9.4	10.1	9.1	9.8	10.1	9.9	10.8	13.9
	0.7	8.9	9.5	8.6	9.2	9.5	9.3	10.1	13.0
	0.8	8.4	9.0	8.1	8.6	8.9	8.8	9.5	12.2
	0.9	7.9	8.5	7.6	8.1	8.4	8.3	8.9	11.4
	1.0	7.4	8.0	7.2	7.7	7.9	7.8	8.4	10.7
<i>Bottom exposed, top and sides of flange protected with mineral wool insulation (min. 1.5 in., 2.5 pcf)</i>	0.5	18.3	19.1	17.8	18.5	18.8	18.4	19.3	22.4
	0.6	17.8	18.6	17.3	18.0	18.3	17.9	18.7	21.6
	0.7	17.4	18.1	17.0	17.5	17.8	17.4	18.1	20.8
	0.8	17.1	17.7	16.0	17.1	17.4	17.1	17.7	20.1
	0.9	16.3	17.3	15.0	16.5	17.1	16.2	17.3	19.4
	1.0	15.4	17.0	14.0	15.5	16.2	15.1	16.8	18.8
<i>All flange surfaces protected with mineral wool insulation (min. 1.5 in., 2.5 pcf)</i>	0.5	26.6	27.5	26.0	26.9	27.3	26.7	27.8	31.2
	0.6	25.8	26.6	25.3	26.1	26.5	26.0	27.0	30.2
	0.7	25.1	25.8	24.7	25.4	25.7	25.3	26.2	29.2
	0.8	24.4	25.1	24.0	24.7	25.0	24.7	25.5	28.3
	0.9	23.8	24.4	23.5	24.1	24.3	24.1	24.8	27.5
	1.0	23.2	23.8	22.9	23.5	23.7	23.5	24.2	26.6
<i>Top and sides of flange protected with mineral wool insulation (min. 1.5 in., 2.5 pcf), bottom protected with 3/4" wood strips</i>	0.5	29.0	29.5	29.2	29.8	30.1	30.4	31.3	34.9
	0.6	28.2	28.7	28.4	29.0	29.2	29.6	30.4	33.9
	0.7	27.5	27.9	27.7	28.2	28.4	28.9	29.6	32.9
	0.8	26.8	27.2	27.1	27.5	27.7	28.2	28.8	31.9
	0.9	26.2	26.6	26.5	26.9	27.1	27.6	28.1	31.0
	1.0	25.7	26.0	26.0	26.3	26.5	27.0	27.5	30.2

¹ Assigned times shall be taken as the lesser of the times assigned to the flange and the web.² Stress ratio is for ASD induced moment divided by ASD resisting moment of I-joist.³ Values are applicable to I-joists that are continuously laterally supported such that C_L = 1.0.

Table 3.8.1.1.3b Structural Fire Resistance Times Assigned to Wood I-joist Web ¹

Insulation Description and Location	I-joists – Web Thickness		
	3/8"	7/16"	1/2"
	Time (minutes) ²		
<i>Both faces exposed, no insulation</i>	2	3	3
<i>Both faces protected with fiberglass insulation (min. 3.5" thick, R13)</i>	5	6	6
<i>Both faces protected with mineral wool insulation (min. 1.5 in. thick, 2.5 pcf.)</i>	19	20	20
<i>Both faces protected with mineral wool insulation (min. 3.5 in. thick, 2.5 pcf.)</i>	21	22	22

¹ Assigned times shall be taken as the lesser of the times assigned to the flange and the web.

² Times calculated assuming full ASD shear design stress ratio.

3.8.1.2 *Protection of Wood Members:* Where a membrane is used to protect wood members in an assembly, the added fire protection time shall be taken as sum of the protection time, t_p , assigned to wood membrane in Table 3.8.1.2a or to Type X gypsum panels in Table 3.8.1.2b.

Table 3.8.1.2a Added Protection Time Assigned to Wood Membrane

Description of Wood Membrane	Max. Framing Spacing, in.	Max. Fastener Spacing		Time, minutes
		Panel Edge, in.	Panel Field, in.	
3/8-inch Wood Structural Panels	24	6	12	10
1/2-inch Wood Structural Panels	24	6	12	14
5/8-inch Wood Structural Panels	24	6	12	17
23/32-inch Wood Structural Panels	24	6	12	19

Interpolation shall be permitted based on panel thickness.

Table 3.8.1.2b Added Protection Time Assigned to Type X Gypsum Panel Membrane

Description of Gypsum Panel Membrane ^{1, 2, 3, 4, 5}	Max. Framing Spacing, in.	Max. Fastener Spacing, in.	Time, minutes
1/2-inch Type X gypsum panel product	16	12	30 ⁶
	24	8	
5/8-inch Type X gypsum panel product	16	12	40 ⁷
	24	8	

¹ Each gypsum panel layer shall be attached with fasteners of sufficient length to penetrate the wood member at least 1 inch or be attached to steel channels capable of supporting the weight of the gypsum panel.

² Panel edges of the gypsum panel face layer shall be taped and finished with joint compound and fastener heads shall be covered with joint compound.

³ Where multiple layers of gypsum panel are required, adjoining panel edges occurring over framing shall be staggered at least one framing spacing from those of the adjacent underlying layer and attached to framing with fasteners offset at least 4 inches from the fasteners in all underlying layers. Unbacked adjoining panel edges shall be offset by at least 12 inches from those of the adjacent underlying layer.

⁴ At wall-to-ceiling intersections, the gypsum panel membrane shall be installed such that the ceiling gypsum panel membrane is installed first, followed by the wall gypsum panel membrane to ensure that the ceiling gypsum panel membrane is supported by each layer of the wall gypsum panel membrane.

⁵ At wall-to-wall intersections, each layer of gypsum panel membrane shall be installed such that the gypsum panel membrane on the wall with a greater fire resistance rating is installed first, followed by the gypsum panel membrane on the intersecting wall.

⁶ For wood-frame walls with studs spaced 16 inches on center or less, the protection time, t_p , for 1/2" Type X gypsum panel with 2-1/4" Type S drywall screws spaced at 7 inches on center or less shall be permitted to be increased to 33 minutes for a single layer or a base layer of 1/2" Type X gypsum panel. Additional layers of 1/2" Type X gypsum panel are limited to 30 minutes/layer.

⁷ For wood-frame walls with studs spaced 24 inches on center or less, the protection time, t_p , for 5/8" Type X gypsum panel with 2-1/4" Type S drywall screws spaced at 7 inches on center or less shall be permitted to be increased to 48 minutes for a single layer or a base layer of 5/8" Type X gypsum panel. Additional layers of 5/8" Type X gypsum panel are limited to 40 minutes/layer.

3.8.2 Calculating the Thermal Separation Time

The calculated thermal separation time provided by an assembly is equal to the sum of the times assigned to the protective membranes on both the fire-exposed side and the unexposed side, and additional contribution by other protective measures such as insulation. Where the calculated thermal separation time for a structural assembly exceeds the structural fire resistance time, the thermal separation time shall be limited to the structural fire resistance time.

3.8.2.1 Contribution from Membranes: Thermal separation times assigned to protective membranes in Tables 3.8.1.2a and 3.8.1.2b shall be permitted to be added except that, where a single layer of wood or Type X gypsum panel is used to provide all of the thermal separation or where the final layer of thermal separation on the unexposed side of the assembly is a wood layer or Type X gypsum panel layer, the time assigned to that wood layer or Type X gypsum panel layer shall be multiplied by 0.85 or 0.50, respectively.

3.8.2.2 Contribution from Insulation: Thermal separation times assigned to insulation, when incorporated into the assembly, shall be permitted to use the values in Table 3.8.2.2. Protection times specified in Table 3.8.2.2 shall not be additive with each other and shall not be increased for additional insulation thickness, density, or R-value.

Table 3.8.2.2 Added Protection Time Assigned to Insulation Membrane

Description of Insulation	Min. Thickness, in.	Time, minutes
Mineral Wool Insulation (minimum nominal density of 2.5 pcf)	3.5	19
	1.5	15
Fiberglass insulation (minimum R-13)	3.5	3

3.9 Design of Protected Connections

Where a member or an assembly is required to have a fire-resistance rating, structural connections to that member or assembly shall be protected from fire exposure for the time corresponding to the required fire resistance rating of the member or assembly. All components of the structural connection, including connectors, fasteners and portions of the connected members that are part of the structural connection, shall be protected. Protection of the structural connection shall be provided by wood, Type X gypsum panel, other approved materials, or a combination thereof. Each wood cover layer shall be attached with fasteners of sufficient length to penetrate the adjacent member or cover at least one inch. Fasteners attaching the protection shall not be required to be protected; however, wood cover shall be attached in accordance with 3.3.1.4 and Type X gypsum panel protection shall be attached in accordance with 3.3.2.3.

Exception: Wood structural connections within a fire-resistance-rated assembly shall be considered to have the fire-resistance rating of the assembly without additional protection.

3.9.1 Connection Protection

Design of the protection shall be in accordance with the thermal separation provisions of 3.5.1 for wood protection and 3.5.2 for Type X gypsum panel protection.

Exception: Connections in fire-resistance-rated assemblies tested in accordance with ASTM E119 or UL 263.

3.9.2 Intersections and Abutting Edges of Exposed Wood Members and Wood Cover

Char penetration between intersections and abutting edges of exposed wood members and wood cover shall be designed in accordance with 3.2.4. Protection of connections at ends and edges of wood members shall address this penetration to ensure the provisions of 3.9.1 are met.

REFERENCES

1. ANSI A190.1-2017 *Standard for Wood Products — Structural Glued Laminated Timber*. APA – The Engineered Wood Association, Tacoma, WA, 2017
2. ANSI A208.1-2016 *Particleboard Standard*. Composite Panel Association, Leesburg, VA, 2016.
3. ANSI 405-2018 *Standard for Adhesives for Use in Structural Glued Laminated Timber*. APA – The Engineered Wood Association, Tacoma, WA, 2018
4. ANSI/ASME B18.2.1-2012 *Square, Hex, Heavy Hex, and Askew Head Bolts and Hex, Heavy Hex, Hex Flange, Lobed Head, and Lag Screws (Inch Series)*. American Society of Mechanical Engineers, New York, NY, 2012.
5. ANSI/ASME B18.6.1-1981(R2016) *Wood Screws (Inch Series)*. American Society of Mechanical Engineers, New York, NY, 2016.
6. ASTM C665-17 *Standard Specification for Mineral-Fiber Blanket Thermal Insulation for Light Frame Construction and Manufactured Housing*. ASTM International, West Conshohocken, PA, 2017.
7. ASTM C764-19 *Standard Specification for Mineral Fiber Loose-Fill Thermal Insulation*. ASTM International, West Conshohocken, PA, 2019.
8. ASTM C840-20 *Standard Specification for Application and Finishing of Gypsum Board*. ASTM International, West Conshohocken, PA, 2020.
9. ASTM C1002-20 *Standard Specification for Steel Self-Piercing Tapping Screws for Application of Gypsum Panel Products or Metal Plaster Bases to Wood Studs or Steel Studs*. ASTM International, West Conshohocken, PA, 2022.
10. ASTM C1177-17 *Standard Specification for Glass Mat Gypsum Substrate for Use as Sheathing*. ASTM International, West Conshohocken, PA, 2017.
11. ASTM C1280-18 *Standard Specification for Application of Exterior Gypsum Panel Products for Use as Sheathing*. ASTM International, West Conshohocken, PA, 2018.
12. ASTM C1396-17 *Standard Specification for Gypsum Board*. ASTM International, West Conshohocken, PA, 2017.
13. ASTM C1658-19 *Standard Specification for Glass Mat Gypsum Panels*. ASTM International, West Conshohocken, PA, 2019.
14. ASTM D5055-19e1 *Standard Specification for Establishing and Monitoring Structural Capacities of Prefabricated Wood I-Joists*. ASTM International, West Conshohocken, PA, 2019.
15. ASTM D5456-19e1 *Standard Specification for Evaluation of Structural Composite Lumber Products*. ASTM International, West Conshohocken, PA, 2019.
16. ASTM D5516-18 *Standard Test Method for Evaluating the Flexural Properties of Fire-Retardant Treated Softwood Plywood Exposed to Elevated Temperatures*. ASTM International, West Conshohocken, PA, 2018.
17. ASTM D5664-17 *Standard Test Method for Evaluating the Effects of Fire-Retardant Treatments and Elevated Temperatures on Strength Properties of Fire-Retardant Treated Lumber*. ASTM International, West Conshohocken, PA, 2017.
18. ASTM D6305-08(2015) *Standard Practice for Calculating Bending Strength Design Adjustment Factors for Fire-Retardant-Treated Plywood Roof Sheathing*. ASTM International, West Conshohocken, PA, 2015.
19. ASTM D6841-16 *Standard Practice for Calculating Design Value Treatment Adjustment Factors for Fire-Retardant-Treated Lumber*. ASTM International, West Conshohocken, PA, 2016.
20. ASTM D8223-19 *Standard Practice for Evaluation of Fire-Retardant Treated Laminated Veneer Lumber*. ASTM International, West Conshohocken, PA, 2019.
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27. ASTM E2768-11(2018) *Standard Test Method for Extended Duration Surface Burning Characteristics of Building Materials (30 min Tunnel Test)*. ASTM International, West Conshohocken, PA, 2018.
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29. ANSI/APA PRG 320-19: *Standard for Performance-Rated Cross-Laminated Timber*. APA – The Engineered Wood Association, Tacoma, WA, 2019
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34. NFPA 286 *Standard Methods of Fire Tests for Evaluating Contribution of Wall and Ceiling Interior Finish to Room Fire Growth*. National Fire Protection Association, Quincy, MA, 2019.
35. PS 1-09 *Structural Plywood*. U.S. Department of Commerce. National Institute of Standards and Technology. Gaithersburg, MD, 2009.
36. PS 2-18 *Performance Standard for Wood Structural Panels*. U.S. Department of Commerce. National Institute of Standards and Technology. Gaithersburg, MD, 2018.
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41. UL 1479 *Standard for Fire Tests of Penetration Firestops*. Underwriters Laboratories Inc, Northbrook, IL, 2015.
42. UL 2079 *Tests for Fire Resistance of Building Joint Systems*. Underwriters Laboratories Inc, Northbrook, IL, 2020.
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Supplement A: Flame Spread Performance of Wood Products Used for Interior Finish

Table A1 Reported Flame Spread Indices of Solid Wood Products

Material ¹	ASTM E84 Flame Spread Index	Flame Spread Class	ASTM E84 Smoke Developed Index	Source ²
Alder	80	C	165	HPVA T-14189 (2013)
Aspen	105	C	45	Exova 15-002-475(C1) (2015)
Birch, Yellow	NA ⁴	C ⁴	NA	UL527 (1971)
Cedar, Alaska	40	B	140	HPVA T-15591 (2017)
Cedar, Alaska Yellow	50	B	115	HPVA T-12704 (2008)
Cedar, Eastern White	40	B	200	HPVA T-15318 (2017)
Cedar, Incense	45	B	150	HPVA T-15204 (2016)
Cedar, Port Orford	60	B	150	HPVA T-12694 (2008)
Cedar, Western Red	45	B	125	HPVA T-15172 (2016)
Cottonwood	NA ⁴	C ⁴	NA	UL527 (1971)
Cypress	75	B	200	HPVA T-14530 (2014)
Douglas-fir	70	B	80	HPVA T-14253 (2013)
Fir, Balsam	45	B	105	HPVA T-15557 (2017)
Fir, White	40	B	80	HPVA T-15088 (2016)
Gum, Red	NA ⁴	C ⁴	NA	UL527 (1971)
Hem-Fir Species Group ³	60	B	70	HPVA T-10602 (2001)
Hemlock, Eastern	35	B	175	HPVA T-15320 (2017)
Hemlock, Western	40	B	60	Exova 15-002-475(A1) (2015)
Maple (flooring)	NA ⁴	C ⁴	155	CWC FP-6 (1973)
Maple (rough sawn)	35	B	250	HPVA T-14573 (2014)
Oak, Red or White	NA ⁴	C ⁴	NA	UL527 (1971)
Pine, Eastern White	70	B	110	HPVA T-14186 (2013)
Pine, Idaho White	NA ⁴	B ⁴	125	HPVA T-592 (1974)
Pine, Jack	50	B	165	HPVA T-15556 (2017)
Pine, Lodgepole	75	B	140	HPVA T-15029 and T-15069 (2015)
Pine, Ponderosa	55	B	135	HPVA T-15067 (2016)
Pine, Red	115	C	65	Exova 15-002-475(B1) (2015)
Pine, Southern Yellow	70	B	165	HPVA T-14254 (2013)
Pine, Sugar	45	B	110	HPVA T-15068 (2016)
Pine, Western White	NA ⁴	B ⁴	NA	UL527 (1971)
Poplar, Yellow	125	C	125	HPVA T-14512 (2014)
Redwood	55	B	135	HPVA T-14185 and T-14243 (2013)
Spruce, Black	45	B	250	HPVA T-14053 (2013)
Spruce, Black (4" thick, 3 layers of cross laminations)	35	B	55	HPVA T-14054 (2013)
Spruce, Eastern Red	65	B	170	HPVA T-15034 (2015)
Spruce, Western White	45	B	120	HPVA T-15032 (2015)
Tamarack	35	B	90	HPVA T-15393 (2017)
Walnut	75	B	125	HPVA T-14526 (2014)

Table A1 Footnotes

¹ Thickness of material tested is one-inch nominal except where indicated.

² Sources: CWC – Canadian Wood Council; Exova – Exova Warringtonfire North America; HPVA – Hardwood Plywood Veneer Association; UL – Underwriters' Laboratories. Test report numbers and year of test are indicated. Where multiple reports are cited, tabulated FSI and SDI values represent the average of values from the respective test reports.

³ The Hem-Fir Species Group represents six species: Californian Red Fir, Grand Fir, Noble Fir, Pacific Silver Fir, Western Hemlock, and White Fir. The reported flame spread index represents a product containing a mixture of these species. When lumber is from a single species refer to the specific species flame spread index.

⁴ Flame spread index cannot be directly determined from the referenced source; however, the reported Flame Spread Class is deemed to be a reasonable estimate based on changes to the analysis method of test results as reported within the referenced source.

Table A2 Reported Flame Spread Indices of Wood Panels

Material	ASTM E84 Flame Spread Index	Flame Spread Class	ASTM E84 Smoke Developed Index	Source ¹
ORIENTED STRAND BOARD (Exterior Glue) ²				
5/16"	127-138	C	155-171	APA (1985)
3/8"	100	C	95	HPVA T-15116 (2016)
7/16"	115-155	C	75-130	APA 8901-8 (1989)
15/32"	100	C	80	HPVA T-15117 (2016)
1/2"	75-172	C	109-194	APA (1985)
19/32"	175	C	95	HPVA T-14312 (2013)
23/32"	100	C	60	HPVA T-15118 (2016)
3/4"	147-158	C	111	APA (1985)
1-1/8"	110	C	115	HPVA T-15298 (2016)
SOFTWOOD PLYWOOD (Exterior Glue) ³				
1/4"	NA ⁵	C ⁵	55-200	UL R6829 (1973)
3/8"	NA ⁵	C ⁵	22-144	UL R6829 (1973)
1/2"	NA ⁵	C ⁵	55	UL R6829 (1973)
19/32"	95	C	50	HPVA T-14311 (2013)
5/8"	NA ⁵	C ⁵	50-85	UL R6829 (1973)
1/4" Douglas-fir Plywood	85	C	70	HPVA T-15293 (2016)
3/8" Douglas-fir Plywood	65	B	60	HPVA T-15295 (2016)
15/32" Douglas-fir Plywood	40	B	50	HPVA T-15114 (2016)
23/32" Douglas-fir Plywood	35	B	55	HPVA T-15294 (2016)
11/32" Southern Pine Plywood	75	B	115	HPVA T-15113 (2016)
15/32" Southern Pine Plywood	95	C	135	HPVA T-15297 (2016)
23/32" Southern Pine Plywood	65	B	175	HPVA T-15296 (2016)
HARDWOOD PLYWOOD⁴				
Ash 3/4" - Particleboard Core	135	C	80	HPVA T-9344 (1995)
Birch 1/4" – MDF Core	120	C	200	HPVA T-14750 (2015)
Birch 1/4" - Douglas Fir Veneer Core	115	C	40	HPVA T-14911 (2015)
Birch 1/4" - Fuma Veneer Core	125	C	15	HPVA T-9665 (1996)
Birch 1/4" - High Density Veneer Core	165	C	65	HPVA T-9234 (1995)
Birch 1/4" – Poplar Veneer Core	110	C	15	HPVA T-14697 (2015)
Birch 3/4" – Combination Core	90	C	120	HPVA T-14691 (2015)
Birch 3/4" - High Density Veneer Core	115	C	50	HPVA T-9317 (1995)
Birch 3/4" - Particleboard Core	125	C	100	HPVA T-9431 (1995)
Birch 3/4" - MDF Core	120	C	110	HPVA T-14917 (2015)
Birch 3/4" – Aspen Veneer Core	135	C	70	HPVA T-14700 (2015)
Birch 3/4" – Baltic Birch Veneer Core	120	C	70	HPVA T-14694 (2015)
Birch 3/4" – Douglas Fir Veneer Core	70	B	55	HPVA T-14704 (2015)
Birch 3/4" – Poplar Veneer Core	95	C	140	HPVA T-14689 (2015)
Birch 3/4" – Russian Birch Veneer Core	110	C	70	HPVA T-14764 (2015)
Mahogany 3/4" - High Density Veneer Core	105	C	90	HPVA T-9354 (1995)
Maple 1/4" – Douglas Fir Veneer Core	130	C	45	HPVA T-14910 (2015)
Maple 1/4" – Poplar Veneer Core	170	C	55	HPVA T-14695 (2015)
Maple 3/4" – Combination Core	100	C	85	HPVA T-14706 (2015)
Maple 3/4" – MDF Core	130	C	70	HPVA T-14763 (2015)
Maple 3/4" – Particleboard Core	85	C	75	HPVA T-14912 (2015)
Maple 3/4" – Aspen Veneer Core	180	C	75	HPVA T-14699 (2015)
Maple 3/4" – Baltic Birch Veneer Core	125	C	70	HPVA T-14693 (2015)

Table A2 **Reported Flame Spread Indices of Wood Panels (continued)**

Material	ASTM E84 Flame Spread Index	Flame Spread Class	ASTM E84 Smoke Developed Index	Source¹
Maple 3/4" – Douglas Fir Veneer Core	95	C	50	HPVA T-14703 (2015)
Maple 3/4" – Poplar Veneer Core	150	C	60	HPVA T-14702 (2015)
Maple 3/4" – Russian Birch Veneer Core	120	C	50	HPVA T-14752 (2015)
Oak 1/4" - High Density Veneer Core	155	C	65	HPVA T-9237 (1995)
Oak 1/4" – Fuma Veneer Core	60	B	50	HPVA T-14698 (2015)
Oak 1/4" – Poplar Veneer Core	140	C	60	HPVA T-14696 (2015)
Oak 3/4" – Medium Density Fiberboard Core	100	C	85	HPVA T-14916 (2015)
Oak 3/4" – Combination Core	90	C	155	HPVA T-14690 (2015)
Oak 3/4" – Particleboard Core	80	C	80	HPVA T-14914 (2015)
Oak 3/4" – Aspen Veneer Core	160	C	75	HPVA T-14701 (2015)
Oak 3/4" – Baltic Birch Veneer Core	105	C	80	HPVA T-14692 (2015)
Oak 3/4" – Douglas Fir Veneer Core	60	B	65	HPVA T-14762 (2015)
Oak 3/4" – Russian Birch Veneer Core	95	C	110	HPVA T-14751 (2015)
Walnut 3/4"	NA ⁵	C ⁵	NA	HUD (1973)
PARTICLEBOARD				
1/3" (No Added Formaldehyde)	130	C	135	HPVA T-14387 (2014)
3/8"	150	C	65	HPVA T-14350 (2014)
1/2"	125	C	125	HPVA T-14376 (2014)
3/4"	95	C	130	HPVA T-14296 (2014)
3/4"	135	C	80	HPVA T-14351 (2014)
3/4" Birch Particle Board	80	C	95	HPVA T-14913 (2016)
3/4" (Floor Underlayment)	110	C	80	HPVA T-14315 (2013)
1" (No Added Formaldehyde)	105	C	145	HPVA T-14386 (2014)
MEDIUM DENSITY FIBERBOARD (MDF)				
7/32"	125	C	200	HPVA T-14370 (2014)
5/8"	120	C	250	HPVA T-9567 (1996)
3/4"	120	C	170	HPVA T-14372 (2014)
6mm (No Added Formaldehyde)	135	C	200	HPVA T-14369 (2014)
1/4"	135	C	300	HPVA T-14371 (2014)
HARDBOARD				
0.118" Tempered Hardboard	155	C	150	HPVA T-14313 (2013)
0.386" Engineered Wood Siding	95	C	50	HPVA T-14297 (2013)

Table A2 Footnotes

¹ Sources: APA – American Plywood Association; DOC – US Department of Commerce; HPVA – Hardwood Plywood Veneer Association; HUD – US Department of Housing and Urban Development Manual of Acceptable Practices to the HUD Minimum Property Standards; UL – Underwriters' Laboratories. Test report numbers and year of test are indicated.

² Values reported for oriented strand board (OSB) are derived from multiple tests performed on panels comprised of a variety of strand species, including aspen, Douglas-fir southern pine, and mixed softwood species.

³ Flame spread classes and Smoke-Developed Indices reported for softwood plywood are derived from multiple tests performed on panels comprised of a variety of veneer species, including Douglas-fir, hemlock, southern pine and cedar.

⁴ Flame spread classes and Smoke-Developed Indices reported for hardwood plywood are derived from multiple tests performed on panels comprised of a variety of face veneer species, core species and adhesive systems.

⁵ Flame spread index cannot be directly determined from the referenced source; however, the reported Flame Spread Class is deemed to be a reasonable estimate based on changes to the analysis method of test results as reported within the referenced source.

Supplement B: Fire-Resistance-Rated Wood-Frame Wall and Floor-Ceiling Assemblies

Table B1 One-Hour Fire-Resistance-Rated Loadbearing Wood-Frame Wall Assemblies

Assemblies Rated from Both Sides						
Studs	Insulation	Sheathing on Both Sides		Fasteners	Details	IBC Assembly ^a
2x4 @ 16" o.c.	3½" mineral wool batts	5/8" Type X Gypsum Wallboard (H)		2¼" #6 Type S drywall screws @ 12" o.c.	WS4-1.1	15-1.15
2x6 @ 16" o.c.	(none)	5/8" Type X Gypsum Wallboard (H)		2¼" #6 Type S drywall screws @ 7" o.c.	WS6-1.1	15-1.14
2x6 @ 16" o.c.	5½" mineral wool batts	5/8" Type X Gypsum Wallboard (H)		2¼" #6 Type S drywall screws @ 12" o.c.	WS6-1.2	15-1.12
2x6 @ 16" o.c.	R-19 fiberglass insulation	5/8" Type X Gypsum Wallboard (V)		2¼" #6 Type S drywall screws @ 12" o.c.	WS6-1.4	15-1.13
Assemblies Rated from One Side (Fire on Interior Only)						
Studs	Insulation	Sheathing		Fasteners	Details	IBC Assembly ^a
2x4 @ 16" o.c.	3½" mineral wool batts	I	5/8" Type X Gypsum Wallboard (H)	2¼" #6 Type S drywall screws @ 12" o.c.	WS4-1.2	16-1.1
		E	3/8" wood structural panels (V)	6d common nails @ 6" edges/12" field		
2x4 @ 16" o.c.	4 mil polyethylene 3½" mineral wool batts	I	5/8" Type X Gypsum Wallboard (V)	6d cement coated box nails @ 7" o.c.	WS4-1.3	
		E	1/2" fiberboard (V)	1½" roofing nails @ 3" edges/6" field		
			3/8" hardboard shiplapped panel siding	8d galv. nails @ 4" edges/8" field		
2x6 @ 16" o.c.	5½" mineral wool batts	I	5/8" Type X Gypsum Wallboard (H)	2¼" #6 Type S drywall screws @ 12" o.c.	WS6-1.3	16-1.2
		E	7/16" wood structural panels (V)	6d common nails @ 6" edges/12" field		
2x6 @ 16" o.c.	R-19 fiberglass insulation	I	5/8" Type X Gypsum Wallboard (V)	2¼" #6 Type S drywall screws @ 7" o.c.	WS6-1.5	16-1.3
		E	3/8" wood structural panels (V)	6d common nails @ 6" edges/12" field		
2x6 @ 24" o.c.	R-19 fiberglass insulation	I	5/8" Type X Gypsum Wallboard (V)	2¼" #6 Type S drywall screws @ 7" o.c.	WS6-1.6	
		E	15/32" wood structural panels (V)	6d common nails @ 6" edges/12" field		
H - applied horizontally with vertical joints over studs I - Interior sheathing V - applied vertically with vertical joints over studs E - Exterior sheathing						

^a Item number of comparable assembly from IBC Table 721.1(2).

Table B2 Two-Hour Fire-Resistance-Rated Loadbearing Wood-Frame Wall Assemblies

Assemblies Rated from Both Sides						
Studs	Insulation	Sheathing on Both Sides		Fasteners	Details	IBC Assembly ^a
2x6 @ 24" o.c.	5½" mineral wool batts	B	5/8" Type X Gypsum Wallboard (H)	2¼" #6 Type S drywall screws @ 24" o.c.	WS6-2.1	15-1.16
		F	5/8" Type X Gypsum Wallboard (H)	2¼" #6 Type S drywall screws @ 8" o.c.		
H - applied horizontally with vertical joints over studs; B - Base layer sheathing; F - Face layer sheathing						

^a Item number of comparable assembly from IBC Table 721.1(2).

Table B3 One-Hour Fire-Resistance-Rated Wood Floor-Ceiling Assemblies

Wood I-Joist Assemblies							
Joists	Insulation	Furring	Ceiling Sheathing		Fasteners	Details	IBC Assembly ^a
I-joists @ 24" o.c. maximum Min. flange depth: 1-1/2" Min. flange area: 5.25 sq. in. Min. web thickness: 3/8" Min. I-joist depth: 9-1/4"	1-1/2" mineral wool batts (2.5 pcf-nominal) Resting on hat-shaped channels	Hat-shaped channels or Resilient channels	F	5/8" Type C Gypsum Wall-board (GWB)	1-1/8" Type S drywall screws spaced 12" o.c. in GWB field spaced 8" o.c. at GWB end joints (see fastening details)	WIJ-1.1	24-1.1
I-joists @ 24" o.c. maximum Min. flange depth: 1-1/2" Min. flange area: 5.25 sq. in. Min. web thickness: 7/16" Min. I-joist depth: 9-1/4"	1-1/2" mineral wool batts (2.5 pcf-nominal) Resting on resilient channels	Resilient channels	F	5/8" Type C Gypsum Wall-board (GWB)	1" Type S drywall screws spaced 12" o.c. in GWB field spaced 8" o.c. at GWB end joints (see fastening details)	WIJ-1.2	25-1.1
I-joists @ 24" o.c. maximum Min. flange depth: 1-5/16" Min. flange area: 2.25 sq. in. Min. web thickness: 3/8" Min. I-joist depth: 9-1/4"	2" mineral wool batts (3.5 pcf-nominal) Resting on 1x4 setting strips	Resilient channels	F	5/8" Type C Gypsum Wall-board (GWB)	1-1/8" Type S drywall screws spaced 7" o.c. in GWB field spaced 7" o.c. at GWB end joints (see fastening details)	WIJ-1.3	23-1.1
I-joists @ 24" o.c. maximum Min. flange depth: 1-1/2" Min. flange area: 3.45 sq. in. Min. web thickness: 3/8" Min. I-joist depth: 9-1/4"	1" mineral wool batts (6 pcf-nominal) Resting on hat-shaped channels under I-joist bottom flange	Hat-shaped channels supported by CSC clips	F	1/2" Type C Gypsum Wall-board (GWB)	1" Type S drywall screws spaced 12" o.c. in GWB field spaced 6" o.c. at GWB end joints (see fastening details)	WIJ-1.4	
I-joists @ 24" o.c. maximum Min. flange depth: 1-1/2" Min. flange area: 2.25 sq. in. Min. web thickness: 3/8" Min. I-joist depth: 9-1/4"	(none)	(none)	B	1/2" Type C Gypsum Wall-board (GWB)	1" Type S drywall screws spaced 12" o.c. in GWB field spaced 12" o.c. at GWB end joints	WIJ-1.5	
			F	1/2" Type C Gypsum Wall-board (GWB)	1-5/8" Type S drywall screws spaced 12" o.c. in GWB field spaced 8" o.c. at GWB end joints 1-1/2" Type G drywall screws spaced 8" o.c. at GWB end joints (see fastening details)		
I-joists @ 24" o.c. maximum Min. flange depth: 1-5/16" Min. flange area: 1.95 sq. in. Min. web thickness: 3/8" Min. I-joist depth: 9-1/2"	(none)	Resilient channels	B	1/2" Type X Gypsum Wall-board (GWB)	1-1/4" Type S drywall screws spaced 12" o.c. in GWB field spaced 12" o.c. at GWB end joints	WIJ-1.6	27-1.1
			F	1/2" Type X Gypsum Wall-board (GWB)	1-5/8" Type S drywall screws spaced 12" o.c. in GWB field spaced 12" o.c. at GWB end joints 1-1/2" Type G drywall screws spaced 8" o.c. at GWB end joints (see fastening details)		
I-joists @ 24" o.c. maximum Min. flange depth: 1-1/2" Min. flange area: 2.25 sq. in. Min. web thickness: 3/8" Min. I-joist depth: 9-1/2"	Fiberglass batts Resting on resilient channels	Resilient channels	B	1/2" Type X Gypsum Wall-board (GWB)	1-1/4" Type S drywall screws spaced 12" o.c. in GWB field spaced 12" o.c. at GWB end joints	WIJ-1.7	30-1.1
			F	1/2" Type X Gypsum Wall-board (GWB)	1-5/8" Type S drywall screws spaced 12" o.c. in GWB field spaced 12" o.c. at GWB end joints 1-1/2" Type G drywall screws spaced 8" o.c. at GWB end joints (see fastening details)		

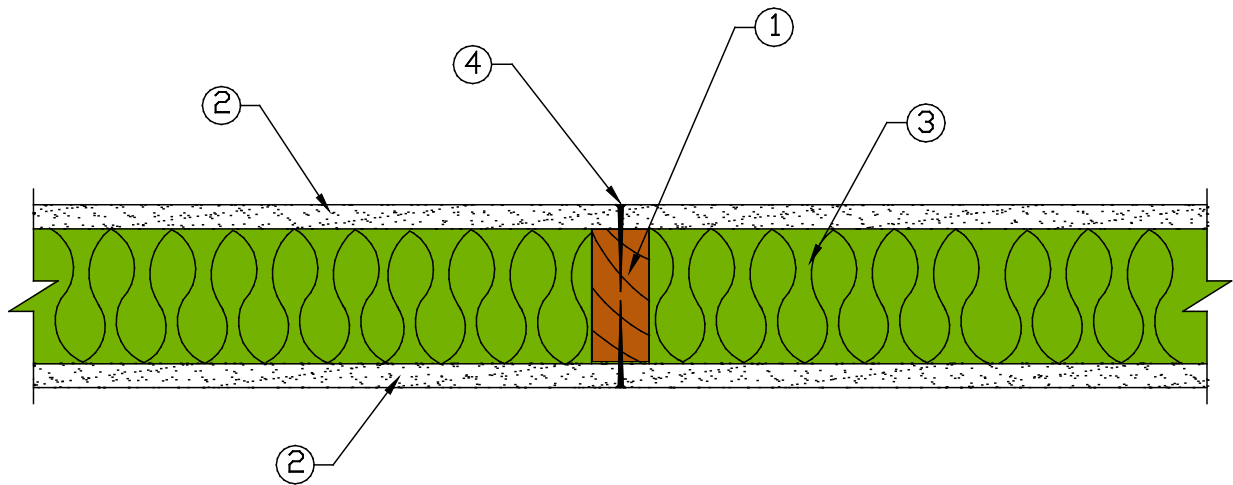
B - Base layer sheathing; F - Face layer sheathing

^a Item number of comparable assembly from IBC Table 721.1(3).

Table B4 Two-Hour Fire-Resistance-Rated Wood Floor/Ceiling Assemblies

Wood I-Joist Assemblies							
Joists	Insulation	Furring	Ceiling Sheathing		Fasteners	Details	IBC Assembly ^a
I-joists @ 24" o.c. maximum Min. flange depth: 1-1/2" Min. flange area: 2.25 sq. in. Min. web thickness: 3/8" Min. I-joist depth: 9-1/4"	3-1/2" fiberglass insulation Supported by stay wires spaced 12" o.c.	(none)	B	5/8" Type C Gypsum Wallboard (GWB)	1-5/8" Type S drywall screws spaced 12" o.c. in GWB field spaced 12" o.c. at GWB end joints	WIJ-2.1	28-1.1
		Hat-shaped channels or Resilient channels	M	5/8" Type C Gypsum Wallboard (GWB)	1" Type S drywall screws spaced 12" o.c. in GWB field spaced 12" o.c. at GWB end joints		
			F	5/8" Type C Gypsum Wallboard (GWB)	1-5/8" Type S drywall screws spaced 8" o.c. in GWB field spaced 8" o.c. at GWB end joints <i>(see fastening details)</i>		
B - Base layer sheathing (direct attached); M - Middle layer sheathing; F - Face layer sheathing							

^a Item number of comparable assembly from IBC Table 721.1(3).

WS4-1.1 One Hour Fire-Resistance-Rated Wood-Frame Wall Assembly**2x4 Wood Stud Wall – 100% Design Load – ASTM E 119/NFPA 251**

1. Framing - Nominal 2x4 wood studs, spaced 16 in. o.c., double top plates, single bottom plate
2. Sheathing - 5/8 in. Type X gypsum wallboard, 4 ft. wide, applied horizontally. Horizontal joints are unblocked. Horizontal application of wallboard represents the direction of least fire resistance as opposed to vertical application.
3. Insulation - 3-1/2-inch-thick mineral wool insulation (2.5 pcf, nominal)
4. Fasteners - 2-1/4 in. #6 Type S drywall screws, spaced 12 in. o.c.
5. Joints and Fastener Heads - Wallboard joints covered with paper tape and joint compound, fastener heads covered with joint compound

Tests conducted at the Fire Test Laboratory of National Gypsum Research Center

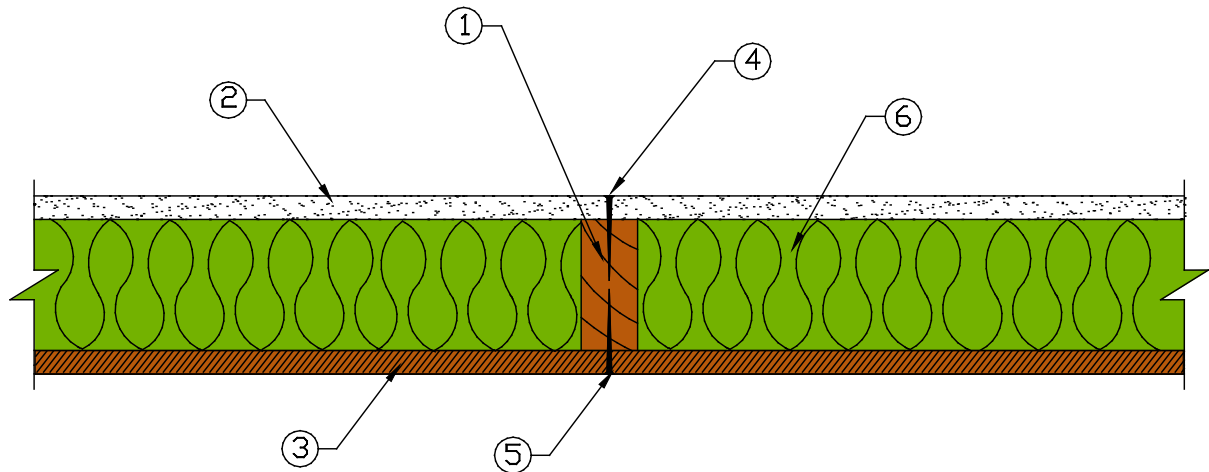
Test No:	WP-1248 (Fire Endurance)	March 29, 2000
	WP-1246 (Hose Stream)	March 09, 2000

Third Party Witness: Intertek Testing Services
Report J20-06170.1

This assembly was tested at 100% design load, calculated in accordance with the 2018 *National Design Specification® for Wood Construction*. The authority having jurisdiction should be consulted to assure acceptance of this report.

WS4-1.2 One-Hour Fire-Resistance-Rated Wood-Frame Wall Assembly (Rated from gypsum wallboard side)

2x4 Wood Stud Wall – 100% Design Load – ASTM E 119/NFPA 251



- 1 Framing - Nominal 2x4 wood studs, spaced 16 in. o.c., double top plates, single bottom plate
2. Interior Sheathing - 5/8 in. Type X gypsum wallboard, 4 ft. wide, applied horizontally. Horizontal joints are unblocked. Horizontal application of wallboard represents the direction of least fire resistance as opposed to vertical application.
3. Exterior Sheathing - Minimum 3/8 in. wood structural panels (oriented strand board), applied vertically, horizontal joints blocked
4. Gypsum Fasteners - 2-1/4 in. #6 Type S drywall screws, spaced 12 in. o.c.
5. Panel Fasteners - 6d common nails (bright) - 12 in. o.c. in the field, 6 in. o.c. panel edges
6. Insulation - 3-1/2-inch-thick mineral wool insulation (2.5 pcf, nominal)
7. Joints and Fastener Heads - Wallboard joints covered with paper tape and joint compound, fastener heads covered with joint compound

Tests conducted at the Fire Test Laboratory of National Gypsum Research Center

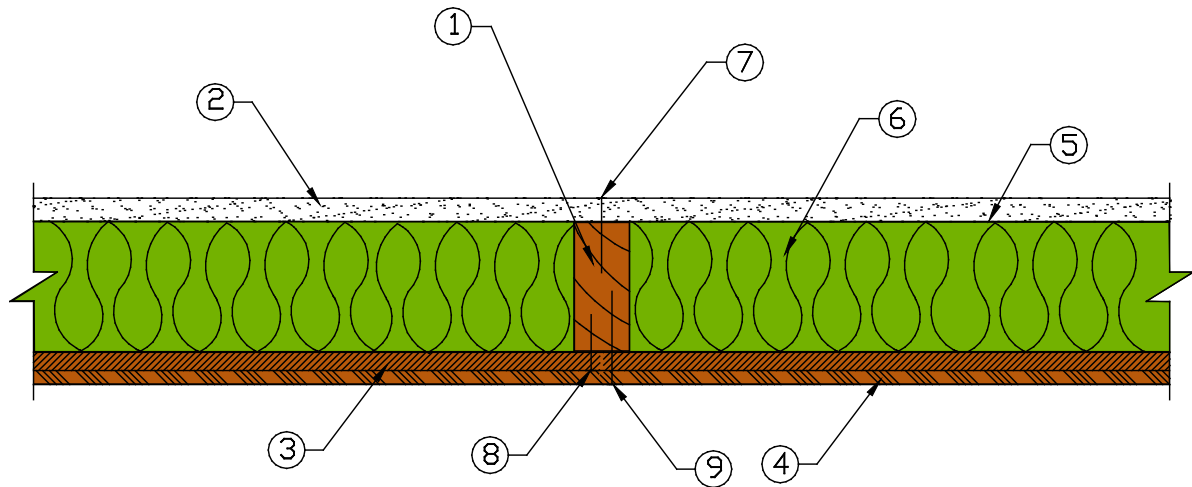
Test No: WP-1261 (Fire Endurance & Hose Stream) November 1, 2000

Third Party Witness: Intertek Testing Services
Report J20-006170.2

This assembly was tested at 100% design load, calculated in accordance with the 2018 *National Design Specification® for Wood Construction*. The authority having jurisdiction should be consulted to assure acceptance of this report.

WS4-1.3 One-Hour Fire-Resistance-Rated Wood-Frame Wall Assembly (Rated from gypsum wallboard side)

2x4 Wood Stud Wall – 78% Design Load – ASTM E 119/NFPA 251



1. Framing - Nominal 2x4 wood studs, spaced 16 in. o.c., double top plates, single bottom plate
2. Interior Sheathing - 5/8 in. Type X gypsum wallboard, 4 ft. wide, applied vertically, unblocked
3. Exterior Sheathing - Minimum 1/2 in. fiberboard sheathing. *Alternate construction - minimum 1/2 in. lumber siding or 1/2 in. wood based sheathing.*
4. Exterior Siding - 3/8 in. hardboard shiplap edge panel siding. *Alternate construction - lumber, wood based, vinyl, or aluminum siding.*
5. Vapor Barrier - 4-mil polyethylene sheeting
6. Insulation - 3-1/2-inch-thick mineral wool insulation (2.5 pcf, nominal)
7. Gypsum Fasteners - 6d cement coated box nails spaced 7 in. o.c.
8. Fiberboard Fasteners - 1-1/2 in. galvanized roofing nails - 6 in. o.c. in the field, 3 in. o.c. panel edges
9. Hardboard Fasteners - 8d galvanized nails - 8 in. o.c. in the field, 4 in. o.c. panel edges
10. Joints and Fastener Heads - Wallboard joints covered with paper tape and joint compound, fastener heads covered with joint compound

Tests conducted at the Gold Bond Building Products Fire Testing Laboratory

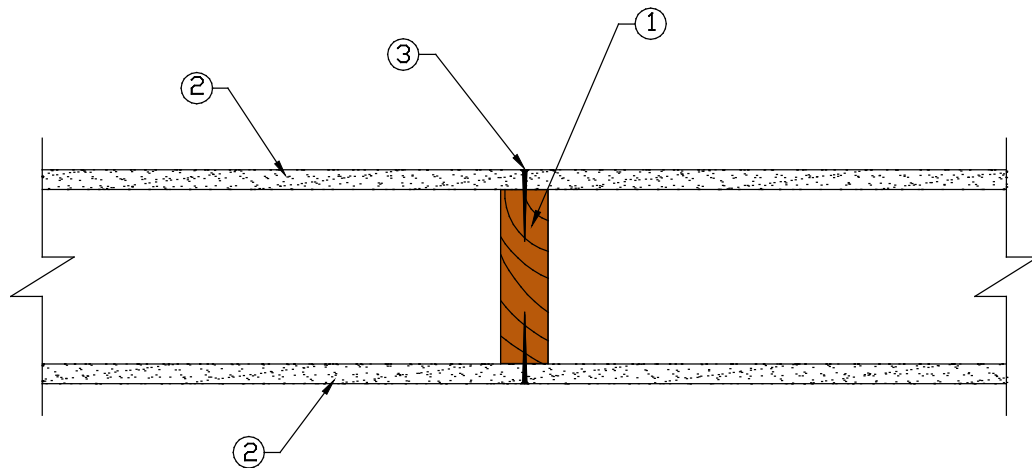
Test No: WP-584 (Fire Endurance & Hose Stream) March 19, 1981

Third Party Witness: Warnock Hersey International, Inc.
Report WHI-690-003

This assembly was tested at 78% design load using an l/d of 33, calculated in accordance with the 2018 *National Design Specification® for Wood Construction*. The authority having jurisdiction should be consulted to assure acceptance of this report.

WS6-1.1 One-Hour Fire-Resistance-Rated Wood-Frame Wall Assembly

2x6 Wood Stud Wall – 100% Design Load – ASTM E 119/NFPA 251



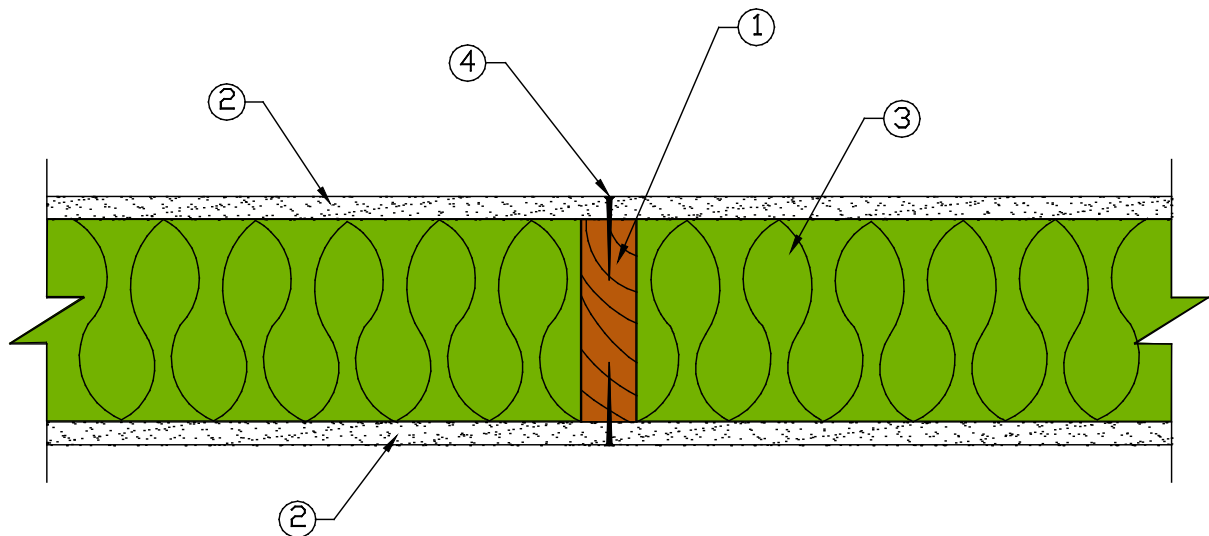
1. Framing - Nominal 2x6 wood studs, spaced 16 in. o.c., double top plates, single bottom plate
2. Sheathing - 5/8 in. Type X gypsum wallboard, 4 ft. wide, applied horizontally. Horizontal joints are unblocked. Horizontal application of wallboard represents the direction of least fire resistance as opposed to vertical application.
3. Fasteners - 2-1/4 in. #6 Type S drywall screws, spaced 7 in. o.c.
4. Joints and Fastener Heads - Wallboard joints covered with paper tape and joint compound, fastener heads covered with joint compound

Tests conducted at the Fire Test Laboratory of National Gypsum Research Center

Test No: WP-1232 (Fire Endurance) September 16, 1999
 WP-1234 (Hose Stream) September 27, 1999

Third Party Witness: Intertek Testing Services
 Report J99-22441.2

This assembly was tested at 100% design load, calculated in accordance with the 2018 *National Design Specification® for Wood Construction*. The authority having jurisdiction should be consulted to assure acceptance of this report.

WS6-1.2 One-Hour Fire-Resistance-Rated Wood-Frame Wall Assembly**2x6 Wood Stud Wall – 100% Design Load – ASTM E 119/NFPA 251**

1. Framing - Nominal 2x6 wood studs, spaced 16 in. o.c., double top plates, single bottom plate
2. Sheathing - 5/8 in. Type X gypsum wallboard, 4 ft. wide, applied horizontally. Horizontal joints are unblocked. Horizontal application of wallboard represents the direction of least fire resistance as opposed to vertical application.
3. Insulation - 5-1/2-inch-thick mineral wool insulation (2.5 pcf, nominal)
4. Fasteners - 2-1/4 in. #6 Type S drywall screws, spaced 12 in. o.c.
5. Joints and Fastener Heads - Wallboard joints covered with paper tape and joint compound, fastener heads covered with joint compound

Tests conducted at the Fire Test Laboratory of National Gypsum Research Center

Test No: WP-1231 (Fire Endurance) September 14, 1999

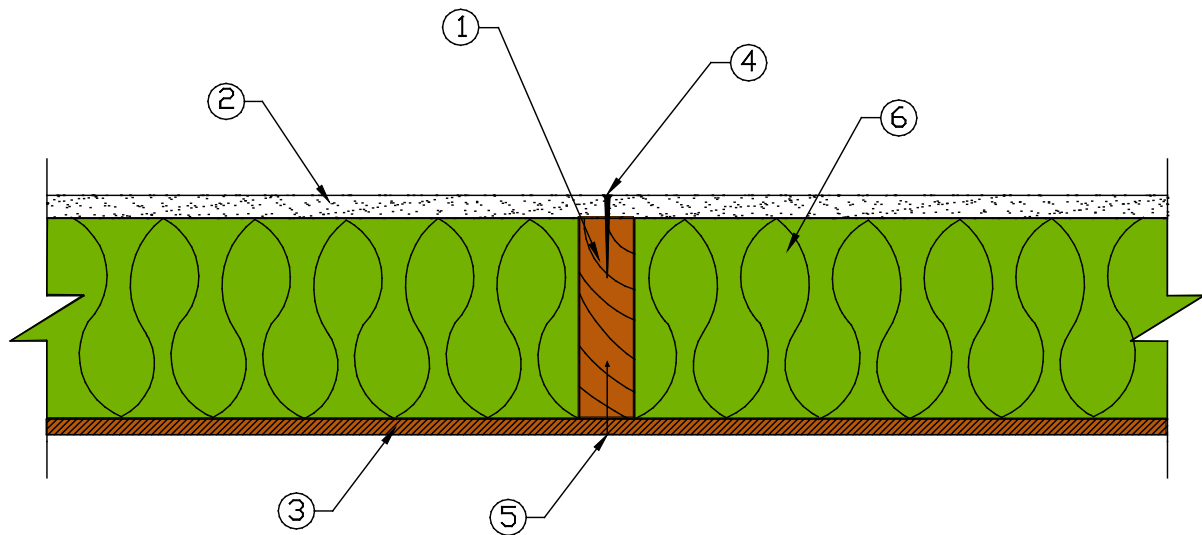
WP-1230 (Hose Stream) August 30, 1999

Third Party Witness: Intertek Testing Services
Report J99-22441.1

This assembly was tested at 100% design load, calculated in accordance with the 2018 *National Design Specification® for Wood Construction*. The authority having jurisdiction should be consulted to assure acceptance of this report.

WS6-1.3 One-Hour Fire-Resistance-Rated Wood-Frame Wall Assembly (Rated from gypsum wallboard side)

2x6 Wood Stud Wall – 100% Design Load – ASTM E 119/NFPA 251



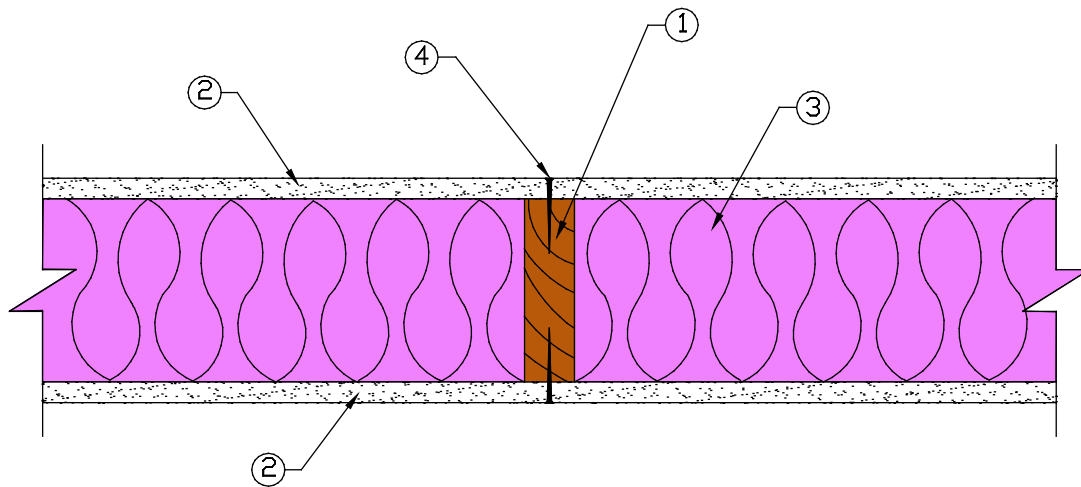
1. Framing - Nominal 2x6 wood studs, spaced 16 in. o.c., double top plates, single bottom plate
2. Interior Sheathing - 5/8 in. Type X gypsum wallboard, 4 ft. wide, applied horizontally. Horizontal joints are unblocked. Horizontal application of wallboard represents the direction of least fire resistance as opposed to vertical application.
3. Exterior Sheathing - Minimum 7/16 in. wood structural panels (oriented strand board), applied vertically, horizontal joints blocked
4. Gypsum Fasteners - 2-1/4 in. #6 Type S drywall screws, spaced 12 in. o.c.
5. Panel Fasteners - 6d common nails (bright) - 12 in. o.c. in the field, 6 in. o.c. panel edges
6. Insulation - 5-1/2-inch-thick mineral wool insulation (2.5 pcf, nominal)
7. Joints and Fastener Heads - Wallboard joints covered with paper tape and joint compound, fastener heads covered with joint compound

Tests conducted at the Fire Test Laboratory of National Gypsum Research Center

Test No: WP-1244 (Fire Endurance & Hose Stream) February 25, 2000

Third Party Witness: Intertek Testing Services
Report J99-27259.2

This assembly was tested at 100% design load, calculated in accordance with the 2018 *National Design Specification® for Wood Construction*. The authority having jurisdiction should be consulted to assure acceptance of this report.

WS6-1.4 One-Hour Fire-Resistance-Rated Wood-Frame Wall Assembly
2x6 Wood Stud Wall – 100% Design Load – ASTM E 119/NFPA 251


1. Framing - Nominal 2x6 wood studs, spaced 16 in. o.c., double top plates, single bottom plate
2. Sheathing - 5/8 in. Type X gypsum wallboard, 4 ft. wide, applied vertically. All panel edges backed by framing or blocking.
3. Insulation - R-19 fiberglass insulation
4. Fasteners - 2-1/4 in. #6 Type S drywall screws, spaced 12 in. o.c.
5. Joints and Fastener Heads - Wallboard joints covered with paper tape and joint compound, fastener heads covered with joint compound

Tests conducted at NGC Testing Services

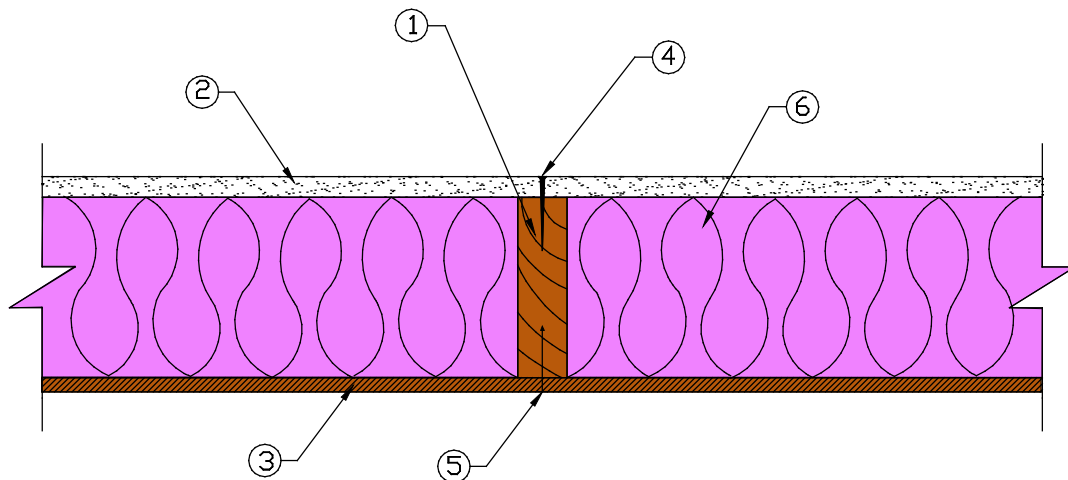
Test No: WP-1346 (Fire Endurance) August 22, 2003
 WP-1351 (Hose Stream) September 17, 2003

Third Party Witness: NGC Testing Services

This assembly was tested at 100% design load, calculated in accordance with the 2018 *National Design Specification® for Wood Construction*. The authority having jurisdiction should be consulted to assure acceptance of this report.

**WS6-1.5 One-Hour Fire-Resistance-Rated Wood-Frame Wall Assembly
(Rated from gypsum wallboard side)**

2x6 Wood Stud Wall – 100% Design Load – ASTM E 119/NFPA 251



1. Framing - Nominal 2x6 wood studs, spaced 16 in. o.c., double top plates, single bottom plate
2. Interior Sheathing - 5/8 in. Type X gypsum wallboard, 4 ft. wide, applied vertically. All panel edges backed by framing or blocking.
3. Exterior Sheathing - Minimum 3/8 in. wood structural panels (oriented strand board), applied vertically, horizontal joints blocked
4. Gypsum Fasteners - 2-1/4 in. #6 Type S drywall screws, spaced 7 in. o.c.
5. Panel Fasteners - 6d common nails (bright) - 12 in. o.c. in the field, 6 in. o.c. panel edges
6. Insulation - R-19 fiberglass insulation
7. Joints and Fastener Heads - Wallboard joints covered with paper tape and joint compound, fastener heads covered with joint compound

Tests conducted at the NGC Testing Services

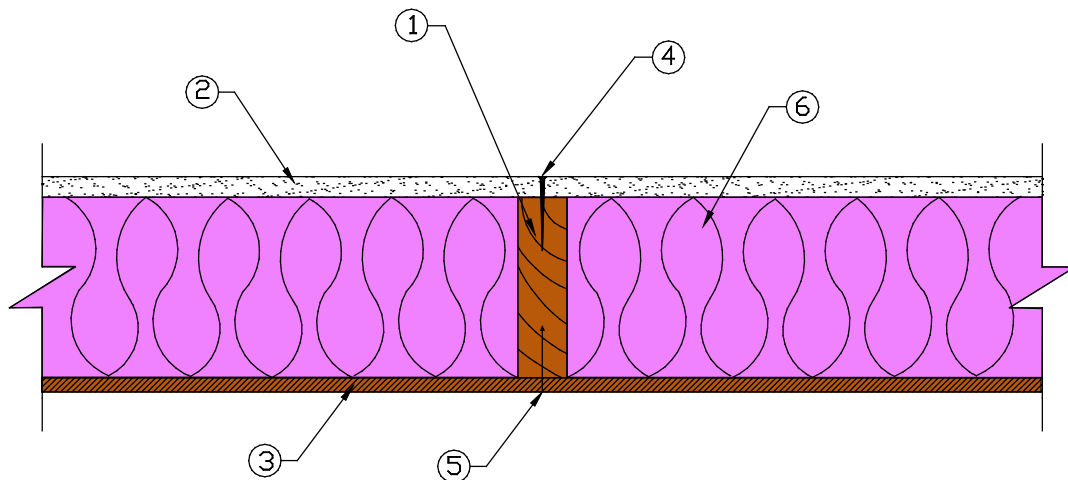
Test No: WP-1408 (Fire Endurance & Hose Stream) August 13, 2004

Third Party Witness: NGC Testing Services

This assembly was tested at 100% design load, calculated in accordance with the 2018 *National Design Specification® for Wood Construction*. The authority having jurisdiction should be consulted to assure acceptance of this report.

WS6-1.6 One-Hour Fire-Resistance-Rated Wood-Frame Wall Assembly (Rated from gypsum wallboard side)

2x6 Wood Stud Wall – 100% Design Load – ASTM E 119/NFPA 251



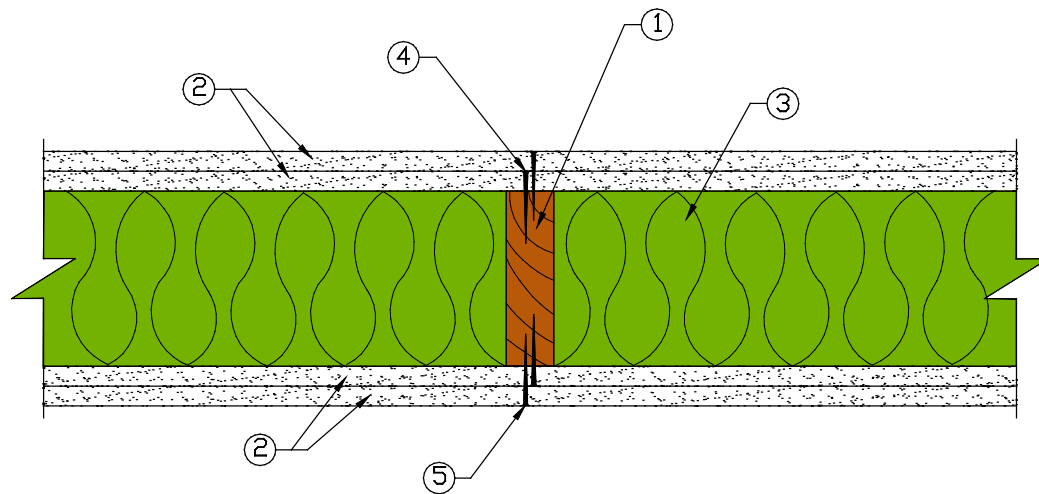
1. Framing - Nominal 2x6 wood studs, spaced 24 in. o.c., double top plates, single bottom plate
2. Interior Sheathing - 5/8 in. Type X gypsum wallboard, 4 ft. wide, applied vertically. All panel edges backed by framing or blocking.
3. Exterior Sheathing - Minimum 15/32 in. wood structural panels, applied vertically, horizontal joints blocked
4. Gypsum Fasteners - 2-1/4 in. #6 Type S drywall screws, spaced 7 in. o.c.
5. Panel Fasteners - 6d common nails (bright) - 12 in. o.c. in the field, 6 in. o.c. panel edges
6. Insulation - minimum R-19 fiberglass insulation
7. Joints and Fastener Heads - Wallboard joints covered with paper tape and joint compound, fastener heads covered with joint compound

Tests conducted at Western Fire Center

Test No: WFCi Report #18090r1 (Fire Endurance & Hose Stream) February 22, 2019

Third Party Witness: Western Fire Center, Inc.

This assembly was tested at 100% design load, calculated in accordance with the 2018 *National Design Specification® for Wood Construction*. The authority having jurisdiction should be consulted to assure acceptance of this report.

WS6-2.1 Two-Hour Fire-Resistance-Rated Wood-Frame Wall Assembly**2x6 Wood Stud Wall – 100% Design Load – ASTM E 119/NFPA 251**

1. Framing - Nominal 2x6 wood studs, spaced 24 in. o.c., double top plates, single bottom plate.
2. Sheathing:
 - Base Layer - 5/8 in. Type X gypsum wallboard, 4 ft. wide, applied horizontally, joints staggered on opposite sides of the wall.
 - Face Layer - 5/8 in. Type X gypsum wallboard, 4 ft. wide, applied horizontally, joints staggered with base layer.
 - Horizontal joints are unblocked. Horizontal application of wallboard represents the direction of least fire resistance as opposed to vertical application.
3. Insulation - 5-1/2-inch-thick mineral wool insulation (2.5 pcf, nominal)
4. Gypsum Fasteners: Base Layer - 2-1/4 in. #6 Type S drywall screws, spaced 24 in. o.c.
5. Gypsum Fasteners: Face Layer - 2-1/4 in. #6 Type S drywall screws, spaced 8 in. o.c.
6. Joints and Fastener Heads - Wallboard joints covered with paper tape and joint compound, fastener heads covered with joint compound

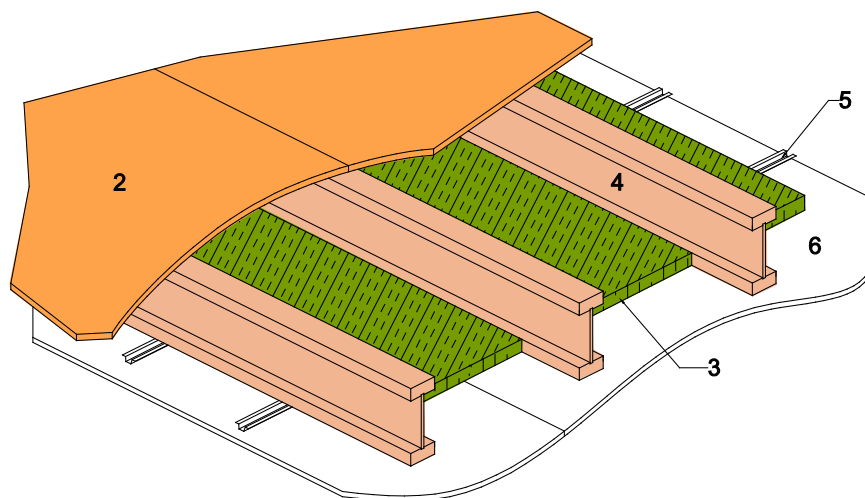
Tests conducted at the Fire Test Laboratory of National Gypsum Research Center

Test No: WP-1262 (Fire Endurance) November 3, 2000

WP-1268 (Hose Stream) December 8, 2000

Third Party Witness: Intertek Testing Services
Report J20-006170.3

This assembly was tested at 100% design load, calculated in accordance with the 2018 *National Design Specification® for Wood Construction*. The authority having jurisdiction should be consulted to assure acceptance of this report.

WIJ-1.1 One-Hour Fire-Resistance-Rated Ceiling Assembly**Floor^a/Ceiling - 100% Design Load - 1 Hour Rating - ASTM E 119 / NFPA 251**

- 1. Floor Topping (optional, not shown):** Gypsum concrete, lightweight or normal concrete topping.
- 2. Floor Sheathing:** Minimum 23/32-inch-thick tongue-and-groove wood sheathing (Exposure 1). Installed per code requirements with minimum 8d common nails and glued to joist top flanges with AFG-01 construction adhesive.
- 3. Insulation:** Minimum 1-1/2-inch-thick mineral wool batt insulation – 2.5 pcf (nominal), supported by furring channels.
- 4. Structural Members:** Wood I-joists spaced a maximum of 24 inches on center. See ASTM D 5055 for qualification requirements. Additional requirements are as follows:

Minimum I-joist flange depth: 1-1/2 inches	Minimum I-joist flange area: 5.25 inches ²
Minimum I-joist web thickness: 3/8 inch	Minimum I-joist depth: 9-1/4 inches
- 5. Furring Channels:** Minimum 0.026-inch-thick galvanized steel hat-shaped furring channels, attached perpendicular to I-joists using 1⁵/₈-inch-long drywall screws. Furring channels spaced 16 inches on center and doubled at each wallboard end joint extending to the next joist. Based on ASTM E2032, minimum 0.019-inch-thick galvanized steel resilient channels may be used in lieu of hat-shaped furring channels if installed at the same spacing and attached in the same manner. In order to achieve the sound ratings given below, resilient channels must be used in lieu of hat-shaped furring channels.
- 6. Gypsum Wallboard:** Minimum 5/8-inch-thick Type C gypsum wallboard installed with long dimension perpendicular to furring channels and fastened to each channel with minimum 1-1/8-inch-long Type S drywall screws. Fasteners spaced 12 inches on center in the field of the wallboard, 8 inches on center at wallboard end joints, and 3/4 inches from panel edges and ends. End joints of wallboard staggered.
- 7. Finish System (not shown):** Face layer joints covered with tape and coated with joint compound. Screw heads covered with joint compound.

Fire Test conducted at Gold Bond Building Products Research Center
 Third Party Witness: Warnock Hersey International, Inc.

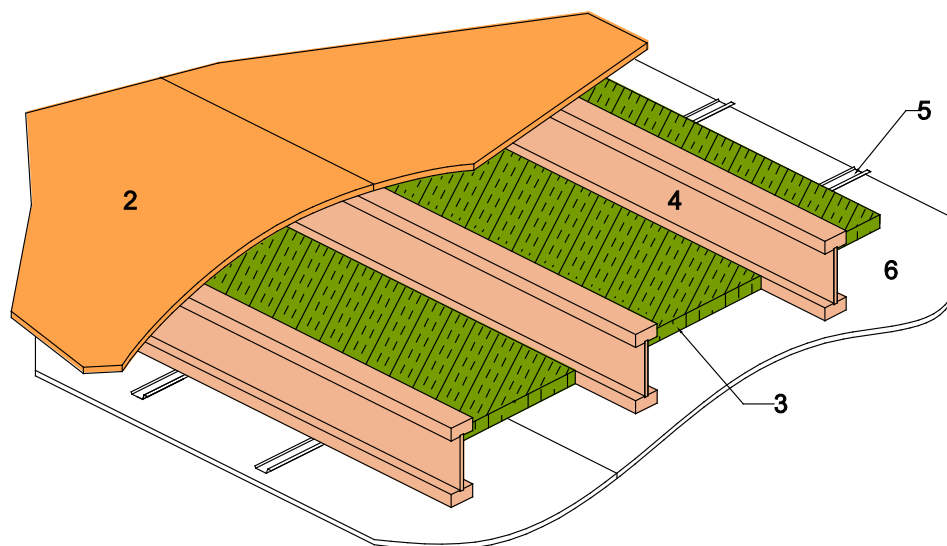
February 9, 1990
 Report No: WHI-651-0311.1

STC and IIC Sound Ratings (with Resilient Channels)								
Joist/ RC Spacing ^c	Without Gypsum Concrete				With 1" Gypsum Concrete			
	Cushioned Vinyl		Carpet & Pad		Cushioned Vinyl		Carpet & Pad	
	STC	IIC	STC	IIC	STC	IIC	STC	IIC
24"o.c./16"o.c.	48 (51) ^b	42 (43) ^b	48 (51) ^b	61 (63) ^b	63 (65) ^b	50 (52) ^b	63 (65) ^b	65 (67) ^b
16"o.c./16"o.c.	44 (46) ^b	37 (39) ^b	44 (46) ^b	60 (61) ^b	56 (57) ^b	46 (47) ^b	56 (57) ^b	58 (59) ^b

^a This assembly may also be used in a fire-rated roof/ceiling application, but only when constructed exactly as described.

^b STC and IIC values established by engineering analysis using the AWC Technical Report 15 (TR15) model, assuming 1.5"-thick mineral wool batt insulation (values in parentheses assume 3.5"-thick mineral wool batt) and resilient channels at 16" o.c.

^c STC and IIC values for assemblies with a joist spacing of 16"o.c. may be used for assemblies with joist spacings between 16"o.c. and 24"o.c..

WIJ-1.2 One-Hour Fire-Resistance-Rated Ceilg Assembly**Floor^a/Ceiling - 100% Design Load - 1 Hour Rating - ASTM E 119 / NFPA 251**

1. **Floor Topping (optional, not shown):** Gypsum concrete, lightweight or normal concrete topping.
2. **Floor Sheathing:** Minimum 23/32-inch-thick tongue-and-groove wood sheathing (Exposure 1). Installed per code requirements with minimum 8d common nails and glued to joist top flanges with AFG-01 construction adhesive.
3. **Insulation:** Minimum 1-1/2-inch-thick mineral wool batt insulation – 2.5 pcf (nominal), supported by resilient channels.
4. **Structural Members:** Wood I-joists spaced a maximum of 24 inches on center. See ASTM D 5055 for qualification requirements. Additional requirements are as follows:
 Minimum I-joist flange depth: 1-1/2 inches Minimum I-joist flange area: 5.25 inches²
 Minimum I-joist web thickness: 7/16 inch Minimum I-joist depth: 9-1/4 inches
5. **Resilient Channels:** Minimum 0.019-inch-thick galvanized steel resilient channels, attached perpendicular to I-joists using 1-5/8-inch-long drywall screws. Resilient channels spaced 16 inches on center and doubled at each wallboard end joint extending to the next joist.
6. **Gypsum Wallboard:** Minimum 5/8-inch-thick Type C gypsum wallboard installed with long dimension perpendicular to resilient channels and fastened to each channel with minimum 1-inch-long Type S drywall screws. Fasteners spaced 12 inches on center in the field of the wallboard, 8 inches on center at wallboard end joints, and 3/4 inches from panel edges and ends. End joints of wallboard staggered.
7. **Finish System (not shown):** Face layer joints covered with tape and coated with joint compound. Screw heads covered with joint compound.

Fire Test conducted at Gold Bond Building Products Research Center

June 19, 1984

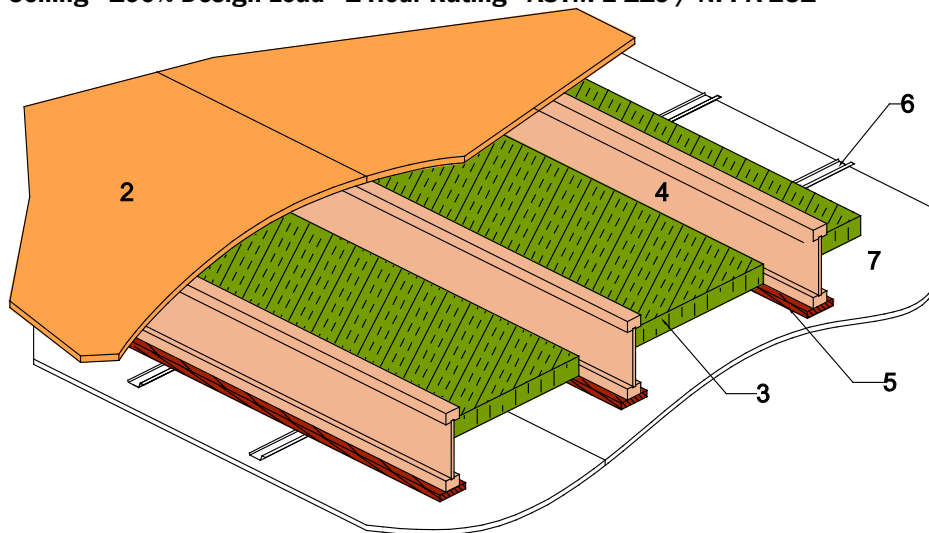
Third Party Witness: Warnock Hersey International, Inc.

Report No: WHI-694-0159

STC and IIC Sound Ratings

Joist/ RC Spacing ^c	Without Gypsum Concrete				With 1" Gypsum Concrete			
	Cushioned Vinyl		Carpet & Pad		Cushioned Vinyl		Carpet & Pad	
	STC	IIC	STC	IIC	STC	IIC	STC	IIC
24"o.c./16"o.c.	48 (51) ^b	42 (43) ^b	48 (51) ^b	61 (63) ^b	63 (65) ^b	50 (52) ^b	63 (65) ^b	65 (67) ^b
16"o.c./16"o.c.	44 (46) ^b	37 (39) ^b	44 (46) ^b	60 (61) ^b	56 (57) ^b	46 (47) ^b	56 (57) ^b	58 (59) ^b

^a This assembly may also be used in a fire-rated roof/ceiling application, but only when constructed exactly as described.^b STC and IIC values established by engineering analysis using the AWC Technical Report 15 (TR15) model, assuming 1.5"-thick mineral wool batt insulation (values in parentheses assume 3.5"-thick mineral wool batt).^c STC and IIC values for assemblies with a joist spacing of 16"o.c. may be used for assemblies with joist spacings between 16"o.c. and 24"o.c..

WIJ-1.3 One-Hour Fire-Resistance-Rated Ceiling Assembly**Floor^a/Ceiling - 100% Design Load - 1 Hour Rating - ASTM E 119 / NFPA 251**

- 1. Floor Topping (optional, not shown):** Gypsum concrete, lightweight or normal concrete topping.
- 2. Floor Sheathing:** Minimum 23/32-inch-thick tongue-and-groove wood sheathing (Exposure 1). Installed per code requirements.
- 3. Insulation:** Minimum 2-inch-thick mineral wool batt insulation – 3.5 pcf (nominal), supported by setting strip edges, friction-fitted between the sides of the I-joist flanges.
- 4. Structural Members:** Wood I-joists spaced a maximum of 24 inches on center. See ASTM D 5055 for qualification requirements. Additional requirements are as follows:

Minimum I-joist flange depth: 1-5/16 inches	Minimum I-joist flange area: 2.25 inches ²
Minimum I-joist web thickness: 3/8 inch	Minimum I-joist depth: 9-1/4 inches
- 5. Setting Strips:** Minimum 1x4 (nominal) wood setting strips attached with 1-1/2-inch-long drywall screws at 24 inches on center along the bottom flange of I-joist creating a ledge to support insulation.
- 6. Resilient Channels:** Minimum 0.019-inch-thick galvanized steel resilient channels, attached perpendicular to I-joists using 1-7/8-inch-long drywall screws. Resilient channels spaced 16 inches on center and doubled at each wallboard end joint extending to the next joist.
- 7. Gypsum Wallboard:** Minimum 5/8-inch-thick Type C gypsum wallboard installed with long dimension perpendicular to resilient channels and fastened to each channel with minimum 1-1/8-inch-long Type S drywall screws. Fasteners spaced 7 inches on center and 3/4 inches from panel edges and ends. End joints of wallboard staggered.
- 7. Finish System (not shown):** Face layer joints covered with tape and coated with joint compound. Screw heads covered with joint compound.

Fire Test conducted at National Gypsum Testing Services, Inc.
 Third Party Witness: Underwriter's Laboratories, Inc.

September 28, 2001
 Report No: NC3369

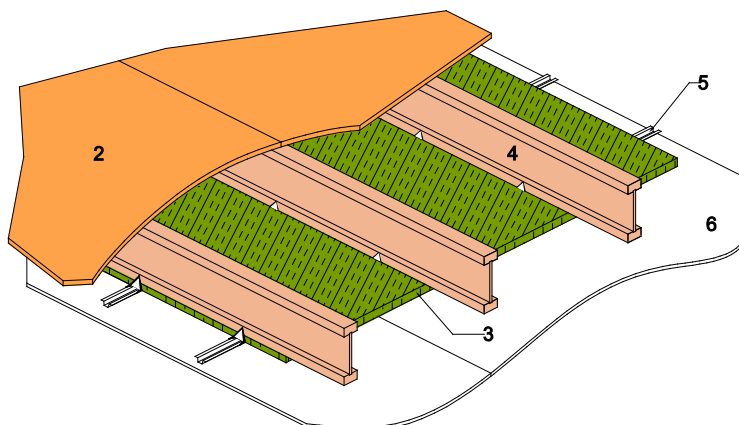
STC and IIC Sound Ratings

Joist/ RC Spacing ^c	Without Gypsum Concrete				With 1" Gypsum Concrete			
	Cushioned Vinyl		Carpet & Pad		Cushioned Vinyl		Carpet & Pad	
	STC	IIC	STC	IIC	STC	IIC	STC	IIC
24"o.c./16"o.c.	50 (51) ^b	43 (43) ^b	52	66	63 (65) ^b	51 (52) ^b	63 (65) ^b	67 (67) ^b
16"o.c./16"o.c.	45 (46) ^b	38 (39) ^b	45 (46) ^b	60 (61) ^b	57 (57) ^b	46 (47) ^b	57 (57) ^b	59 (59) ^b

^a This assembly may also be used in a fire-rated roof/ceiling application, but only when constructed exactly as described.

^b STC and IIC values established by engineering analysis using the AWC Technical Report 15 (TR15) model, assuming 2"-thick mineral wool batt insulation (values in parentheses assume 3.5"-thick mineral wool batt) and neglecting the influence (if any) of the setting strips.

^c STC and IIC values for assemblies with a joist spacing of 16"o.c. may be used for assemblies with joist spacings between 16"o.c. and 24"o.c..

WIJ-1.4 One-Hour Fire-Resistance-Rated Ceiling Assembly**Floor^a/Ceiling - 100% Design Load - 1 Hour Rating - ASTM E 119 / NFPA 251**

- 1. Floor Topping (optional, not shown):** Gypsum concrete, lightweight or normal concrete topping.
- 2. Floor Sheathing:** Minimum 23/32-inch-thick tongue-and-groove wood sheathing (Exposure 1). Installed per code requirements with minimum 8d common nails.
- 3. Insulation:** Minimum 1-inch-thick mineral wool batt insulation – 6 pcf (nominal), with width equal to the on-center spacing of the I-joists. Batts installed on top of furring channels and under bottom flange of I-joists with the sides butted against support clips. Abutted ends of batts centered over furring channels with batts tightly butted at all joints.
- 4. Structural Members:** Wood I-joists spaced a maximum of 24 inches on center. See ASTM D 5055 for qualification requirements. Additional requirements are as follows:

Minimum I-joist flange depth: 1-1/2 inches	Minimum I-joist flange area: 3.45 inches ²
Minimum I-joist web thickness: 3/8 inch	Minimum I-joist depth: 9-1/4 inches
- 5. Furring Channels:** Minimum 0.019-inch-thick galvanized steel hat-shaped furring channels, attached perpendicular to I-joists spaced 24 inches on center. At channel splices, adjacent pieces overlapped a minimum of 6 inches and tied with a double strand of No. 18 gage galvanized steel wire at each end of the overlap. Channels secured to I-joists with Simpson Type CSC support clips at each intersection with the I-joists. Clips nailed to the side of I-joist bottom flange with one 1-1/2-inch-long No. 11 gage nail. A row of furring channel located on each side of wallboard end joints and spaced 2.25 inches from the end joint (4.5 inches on center).
- 6. Gypsum Wallboard:** Minimum 1/2-inch-thick Type C gypsum wallboard. Wallboard installed with long dimension perpendicular to furring channels and fastened to each channel with minimum 1-inch-long Type S drywall screws. Fasteners spaced 12 inches on center in the field of the wallboard, 6 inches on center at wallboard end joints, and 3/4 inches from panel edges and ends. End joints of wallboard staggered. For staggered wallboard end joints, furring channels extend a minimum of 6 inches beyond each end of the joint.
- 7. Finish System (not shown):** Face layer joints covered with tape and coated with joint compound. Screw heads covered with joint compound.

Fire Test conducted at Underwriter's Laboratories, Inc.

May 11, 1983

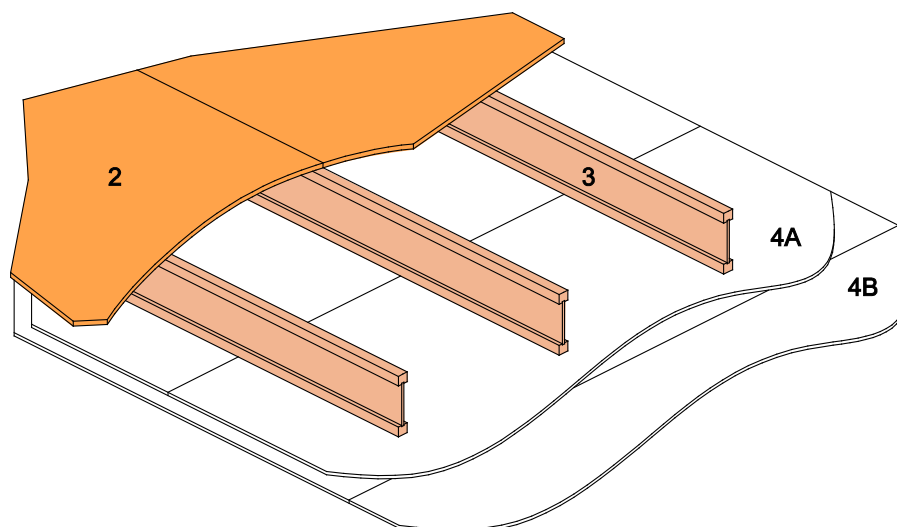
Third Party Witness: Underwriter's Laboratories, Inc.

Report No: UL R10371-1

STC and IIC Sound Ratings^b

Joist /RC Spacing	Without Gypsum Concrete				With 3/4" Gypsum Concrete			
	Cushioned Vinyl		Carpet & Pad		Cushioned Vinyl		Carpet & Pad	
	STC	IIC	STC	IIC	STC	IIC	STC	IIC
24"o.c./24"o.c.	-	-	46	68	51	47	50	73

^a This assembly may also be used in a fire-rated roof/ceiling application, but only when constructed exactly as described.^b Tabulated STC and IIC sound ratings are based tests of assemblies having 5/8-inch-thick gypsum wallboard.

WIJ-1.5 One-Hour Fire-Resistance-Rated Ceiling Assembly**Floor^a/Ceiling - 100% Design Load - 1 Hour Rating - ASTM E 119 / NFPA 251**

1. **Floor Topping (optional, not shown):** Gypsum concrete, lightweight or normal concrete topping.
2. **Floor Sheathing:** Minimum 23/32-inch-thick tongue-and-groove wood sheathing (Exposure 1). Installed per code requirements with minimum 8d common nails.
3. **Structural Members:** Wood I-joists spaced a maximum of 24 inches on center. See ASTM D 5055 for qualification requirements. Additional requirements are as follows:

Minimum I-joist flange depth: 1-1/2 inches

Minimum I-joist flange area: 2.25 inches²

Minimum I-joist web thickness: 3/8 inch

Minimum I-joist depth: 9-1/4 inches

4. **Gypsum Wallboard:** Two layers of minimum 1/2 inch Type C gypsum wallboard attached with the long dimension perpendicular to the I-joists as follows:

4a. Wallboard Base Layer: Base layer of wallboard attached to bottom flange of I-joists using 1 inch Type S drywall screws at 12 inches on center. End joints of wallboard centered on bottom flange of the I-joist and staggered.

4b. Wallboard Face Layer: Face layer of wallboard attached to bottom flange of I-joists through base layer using 1-5/8 inch Type S drywall screws spaced 12 inches on center on intermediate joists and 8 inches on center at end joints. Edge joints of wallboard face layer offset 24 inches from those of base layer. End joints centered on bottom flange of I-joists and offset a minimum of 48 inches from those of base layer. Additionally, wallboard face layer attached to base layer with 1-1/2 inch Type G drywall screws spaced 8 inches on center with a 4" stagger, placed 6 inches from face layer end joints.

5. **Finish System (not shown):** Face layer joints covered with tape and coated with joint compound. Screw heads covered with joint compound.

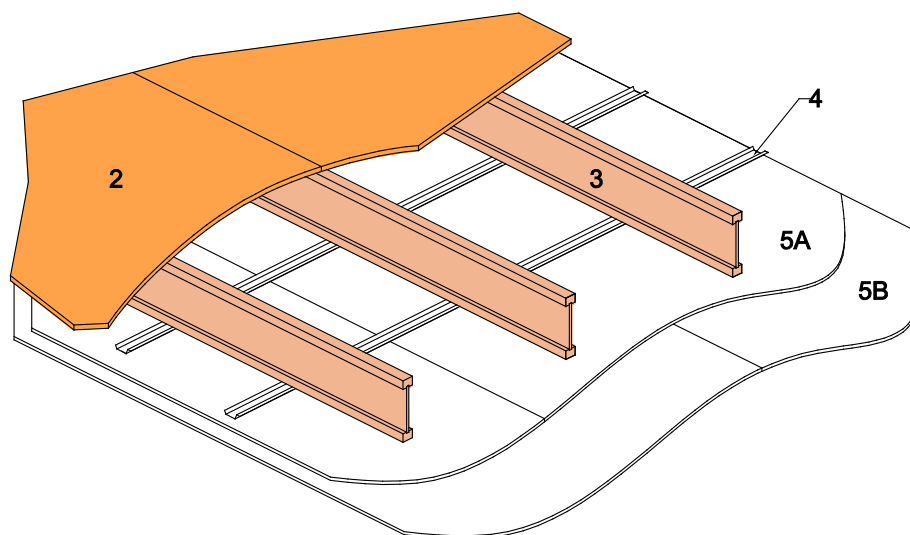
Fire Test conducted at NGC Testing Services, Inc

Report No. FC-687 January 25, 2007

STC and IIC Sound Ratings								
Joist Spacing	Without Gypsum Concrete				With 3/4" Gypsum Concrete			
	Cushioned Vinyl		Carpet & Pad		Cushioned Vinyl		Carpet & Pad	
	STC	IIC	STC	IIC	STC	IIC	STC	IIC
24"o.c.	-	-	-	-	-	-	49 ^b	55 ^b

^a This assembly may also be used in a fire-rated roof/ceiling application, but only when constructed exactly as described.

^b STC and IIC values established by engineering analysis performed by David L. Adams Associates, Inc.

WIJ-1.6 One-Hour Fire-Resistance-Rated Ceiling AssemblyFloor^a/Ceiling - 100% Design Load - 1 Hour Rating - ASTM E 119 / NFPA 251

- 1. Floor Topping (optional, not shown):** Gypsum concrete, lightweight or normal concrete topping.
- 2. Floor Sheathing:** Minimum 23/32-inch-thick tongue-and-groove wood sheathing (Exposure 1). Installed per code requirements with minimum 8d common nails.
- 3. Structural Members:** Wood I-joists spaced a maximum of 24 inches on center. See ASTM D 5055 for qualification requirements. Additional requirements are as follows:

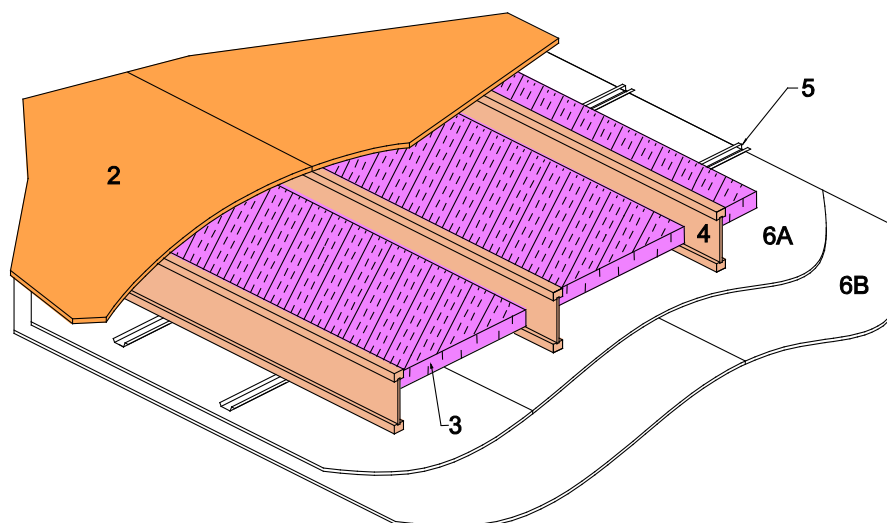
Minimum I-joist flange depth: 1-5/16 inches	Minimum I-joist flange area: 1.95 inches ²
Minimum I-joist web thickness: 3/8 inch	Minimum I-joist depth: 9-1/2 inches
- 4. Resilient Channels^b:** Minimum 0.019-inch-thick galvanized steel resilient channel attached perpendicular to the bottom flange of the I-joists with one 1-1/4 inch drywall screw. Channels spaced a maximum of 16 inches on center [24 inches on center when I-joists are spaced a maximum of 16 inches on center].
- 5. Gypsum Wallboard:** Two layers of minimum 1/2 inch Type X gypsum wallboard attached with the long dimension perpendicular to the resilient channels as follows:
 - 5a. Wallboard Base Layer:** Base layer of wallboard attached to resilient channels using 1-1/4 inch Type S drywall screws at 12 inches on center.
 - 5b. Wallboard Face Layer:** Face layer of wallboard attached to resilient channels through base layer using 1-5/8 inch Type S drywall screws spaced 12 inches on center. Edge joints of wallboard face layer offset 24 inches from those of base layer. Additionally, wallboard face layer attached to base layer with 1-1/2 inch Type G drywall screws spaced 8 inches on center, placed 1-1/2 inches from face layer end joints.
- 6. Finish System (not shown):** Face layer joints covered with tape and coated with joint compound. Screw heads covered with joint compound.

Fire Test conducted at National Research Council of Canada Report No. A-4440.1 June 24, 1997

STC and IIC Sound Ratings^b

Joist/ RC Spacing ^c	Without Gypsum Concrete				With 1" Gypsum Concrete			
	Cushioned Vinyl		Carpet & Pad		Cushioned Vinyl		Carpet & Pad	
	STC	IIC	STC	IIC	STC	IIC	STC	IIC
24"o.c./16"o.c.	46 ^c	44 ^c	46 ^c	61 ^c	58 ^c	47 ^c	58 ^c	67 ^c
16"o.c./24"o.c.	47 ^c	43 ^c	47 ^c	64 ^c	60 ^c	49 ^c	60 ^c	67 ^c

^a This assembly may also be used in a fire-rated roof/ceiling application, but only when constructed exactly as described.^b Direct attachment of gypsum wallboard in lieu of attachment to resilient channels is typically deemed acceptable. When gypsum wallboard is directly attached to the I-joists, the wallboard should be installed with long dimension perpendicular to the I-joists and sound ratings for WIJ-1.5 should be used.^c STC and IIC values established by engineering analysis using the AWC Technical Report 15 (TR15) model.^c STC and IIC values for assemblies with a joist spacing of 16"o.c. may be used for assemblies with joist spacings between 16"o.c. and 24"o.c..

WIJ-1.7 One-Hour Fire-Resistance-Rated Ceiling Assembly**Floor^a/Ceiling - 100% Design Load - 1 Hour Rating - ASTM E 119 / NFPA 251**

1. **Floor Topping (optional, not shown):** Gypsum concrete, lightweight or normal concrete topping.
2. **Floor Sheathing:** Minimum 23/32-inch-thick tongue-and-groove wood sheathing (Exposure 1). Installed per code requirements with minimum 8d common nails.
3. **Insulation:** Fiberglass insulation placed between I-joists supported by the resilient channels.
4. **Structural Members:** Wood I-joists spaced a maximum of 24 inches on center. See ASTM D 5055 for qualification requirements. Additional requirements are as follows:

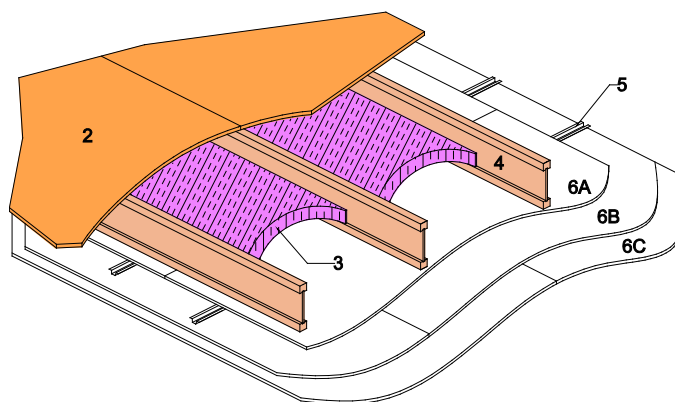
Minimum I-joist flange depth: 1-1/2 inches	Minimum I-joist flange area: 2.25 inches ²
Minimum I-joist web thickness: 3/8 inch	Minimum I-joist depth: 9-1/2 inches
5. **Resilient Channels:** Minimum 0.019-inch-thick galvanized steel resilient channel attached perpendicular to the bottom flange of the I-joists with one 1-1/4 inch drywall screw. Channels spaced a maximum of 16 inches on center [24 inches on center when I-joists are spaced a maximum of 16 inches on center].
6. **Gypsum Wallboard:** Two layers of minimum 1/2 inch Type X gypsum wallboard attached with the long dimension perpendicular to the resilient channels as follows:
 - 6a. **Wallboard Base Layer:** Base layer of wallboard attached to resilient channels using 1-1/4 inch Type S drywall screws at 12 inches on center.
 - 6b. **Wallboard Face Layer:** Face layer of wallboard attached to resilient channels through base layer using 1-5/8 inch Type S drywall screws spaced 12 inches on center. Edge joints of wallboard face layer offset 24 inches from those of base layer. Additionally, wallboard face layer attached to base layer with 1-1/2 inch Type G drywall screws spaced 8 inches on center, placed 1-1/2 inches from face layer end joints.
7. **Finish System (not shown):** Face layer joints covered with tape and coated with joint compound. Screw heads covered with joint compound.

Fire Test conducted at National Research Council of Canada Report No. A-4219.13.2 March 23, 1998

STC and IIC Sound Ratings

Joist/ RC Spacing	Without Gypsum Concrete				With 1" Gypsum Concrete			
	Cushioned Vinyl		Carpet & Pad		Cushioned Vinyl		Carpet & Pad	
	STC	IIC	STC	IIC	STC	IIC	STC	IIC
24"o.c./16"o.c.	56 ^b	51 ^b	56 ^b	69 ^b	64 ^b	53 ^b	64 ^b	71 ^b
16"o.c./24"o.c.	55 ^b	48 ^b	55 ^b	67 ^b	64 ^b	54 ^b	64 ^b	67 ^b

^a This assembly may also be used in a fire-rated roof/ceiling application, but only when constructed exactly as described.^b STC and IIC values established by engineering analysis using the AWC Technical Report 15 (TR15) model, assuming minimum 3.5"-thick fiberglass insulation is used.^c STC and IIC values for assemblies with a joist spacing of 16"o.c. may be used for assemblies with joist spacings between 16"o.c. and 24"o.c.

WIJ-2.1 Two-Hour Fire-Resistance-Rated Ceiling Assembly**Floor^a/Ceiling - 100% Design Load - 2 Hour Rating - ASTM E 119 / NFPA 251**

1. **Floor Topping (optional, not shown):** Gypsum concrete, lightweight or normal concrete topping.
2. **Floor Sheathing:** Minimum 23/32-inch-thick tongue-and-groove wood sheathing (Exposure 1). Installed per code requirements.
3. **Insulation:** Minimum 3-1/2-inch-thick unfaced fiberglass insulation fitted between I-joists supported by stay wires spaced 12 inches on center.
4. **Structural Members:** Wood I-joists spaced a maximum of 24 inches on center. See ASTM D 5055 for qualification requirements. Additional requirements are as follows:

Minimum I-joist flange depth: 1-1/2 inches	Minimum I-joist flange area: 2.25 inches ²
Minimum I-joist web thickness: 3/8 inch	Minimum I-joist depth: 9-1/4 inches
5. **Furring Channels:** Minimum 0.0179-inch-thick galvanized steel hat-shaped furring channels, attached perpendicular to I-joists using 1⁵/₈-inch-long drywall screws. Furring channels spaced 16 inches on center (furring channels used to support the second and third layers of gypsum wallboard). Based on ASTM E2032, minimum 0.019-inch-thick galvanized steel resilient channels may be used in lieu of hat-shaped furring channels if installed at the same spacing and attached in the same manner. In order to achieve the sound ratings given below, resilient channels must be used in lieu of hat-shaped furring channels.
6. **Gypsum Wallboard:** Three layers of minimum 5/8 inch Type C gypsum wallboard as follows:
 - 6a. **Wallboard Base Layer:** Base layer of wallboard attached to bottom flange of I-joists using 1-5/8 inch Type S drywall screws at 12 inches on center with the long dimension of wallboard perpendicular to I-joist. End joints of wallboard centered on bottom flange of the I-joist and staggered from end joints in adjacent sheets.
 - 6b. **Wallboard Middle Layer:** Middle layer of wallboard attached to furring channels using 1 inch Type S drywall screws spaced 12 inches on center with the long dimension of wallboard perpendicular to furring channels. End joints staggered from end joints in adjacent sheets.
 - 6c. **Wallboard Face Layer:** Face layer of wallboard attached to furring channels through middle layer using 1-5/8 inch Type S drywall screws spaced 8 inches on center. Edge joints of face layer of wallboard offset 24 inches from those of middle layer. End joints of face layer of wallboard staggered with respect to the middle layer.
7. **Finish System (not shown):** Face layer joints covered with tape and coated with joint compound. Screw heads covered with joint compound.

Fire Test conducted at Gold Bond Building Products Research Center

December 16, 1992

Third Party Witness: PFS Corporation

Report No: #92-56

STC and IIC Sound Ratings (with Resilient Channels)

Joist /RC Spacing	Without Gypsum Concrete				With 1" Gypsum Concrete			
	Cushioned Vinyl		Carpet & Pad		Cushioned Vinyl		Carpet & Pad	
	STC	IIC	STC	IIC	STC	IIC	STC	IIC
24"o.c./16"o.c.	-	-	49 ^b	54 ^b	58	45	58	64

^a This assembly may also be used in a fire-rated roof/ceiling application, but only when constructed exactly as described.^b STC and IIC values established by engineering analysis performed by David L. Adams Associates, Inc.

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