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**GYPSUM ASSOCIATION**

# **FIRE RESISTANCE DESIGN MANUAL**

**SOUND CONTROL**

# **GYPSUM SYSTEMS**

**18<sup>th</sup>  
Edition**  
GA-600-2006



# FOREWORD

The Gypsum Association *FIRE RESISTANCE DESIGN MANUAL* is referenced by the following code and standards writing organizations:

*INTERNATIONAL BUILDING CODE*, published by:

International Code Council, Inc.  
5203 Leesburg Pike, Suite 600  
Falls Church, Virginia 22041  
(Tables 720.1(1), 720.1(2), and 720.1(3))

*BOCA NATIONAL BUILDING CODE*, published by:

Building Officials and Code Administrators International, Inc.  
4051 West Flossmoor Road  
Country Club Hills, Illinois 60478-5795  
(See Chapters 7, 12, and 25, Commentary to the BOCA National Building Code)

*UNIFORM BUILDING CODE*, published by:

International Conference of Building Officials  
5360 Workman Mill Road  
Whittier, California 90601  
(See footnote a, Tables No. 7-A, -B, and -C, and Appendix Section 1209)

*STANDARD BUILDING CODE*, published by:

Southern Building Code Congress International, Inc.  
900 Montclair Road  
Birmingham, Alabama 35213-1206  
(See Section 701.5.2)

*THE NATIONAL FIRE CODES*, published by:

National Fire Protection Association  
1 Batterymarch Park  
P.O. Box 9101  
Quincy, Massachusetts 02269-9101  
(See NFPA 90A, NFPA 101, NFPA 221, NFPA 5000, and the Life Safety Code Handbook)

The *FIRE RESISTANCE DESIGN MANUAL* is also referenced in the code documents of major jurisdictions in the United States such as Florida, Chicago, Los Angeles, and New York City. In addition, the Manual has been recognized in major jurisdictions in Canada.

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## INTRODUCTION

NOTE: This Introduction constitutes an essential part of the system descriptions contained in Section IV. It is important that the user be familiar with this introductory material.

This Manual is a convenient and useful specification aid for anyone concerned with the design, construction, or inspection of fire resistive and sound control systems. Design information is quickly and easily determined. Comparison of these characteristics allows the user to be more accurate in meeting design and code requirements. The data provided are especially useful to builders, architects, code officials, fire service, and insurance personnel.

The systems in this Manual utilize gypsum products to provide fire resistance to walls, partitions, floor-ceilings, roof-ceilings, columns, beams, girders, and trusses. Systems are classified according to their typical uses and their fire-resistance ratings. Walls, partitions, and floor-ceiling systems are further classified by Sound Transmission Class (STC) or Field Sound Transmission Class (FSTC). The Impact Insulation Class (IIC) is included for many wood framed floor-ceiling systems.

WHERE THE WORD "PROPRIETARY" APPEARS IN SYSTEM DESCRIPTIONS EITHER THE SYSTEM OR ONE OR MORE OF ITS COMPONENTS IS CONSIDERED PROPRIETARY. EACH PROPRIETARY SYSTEM SHALL BE BUILT UTILIZING THE COMPONENTS SPECIFIED BY THE COMPANY OR COMPANIES LISTED UNDER THE DETAILED DESCRIPTION FOR THAT SYSTEM. ALL OTHER SYSTEMS ARE GENERIC. GENERIC SYSTEMS ARE APPLICABLE TO THE PRODUCTS OF ANY MANUFACTURER, WHETHER A MEMBER OF THE GYPSUM ASSOCIATION OR NOT, PROVIDED THE PRODUCTS MEET THE APPROPRIATE STANDARDS LISTED IN SECTION I AND, WHEN APPLICABLE, THE REQUIREMENTS SET FORTH IN SECTION II.

To maintain industry-wide quality assurance standards for gypsum board defined in this Manual as "type X," the Gypsum Association requires that all companies listing proprietary tests or systems, or relying on the generic systems in this manual, shall subscribe to an on-going third-party, in-plant product inspection and labeling service. Additionally, each member company makes annual written certification to the Gypsum Association that its products manufactured for use in systems listed in this Manual continue to be inspected and labeled by an independent third-party testing service as listed on page 10.

Fire-resistance ratings, STCs, FSTCs, and IICs are the results of tests conducted on systems composed of specific materials put together in a specified manner. Substitution of other materials or deviation from the specified construction could adversely affect performance. For example, if batt or blanket insulation is shown, then it is a required component of the system. In each system containing batt or blanket insulation the

insulation is specified to be either mineral or glass fiber and, for fire resistance, the system shall be constructed using the type specified.

*Mineral fiber or glass fiber shall not be arbitrarily added to floor-ceiling or roof-ceiling systems to increase either STCs or R-values. This practice has been shown to reduce the fire-resistance rating.* The addition of up to 16<sup>3</sup>/<sub>4</sub> inches of 0.5 pcf glass fiber insulation (R-40), either batt or loose-fill, to any 1- or 2-hour fire resistance rated floor-ceiling or roof-ceiling system having a cavity deep enough to accept the insulation is permitted provided that one additional layer of either 1/2 inch or 5/8 inch type X gypsum board is applied to the ceiling. The additional layer of gypsum board shall be applied as described for the face layer of the tested system except that the fastener length shall be increased by not less than the thickness of the additional layer of gypsum board.

The detailed descriptions for the systems included in this Manual are summaries. For complete information on the systems or components tested, the listing or test report should be reviewed. Details regarding generic systems may be requested from the Gypsum Association; details on proprietary systems are available from the companies listed for those systems.

For information on limiting heights of nonload-bearing steel stud walls and partitions see ASTM C 754, *Standard Specification for Installation of Steel Framing Members to Receive Screw Attached Gypsum Panel Products*, or steel stud manufacturer's literature.

References to ASTM standards, CAN/ULC standards, or other standards refer to the respective standard in effect on the date that the test was performed. Each test reference contains the test report date.

The information in this Manual is based on characteristics, properties, and performance of materials and systems obtained under controlled test conditions as set forth in the appropriate standards in effect at the time of the test. The Gypsum Association and its member companies make no warranties or other representations as to the characteristics, properties, or performance of any materials or systems in actual construction. No warranty or representation is made that any material or component of any system, other than the gypsum material used in such system, conforms to any standard or standards.

## SECTION I - USE OF THIS MANUAL AND GENERAL EXPLANATORY NOTES

### OVERVIEW

The systems are divided into five major categories and listed in the Table of Contents on pages 4 and 5 under these headings:

- Wall and Partition Systems
- Floor-Ceiling Systems
- Roof-Ceiling Systems
- Column Protection Systems
- Beam, Girder, and Truss Protection Systems

In the case of walls and partitions, floor-ceilings, and roof-ceilings, noncombustible systems are listed first, followed by wood-framed systems. They are further subdivided by fire-resistance rating starting with one hour and increasing. STCs (or FSTCs) are listed in descending order. *Where sound test data are not available, estimated STCs are based on evaluations of similar systems for which test data are available.*

Each system has been assigned a reference number - the GA File Number. *Cite this GA File Number in specifications and on plans, or when making inquiries about specific systems.*

All system descriptions contain a brief list of the major components of the system followed by a more detailed description. The detailed descriptions of interior systems begin with the material exposed to the test fire and its method of attachment, followed by a description of the framing members and their methods of installation. Finally, the unexposed side and its method of attachment is described.

Where unsymmetrical systems were tested from one side only, the side exposed to the test fire is indicated by the words "Fire Side" on the system detail. When documentation is available to show that the wall was tested with the least fire-resistive side exposed to the test fire, the wall need not be subjected to tests from the opposite side and a "Fire Side" is not specified. All floor-ceiling and roof-ceiling systems were tested with fire exposure on the ceiling side.

When mineral or glass fiber insulation was a basic component of a fire tested system, it is included in the description as an integral part of the system. The insulation thickness, type, and density are described, and both the fire and sound details show fibrous insulation. If the insulation was used solely to increase the STC, the fibrous insulation is shown only in the sound detail. *When the insulation is not needed for the fire-resistance rating, but is used to improve the STC of the system, the last sentence of the detailed description*

NOTE: Listing of a system in a specific category in this Manual is not intended to limit its use to that category (see General Explanatory Note 13 on page 8). However, this shall not be interpreted to imply that vertical systems, such as walls and partitions, are permitted to arbitrarily be used in a horizontal orientation. In addition, the manufacturer shall be consulted for other products which satisfy the fire and sound requirements shown for the systems.

*states, "Sound tested with [mineral] [glass] fiber insulation." (See General Explanatory Notes 10, 11, and 12 on page 8.)*

Unless indicated otherwise, all load-bearing wood stud systems were tested while being subjected to the maximum load allowed by design under nationally recognized design criteria at the time of the test. Due to an increase in the maximum allowable loading in the *National Design Specifications* (1982 and later editions), the American Forest and Paper Association issued the following statement:

Where a load-bearing fire rated wood stud wall assembly contained in this Manual is specifically designed for structural capacity, the design value in compression parallel to grain adjusted for slenderness ratio ( $F_c'$ ) used in such analysis shall be taken as 78 percent of the maximum  $F_c'$  value determined in accordance with normal design practice but shall not exceed 78 percent of the  $F_c'$  value for such member having a slenderness ratio ( $l_e/d$ ) of 33.

### DESCRIPTION OF TERMS USED IN THIS MANUAL

**Gypsum Board** - defined in ASTM C 11, *Standard Terminology Relating to Gypsum and Related Building Materials and Systems*, as "the generic name for a family of sheet products consisting of a noncombustible core primarily of gypsum with paper surfacing." Gypsum board may be further described as follows:

**Regular Gypsum Board** - a gypsum board with naturally occurring fire resistance from the gypsum in the core; or

**Type X Gypsum Board** - a gypsum board with special core additives to increase the natural fire resistance of regular gypsum board.

**Limited Load-Bearing** - this means that a constant superimposed load was applied to the test specimen throughout the fire test to simulate a design load less than 78% of the maximum allowable design load.

**Load-Bearing** - unless otherwise noted in the detailed description, this means that a constant superimposed load was applied to the test specimen throughout the fire test to simulate 78% or more of the maximum allowable design load.

**Mineral Fiber** - refers to either rock or slag wool products.

**Metal Studs** - refers to nominal 25 gage steel studs and runners (track) manufactured to comply with ASTM C 645 unless otherwise specified in the detailed description.

**(NLB)** - nonload-bearing.

NOTE: Where the word "proprietary" appears in system descriptions either the system or one or more of its components is considered proprietary. Each proprietary system shall be built utilizing the components specified by the company or companies listed under the detailed description for that system.

## GENERAL EXPLANATORY NOTES

1. All dimensions, weights, temperatures, and pressures are in U.S. customary units. For commonly used metric (SI) conversions refer to the Appendix on page 155 and IEEE/ASTM S 10-2002, *Standard for Use of the International System of Units (SI): The Modernized Metric System*.
2. Nails shall comply with ASTM F 547 or ASTM C 514. Other nails, suitable for the intended use, and having dimensions not less than those specified in this Manual shall be permitted as substitutions.
3. Fasteners installed along the edges of gypsum board shall be placed along the paper bound edges on the long dimension of the board. Fasteners at the end shall be placed along mill or field cut ends on the short dimension. Fasteners on the perimeter of the board shall be placed along both edges and ends.
4. Screws meeting ASTM C 1002 shall be permitted to be substituted for the prescribed nails, one for one, when the length and head diameter of the screws equal or exceed those of the nails specified in the tested system and the screw spacing does not exceed the spacing specified for the nails in the tested system.
5. Vertically applied gypsum board shall have the edges parallel to framing members. Horizontally applied gypsum board shall have the edges at right angles to the framing members. Intermediate vertical framing members are those between the vertical edges or ends of the board.
6. Unless otherwise specified, the face layers of all systems, except those with predecorated or metal covered surfaces, shall have joints taped (minimum Level 1 as specified in GA-214, *Recommended Levels of Gypsum Board Finish*) and fastener heads treated. Base layers in multi-layer systems shall not be required to have joints or fasteners taped or covered with joint compound.
7. When a fire-resistance rated partition extends above the ceiling, the gypsum board joints occurring above the ceiling need not be taped and fasteners need not be covered when all of the following conditions are met.
  - a. The ceiling is part of a fire-resistance rated floor-ceiling or roof-ceiling system;
  - b. All vertical joints occur over framing members;
  - c. Horizontal joints are either staggered 24 inches o.c. on opposite sides of the partition, or are covered with strips of gypsum board not less than 6 inches wide; or the partition is a two-ply system with joints staggered 16 inches or 24 inches o.c.; and
  - d. The partition is not part of a smoke or sound control system.

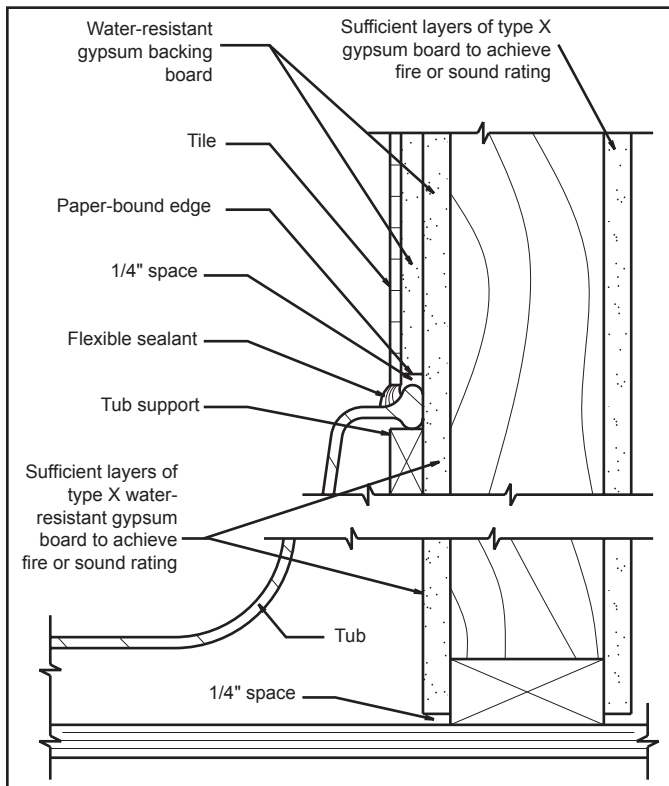
Where joint treatment is discontinued at or just above the ceiling line, the vertical joint shall be

cross taped at this location to reduce the possibility of joint cracking.

8. Metallic outlet boxes shall be permitted to be installed in wood and steel stud walls or partitions having gypsum board facings and classified as two hours or less. The surface area of individual boxes shall not exceed 16 square inches. The aggregate surface area of the boxes shall not exceed 100 square inches in any 100 square feet. Boxes located on opposite sides of walls or partitions shall be in separate stud cavities and shall be separated by a minimum horizontal distance of 24 inches. Approved nonmetallic outlet boxes shall be permitted as allowed by local code.
9. Water-resistant gypsum backing board shall be installed over or as part of the fire-resistance rated system in shower and tub areas to receive ceramic or plastic wall tile or plastic finished wall panels. When fire or sound ratings are necessary, the gypsum board required for the rating shall extend down to the floor behind fixtures so that the construction will equal that of the tested system. (See Figure 1 on page 9.)
 

Note: The use of water-resistant gypsum backing board as a base for tile in wet areas is regulated by local codes. Consult local building codes for requirements.
10. When not specified as a component of a fire tested wall or partition system, mineral fiber, glass fiber, or cellulose fiber insulation of a thickness not exceeding that of the stud depth shall be permitted to be added within the stud cavity.
11. In floor-ceiling or roof-ceiling systems, the addition or deletion of mineral or glass fiber insulation in ceiling joist spaces could possibly reduce the fire-resistance rating. The addition of up to 16<sup>3</sup>/<sub>4</sub> inches of 0.5 pcf glass fiber insulation (R-40), either batt or loose-fill, to any 1- or 2-hour fire resistance rated floor-ceiling or roof-ceiling system having a cavity deep enough to accept the insulation is permitted provided that one additional layer of either 1/2 inch type X or 5/8 inch type X gypsum board is applied to the ceiling. The additional layer of gypsum board shall be applied as described for the face layer of the tested system except that the fastener length shall be increased by not less than the thickness of the additional layer of gypsum board.
12. In each system containing batt or blanket insulation the insulation is specified to be either mineral or glass fiber and, for fire resistance, the system shall be built using the type specified.
13. Although the systems are arranged in general groupings (i.e. walls and interior partitions, floor-ceilings, roof-ceilings, etc.), this is not intended to limit their use only to the specific category in which they are listed. For example, systems listed as shaft walls shall be permitted to be used as interior partitions. However, systems tested vertically (walls

- and partitions) shall not be permitted to be arbitrarily used in a horizontal orientation.
14. Metal studs and runners are nominal 25 gage unless otherwise specified.
  15. Greater stud sizes (depths) shall be permitted to be used in metal- or wood-stud systems. Metal studs of heavier gage than those tested shall be permitted. The assigned rating of any load-bearing system shall also apply to the same system when used as a nonload-bearing system. Indicated stud spacings are maximums.
  16. Specified floor-ceiling and roof-ceiling framing sizes or truss dimensions are minimums. Greater joist or truss sizes (depths) shall be permitted to be used in metal- or wood-framed systems. Indicated joist and truss spacings are maximums.
  17. Within design limitations, the distance between parallel rows of studs, such as in a chase wall, shall be permitted to be increased beyond that tested. When stud cavities in walls constructed of parallel rows of steel studs exceed 9 1/2 inches and cross bracing is required the cross bracing shall be fabricated from steel studs.
  18. Systems tested with metal furring channels attached directly to the bottom chords of steel beams, bar joists, or wood trusses or framing shall be permitted to be suspended. Generally, furring channels are attached to 1 1/2 inch cold rolled carrying channels 48 inches o.c. suspended from joists by 8 gage wire hangers spaced not greater than 48 inches o.c.
  19. Floor-ceiling and roof-ceiling systems were fire tested at less than 36 inches total depth. However, the total depth of the systems, with either directly attached or suspended ceiling membranes, shall be permitted to extend greater than 36 inches.
  20. Where laminating compound is specified, taping, all-purpose, and setting type joint compounds shall be permitted.
  21. Additional layers of type X or regular gypsum board shall be permitted to be added to any system.
  22. When not specified as a component of a fire-resistance rated wall or partition system, wood structural panels shall be permitted to be added to one or both sides. Such panels shall be permitted to be applied either as a base layer directly to the framing (under the gypsum board), as a face layer (over the face layer of gypsum board), or between layers of gypsum board in multi-layer systems. When such panels are applied under the gypsum board or between layers of gypsum board the length of the fasteners specified for the attachment of the gypsum board applied over the wood structural panels shall be increased by not less than the thickness of the wood structural panels. Fastener spacing for the gypsum board and the number of layers of gypsum board shall be as specified in the system description.
  23. Each proprietary system lists specific products that are acceptable for use in the specific system in which they are listed. Consult the manufacturer for information on additional proprietary products that are suitable for use in specific proprietary systems.



**Figure 1**  
**Section Through Typical One-Hour System**



## TESTING AGENCIES

Each detailed description is accompanied by a cross-section detail of the system. Also included is design information giving total thickness, limiting height where appropriate, and approximate weight of the system in pounds per square foot. Fire and sound test references identifying the agency which certified the test as well as a report number and date are also provided (see Tables I and II).

**TABLE I  
FIRE TESTING AGENCIES**

BMS	Building Materials & Structures, National Bureau of Standards (now National Institute of Standards and Technology)
CTC	Commercial Testing Company
FM	Factory Mutual Research Corporation
GET	George E. Troxell, P.E., Consulting Engineer
ITS	Intertek Testing Services NA Inc.
NBS	National Bureau of Standards (now National Institute of Standards and Technology)
NRCC	National Research Council of Canada
OPL	Omega Point Laboratories, Inc.
OSU	The Ohio State University
PCA	Portland Cement Association
SFT	Standard Fire Test, Fire Prevention Research Institute
SWRI	Southwest Research Institute
UC	University of California
UL	Underwriters Laboratories Inc.
ULC	Underwriters' Laboratories of Canada
WHI	Warnock Hersey, Inc. (now Intertek Testing Services NA Inc.)

**TABLE II  
SOUND TESTING AGENCIES**

ACI	Acoustical Consultants, Inc.
ASL	Acoustic Systems Acoustical Research Facility
BBN	Bolt, Beranek, and Newman, Inc.
BGL	British Gypsum Limited
BMS	Building Materials & Structures, National Bureau of Standards (now National Institute of Standards and Technology)
CK	Cedar Knolls Acoustical Laboratories (now Noise Unlimited, Inc.)
DRC	Domtar Research Center
G&H	Geiger and Hamme
INTEST	International Acoustical Testing Laboratories
KAL	Kodaras Acoustical Laboratories (now Electrical Testing Laboratories, ETL)
KG	Kaiser Acoustical Laboratories
NBS	National Bureau of Standards (now National Institute of Standards and Technology)
NGC	National Gypsum Company's Gold Bond Acoustical Laboratories (now NGC Testing Services)
NRCC	National Research Council of Canada
OR	Ohio Research Corporation
RAL	Riverbank Acoustical Laboratories
SA	Shiner & Associates
USG	USG Research & Technology Center
WEAL	Western Electro Acoustical Laboratory, Inc.
WHI	Warnock Hersey, Inc. (now Intertek Testing Services NA Inc.)

**PRODUCT IDENTIFICATION**

All gypsum products are identified with the manufacturer's name and trademark. The thickness and type of gypsum board are shown on the end bundling tape or on the board. Ready-mixed joint compounds are identified on the container. Bagged products are identified on the bag.

ASTM standard product specifications are shown in Table III.

**TABLE III  
APPLICABLE ASTM PRODUCT STANDARDS**

<u>Product</u>	<u>ASTM</u>
Gypsum Board	C 1396*
Gypsum Wallboard	C 1396*
Predecorated Gypsum Board	C 1396*
Gypsum Lath	C 1396*
Gypsum Sheathing Board	C 1396*
Gypsum Backing Board	C 1396*
Gypsum Coreboard	C 1396*
Gypsum Shaftliner Board	C 1396*
Water-Resistant Gypsum Backing Board	C 1396*
Gypsum Ceiling Board	C 1396*
Exterior Gypsum Soffit Board	C 1396*
Gypsum Base for Veneer Plasters	C 1396*
Glass Mat Gypsum Substrate for Use as Sheathing	C 1177
Glass Mat Water-Resistant Gypsum Backing Panel	C 1178
Fiber Reinforced Gypsum Panels	C 1278
Joint Compound	C 475
Gypsum Plasters	C 28
Gypsum Veneer Plaster	C 587
Metal Lath	C 847
Accessories for Gypsum Wallboard and Gypsum Veneer Base	C 1047
Nails for the Application of Gypsum Board	C 514
Steel Drill Screws for the Application of Gypsum Panel Products or Metal Plaster Bases (Types G, W, and S)	C 1002
Steel Drill Screws for the Application of Gypsum Panel Products or Metal Plaster Bases to Steel Studs from 0.033 in. (0.84 mm) to 0.112 in. (2.84 mm) in Thickness (Type S-12)	C 954
Nonstructural Steel Framing Members	C 645
Load-Bearing (Transverse and Axial) Steel Studs, Runners (Tracks), and Bracing or Bridging for Screw Application of Gypsum Panel Products and Metal Plaster Bases	C 955

\* ASTM Specification C 1396 is a consolidation of previous ASTM Standards C 36, C 37, C 79, C 442, C 588, C 630, C 931, C 960, and C 1395, which have been withdrawn.

**ABBREVIATIONS**

Abbreviations used in this Manual are shown in Table IV (also see Tables I and II on page 10).

**TABLE IV  
ABBREVIATIONS**

ASTM	American Society for Testing and Materials
C&P	carpet and pad
dB	decibel
dia	diameter
DOC	U. S. Department of Commerce
est	estimated
FSTC	Field Sound Transmission Class
FSTL	Field Sound Transmission Loss
ft	foot
ga	gage or gauge
galv	galvanized
Hz	hertz (cycles/second)
hr	hour
IIC	Impact Insulation Classification
in.	inch
lab	laboratory
lb	pound
mfr	manufacturer
mm	millimeter
min	minimum
nom	nominal
NLB	nonload-bearing
o.c.	on center
oz	ounce
pcf	pounds per cubic foot
psf	pounds per square foot
rev	revised
sq	square
STC	Sound Transmission Class
STL	Sound Transmission Loss
T&G	tongue and groove

**NOTE:**

ASTM Standards are available from:  
 ASTM International  
 100 Barr Harbor Drive  
 West Conshohocken, PA 19428-2959  
 (610) 832-9585  
 Fax: (610) 832-9555  
 E-mail: [service@astm.org](mailto:service@astm.org)  
 Website: <http://www.astm.org>

## SECTION II - REQUIREMENTS FOR FIRE PROTECTION

### FIRE RESISTIVE PROPERTIES OF GYPSUM

Gypsum is approximately 21 percent by weight chemically combined water which greatly contributes to its effectiveness as a fire resistive barrier. When gypsum board or gypsum plaster is exposed to fire, the water is slowly released as steam, effectively retarding heat transmission (Figure 2). It can, in a sense, be compared to what happens when a blowtorch is turned on a block of ice. Although the ice is being melted, one can hold a hand on the opposite side without being burned. Even though the ice gets very thin it effectively blocks the transfer of the intense heat and one's hand would not be burned until the ice is melted.

When gypsum-protected wood or steel structural members are exposed to a fire, the chemically combined water (being released as steam) acts as a thermal barrier until this slow process, known as calcination, is completed. The temperature directly behind the plane of calcination is only slightly higher than that of boiling water (212°F), which is significantly lower than the temperature at which steel begins losing strength or wood ignites. Once calcination is complete, the in-place calcined gypsum continues to act as a barrier protecting the underlying structural members from direct exposure to flames.

### TYPE X GYPSUM BOARD

ASTM C 1396 describes two types of gypsum board - regular and type X - each providing a different degree of fire resistance. Where fire-resistance rated systems are specified, type X gypsum board is typically required

to achieve the rating. Type X gypsum board is defined in ASTM C 1396 as gypsum board that provides not less than one-hour fire resistance for boards  $\frac{5}{8}$  inch thick or not less than  $\frac{3}{4}$ -hour fire-resistance rating for boards  $\frac{1}{2}$  inch thick, applied parallel with and on each side of load bearing 2x4 wood studs spaced 16 inches on center with 6d coated nails,  $\frac{17}{8}$  inch long, 0.095 inch diameter shank,  $\frac{1}{4}$  inch diameter heads, spaced 7 inches on center with gypsum board joints staggered 16 inches on each side of the partition and tested in accordance with the requirements of ASTM E 119.

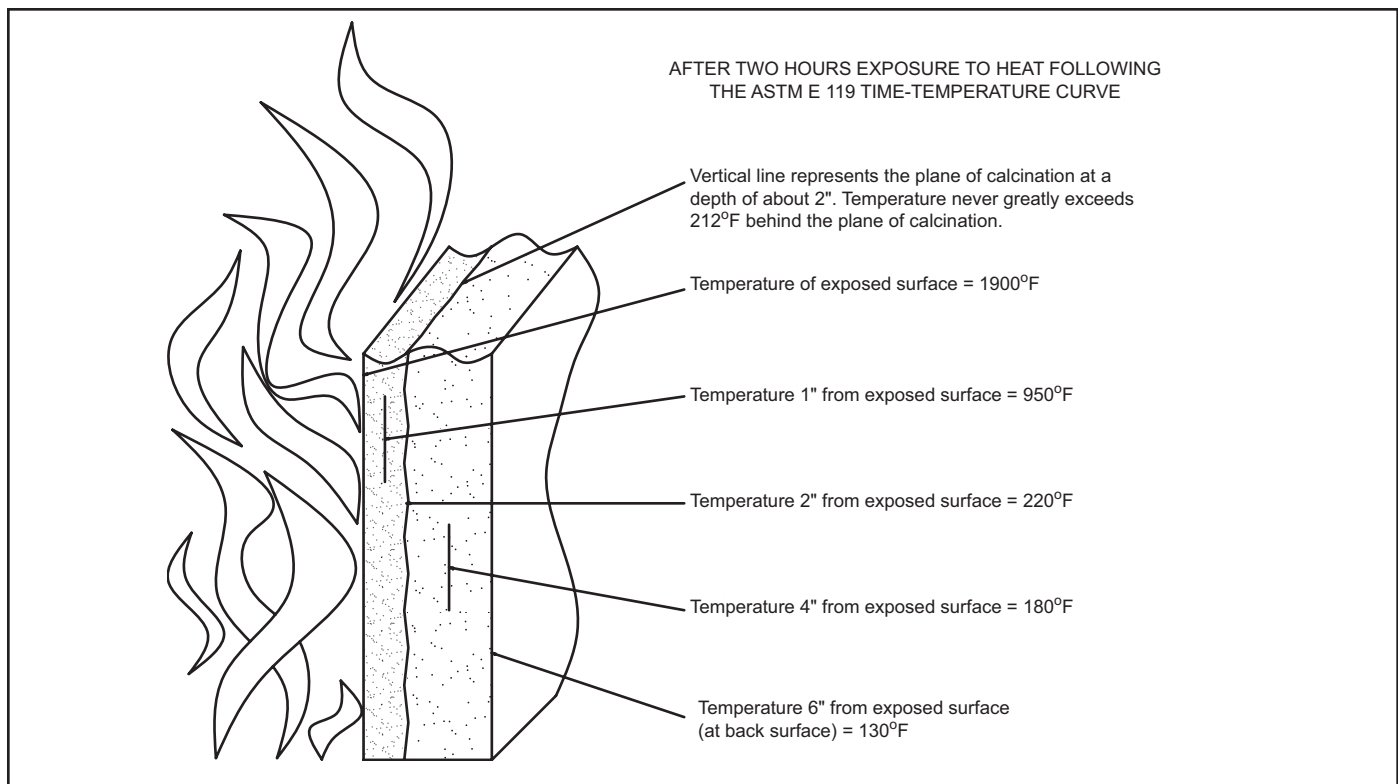
In order to qualify for use in generic systems contained in this Manual, the Gypsum Association also requires that  $\frac{1}{2}$  inch type X gypsum board shall achieve a one-hour fire-resistance rating when applied to a floor-ceiling system as described by GA File Number FC 5410 on page 124.

Where  $\frac{3}{4}$  inch or 1 inch gypsum board is described as "type X" in proprietary systems contained in this Manual, consult the manufacturer to determine what specific products are required.

### PERFORMANCE OF GYPSUM PLASTER

Job performance of gypsum plaster systems can be affected by several factors such as: extreme weather conditions, poor or no ventilation, thermal shock, unusual framing or frame loading, etc. Precautions shall be taken to prevent these and other adverse conditions.

Mix ratios such as 1:2 gypsum-perlite, -vermiculite, or -sand are used to describe a mixture consisting of 100 pounds of gypsum plaster to 2 cubic feet of



**Figure 2**  
**How Gypsum Retards Heat Transmission**

aggregate (3 cubic feet where the ratio is given as 1:3). Many fire tests have been conducted to show that 1:2 gypsum-vermiculite mix may be substituted for 1:3 gypsum-vermiculite mix in all fire-resistance rated systems. A 1:2 gypsum-perlite mix may be substituted for 1:3 gypsum-perlite mix in one-hour and two-hour rated systems only. Perlite and vermiculite shall be permitted to be interchanged in one-hour and two-hour rated systems.

Plaster thicknesses are measured from the face of the lath, regardless of the plaster base used.

### FIRE RESISTANCE TESTS

All fire-resistance classifications described in this Manual are derived from full-scale fire tests conducted in accordance with the requirements of ASTM E 119 or CAN/ULC-S101 (as amended and in effect on the date of the test) by recognized independent laboratories. Fire-resistance classifications are the results of tests conducted on systems made up of specific materials put together in a specified manner.

There are a number of nationally recognized laboratories capable of conducting tests to establish fire-resistance classifications according to the procedures outlined in ASTM E 119 or CAN/ULC-S101. The conditions under which tests are conducted are thoroughly detailed and the fire-resistance classification is established as the time at which there is excessive temperature rise, passage of flame, or structural collapse. In addition, failure may result because of penetration by the pressurized hose stream required in the fire test procedure for walls.

With reference to all tested systems, ASTM E 119 states:

It is the intent that classifications shall register performance during the period of exposure and shall not be construed as having determined suitability for use after fire exposure.

Comprehensive research by fire protection experts has determined the average combustible content normally present within any given occupancy. In addition, evacuation times, the time required for the contents to be consumed by fire, and the resulting temperature rise have been quantified. Fire-resistance requirements are established accordingly in building codes and similar regulations.

In ASTM E 119 fire tests, wall, ceiling, column, and beam systems are exposed in a furnace which reaches the indicated average temperatures at the time stated in the standard time-temperature curve (Figure 3) and Appendix X1 of ASTM E 119. The unexposed surface of all systems refers to the surface away from the fire during a test. The exposed surface refers to the surface facing the fire.

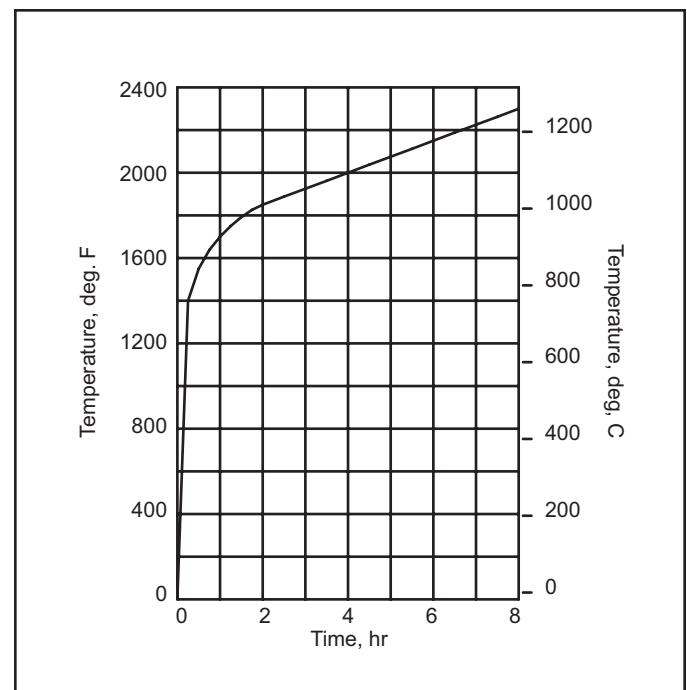
### WALL AND PARTITION SYSTEMS

All walls and partitions tested and classified are required to be at least 100 square feet in area with no edge dimension less than nine feet. Surface temperatures on the unexposed side of the test specimen are measured at a minimum of nine locations.

When load-bearing walls and partitions are tested, the applied load is required to simulate the working stresses of the design.

Walls and partitions are required to stop flame or hot gases capable of igniting cotton waste. The average temperature of the unexposed surface is not permitted to increase more than 250°F above ambient nor is any individual thermocouple permitted to rise more than 325°F above ambient. A duplicate of the system (rated for one-hour fire resistance or more) is fire tested for one-half the specified fire-resistance period, but no longer than one-hour, after which it is required to withstand the impact, erosion, and cooling effect of a hose stream.

Openings in walls for fire door frames and fire window frames shall be coordinated between the architect, the general contractor, the drywall contractor, and the frame supplier to ensure that installation details for the wall and the frame are considered. The installation instructions supplied with frames vary and shall be followed to comply with local code requirements. All fire door and fire window assemblies are required to be installed in accordance with ANSI/NFPA 80 and subject also to the conditions, limitations, and/or allowances of their certification label and listing.

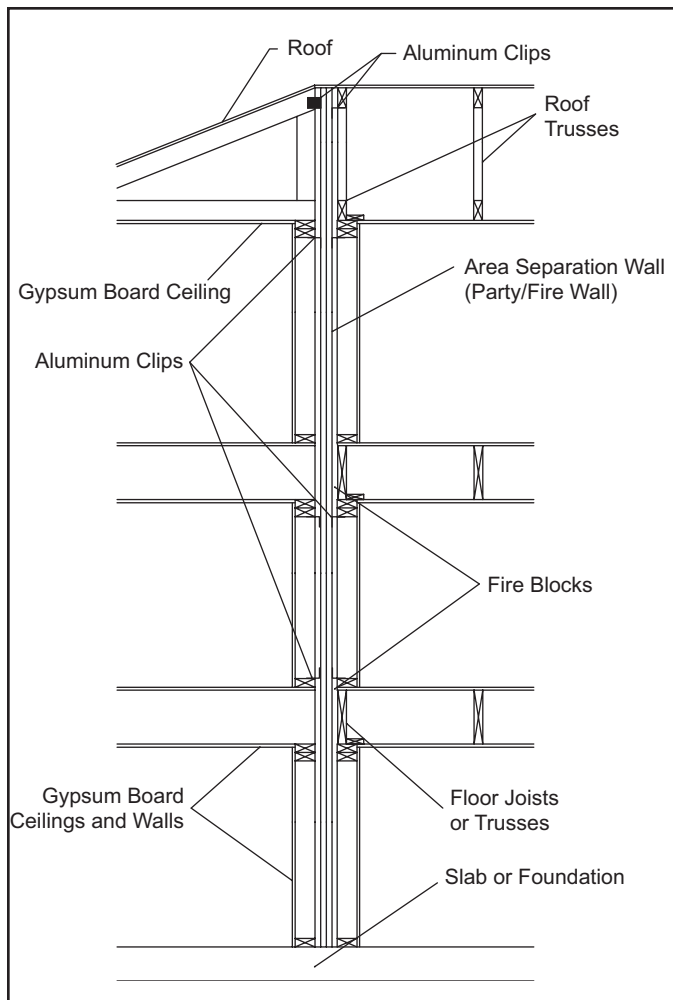


**Figure 3**  
**Standard Time-Temperature Curve**  
**(ASTM E 119)**

### AREA SEPARATION WALLS (PARTY/FIRE WALLS)

Fire-resistance rated gypsum board systems (solid and cavity types) can serve as area separation walls (also known as party walls or fire walls) between adjacent wood frame and steel frame dwelling units such as townhouses, condominiums, and apartments; and in commercial and institutional buildings. These walls are erected one floor at a time, beginning at the foundation and continuing up to or through the roof. At intermediate floors metal floor/ceiling track shall be installed back-to-back to secure the top of the lower section of the partition to the bottom of the next section being installed.

At intermediate floors and other specified locations the area separation walls shall be attached to adjacent wood or steel framing on each side with aluminum clips that soften when exposed to fire (Figure 4). If one side of the structure becomes involved in a fire, the clips on the fire side allow collapse of the structure on that side. The clips on the other side support the area separation wall keeping it in place, thereby protecting the adjacent structure. Consult gypsum board manufacturer for clip detail, placement, and height limitations.



**Figure 4**  
**Typical Gypsum Board Area**  
**Separation Wall Construction**

### FLOOR-CEILING AND ROOF-CEILING SYSTEMS

Floor-ceiling and roof-ceiling systems tested and classified are required to be a minimum of 180 square feet in area with their shortest edge dimension not less than 12 feet. The system is required to sustain the design load throughout the test and not permit the passage of either flame or hot gases capable of igniting cotton waste. Surface temperatures on the unexposed side of the test specimen are measured at a minimum of nine locations. The average temperature of the unexposed surface is not permitted to increase more than 250°F above ambient nor is any individual thermocouple permitted to rise more than 325°F above ambient.

#### Ceiling Openings

Many fire-resistance rated floor-ceiling systems have been tested with openings through the ceiling membrane for air ducts, electrical outlets, and lighting fixtures.

Building codes permit air duct openings in most ceiling systems when the air duct openings are protected with approved ceiling dampers.

Building codes also permit membrane penetrations in maximum two-hour fire-resistance-rated horizontal systems by steel outlet boxes that do not exceed 16 square inches in area provided the aggregate area of such penetrations does not exceed 100 square inches in any 100 square feet of ceiling area and the annular space between the ceiling membrane and the box does not exceed 1/8 inch.

Many approved recessed lighting fixtures require special protection. Consult the fire test report or listing for the specific system for protection details and the opening area limitation.

## BEAM, GIRDER, AND TRUSS PROTECTION SYSTEMS

Beams are tested with superimposed loads applied to simulate the maximum theoretical dead and live loads permitted by nationally recognized design standards. A fire-resistance rating is established for a system when the test specimen supports the load during the test and meets specific temperature requirements for the prescribed period. Beams, girders, and trusses shall be protected by either (1) a continuous ceiling membrane of either gypsum lath and plaster or gypsum board or (2) enclosing them individually.

### Continuous Ceiling Protection

Building codes allow for the use of the gypsum board or gypsum lath and plaster ceilings described in the Floor-Ceiling Systems portion of this Manual for beam or girder protection. The complete floor-ceiling system shall provide no less than the rating required for the structural member being protected.

If the bottom of the beam projects 6 inches or less below the plane of the ceiling, the ceiling is furred down and around the beam (Figure 5). If the projection is greater than 6 inches, the gypsum board or lath and plaster beam protection system shall extend from the ceiling to the floor above. (See Individual Encasement Protection.)

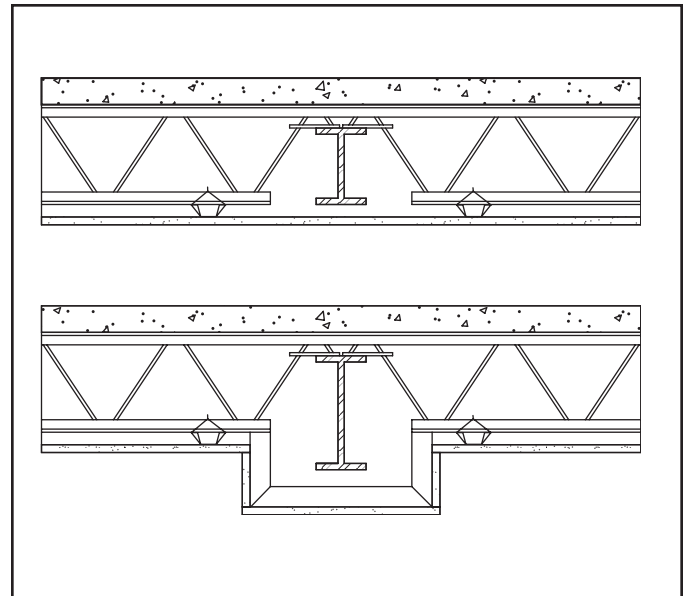
A ceiling used as membrane fireproofing usually consists of either gypsum board or gypsum plaster over gypsum or metal lath. These systems may be either attached directly to or suspended from the primary structural elements. The tested assembly consists of the ceiling membrane, beams, girders, joists, or trusses and the floor or roof deck system above.

### Individual Encasement Protection

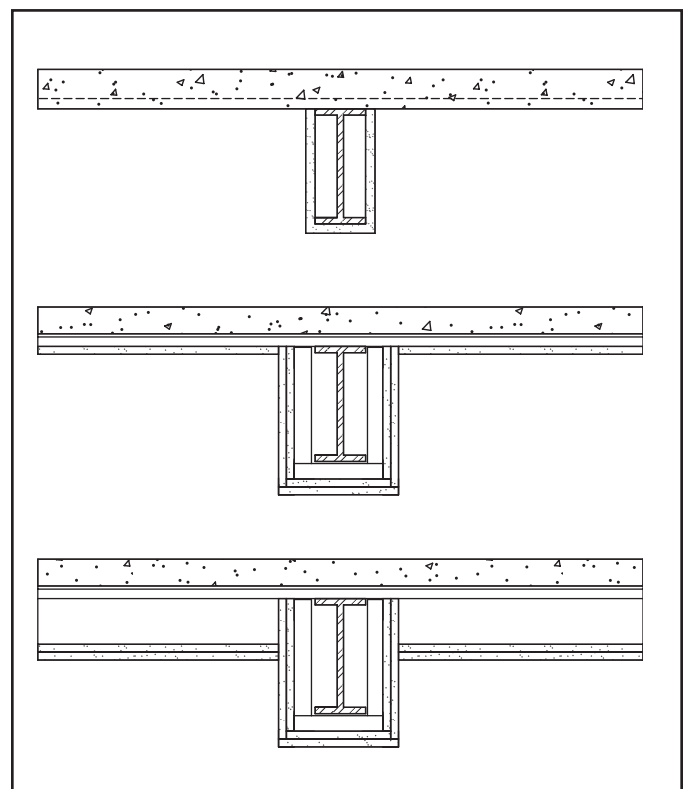
Individual encasement of beams, girders, and trusses with gypsum lath and plaster or gypsum board (Figure 6) is permitted where one or more of the following conditions exist.

1. When the fire-resistance requirement for the beam, girder, or truss is greater than the fire-resistance requirement for the floor-ceiling or roof-ceiling system being supported. Where there are relatively few three-hour or four-hour protected beams or girders, and only a two-hour floor-ceiling requirement, it is generally uneconomical to use a three-hour or four-hour floor-ceiling system throughout, or
2. When either no ceiling is required or a non-rated ceiling is used, or
3. When the bottom of the beam projects greater than 6 inches below the plane of the ceiling.

When structural members support more than one floor, or a floor and a roof, consult local building codes for requirements.



**Figure 5**  
**Membrane Protected Steel Beam - Continuous**



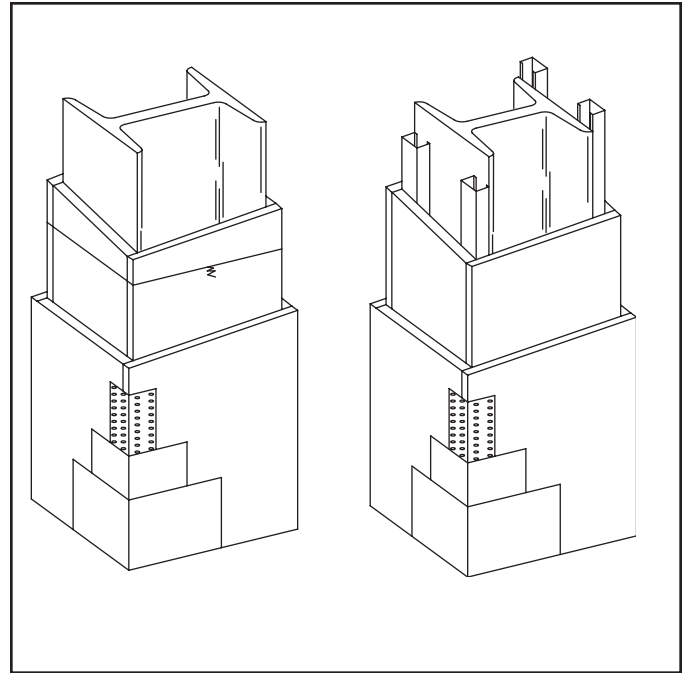
**Figure 6**  
**Steel Beam - Individual Encasement Protection**

## COLUMN PROTECTION SYSTEMS

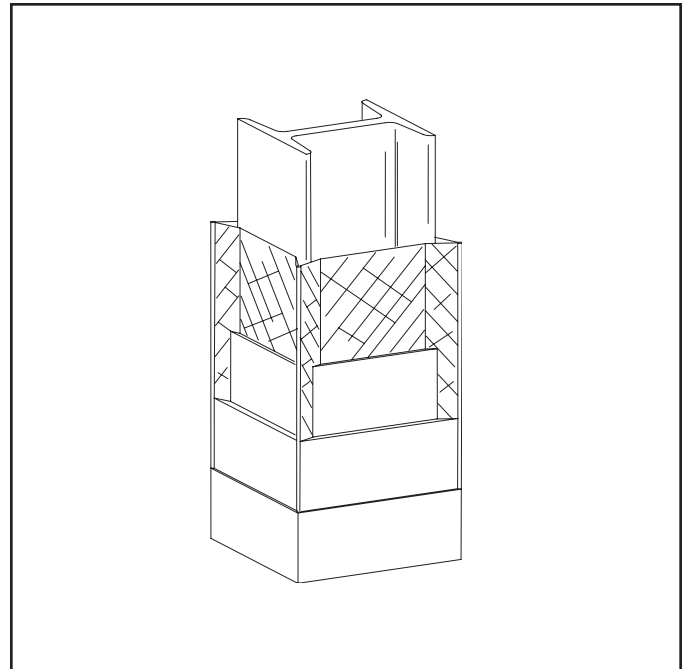
Columns are tested under a temperature limit criteria. The temperature of the steel is measured by not less than four thermocouples at each of four levels. A test is successful when the average temperature of any level does not exceed 1000°F and no individual thermocouple exceeds 1200°F within the prescribed time period.

All column systems in this Manual were tested with the column size specified in the system. Fire-resistance ratings for the heavier steel columns are not applicable to the lighter steel columns.

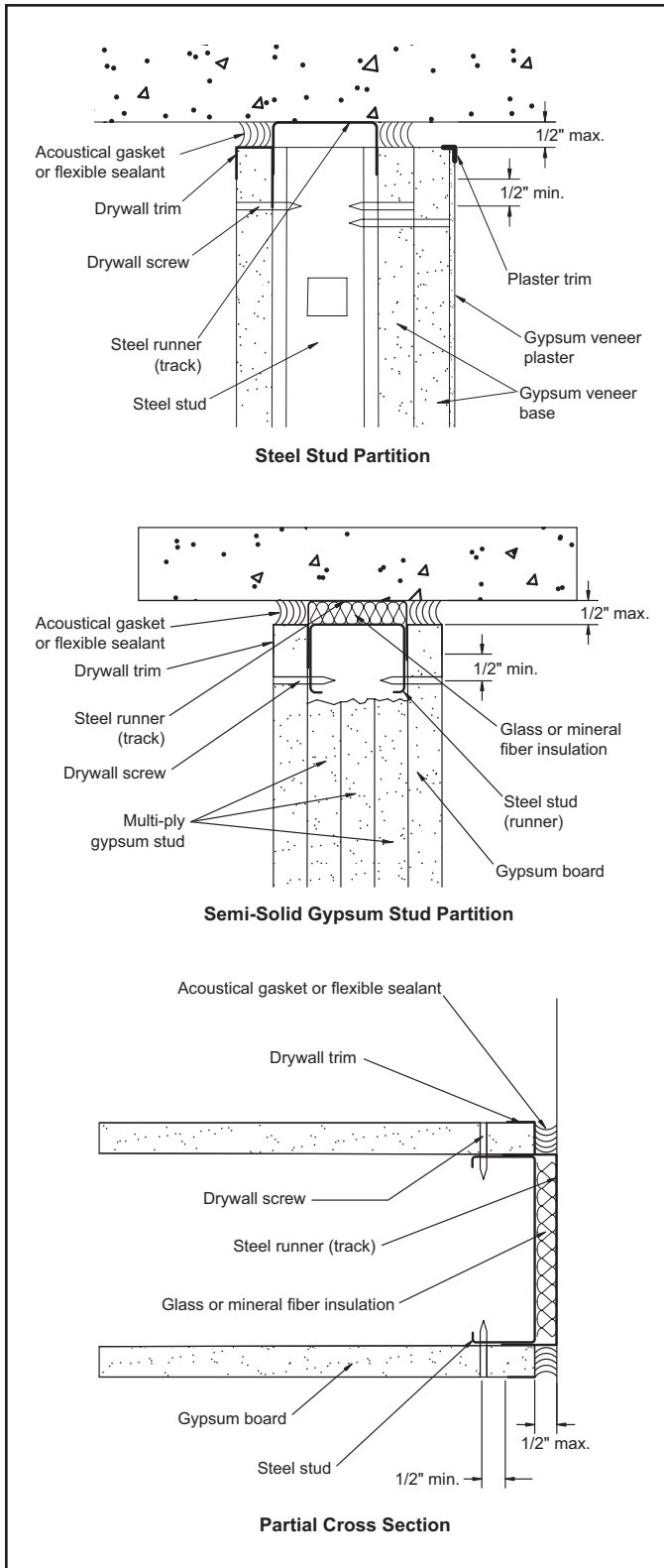
Typical column protection systems are shown in Figures 7 and 8.



**Figure 7**  
**Column Protection -**  
**Gypsum Board or Veneer Base**



**Figure 8**  
**Column Protection -**  
**Metal Lath and Plaster**



**Figure 9**  
**Perimeter Relief Details**  
 (FM 16738.69, 6/18/69; UL R4024-7-8, 6/23/66)

**FIRE BLOCKING**

All fire-resistive systems shall be fire blocked in accordance with applicable code requirements.

All penetrations in a fire rated system shall be filled with firestopping material as required by the local code.

**SMOKE BARRIERS**

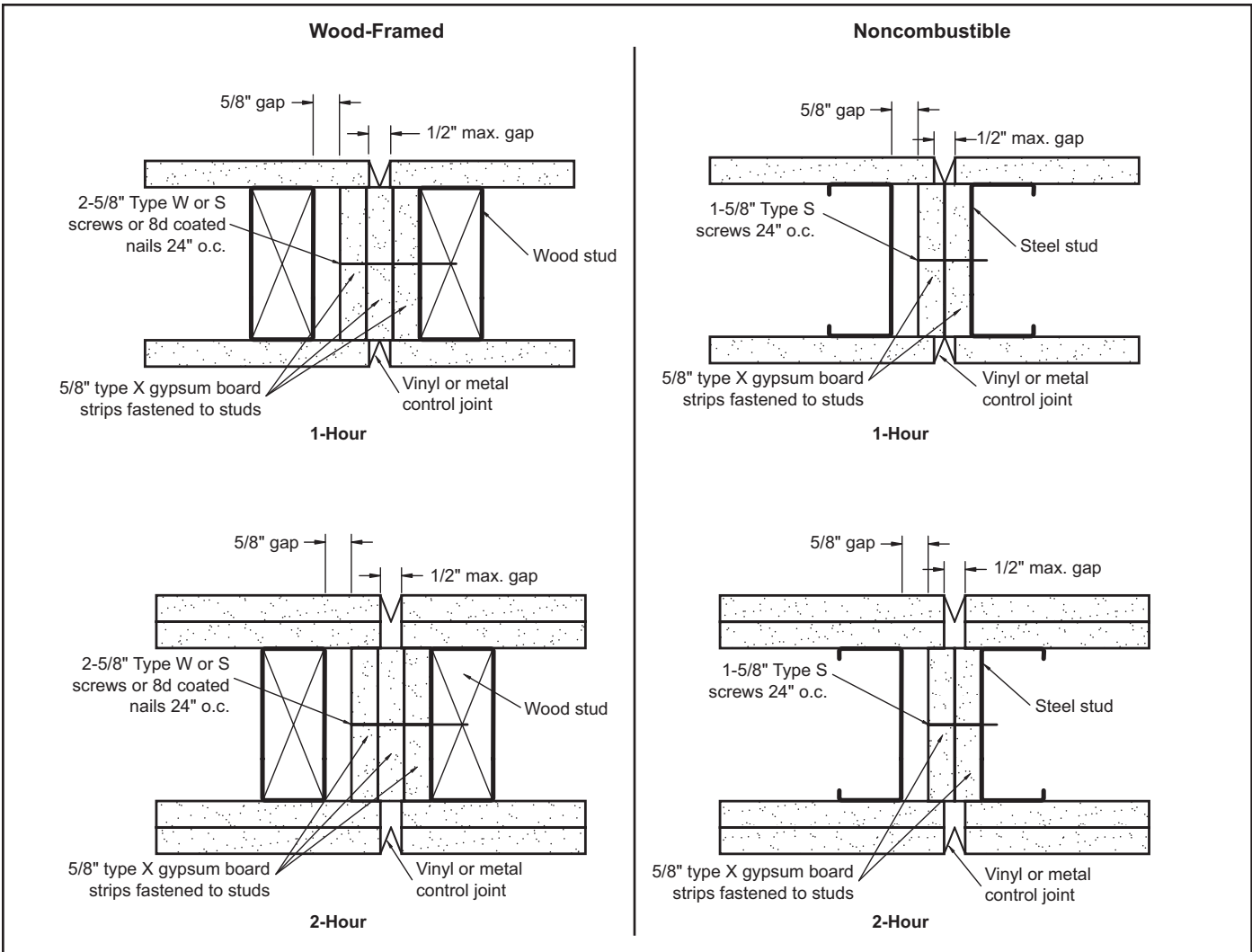
Building codes require certain designated wall and ceiling systems to function as "smoke barriers" which are defined in the codes as continuous membranes that resist the passage of smoke. Fire-resistive gypsum systems with perimeters and penetrations sealed to achieve listed STCs also function to resist the passage of smoke.

Minimum one-hour fire-resistance rated gypsum board systems with joints finished in accordance with Level 1 as specified in GA-214, *Recommended Levels of Gypsum Board Finish*, (all joints and interior angles shall have tape embedded in joint compound) with perimeters and penetrations sealed with an approved sealant satisfy building code requirements for a smoke barrier.

**PERIMETER RELIEF AND CONTROL JOINTS**

Engineering studies and fire tests have been conducted on perimeter relief and control joint systems. This research demonstrates that the perimeter relief systems detailed in Figure 9 can be used in most nonload-bearing metal stud partition systems without reducing the fire-resistance rating of the partition. The research also demonstrates that the control joint systems detailed in Figure 10 on page 18 can be used in all one-hour or two-hour, load-bearing or nonload-bearing, wood or steel framed, wall and partition systems in this Manual without adversely affecting the fire-resistance rating. The tests were conducted in accordance with ASTM E 119 and utilized perimeter relief systems and control joint systems as detailed herein. Other similar systems are available from individual manufacturers.





**Figure 10**  
**Control Joint Details**  
 (WHI-651-0318-1, 3/20/90; UL R4024, 96NK13566, 7/29/96)

**SURFACE BURNING CHARACTERISTICS**

The test method used to establish surface burning characteristics is ASTM E 84 or CAN/ULC-S102, commonly referred to as the Tunnel Test. This test measures the relative flame spread and relative amount of smoke generated by the material being tested when compared to inorganic reinforced cement board and red oak flooring. Table V lists typical surface burning characteristics for gypsum products as well as the standard materials referenced in the test method.

Surface burning characteristics are intended to be used as a guide in the selection and use of interior finish materials and are obtained under controlled laboratory conditions.

<b>TABLE V</b>		
<b>SURFACE BURNING CHARACTERISTICS</b>		
	<b>FLAME SPREAD</b>	<b>SMOKE DEVELOPED</b>
Inorganic Reinforced Cement Board	0	0
<b>Gypsum Plaster</b>	<b>0</b>	<b>0</b>
<b>Glass Mat Gypsum Substrate for Use as Sheathing</b>	<b>0</b>	<b>0</b>
<b>Fiber Reinforced Gypsum Panels</b>	<b>5</b>	<b>0</b>
<b>Gypsum Lath</b>	<b>10</b>	<b>0</b>
<b>Gypsum Wallboard</b>	<b>15</b>	<b>0</b>
<b>Gypsum Sheathing</b>	<b>15</b>	<b>0</b>
<b>Water-Resistant Gypsum Backing Board</b>	<b>15</b>	<b>0</b>
Red Oak	100	100

## SECTION III - SOUND CONTROL

### SOUND INSULATION

The first essential for airborne sound insulation using any system is to close off air leaks and/or flanking paths by which noise can go through or around the system. Small cracks or holes will increase the sound transmission at the higher frequencies. This can have a detrimental effect on the overall acoustical performance and the STC, particularly for higher rated systems. Failure to observe special construction and design precautions can reduce the effectiveness of the best planned sound control methods.

*Systems shall be airtight.* Recessed wall fixtures, such as medicine cabinets or electrical, telephone, television, and intercom outlets, that penetrate the gypsum board shall not be located back-to-back or in the same stud cavity. Any opening for fixtures or pipes shall be cut to the proper size and sealed. The entire perimeter of a sound insulating system shall be made airtight to prevent sound flanking. Flexible sealant or an acoustical gasket shall be used to seal between the STC rated system and all dissimilar surfaces and also between the system and similar surfaces where perimeter relief is required. TAPING GYPSUM BOARD WALL AND WALL-CEILING INTERSECTIONS PROVIDES AN ADEQUATE AIR SEAL AT THESE LOCATIONS. ASTM E 497, *Standard Practice for Installing Sound-Isolating Lightweight Partitions*, provides additional information. Consult the

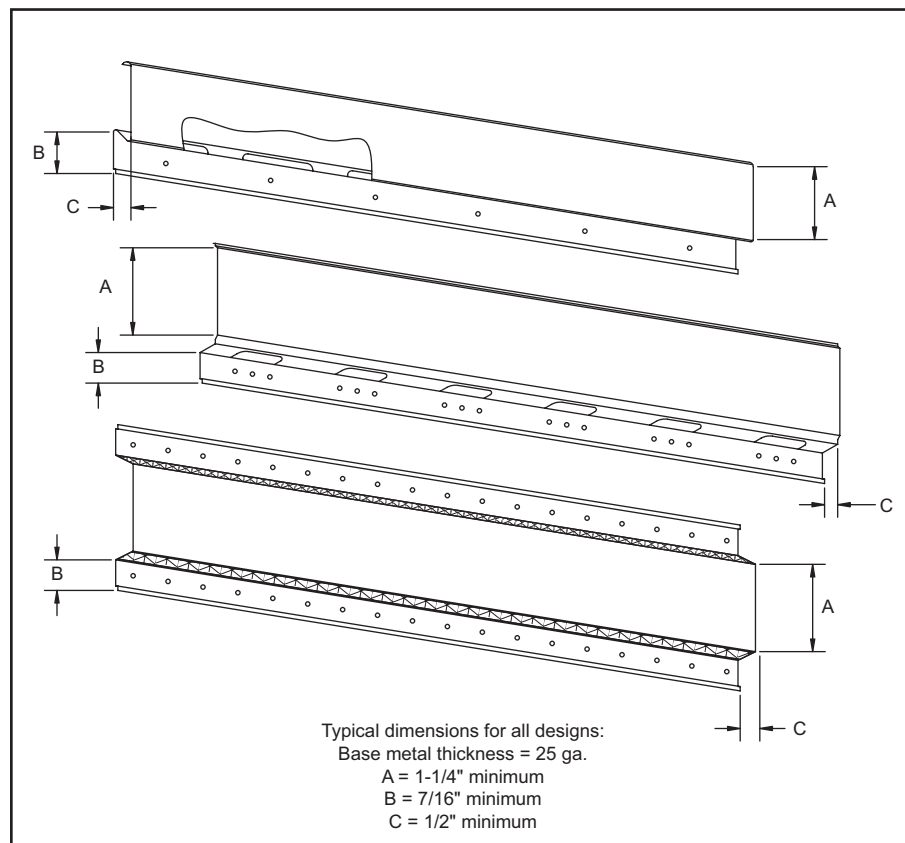
manufacturer of the gypsum board for any special recommendations.

Systems are grouped in ranges according to their Sound Transmission Class (STC) or Field Sound Transmission Class (FSTC). The higher ranges are shown first. All of the sound tests referenced were conducted according to the requirements of either ASTM E 90, for laboratory tests, or ASTM E 336, for field tests. The designer shall adhere to the specified materials and construction details for STC and FSTC rated systems, particularly in plaster systems, because substitution of lightweight aggregates for sand, or reduction of the sand proportion, may reduce the rating. ALL OPENINGS THROUGH THE SYSTEM, AND ITS ENTIRE PERIMETER, SHALL BE SEALED AIRTIGHT.

SUBSTITUTING MECHANICAL FASTENERS FOR ADHESIVES, OR THE USE OF MORE FASTENERS, MAY AFFECT THE RATING.

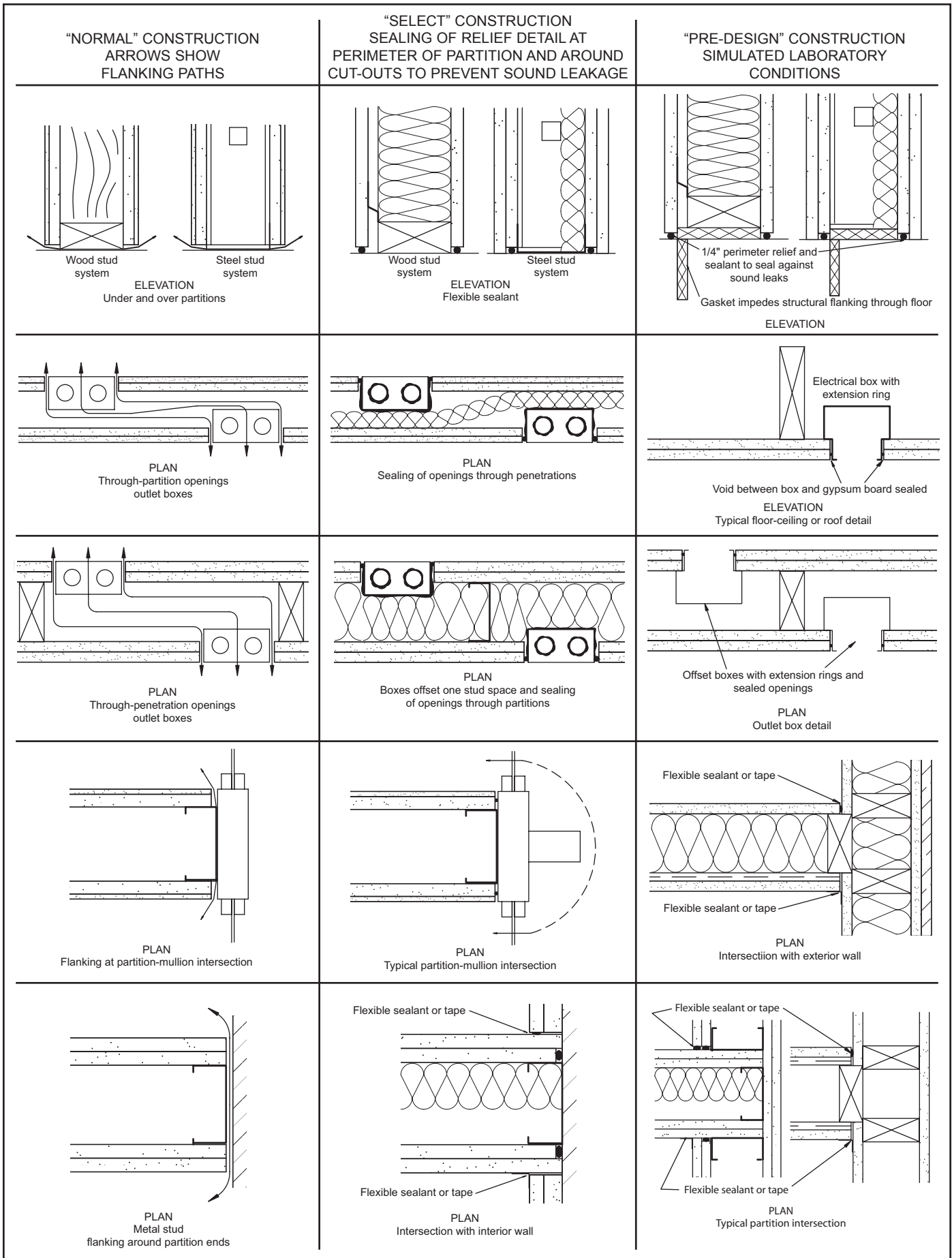
Details of sound tests issued by sound testing agencies are on file and a summary is available from the Gypsum Association or the test sponsor.

Figure 11 shows three typical resilient channel configurations. Where resilient channels are included in systems, the resilient channels are shown by a dashed line to distinguish them from rigid furring channels. Figure 12 on page 20 distinguishes between standard construction practices and those practices recommended for improved sound control.



**Figure 11**  
**Resilient Furring Channels**

**Figure 12**  
**Sound Isolation Construction**



## SOUND TRANSMISSION LOSS TESTS

ASTM E 90, *Standard Test Method for Laboratory Measurement of Airborne Sound Transmission Loss of Building Partitions*, is the procedure for measuring the sound transmission loss (STL) in a laboratory. The STL is the difference between the sound energy (sound pressure level) in a source room and a receiving room when the two rooms are separated by the system being tested.

ASTM E 336, *Standard Test Method for Measurement of Airborne Sound Insulation in Buildings*, is the procedure to determine the field sound transmission loss (FSTL) between two rooms under field conditions.

The STL or the FSTL is measured at  $1/3$  octave test frequencies (Hz) as follows and the sound transmission loss curve is plotted:

125	315	800	2000
160	400	1000	2500
200	500	1250	3150
250	630	1600	4000

A system's overall effectiveness in resisting the transmission of airborne sound, whether it is a wall, partition, or floor-ceiling, is reported as a single number derived from an analysis of the STL or FSTL curve. This rating is the Sound Transmission Class (STC) or Field Sound Transmission Class (FSTC). This Manual uses STC/FSTC ranges to make comparing systems more significant.

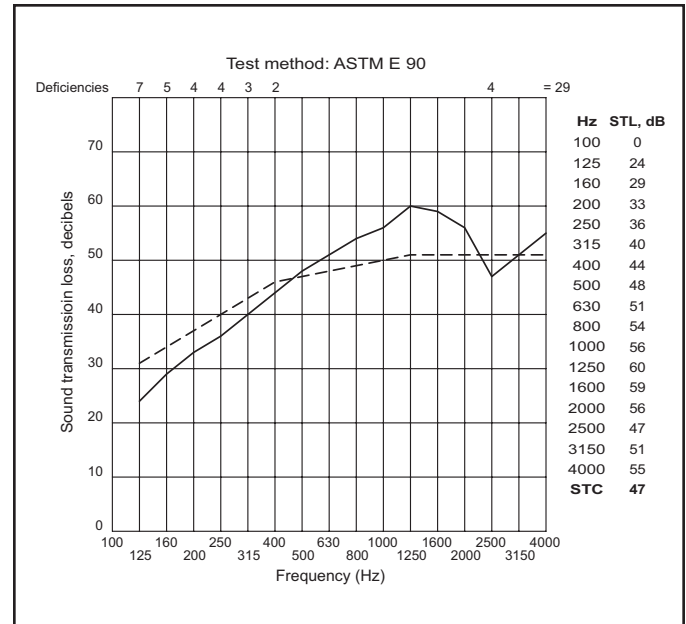
ASTM E 413, *Classification for Rating Sound Insulation*, is the method used to derive the STC/FSTC from the STL/FSTL curve. Using the rules stated in ASTM E 413, a reference contour is fitted to the sound transmission loss curve. The STC/FSTC is the point where the reference contour crosses the 500 Hz line.

The reference contour, shown by the dashed line in Figure 13, has a flat portion from 4000 Hz to 1250 Hz. It drops 5 dB between 1250 Hz and 400 Hz, and 15 dB between 400 Hz and 125 Hz. In fitting the reference contour to the measured curve, the following conditions are required to be met:

1. The STL curve is not permitted to be greater than 8 dB below the reference contour at any test frequency, and
2. The sum of the dB differences between the points on the reference contour and the corresponding points on the STL curve at each of the test frequencies is not permitted to be greater than 32 dB.

Some of the STC ratings in this Manual were derived according to slightly different standards in use prior to 1970. For instance, ASTM E 90-61T, the previous sound test procedure, called for measurements at  $1/2$  octave frequencies, and the rules for fitting the standard curve were different.

The smallest dimension of the system tested in accordance with ASTM E 90 is not permitted to be less



**Figure 13**  
**STL Curve**

than 7 feet, 10 inches and the minimum volume for each of the sound source and receiving rooms is 2,825 cubic feet. The system is constructed to separate the source and receiving rooms, which are arranged so that the only significant sound transmission is through the test specimen.

The source room contains one or more sound sources, a diffusing system such as multiple stationary and/or rotating reflectors, and microphones located to adequately sample the sound field in the space. A single microphone on a rotating boom may be optionally used. The receiving room is similarly equipped, except that the sound source(s) is used only to determine the reverberation time for correction purposes. The sound measurements in both rooms are made according to ASTM E 90.

Research by recognized sound test authorities indicates that the STC's on unsymmetrical walls are not affected by sound testing from either side. Therefore, the laboratory sound source side is not indicated for unsymmetrical systems in this Manual.

## IMPACT NOISE TEST

To determine the Impact Insulation Classification (IIC) of a floor, a standard ISO impact machine with steel hammers taps on a test floor system installed above a special receiving room. Microphones in the receiving room record the average sound pressure level produced by the tapping machine at  $1/3$  octave frequency bands between 100 and 3150 Hz. These measured levels are then normalized to a standard room absorption. The method used is described in ASTM E 492, *Standard Test Method for Laboratory Measurement of Impact Sound Transmission Through Floor-Ceiling Assemblies Using the Tapping Machine*.

The IIC is determined by comparing the normalized impact sound pressure levels at the 16 test frequencies with an IIC reference contour. The reference contour has a flat portion from 100 to 315 Hz, a middle line segment decreasing 5 dB in the interval 315 to 1000 Hz, followed by a high frequency line segment decreasing 15 dB in the interval 1000 to 3150 Hz. In fitting the reference contour to the measured sound pressure levels in the receiving room, the following conditions are required to be met:

1. The noise level at any test frequency is not permitted to be greater than 8 dB above the reference contour, and
2. The sum of the dB differences between the points on the reference contour and the corresponding points on the curve of the normalized impact noise levels at each of the test frequencies is not permitted to be greater than 32 dB.

The IIC for the specimen is the difference between 110 and the value on the normalized impact noise level scale (i.e., ordinate scale) at 500 Hz of the lowest contour for which the above conditions are fulfilled.

The IIC listings for floor-ceiling systems in this Manual are for bare floors (no floor covering) and for the addition of a carpet over a separate pad, which is identified as "C&P."

Although any carpet, with or without a pad, will improve the IIC, a heavy wool carpet over a good quality pad will make a significant improvement, as illustrated for FC 5300 on page 122. The addition of a 44 oz. woven loop pile carpet over a 40 oz. hair felt pad increased the IIC from 38 to 63. The IIC (C&P) listings in this Manual are for the carpet and pad described above for FC 5300 unless otherwise noted. The use of other types of carpets, both with and without pads, will result in increases in the IIC, and in some instances may equal that achieved by use of the aforementioned carpet and pad.

## SECTION IV - FIRE RESISTANCE AND SOUND RATED SYSTEMS

### INDEX TO SYSTEMS BY STC RATING

NONCOMBUSTIBLE WALLS & PARTITIONS				WOOD FRAMED WALLS & PARTITIONS		SHAFT WALLS	
STC	GA FILE NO.	STC	GA FILE NO.	STC	GA FILE NO.	STC	GA FILE NO.
65 - 69	WP 5060	45 - 49	WP 1070	60 - 64	WP 3010	50 - 54	WP 7051
			WP 1071				WP 7052
60 - 64	WP 2945		WP 1072	55 - 59	WP 3110		WP 7053
	WP 5005		WP 1073		WP 3810		WP 7056
	WP 5006		WP 1076		WP 3812		WP 7057
	WP 5070		WP 1081		WP 3820		WP 7060
			WP 1082		WP 5510		WP 7061
55 - 59	WP 1015		WP 1085		WP 5520		WP 7062
	WP 1470		WP 1090				WP 7064
	WP 1505		WP 1615	50 - 54	WP 3240		
	WP 1510		WP 1616		WP 3241	45 - 49	WP 6800
	WP 1515		WP 1625		WP 3242		WP 7073
	WP 1516		WP 1630		WP 3243		WP 7074
	WP 1520		WP 1632		WP 3260		WP 7076
	WP 1521		WP 1635		WP 3910		WP 7077
	WP 1522		WP 6010		WP 5530		WP 7078
	WP 2800		WP 6020				WP 7079
	WP 2960		WP 6025	45 - 49	WP 3330		WP 7080
	WP 2961		WP 6040		WP 3340		WP 7081
	WP 2963		WP 6070		WP 3341		WP 7082
	WP 2964				WP 3342		WP 7083
	WP 5105	40 - 44	WP 1204		WP 3360		WP 7084
	WP 5106		WP 1206		WP 3370		WP 7095
			WP 1240		WP 5512		WP 7096
50 - 54	WP 1021		WP 1290				WP 7097
	WP 1022		WP 1296	40 - 44	WP 3380		WP 7098
	WP 1023		WP 1714		WP 3430		WP 7099
	WP 1024		WP 1716		WP 3431		WP 7451
	WP 1041		WP 6130		WP 3436		WP 7452
	WP 1050		WP 6135		WP 3441		
	WP 1051		WP 6152		WP 4135	40 - 44	WP 6905
	WP 1052				WP 4136		
	WP 1053	35 - 39	WP 1311		WP 5515	35 - 39	WP 7000
	WP 1054		WP 1330				WP 7001
	WP 1530		WP 1340	35 - 39	WP 3510		WP 7008
	WP 1545		WP 1350		WP 3514		WP 7020
	WP 1546		WP 1370		WP 3520		WP 7117
	WP 1548		WP 1380				WP 7125
	WP 1560		WP 1390	30 - 34	WP 3605		
	WP 1565		WP 1400		WP 3615	30 - 34	WP 7210
	WP 1570		WP 1830		WP 3620		
	WP 2921		WP 1841				
	WP 2922		WP 1870				
	WP 2924		WP 6210				
	WP 2970		WP 6220				
	WP 5015		WP 6240				
	WP 5016		WP 6250				
	WP 5130		WP 6254				
	WP 5910						
	WP 6525	30 - 34	WP 1930				

## INDEX TO SYSTEMS BY STC RATING

<b>AREA SEPARATION WALLS</b>	
<u>STC</u>	<u>GA FILE NO.</u>
60 - 64	ASW 1000
	ASW 1001
	ASW 1002
	ASW 1003
	ASW 1004
55 - 59	ASW 1005
50 - 54	ASW 1100
	ASW 1105
45 - 49	ASW 1200
	ASW 1201
	ASW 1205
	ASW 1206
	ASW 1215

<b>NONCOMBUSTIBLE FLOOR-CEILINGS</b>	
<u>STC</u>	<u>GA FILE NO.</u>
50 - 54	FC 1105
	FC 2030
	FC 3012

<b>STEEL FRAMED FLOOR-CEILINGS WOOD FLOOR</b>	
<u>STC</u>	<u>GA FILE NO.</u>
50 - 54	FC 4340
45 - 49	FC 4370
35 - 39	FC 4490

<b>WOOD FRAMED FLOOR-CEILINGS</b>	
<u>STC</u>	<u>GA FILE NO.</u>
65 - 69	FC 5000
60 - 64	FC 5011
55 - 59	FC 5104
	FC 5105
	FC 5106
	FC 5107
	FC 5109
50 - 54	FC 5110
	FC 5111
	FC 5112
	FC 5115
	FC 5116
	FC 5120
45 - 49	FC 5240
	FC 5241
	FC 5242
	FC 5250
40 - 44	FC 5300
	FC 5310
35 - 39	FC 5406
	FC 5407
	FC 5408
	FC 5410
	FC 5415
	FC 5420
	FC 5470
FC 5490	

NOTE: Some systems appearing in previous editions have been deleted and are not included in this edition. In addition, several new systems have been added to this edition. The following Table may be helpful.

**DELETED SYSTEMS**

WP 1121  
 WP 1200  
 WP 1201  
 WP 1295  
 WP 1711  
 WP 1850  
 WP 1940  
 WP 3445  
 WP 7094  
 WP 7490  
 WP 8003  
 WP 8104  
 WP 8124  
 WP 8125  
 WP 8201

**NEW SYSTEMS**

WP 1024	ASW 1004
WP 1054	ASW 1206
WP 1350	FC 1141
WP 1516	FC 1142
WP 1616	FC 1143
WP 1943	FC 1144
WP 3242	FC 1181
WP 3243	FC 4504
WP 3342	FC 5011
WP 5006	FC 5104
WP 5016	FC 5109
WP 5060	FC 5112
WP 5106	FC 5509
WP 7254	FC 5518
WP 7255	FC 5519
WP 7491	FC 5752
WP 7691	RC 2604
WP 8006	RC 2605
WP 8111	RC 2606
WP 8132	RC 2607
WP 8203	RC 2752
WP 8416	
WP 8417	