How to modify a tested fire-rated wall to improve its STC sound rating, while maintaining its official fire-rated qualification

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ABSTRACT

Local regulatory agencies generally require wall designs that meet specific fire ratings. Architects and acoustical consultants also have to select designs that have appropriate sound transmission properties. While most standard designs have been independently tested for both their fire and sound transmission ratings, many specialized wall designs have been tested only for sound transmission or fire resistance, but not for both. Shaft walls and walls that provide exceptionally high sound transmission loss often fit into these categories. To overcome this limitation, select a wall design that is close to the desired configuration that has been tested to the required fire rating. Then proceed to modify that design to improve its sound transmission rating, while respecting the Underwriters Laboratories design guidelines for fire ratings. For example, the UL guidelines permit the spacing between wall elements and the number of layers and thickness of gypsum board to be increased without affecting the tested fire rating. These modifications will significantly increase the sound transmission ratings. The paper presents specific examples.

Keywords: 51.3 Sound transmission thru windows, doors, walls, ceilings, floors

1. INTRODUCTION

Codes and regulations governing building design and construction are generally issued by municipal and state or provincial governments. The regulations covering the designs for fire safety usually are based on Underwriters Laboratories (UL) standards or a subsidiary company in each country. Walls must be constructed in accordance with designs that have been tested in approved facilities to meet specific ratings, such as 1 hour or 2 hour resistance to fire.

Walls designs are also evaluated on their sound transmission loss values and are rated on their Sound Transmission Class (STC) or an equivalent rating system. There are hundreds of examples of wall partition designs that have been tested for their STC, but there is no general obligation for a designer to actually have to select a tested design to be able to meet sound criteria.

Several publications list both the fire and sound test results of many types of walls with huge numbers of permutations and combinations of materials, thicknesses, etc. Some of the most prominent lists of tested designs are in brochures published by United States Gypsum Corp (USG) and its subsidiaries in different countries. Additional lists of tested designs are often available in building codes of each country, such as in the National Building Code of Canada. Unfortunately not all wall designs that have been tested for fire have also been tested for sound, and vice versa. This often creates a dilemma for the designer who is searching for a single design that will satisfy two independent criteria.

Fortunately, there is a legitimate way to work around this limitation. Wall partitions, as well as floor/ceiling partitions, that have been tested and qualified for a fire rating can be modified to improve their sound transmission loss and still retain their fire ratings provided the modifications fall within the guidelines issued by UL.

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2. UNDERWRITER LABORATORIES CERTIFICATION DOCUMENTS

2.1 Design Guidelines for Fire Ratings

Underwriters Laboratories covers design guidelines for fire ratings in the United States. UL subsidiaries in other countries have similar guidelines with minor variations from the U.S. version. The design guidelines list modifications that are permitted to a tested design that do not affect the tested fire rating. The following excerpts are reprinted from document No. BXUV (1) in the UL Product Directory:

> The hourly rating of a load-bearing assembly also applies to the same assembly when it is used as a non-load-bearing assembly.
>
> The hourly rating of a load-bearing assembly also applies to the same assembly when it is used as a non-load-bearing assembly.
>
> The spacing of studs is a maximum unless otherwise stated in the individual designs.
>
> The size of studs is minimum unless otherwise stated in the individual designs.
>
> Spacing between parallel rows of studs are minimums unless otherwise stated in the individual designs.
>
> Gypsum board thicknesses specified in specific designs are minimums. Greater thicknesses of gypsum board are permitted as long as the fastener length is increased to provide penetration into framing that is equal to or greater than that achieved with the specified gypsum board thickness and fasteners.
>
> Additional layers of gypsum board are permitted to be added to any design.

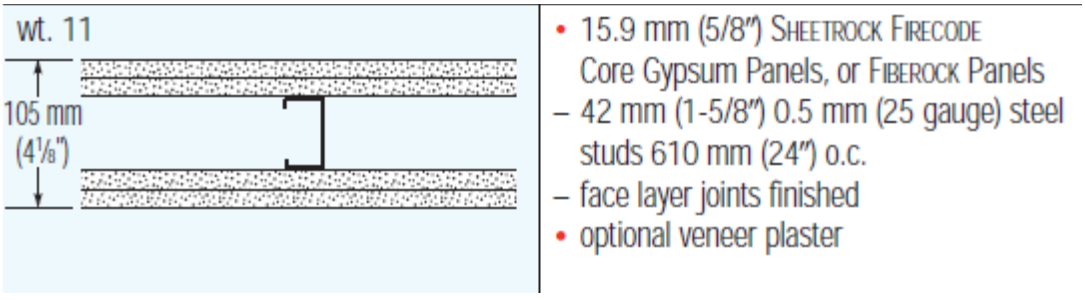
(From ULC document No. BXUVC (2) - applicable to Canadian jurisdictions)

> Listed and labeled mineral fibre thermal building insulation processed from rock, slag and glass only be used in UL non load-bearing wall assembly designs consisting of wallboard and steel or wood with a fire-resistance rating not exceeding two hours when illustrated without insulation, without detracting from the rating assigned to the assembly.

Every one of the allowable modifications can be used to improve a wall's resistance to sound transmission. A designer can start by selecting a wall design that is close to the desired configuration that has been tested to the required fire rating. Alternatively he can select a wall design that has been tested to provide the required sound transmission loss and then search for a fire-tested wall design with a similar configuration. He can then proceed to modify the fire rated wall design step by step, in accordance with the UL guidelines, until the wall conforms to a tested design with the desired sound transmission loss, or STC.

2.2 Example of "Standard" Wall Designs

The example below depicts a standard wall design that has been tested for both fire resistance (2 hour rating) and for its sound transmission loss (its STC ratings) for different variants of the basic design. The image is an excerpt from the Canadian Gypsum Company (CGC) brochure on "Fire-Resistant Assemblies, SA-100" (3). The American equivalent from USG is essentially identical except that it omits values in metric units.



2.2 continued

This basic design with non-loadbearing steel studs has been tested to meet a two hour fire resistance rating. When 92 mm (3⅝") steel studs are substituted, the wall has an STC rating of 48. When 75 mm (3") of mineral wool sound batts are added to the wall cavity, the STC rises to 56.

The available range of sound transmission loss capabilities using standard designs is adequate to satisfy most conditions without requiring special designs. Let us examine what can be done for special situations that fall outside the range of standard wall partition designs.

2.3 High Performance Double Stud Wall Design

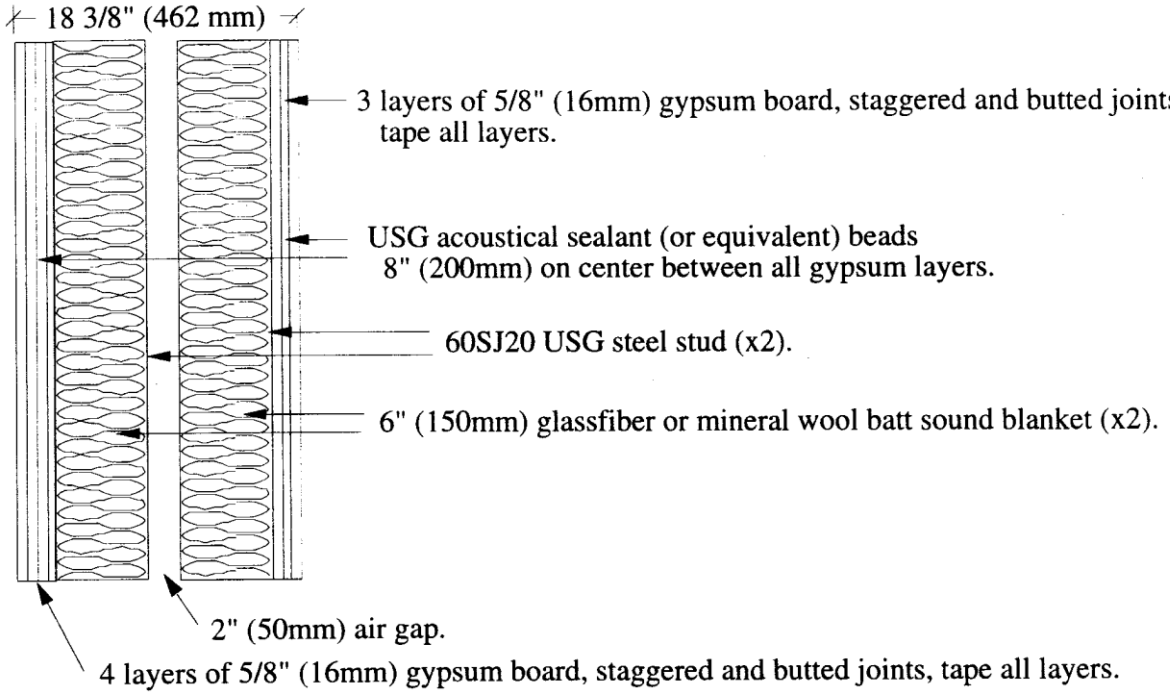
Consider the situation where a very high sound transmission loss is required, such as where loud music is being played in a bar adjacent to residences, or between movie theatre auditoriums. Theatre designs must have wall partitions capable of resisting extremely high sound levels at low frequencies, as indicated in the following table:

Table 1
Recommended Sound Transmission Loss Between Theatre Auditoriums

Octave Band	31.5 Hz	63 Hz	125 Hz	250 Hz	500 Hz & above
dB Reduction	38	48	52	54	66

None of the standard fire tested wall designs will provide adequate acoustical performance at these low frequencies. Special designs for theatres, such as the double stud (chase wall) shown on the next page, will achieve a very high sound transmission loss, with an approximate STC value of 75.

A typical high acoustical performance double stud wall design



Notes:

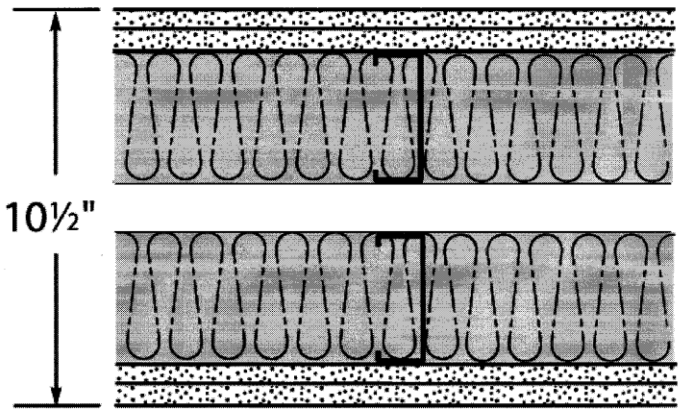
1. Isolation wall system should extend from the floor to the roof deck.
2. Each layer of the wall system should be continuously sealed at the floor, roof deck, and any adjoining walls, columns, etc.
3. Avoid all isolation wall penetrations.
4. There should be no connections between the studs other than at the floor and at the roof deck.

2.3 continued

The design on the previous page has not been tested for its fire resistance, but it can be shown that it meets a two hour fire rating by extension of a tested design, using the UL allowable modifications. A UL approved double stud wall (chase wall) that is similar in concept to the theatre wall design is depicted in the Underwriters Laboratories Fire Test UL V446 (shown below).

Extract from Underwriters Laboratories Fire Test UL V446 (4) and UL Online Certification Directory (5):

Fire Rated System Design - UL V446



UL V446

Area Separation Wall - Steel Stud (Loadbearing)

Fire Rating	STC / Sound Test	System Thickness
2 hour	N/A	10.5 in.

Detail Description

- **Gypsum Board** - 15.9 mm (5/8 in.) thick gypsum board applied vertically or horizontally. - **SHEETROCK Brand FIRECODE Core (Type X)**
- **Gypsum Board** - 15.9 mm (5/8 in.) thick gypsum board applied vertically or horizontally. - **SHEETROCK Brand FIRECODE Core (Type X)**
- **Steel Studs** - 89 mm (3-1/2 in.) wide by min 41 mm (1-5/8 in.) deep min. 0.9 mm (20 gauge) galv steel stud, spaced @ max 406 mm (24 in.) OC - **350S125-30**
- **Batts and Blankets** - Any thickness of classified fiberglass insulation.
- **Bracing** - Min 1-1/2 in. wide by min 33 mil steel strap, cut from steel runners or studs, fastened to the interior side of the steel studs at the mid-height
- **Air Cavity** - 25.4 mm (1 in.) air cavity layer
- **Steel Studs** - 89 mm (3-1/2 in.) wide by min 41 mm (1-5/8 in.) deep min. 0.9 mm (20 gauge) galv steel stud, spaced @ max 406 mm (24 in.) OC - **350S125-30**
- **Batts and Blankets** - Any thickness of classified fiberglass insulation.
- **Gypsum Board** - 15.9 mm (5/8 in.) thick gypsum board applied vertically or horizontally. - **SHEETROCK Brand FIRECODE Core (Type X)**
- **Gypsum Board** - 15.9 mm (5/8 in.) thick gypsum board applied vertically or horizontally. - **SHEETROCK Brand FIRECODE Core (Type X)**

The modifications to convert the fire rated design to the theatre wall design are shown in Table 2.

2.3 continued

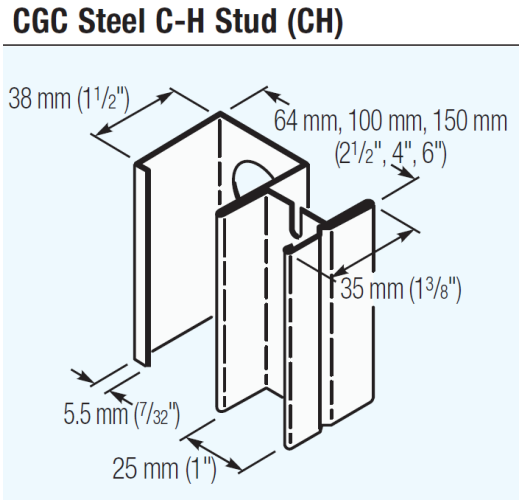
Table 2
Modification of Double Stud Wall Design to a Theatre Wall Design

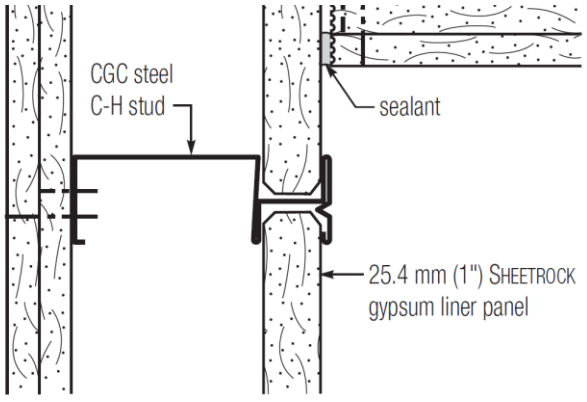
Parameter	Standard wall with 2 hour fire rating per UL V446	High performance theatre wall design	UL allowed modification
Wall panels	2 sheets 15.9 mm (5/8") gypsum board each side, Type X (fire resistant)	3 sheets 15.9 mm (5/8") gypsum board on one side, 4 sheets other side	Additional fire resistant (Type X) gypsum board sheets may be added
Steel studs (2 sets)	89 mm (3½"), 20 gauge, spaced at 406 mm (24")	150 mm (6"), 20 gauge, spaced at 406 mm (24")	Studs with larger dimensions are permitted
Fibreglass insulation	Any thickness	150 mm (6"), fibreglass or mineral wool, both sides	Complies
Cross bracing of studs	At mid-height	No connection between studs	The larger 150 mm (6") studs do not require cross-bracing for support. Their removal does not affect the fire resistance.
Air gap between studs	25.4 mm (1")	50 mm (2")	Larger spacing between parallel rows of studs is permitted

Conclusion: The theatre wall design, as described above, meets the UL two hour fire rating by extension of the test for wall design UL V466.

2.4 High Performance Shaft Wall Design

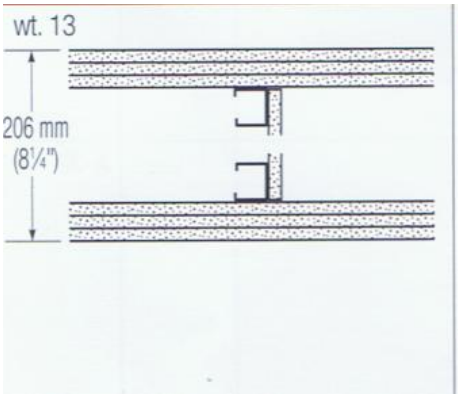
Shaft walls are designs to enclose shafts, such as for elevators, stairwells and mechanical shafts for HVAC and ductwork. Shaft wall systems permit all the gypsum board panels to be installed from outside the shaft, to avoid having to construct scaffolding. The designs incorporate thicker than normal gypsum board panels, usually 25 mm (1"), which are friction fitted into special steel studs, called "C-H studs, on the rear of the wall adjacent to the shaft. Illustrations of C-H studs are shown below (6):





2.4 continued

The highest rated acoustical performance amongst the numerous fire rated shaft walls has an STC of 58, which in some cases, is not sufficient. Here is a specific example of how a double stud wall with a two hour fire rating can be modified into a shaft wall design, while retaining its fire rating, and then further modified into a high performing acoustical wall. The starting point was to select an approved double stud design #A-36 from the USG or CGC brochure #SA-100 (7), with a 2 hour fire rating per UL test No. Des U436 when constructed with two layers of 13 mm (½") gypsum board on each side. That design was not tested for its acoustical performance. It is shown below.



- 12.7 mm (1/2") SHEETROCK FIRECODE C Core Gypsum Panels
- 42 mm (1-5/8") 0.5 mm (25 gauge) steel studs 610 mm (24") o.c. in two rows
- steel truss member
- gypsum panel gussets or steel runner braces spanning chase screw-attached to studs
- face layer joints finished
- 2 hr. rating applies with 2 layers panels each side
- 1 hr. rating applies with single layer 15.9 mm (5/8") panels each side

The Double Stud Wall Design can be modified to a Shaft Wall Design as follows:

Table 3
Modification of Double Stud Wall to Shaft Wall Design

Parameter	Std. Chase Wall Design UL Test No. Des U436	Shaft Wall Design	UL Allowed Modifications
Rear studs	42 mm (1⅝"), 25 gauge steel at 610 mm (24")	Substitute 64 mm (2½") type C-H studs, 25 gauge steel at 610 mm (24")	Studs with larger dimensions are permitted
Wall panels at rear	2 layers of 13 mm (½") gypsum board, Type X	Substitute 25 mm (1") fire-resistant 'Sheetrock' gypsum board	No change in total thickness
Front studs	42 mm (1⅝"), 25 gauge steel at 610 mm (24")	Substitute 64 mm (2½") studs, 25 gauge steel at 610 mm (24")	Studs with larger dimensions are permitted
Wall panels at front	2 layers of 13 mm (½") gypsum board, Type X	No change	
Spacing between studs	51 mm (2")	No change	
External width	184 mm (7¼")	229 mm (9")	Allowed
Cross bracing of studs	At mid-height	No change	
Insulation	None	Add 65 mm (2½") rock wool or glass fibre batts to both sets of studs	Allowed

2.4 continued

A sound transmission loss test of a wall with similar parameters to the modified shaft wall design was performed by the National Research Council Canada (8). The test results are shown below:

NRC-CNRC National Research Council Canada

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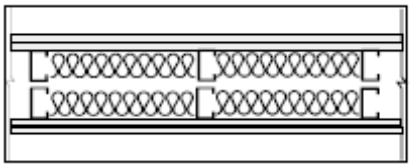
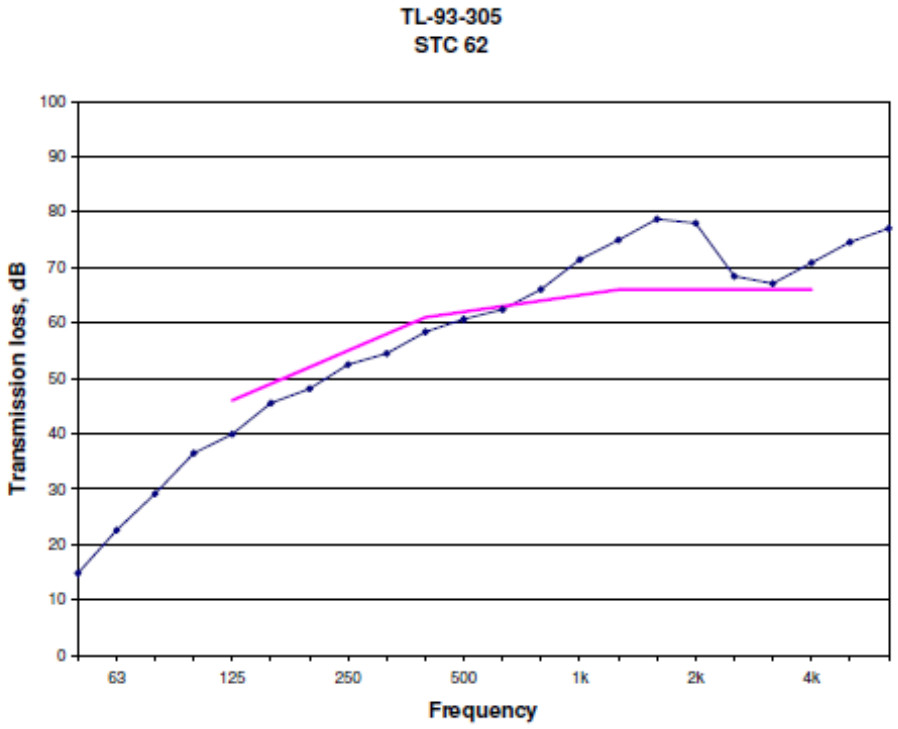
2G13_SS65(610)_GFB65_AIR20_SS65(610)_GFB65_2G13

Element	Description:
1	single layer of 13 mm type X gypsum board
2	single layer of 13 mm type X gypsum board
3	65 mm steel studs at 610 mm on centre
4	65 mm of glass fibre insulation in cavity
5	16 mm gap filled with cross brace
6	65 mm steel studs at 610 mm on centre
7	65 mm of glass fibre insulation in cavity
8	single layer of 13 mm type X gypsum board
9	single layer of 13 mm type X gypsum board



TestID	TL-93-305
STC	62
50 Hz	14.8
63 Hz	22.6
80 Hz	29.1
100 Hz	36.5
125 Hz	39.9
160 Hz	45.5
200 Hz	48.1
250 Hz	52.4
315 Hz	54.5
400 Hz	58.4
500 Hz	60.7
630 Hz	62.4
800 Hz	66.0
1000 Hz	71.4
1250 Hz	74.9
1600 Hz	78.7
2000 Hz	78.0
2500 Hz	68.4
3150 Hz	67.1
4000 Hz	70.9
5000 Hz	74.6
6300 Hz	77.1

TL-93-305	element 1	element 2	element 3	element 4	element 5	element 6	element 7	element 8	element 9
type	gypsum board	gypsum board	stud	insulation	gap	stud	insulation	gypsum board	gypsum board
material	AX	AX	steel	G1	cross brace	steel	G1	AX	AX
thickness mm	13	13	65	65	16	65	65	13	13
gauge			25			25			
spacing mm			610			610			
surface density kg/m²	10.3	10.3		0.5			0.5	10.2	10.2
linear density kg/m			0.5			0.5			
total weight kg	76.2	76.8	9.4	5.3		9.5	5.3	76.0	76.0
fastener spacing - edge mm	305	305						305	305
fastener spacing - field mm	305	610						610	305
fastener top track pattern	a	a						a	a
fastener base track pattern	a	a						a	a
stud attached to top track			yes			yes			
double header									
orientation	vertical	vertical						vertical	vertical



Conclusion: The resulting design is a shaft type of wall with a 2 hour fire rating per UL test U436, and an STC rating of 62, per NRC (National Research Council Canada) test No. TL-93-305.

3. SUMMARY

When architects or acoustical consultants specify wall partitions to be used in a project, they must ensure that both the acoustical performance of the partitions as well as their fire ratings comply with the requirements. When no single design has been tested for both requirements, then do the following:

- select a design that meets the required acoustical performance,
- search for a fire rated design that is similar in concept to the selected acoustical design, and
- proceed to modify the fire-tested design in accordance to the UL guidelines to match the design of the selected acoustical wall.

If the fire rated design can be modified in accordance with the UL guidelines to meet the acoustical design requirements, then the fire rated qualification of the original design will also apply to the modified wall design.

REFERENCES

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5. Underwriters Laboratories Design No. V446, reprinted from UL Online Certificate Directory (Copyright © 2014 UL LLC), with permission from UL LLC, at: http://database.ul.com/cgi-bin/XYV/template/LISEXT/1FRAME/showpage.html?name=BXUV.V446&ccnshorttitle=Fire+Resistance+Ratings+-+ANSI/UL+263&objid=1076418152&cfgid=1073741824&version=versionless&parent_id=1073984818&sequence=1
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