

REEROOFING FIRE RATED CONSTRUCTION

By Hubert T. Dudley and John W. Rose

To avoid compromising a building's original fire rated construction when reroofing or recovering an existing assembly, it is important to understand the positions of Underwriters Laboratories (UL) and Factory Mutual (FM) and their relationship to the prevailing building code on fire rated constructions for roof assemblies. Navigating one's way through published UL and FM requirements and local building codes is only the beginning. It is equally important to recognize how these published requirements are interpreted by various authorities that have jurisdiction. This paper will review the mechanics of using the *UL Directory* and current UL and FM positions on the subject. Finally, the role of the consultant in the process of securing necessary approvals will be considered, and guidelines are offered for dealing with local field representatives from UL, FM, and building code offices.

When reviewing the requirements of UL and FM, it is helpful to keep in mind the distinction between the two organizations. UL's purpose in promoting fire rated construction is to ensure life safety for building occupants. Because of this, codes rely heavily on UL testing to certify a building's fire resistant characteristics. FM is an insurance organization. Therefore, their requirements have been developed from the perspective of loss prevention. Generally, it is only necessary to consider FM fire ratings when working on an FM-insured facility or a facility designed to meet FM criteria.

To maintain a building's fire ratings during reroofing and recover, one must first understand the original construction that allowed the facility to achieve those ratings. So, before beginning a discussion of reroofing and recover, it is worthwhile to consider

how the type and duration of fire protection required for a newly constructed building are determined.

Determining the Type and Duration of Fire Protection Required in New Construction

Building codes dictate the type and duration (hourly rating) of fire protection required for a structure. The type of fire protection and duration required are determined by the occupancy (or use), the height and area limitations of the building, and the type of construction used.

Building codes classify buildings into Use Groups based on occupancy. Following is a list of occupancy categories and their corresponding Use Groups. Sub-groups of each Use Group are also defined by building codes.

<u>Occupancy</u>	<u>Use Group</u>
Assembly	A
Business	B
Educational	E
Factory and Industrial	F
High Hazard	H
Institutional	I
Mercantile	M
Residential	R
Storage	S
Utility and Miscellaneous	U

The various types of construction that are acceptable for a given Use Group can be determined based on the building height and area. For example, Table 503 from the BOCA National



Table 503

Height and Area Limitations of Buildings

Height limitations of buildings (shown in upper figure as stories and feet above grade plane^m) and area limitations of one- or two-story buildings facing on one street or public space not less than 30 feet wide (shown in lower figure as area in square feet per floor^m).

See Note a.

Use Group	Type of construction									
	Noncombustible					Noncombustible/Combustible			Combustible	
	Type 1		Type 2			Type 3		Type 4	Type 5	
	Protected Note b		Protected		Unprotected	Protected	Unprotected	Heavy timber	Protected	Unprotected
Note a	1A	1B	2A	2B	2C	3A	3B	4	5A	5B
E Educational Note c	Not limited	Not limited	5 St. 65' 34,200	3 St. 40' 22,500	2 St. 30' 14,400	3 St. 40' 19,800	2 St. 40' 14,400	3 St. 40' 21,600	1 St. 20' 15,300 Note d	1 St. 20' 7,200 Note d

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Building Code issued by the Building Officials & Code Administrators International, Inc. (shown above) provides type of construction information based on building height and building area for the Educational Use Group.

The Types of Construction are defined as follows:

- **Type 1 and Type 2** - Noncombustible materials must be used for walls, partitions, structural elements, floors, ceiling, roof, and exits.
- **Type 3** - Noncombustible materials must be used for exterior walls and code-approved materials for interior structural elements.
- **Type 4** - Noncombustible exterior walls with solid or laminated wood for interior structural members or load bearing walls, partitions, floors, and roofs of noncombustible materials.
- **Type 5** - Code-approved materials must be used as structural elements.

Having determined the type of construction, the specifier can then find the fire resistance ratings of the structure elements required by the code. BOCA National Building Code Table 602, "Fire Resistance Ratings of Structure (sic) Elements," defines the

hourly ratings that must be met for each structure element. The portion of Table 602 shown below deals with roof construction. The hourly rating requirement ranges from two hours to 0 hours, depending upon the type of construction.

Achieving Required UL Hourly Fire Ratings

The building code defines the methods of achieving required hourly fire ratings. These methods include active systems (such as sprinkler systems, which are designed in accordance with principles stated in NFPA 13, published by the National Fire Protection Association) and passive systems (such as fire rated ceilings and structural element protection provided by sprayed fireproofing, intumescent coatings, and fire protection board). Combinations of both active and passive fire protection may be used. The hourly rating for a roof system being installed using passive fire protection is clearly defined in the *Underwriters Laboratories Fire Resistance Directory*.

UL publishes hourly fire resistance ratings for various roof systems. These UL hourly fire resistance ratings are used to determine the specific construction materials required to meet the prevailing building code.

Underwriters Laboratories uses the ASTM E 119 fire test to

Table 602

Fire Resistance Ratings of Structure Elements

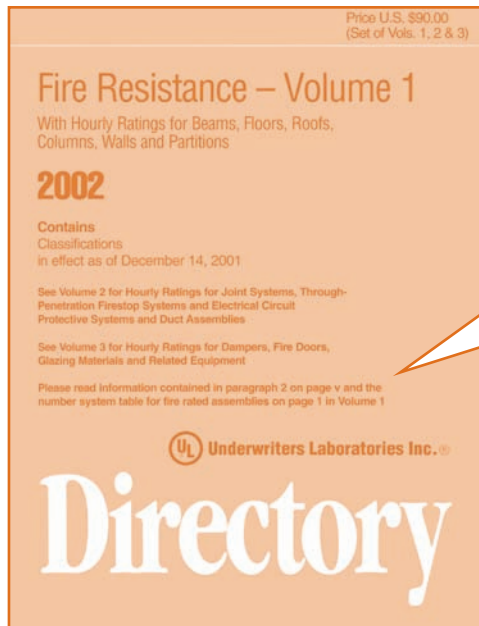
Structure element Note a	Type of construction Section 602.0									
	Noncombustible					Noncombustible/Combustible			Combustible	
	Type 1 Section 603.0		Type 2 Section 603.0			Type 3 Section 604.0		Type 4 Section 605.0	Type 5 Section 606.0	
	Protected		Protected	Unprotected		Protected	Unprotected	Heavy timber Note c	Protected	Unprotected
1A	1B	2A	2B	2C	3A	3B	4	5A	5B	
10 Floor construction including beams (Section 713.0 and Note h)	3	2	1 1/2 Note l	1	0	1	0	See Sec. 605.0 Note c	1	0
11 Roof construction, including beams, trusses and framing, arches and roof deck (Section 715.0 and Notes e, m)	15' or less in height to lowest member		1	1	0	1	0	See Sec. 605.0 Note c	1	0
	More than 15' but less than 20' in height to lowest member		-----Note d-----					See Sec. 605.0	2	2
	20' or more in height to lowest member		-----Note d-----					See Sec. 605.0	0	0

Note a. For fire resistance rating requirements for structural members and assemblies that support other fire resistance rated members or assemblies, see Section 716.1.

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investigate the length of time a roof system subjected to fire can support design structural loads and maintain its structural integrity. The results of this test provide the hourly fire resistance ratings referenced in building codes. The hourly ratings are intended to allow time for the public to exit a burning building and to protect firefighters from structural collapse. The ASTM E 119 test measures the amount of time it takes for the structural support system of a building to reach temperatures that may cause a loss of material properties and structural failure. It also evaluates the exposed surface temperature of the roof membrane to ensure it does not exceed limits and ignite. Both the exposed roof membrane temperature and the structural support temperature can limit the hourly fire resistance value.

Hourly fire resistive constructions refer to assemblies having an approved hourly fire rating when tested in accordance with ASTM E 119 procedures. These ratings result in hourly fire resis-



Graphic 1. Reprinted with permission from United Laboratories

tance listings for the specific test assemblies. All of these assembly listings generally incorporate a rigid roof insulation or lightweight insulating concrete over a steel deck or structural concrete. Further, underside treatment may be required to achieve the assembly rating. The assemblies are listed by design numbers in the *UL Fire Resistance Directory*.

UL also lists roof systems that are “fire classified.” Fire classified systems are only subjected to a spread of flame test, which is conducted in a Steiner Tunnel. This test determines the rate of flame propagation on the underside of the structural deck. It does not consider the issue of temperature transmission through the assembly or the structural performance, neither does it provide any hourly fire resistance ratings. These A, B, or C classifications appear as a part of the rated assembly requirements and, further, are referred to by code officials in decisions regarding reroofing applications.

Please read information contained in paragraph 2 on page v and the number system table for fire rated assemblies on page 1 in Volume 1.

Identifying the Proper UL Fire Resistive Designs

The *UL Fire Resistance Directory* lists fire rated assemblies. Knowing how to use the directory is a necessity for new construction circumstances. The ability to understand and evaluate the assemblies upon which building life safety criteria are based is essential in dealing with building code compliance issues. In new construction, the building structure and architecture are based on tested fire rated assemblies and built to be compliant with UL tested assemblies to achieve local code requirements. In reroofing, the need to accurately identify the existing roof assembly may or may not be required, but the understanding of them is critical in dealing with local authorities having jurisdiction. In either case, it

should not be assumed that roof assemblies designed to meet a specific fire resistance criteria and installed during building construction were installed correctly and

are in compliance with the actual tested assembly. “As built” documents should always be verified by field examination. Some of the primary items to identify during field examination include the type

of insulation, roof membrane, steel roof deck, and adhesives. Identifying the specific manufacturer of the components can also help determine the existing assembly. The tendency to group similar roofing insulation products together under generic names (such as perlite board, isocyanurate, and lightweight insulating concrete) should be avoided. Although they have a generic name association, these products can be manufactured differently and

Table 3

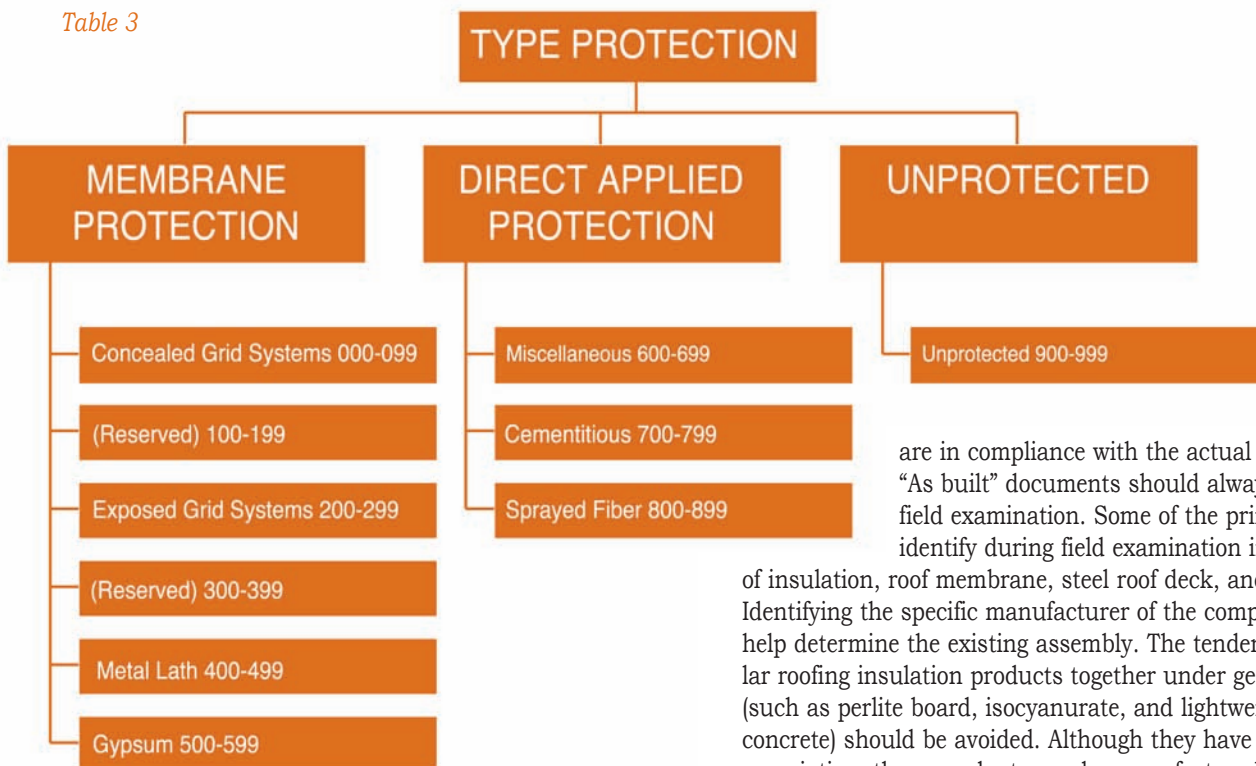
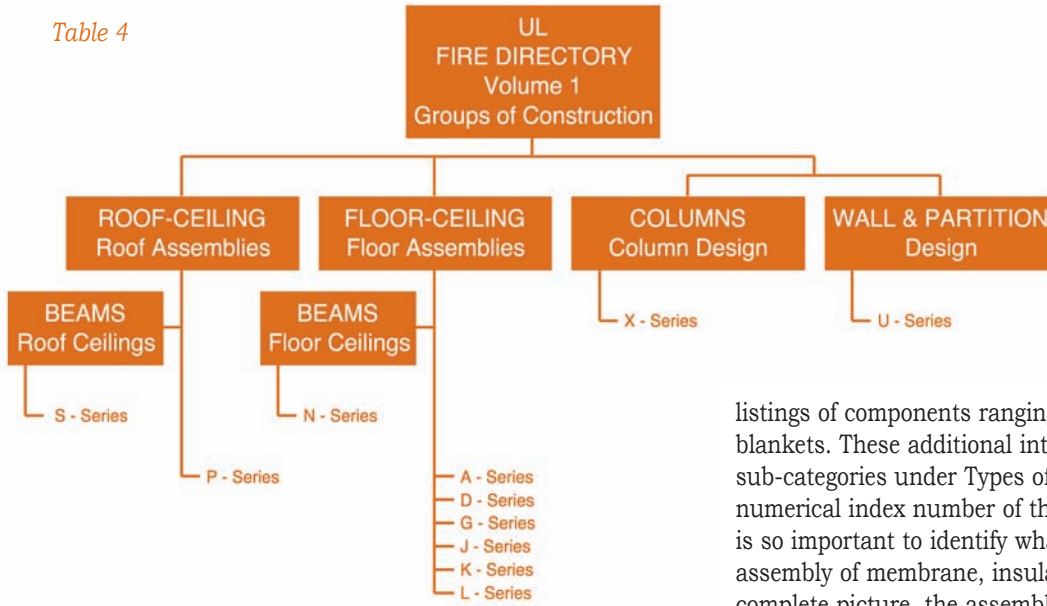


Table 4



have different material thermal characteristics and assembly ratings. This information may be even more critical in the future, as new formulations of products (such as the new generation of isocyanurates) enter the marketplace.

It is also vital to identify what is underneath the roof assembly in the interior of the building. Is there a suspended ceiling, exposed ceiling, acoustical tile, or other component in the assembly? These components contribute to locating and properly identifying the correct roof ceiling assembly in the *UL Fire Resistance Directory*. This information is important later, when determining the UL type of constructions and corresponding numerical location.

Using the UL Fire Resistance Directory

The process of finding the correct fire resistant assembly in the *UL Fire Resistance Directory* can be challenging and at times frustrating. The *UL Directory* includes instructions to simplify this process. These guidelines begin on the cover of the *Directory*.

The cover (*Graphic 1*) instructs the reader to go to page 1 and refer to the number system table for fire rated assemblies. The *Directory* is organized by the relationship between Groups of Construction and Types of Protection. This is the base of the alphanumerical classification of all listed assemblies (*See Table 3*).

The Groups of Construction are classified by different sets of assemblies that contribute to the building structural elements. These include columns, floors, beams, walls, partitions, and – important from our perspective – roof-ceiling assemblies. These constructions are designated by an alphabetic prefix ranging from A to Z. Each letter or grouping of letters is assigned to a construction type (*See Table 4*).

The Types of Protections are defined by a numerical numbering system. This system is broken into three main categories: Membrane Protection, Direct-applied Protection, and Unprotected. These three main categories are sub-divided by specific protection types (*See Table 5*).

“Membrane protection” has the broadest range of

sub-categories with six numerical sub-groups. “Unprotected” has the narrowest with one numerical sequence (*See Table 6*).

Most roof-ceiling assemblies are found in the P series. (Prefixes Q and R are not currently used and are reserved for future assemblies.) By reviewing the types of protection and various sub-categories, a consultant will note some miscellaneous

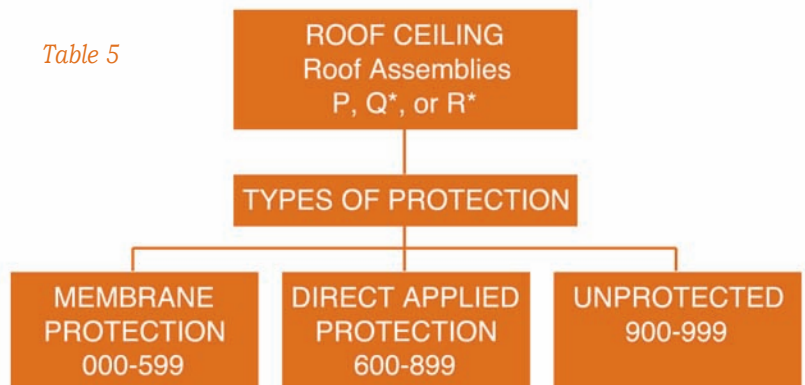
listings of components ranging from grid systems to batts and blankets. These additional interior components that comprise the sub-categories under Types of Protection will determine the numerical index number of the fire rated assembly. This is why it is so important to identify what components are underneath the assembly of membrane, insulation, and substrate. Without a complete picture, the assembly and its rating can not be accurately identified.

Mechanical screw-type fasteners are used frequently during reroofing. It should be noted that these fasteners are not commonly listed as components in UL roof-ceiling fire resistance assemblies. For example, less than 20% of the assemblies in the 2002 *UL Fire Resistance Directory P-800* series list mechanical screw-type fasteners as a component. In the P-700 series, less than 40% of the assemblies are approved with a mechanically fastened rigid insulation.

Handling “Future Floor” Constructions

There are other roof ceiling assemblies that are not found in the P-series. These can be found in the D-series or floor assemblies. These assemblies are sometimes referred to as “future floor” constructions. They are actually floor assemblies with a roof installed on top. Some design criteria call for a building to be constructed to a certain height. The master plan may require an expansion at some later date to increase the height of the building. This would require the original construction to have the top of the building initially function as a roof assembly. The construction would also require the flexibility at some later date to function as a floor assembly when the building is expanded and additional floors are added to the structure.

Table 5



Groups of Construction	Membrane Protection							Direct Applied Protection		Unprotected
	000-099	100-199	200-299	300-399	400-499	500-599	600-699	700-799	800-899	900-999
Floor Ceilings A, B*, or C* Concrete and Cellular Steel Floor	Concealed Grid Sys.	(Reserved)	Exposed Grid System	(Reserved)	Metal Lath	Gypsum Board	Misc.	Cementitious	Sprayed Fiber	Unprotected
D, E*, F* Concrete and Steel Floor Units	Concealed Grid Sys.	(Reserved)	Exposed Grid System	(Reserved)	Metal Lath	Gypsum Board	Misc.	Cementitious	Sprayed Fiber	Unprotected
G, H*, or I* Concrete and Steel Joists	Concealed Grid Sys.	(Reserved)	Exposed Grid System	(Reserved)	Metal Lath	Gypsum Board	Misc.	Cementitious	Sprayed Fiber	Unprotected
J or K Concrete	Concealed Grid Sys.	(Reserved)	Exposed Grid System	(Reserved)	Metal Lath	Gypsum Board	Misc.	Cementitious	Sprayed Fiber	Unprotected
L & M* Joist or Combination Wood and Steel Assemblies	Concealed Grid Sys.	(Reserved)	Exposed Grid System	(Reserved)	Metal Lath	Gypsum Board	Misc.	Cementitious	Sprayed Fiber	Unprotected
Beams: N or O* for Floor Ceiling	Concealed Grid Sys.	(Reserved)	Exposed Grid System	Batts and Blankets or Mineral and Fiber Boards	Metal Lath	Gypsum Board	Misc.	Cementitious	Sprayed Fiber	Unprotected
Roof-Ceiling: P, Q*, or R*	Concealed Grid Sys.	(Reserved)	Exposed Grid System	(Reserved)	Metal Lath	Gypsum Board	Misc.	Cementitious	Sprayed Fiber	Unprotected
Beams: S or T* Roof-Ceiling	Building Units	(Reserved)	Exposed Grid System	(Reserved)	Metal Lath	Gypsum Board	Misc.	Cementitious	Sprayed Fiber	Unprotected
Wall & Partition: U, V, or W*	Bldg. Or Partition Panel Units	(Reserved)	Insulating Concrete	Wood Stud Gypsum Bd Lath &/or Plaster	Metal Stud Gypsum Bd Lath &/or Plaster	Misc.	Metal Panels Gypsum Bd Lath &/or Plaster	Metal Panels or Supports Cementitious	Metal Panels or Supports Sprayed Fiber	Masonry
Columns: X, Y, or Z*	Building Units	Prefabricated	(Reserved)	Batts and Blankets or Mineral and	Metal Lath & Plaster	Gypsum Board	Misc.	Cementitious	Sprayed Fiber	(Reserved)

Table 6: Numbering systems for Fire Rated Assemblies
Types of Protection

Understanding FM Fire Resistance Ratings

Factory Mutual uses a calorimeter to determine the interior fire resistance of all roof systems as part of its Class 1 approval criteria. This test subjects a roof system sample (decking, insulation, roof membrane) to a fire on the underside of the structural deck. The amount of fuel generated by the burning roof system sample is compared to the amount generated by a similar sample made of noncombustible refractory materials. The difference in the amount of fuel generated by the two samples provides the amount of fuel generated by the roof system being tested. Class 1 approval is based on the maximum fuel contribution rate at various time intervals. Therefore, the addition of more insulation or more roofing membranes may cause a given roof construction to contribute an amount of fuel exceeding the acceptable fuel contribution rate for Class 1 approval.

Determining Acceptable Actions for Recover Applications

If the information included in this paper followed its title, "Reroofing Fire Rated Construction," we could stop here. The fact is, meeting criteria for fire rated construction when reroofing is simple, because the roof system is being rebuilt from the deck up. Therefore, as long as the new system is comprised of the same materials as were in the original construction, all of the ratings should remain intact. So, when dealing with new construction and reroofing, the requirements for fire rated assemblies are fairly

clear. However, in the case of recover applications, what is allowable? Both UL and FM have positions on the subject that can be summarized quickly:

- Technically, UL does not allow recover applications for hourly ratings. To maintain UL approval, the existing assembly must be torn off and the facility reroofed with an assembly defined in the P Series.
- Likewise, to achieve required FM ratings, the existing assembly can be torn off and replaced with an approved assembly. Alternatively, FM allows up to 1" of additional insulation in recover applications, if both the existing system and overlay systems are FM Class 1 rated.

Those are the official rules. However, is that the reality? Of course not.

There are levels of interpretation involved in determining whether the design of a re-cover application will maintain both UL and FM fire resistance ratings. These possibilities merit discussion.

The UL Position on Recover and Reroofing Applications

UL does not make any provisions for recovering existing fire rated designs. This is because the addition of a new roof, which may require new insulation, will change the thermal characteristics of the assembly. Insulation may be added during reroofing

applications, but only as defined by the specific fire rated design being replaced. Therefore, in reroofing applications, the insulation thickness cannot exceed that listed and must be of the approved type and by the approved manufacturer. If screws are used to attach the insulation or roofing products, they must be listed in the design.

The majority of in-place lightweight insulating roof deck systems meet specific hourly fire rated designs. The simplest method of reroofing a lightweight insulating concrete system is to remove the old membrane and install a new roof membrane directly to that surface. Seldom does the lightweight insulating concrete system need to be replaced.

There are three ways to ensure that a recover or reroofing design and its fire resistive qualities will be acceptable:

1. Reference the *UL Directory*, which would require tear-off of the existing assembly.
2. Work with the manufacturer of the products listed in the assembly to conduct an engineering study wherein UL will determine the acceptability of the assembly. In some cases, manufacturers may already have such studies.
3. Work with building code authorities. Even though UL does not include recover applications with hourly ratings in the *UL Directory*, building code authorities will often allow such assemblies. Weight is the primary building code concern with recover applications. Building codes will accept a second roof system if it carries a fire rating equal to or greater than that of the original system, as long as the structure can carry the additional weight. In recover situations, before ordering a UL engineering study, it can be beneficial to check with the roof membrane manufacturer. They may have an engineering study on a previously completed recover project that could provide useful information.

The FM Position on Recover and Reroofing Applications

As with UL, when recovering an existing system, there are three options to ensure that the design will be acceptable to FM:

1. Leaving the membrane in place, FM will allow the introduction of a maximum 1-inch thickness of additional insulation into the system without testing if the existing system is Class 1 rated. A second membrane may be added over the insulation. Insulation additions greater than 1 inch can only be employed if that specific recover assembly has been tested by FM. If the original roof system has not been fire tested and approved by FM, it can be assumed that the assembly is Class 2 and will require the addition of a sprinkler system or passive sprayed fire protection under the roof deck.
2. If an insulation addition of greater than 1 inch is necessary, check with the manufacturer to see if FM testing has already been secured on such an assembly.

3. Work with an FM field engineer to have the assembly tested and approved.

Substituting Materials

When reroofing and recovering, any materials used in substitution must be included in the approved assembly listing for both FM and UL constructions. In addition, all parts of the construction must be installed as defined by the assembly listing. Incorrect substitutions or incomplete constructions will negate the assembly's code approval.

Protecting a Building's Fire Rating – and Protecting Yourself

Although published UL and FM requirements and positions on recover applications seem draconian, the reality is that the interpretation of the data by FM field engineers and local building code officials makes defining such assemblies a much more practical matter. Design professionals should recognize that this room for interpretation exists, but should not try to make those interpretations on their own. Rather, it is advisable always to contact local building code officials (and FM field engineers in the case of FM insured buildings) for proper approval of designs for recover or reroofing of fire rated assemblies. ■

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