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SUBJECT: Fire Rated Assemblies For Residential Fireplace Hearths
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Man has long had a relationship with fire. It has provided warmth and comfort for longer than history has recorded. The influences that fire enacts upon the clays of the earth has yielded many pleasant surprises for man as well. Producing materials that exhibit marvelous properties, many of which are not completely understood at the time of this writing. Fire and Ceramic Tiles are inextricably linked together throughout recorded history. It is not surprising then, that ceramic tile has adorned many fireplaces through the ages. In a periodical entitled "American Homes and Gardens" dated May 1912 the following statement was made. "The fireplace is everywhere the center of life, and tiling is used wherever the fireplace is found; in fact, the use of tiles is so largely in connection with the fireplace that many people think of them chiefly as a decorative adjunct to the mantle or chimney piece."' A sense of romance has long been associated with the fireplace. In a book entitled "Fireplaces" Paul Vincent Wiseman writes; "There is something reassuringly elemental and real about wood burning in a grate, for who among us is not drawn to a lighted fire, around which, after all, we have gathered since the dawn of human history? There is nothing like a fire to enhance the mood of a social occasion or to offer companionship during a moment of solitude."

However, the sense of romance is quickly lost when fire is allowed to wander freely consuming virtually everything in it's path. In a book entitled "The History of American Ceramics 1607 to The Present" Author Elaine Levin writes "The the making process James Robertson introduced to America was an English invention of 1840, which by reducing warping and shrinking facilitated mass production. Evidence of the expanded English tile industry appeared in Philadelphia in 1876; the British had sent an elaborate display hoping to generate an American market for their product. Instead, the variety of examples encouraged American manufacturers to develop their own tiles. Among the many factors contributing to a renewed use of tile was the disastrous Chicago fire of 1871. Because so many of the city's wooden structures were destroyed, the fireproofing qualities of ceramic tile for public architecture became increasingly attractive."

For much of the time that man has been building and using fireplaces he has relied upon the tried and true method of building the entire assembly out of masonry. This type of construction offers many benefits in that masonry conducts heat well and, due to its large mass, stores and emanates heat efficiently back into the living space. Fireplaces of old were less about romance and more about survival. In many cases the fireplace was the sole source of heat and the appliance where all of the cooking took place. Many of the older homes had the kitchens built separately from the house because the fires were a frequent cause of burning the entire house to the ground. Using masonry to build a fireplace does not guarantee a safe fire. There are many configurations that a masonry fireplace may be built and some combustibles placed directly in contact with the masonry or in near enough proximity to the masonry may cause an accidental fire to erupt.

Modern man, in an attempt to decrease the likelihood of accidental fires, has implemented a system of building codes followed with inspections by qualified construction inspectors during the construction phase of the fireplace. And, if all goes according to this best laid plan of mice and men, a successful fireplace design is in place to provide many years of reliable and safe service. Hereafter, I will discuss the intended designs of the fireplace hearth extension as it appears in the building codes handed down to the modern day construction worker.

First some definitions are in order so that my words do not create confusion. NFPA 211 1-5 definitions states; Hearth- The floor area within the fire chamber of a fireplace or a fireplace stove.

Hearth extension- The noncombustible surfacing applied to the floor area extending in front of and at the sides of the hearth opening of a fireplace or a fireplace stove or beneath an elevated overhanging fireplace hearth[4].

The construction of the masonry fireplace hearth and hearth extension is explained in the NFPA 211 document. The NFPA or the National Fire Protection Agency writes codes , which act as a template for other code bodies to adopt.

NFPA 211, 7-3 Hearth extensions

7-3.1 Masonry fireplaces shall have hearth extensions of brick, concrete, stone, tile, or other approved noncombustible material properly supported and with no combustible material against the underside thereof. Wooden forms used during the construction of hearth and hearth extensions shall be removed when the construction is completed.

[3]"The History of American Ceramics 1607 to The Present" page 82
[4]NFPA 211 1992 volume 5

The following code bodies have adopted this code requirement:
UBC 3102.7.11[1], CABO1003.7[2]

One Notable Exception is SBCCI 2114.3.8 1997, which allows the following ; "A header of combustible material may be used to support the hearth extension provided that it is located more than 12 inches (305 mm) from the face of the fireplace."[3]

Other NFPA codes , 7-3.2 and 7-3.3 state the minimum size allowable for the fireplace hearth extension.

NFPA 211 7-3.2 1992 Where the fireplace opening is less than 6 square feet (.56m2), the hearth extension shall extend at least 16 inches (406mm) in front of the facing material and at least 8 inches(203mm) beyond each side of the fireplace opening.

NFPA 211 7-3.3 1992 Where the fireplace opening is 6 square feet (.56m2) or larger, the hearth extension shall extend at least 20 inches(508mm) in front of the facing material, and at least 12 inches (305mm) beyond each side of the fireplace opening.

All of the following code bodies have adopted this code without exception:

UBC 3102.7.12, CABO 1003.8, SBCCI 2114.3.7

With respect to the fireplace hearth extension on masonry fireplaces, the aforementioned code bodies are in relative agreement. In general terms, the construction of a masonry fireplace begins with the placement of an acceptable footer. Masonry is then brought up to a level close to the hearth and hearth extension, the brick are then corbeled (or stepped out to form a ledge) to receive the hearth extension. In a masonry fireplace the hearth and hearth extension are a single reinforced concrete slab that is typically a minimum of 4 inches thick. Some fireplace designs incorporate a cantilevered hearth extension and omit the need to corbel the brick out to form a supporting ledge.

NFPA 211 1992 7-2.3 Clearance

NFPA 211 1992 7-2.3.1 All wood beams, Joists, Studs and other combustible material shall have a clearance of not less than 2 inches (51mm) from the front faces and sides of masonry fireplaces. And not less than 4 inches (102mm) from the back faces of masonry fireplaces.

The codes with respect to masonry fireplaces are generally in agreement from one code body to another. Perhaps one reason for this is that masons have had many years to perfect this type of fireplace and there appears to be a unified character to the codes with a few exceptions.

FACTORY- BUILT FIREPLACE INSERTS

Factory-built fireplace inserts have not been around as long as masonry built fireplaces and do not enjoy the proven track record that only the centuries could have imparted to them. The first U.L. 127 listing for a factory-built fireplace was published in 1958. These units are attractive to modern day contractors because they provide a means to serve the homeowner's desire for a fireplace in a cost- effective manner. Homeowners that want to add a fireplace in a remodel situation find these units are easily incorporated into the existing structure with a minimum of modifications to the house. Many configurations exist and the fuel sources are varied. The factory-built fireplace units that burn wood are of particular interest to this paper.

The following statement defines what a factory-built fireplace consists of according to the Uniform Building Code:

"Uniform Building Code 1997 Chapter 31 SPECIAL CONSTRUCTION 3102.2 Definitions - Factory-built Fireplace is a listed assembly of a fire chamber, its chimney and related factory-made parts designed for unit assembly without requiring field construction. Factory-built fireplaces are not dependent on mortar filled joints for continued safe use."

With respect to the hearth extension the following appears in the Uniform Building Code:

"Uniform Building Code 1997 3102.5 Factory-built chimneys and fireplaces

3102.5.2 Hearth extensions, Hearth extensions of listed factory-built fireplaces shall conform to the conditions of listing and the manufacturer's installation instructions."

With regards to the actual size of the hearth extension all parties seem to be in agreement. It would seem that the size determinations set forth by the NFPA 211 document are universally accepted in masonry and factory- built fireplace installations.

The building codes require the use of a listed factory–built fireplace unit. This listing is achieved by compliance to the U.L.127 test standard[4]. The U.L.127 test is performed by mounting the factory-built fireplace, complete with chimney, into a test mock up that simulates the fireplace installation in a multi-story structure. The fireplace manufacturers will typically install a hearth extension that usually consists of Micore board covered with sheet metal for the test. The insulative value of this assembly is designed to sufficiently protect the sub-floor from excessive radiant heat gain. Thermocouples are installed in strategic locations and the fire chamber is fired up in a number of different ways for specific lengths of time and the thermocouples record the temperature at various locations.

To prepare the Factory–built fireplace for the test, one of the following parameters are observed:

U.L.127 1996 9.19 The face areas of a fireplace that are intended to be covered with decorative materials, such as Slate, Tile, or Marble are to be covered with such materials when provided with the fireplace, otherwise, with non combustible material having a 3/8 inch *minimum thickness.* (This spec has been revised to ½" in the most current revision of U.L.127)

The test is to determine, among other things, what radiant heat exposure the floor is subjected to in front of the firebox in the hearth extension area. Apparently, fireplaces of different design, reflect radiant heat in different ways and some designs reflect more radiant heat onto the hearth extension than others. The measurements taken by the thermocouples document the radiant heat exposure to the underside of the hearth extension. This test is designed to be a pass or fail scenario for the specific fireplace design that is being tested.

U.L.127 January 26, 1998 12.9 When the fireplace is fired as described in 12.5 – 12.7 , the maximum temperature rise above ambient zone temperature shall not exceed:

a) 117 degrees F (65 degreesC) on exposed surfaces of the test enclosure and
b) 90 degrees F (50 degrees C) on concealed surfaces of the test enclosure, such as beneath the hearth (fire chamber), beneath the hearth extension, behind the wall mounted shields, within the chimney enclosure and surrounding the fire chamber.[5]

The purpose of the Hearth Extension is to protect the combustible sub-floor from the radiant heat that the fireplace generates during normal operation, and to provide a non-combustible surface for sparks and flying embers to encounter. In the event of a log roll-out the Hearth Extension is subjected to higher heat values. The U.L. test procedure 1618 for wall protectors, floor protectors, and hearth extensions9 exposes the intended hearth extension design to extreme heat and physical abuse:

U.L. 1618 1991- 12.5 The floor protector is to be mounted such that the underside of the floor protector can be observed. The burning brand is to be placed on the surface of the floor protector at the location considered most vulnerable with respect to ignition of the floor protector.

The "Burning Brand" referred to in this section is 500 grams +or- 50 grams of kiln dried and conditioned Douglas Fir configured to maximize combustion.

U.L. 1618 1991- 12.6 The test is to continue until the brand is consumed and until all evidence of flame, glow, and smoke has disappeared from both the exposed surface of the material being tested and the underside of the floor protector, or until unacceptable results occur, but not more than 1-1/2 hours.

U.L 1618 1991-13.2 The floor protector is to be subjected to three successive impacts from a 5-inch (127mm) diameter hardwood log, 18 inches (457mm) long, weighing 12 pounds-mass (5.4kg), and dropped from a height of 48 inches (1.22m) with its major axis parallel, perpendicular, and at a 45 degree angle to the surface of the floor protector.

U.L.1618 1991-13.3 The floor protector is to be subjected to a 600-pound-mass (272-kg) static load applied to a 1-square-inch (6.45-cm2) area for 30 minutes.

I obtained the installation instructions from three different factory-built fireplace manufacturers. Two of these manuals offered the option of purchasing an accessory precut board to be used as an underlayment that possesses the necessary thermal insulation value to protect the sub-floor from the radiant heat gain. All three manuals discussed alternate ways of achieving the required K or r value necessary to protect the sub-floor from the radiant heat. Calculations are required, and the performance characteristics of the intended alternate materials must be known in order to determine the effectiveness of the assembly to protect the sub-floor.

The following statements are taken from the textbook of the Hearth Education Foundation and describe the various methods for determining the R and k - values;[6]

APPENDIX E.CALCULATING HEARTH EXTENSION MATERIAL REQUIREMENTS

1.1 Thermal conductivity : k value
The k value indicates the amount of heat (in Btus) that will flow in one hour through one square foot of a uniform material one inch thick for each degree (F) of temperature difference from one side of the material to the other:

$$\frac{\text{(Btu) (Inch)}}{\text{(foot2) (hour) (DegreeF)}}$$

The higher the k factor the more heat being conducted through the non-combustible material to the combustible material beneath it. Added thickness reduces heat transfer. For example, a material one- inch thick with a k-factor of .84 would transfer 84 BTUS per hour if there were a 100 degree F temperature rise. A two- inch thick piece of the same material under the same conditions would transfer half that amount, or 42Btus per hour. The lower the k factor, the less heat a material will transfer and the cooler the combustible material stays.

1.2 Thermal Resistance: R Value
The R- value is a measure of a materials resistance to heat transfer. R- value is convenient when more than one material is used since it is additive, whereas k values are not. Thus, materials with different k values can be converted to R and the R - values added to determine appropriate thickness and materials.

The higher the R - value, the less heat transferred to the combustible material.

2. Conversion

Since manufacturer's instructions and reference material's state thermal properties in different ways, it is important to be able to convert from one form to another.

Converting k to R:

Divide one by k and multiply the results times the thickness in inches of the material.

R= 1/k X inches of thickness

Converting R to k:

Divide the inches of thickness by R.

k= inches of thickness / R

For the Heat–N-Glo model EM-415 The installation instructions[11] require that a minimum R-value of 1.16 be attained in the hearth extension. The assembly that I will evaluate is a layer of Micore 230 and a layer of ½" Util-A-Crete. The first step is to convert the k values of the materials in question into R so that we may add them up and determine if they will provide the necessary insulation value required by the manufacturer.

Micore 230 has a k value[12] of .43 so –

1 divided by k = 2.32 times the thickness .375 (3/8") = 0.87

Util-A-Crete has a k value of 1.6 so –

1divided by k = .625 times the thickness .5 (1/2") = 0.3125

Add the values together 0.87 plus 0.3125 = 1.1825 This R- value is an acceptable assembly.

What if we decide to use only one material? In this example, only Util-A-Crete.

We could use the published R-Value of Util-A-Crete[13] which is .31 in the ½" material and add them up to the value of the minimum required which is R=1.16

1.16 divided by .31 = 3.74 This assembly would require 3.74 layers of ½" Util-A-Crete to reach the necessary R-value required. Obviously, you would have to round up to the next layer, which would mean that you would have two inches of Util-A-Crete.

FMI – Fireplace Manufacturers Incorporated Model – 2EC- LA COSTA II Installation instructions specifies that the hearth extension be comprised of "a layer of a non-combustible, inorganic material having a thermal conductivity of k=0.64 BTU IN/FT .HR (or less) at 1" thick. If the material selected has a k-factor of 0.25 such as glass fiber, then the following formula would apply: 0.25 divided by 0.64 times 1 inch = .39 inches thick. This must be covered by a non-combustible material such as tile, slate, brick, concrete, metal, glass, marble, stone, etc. Fasten the hearth extension to the floor to prevent shifting and seal the gap between the fireplace frame and the hearth extension with a non-combustible material."14

In this case we are asked to meet a certain k-value requirement. If you are working with one material and you know the k-value of that material you can proceed in the following manner:

Util-A-Crete which has a published k-value of (typical average) 1.6 will be used in this example.

K-value is always expressed as a one - inch thick material. If you know the required k-value and you know the k-value (per inch) and the thickness of the material that you are going to use. You can divide k-value per inch of material by actual thickness. The results must be equal to or smaller than the required k-value to be acceptable.

Util-A-Crete ½" thickness – Divide 1.6 by .5" = 3.2 k This Would not be an acceptable hearth extension assembly according to the FMI installation manual. However, if we add thickness to the Util-A-Crete we can attain the acceptable k-value:

Divide 1.6 by 2.5" = 0.64 This would meet the required k-value, however, two and a half inches of underlayment may not be a desirable assembly from an aesthetic point of view.

I have taken the reader through this exercise to illustrate, in some detail, the manufacturer's requirements for the hearth extension. The ideal material for this application would seem to be asbestos board. Asbestos board would provide excellent protection for the sub-floor and a fairly dense and rigid surface to adhere ceramic tile or marble tiles directly on top of. However, the use of asbestos is not a possibility because of the possible harmful effects upon the health of people that work with it. Therefore, the construction community is required to provide a layer of thermal protection under the tile installation with materials that are quite at odds with one another. A material that provides good R-value is typically a material that has characteristics of being easily compressed, porous, and damaged by abrasion.The material that would exhibit the necessary properties called for in the U.L.1618 test, is not currently known to me. Perhaps, more research on this subject is necessary to reveal the modern building material that is ideal for this application.

Frankly, it would seem that the tile-setting community is being put into a position of extreme liability. If the tile-setter installs a hearth extension improperly, and a family perishes because of inattention to detail on behalf of the tile-setter, it would seem to be an untenable position for the installer in today's litigious environment. It does seem to be an irony that one of the oldest applications for ceramic tile is still in question. I would encourage others, more knowledgeable than I, to help find a comprehensive answer to this modern day dilemma. Given the constraints imposed, the best method that I have been able to devise would be the attachment of the Micor board, of sufficient thickness, to the sub-floor with the use of silicone. Followed by the attachment of ½" Util-A-Crete to the Micor board with silicone, then the application of the tile to the Util-A-Crete with Dry-set or Latex Modified Mortar. The silicone used as an adhesive would allow the insulation layer to remain intact and preclude the thermal performance of the board to be adversely affected by the use of mechanical fasteners. I imagine that the use of mechanical fasteners would provide an unwanted avenue for the heat to travel directly through the layer of insulation into the combustible sub-floor underneath.

A real world test of such an assembly would, of course, be advisable. Without such a test and the ensuing data to base a hearth extension installation upon, this tile-setter will be reluctant to perform and guarantee the effectiveness of such an installation and will require a signed waiver by the affected parties before undertaking the job.

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