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REVIEW OF UL'S "STUDY OF RESIDENTIAL ATTIC FIRE MITIGATION TACTICS AND EXTERIOR FIRE SPREAD HAZARDS ON FIRE FIGHTER SAFETY"

Prepared For

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1. BACKGROUND

Underwriter's Laboratories, Inc. (UL) is currently conducting a multi-year project " to examine fire service attic fire mitigation tactics and the hazards posed to firefighter safety by the changing modern residential fire environment and construction practices." [1]

As part of this program a series of fire tests were conducted at UL's Northbrook test facility and the results of these tests are reported in UL's report "Study of Residential Attic Fire Mitigation Tactics and Exterior Fire Spread Hazards on Fire Fighter Safety." [1] This report is a compilation and analysis of thirty-two wall fire tests, three eave/wall fire tests, eight full-scale attic fire tests and three knee wall & attic field experiments.

Since the publication of the test report, there have been questions raised concerning some of the specific test fire parameters, the appropriateness of the construction materials especially with respect to their actual use and flammability properties, and potential concerns with the description and analysis of the test results.

With these questions in mind, the National Association of Home Builders (NAHB) contracted with JENSEN HUGHES to perform a technical review of the report "Study of Residential Attic Fire Mitigation Tactics and Exterior Fire Spread Hazards on Fire Fighter Safety."

2. REVIEW

2.1. Scope of UL Project

The purpose of the UL research study as stated in the report was to "increase firefighter safety by providing the fire service with scientific knowledge on the dynamics of attic and exterior fires and the influence of coordinated fire mitigation tactics from full-scale fire testing in realistic residential structures."

In order to accomplish this, UL selected a fire growth path that included vertical flame-spread of an exterior wall assembly, entrance into the attic space via the eaves and fire growth within the attic. Based on this fire path, UL performed a series of thirty-two wall tests, three eave/wall tests, eight full-scale attic tests and three knee wall/attic field experiments.

The wall tests and the eave/wall tests evaluated potential flame-spread and fire development of those specific assemblies. The eight full-scale attic tests and the three knee wall/attic tests were primarily focused on the fire-fighting aspects of attic fires.

The report provides statistics that address the exterior fire problem and purport to substantiate the purpose for the study. The report identifies that there are 10,000 residential building attic fires per year, causing an estimated 30 civilian deaths and 125 civilian injuries [2]. The referenced 2011 USFA report relies on data collected from NFIRS between 2006 and 2008 for these statistics. Although new data may not be readily available, it would be useful to understand the trend in residential attic fires over the past 7 to 9 years, especially since the UL report continually refers to modern construction techniques as being a precipitating factor.

Furthermore, the magnitude of the inferred exterior exposure fire problem is not defined and the way it is presented in the UL document can be misleading. According to the 2011 USFA report, only 2.5 percent of the annual 10,000 residential attic fires (250 fires) in the 2006 to 2008 reporting period originated from "exposures" [2]. There is no data presented in the referenced USFA report to differentiate between the types of external exposure, the materials comprising the exterior wall of the residential home, or the configuration / construction of the eave relative to the wall. Of these 250 annual fires, it is not reported how many originated from wildland urban interface (WUI) fires, vehicles, or other fuel package adjacent to an exterior wall. Moreover, flames from an interior fire projecting through a window opening are also considered as an "exposure" in the data reported by USFA. In short, the USFA report and its referenced data does not define the perceived exposure fire problem that is part of the focus of UL's report.

Yet, the UL report states that the number of residential structure fires originating from the building exterior has been increasing. It cites a second, more dated, USFA report from 2007 titled, “Fires and Exposure,” which presents 2004 data from NFIRS and an NFPA Annual Survey. [3] The 11 year old data used in the USFA report does not differentiate between commercial and residential structures. Nor does it cite, specifically, residential attic fires. The UL report states,

> *“The number of residential structure fires originating from the building exterior such as an adjacent structure fire, garage fire, deck or porch fire, mulch/vegetation fire or a wildland fire has been increasing. Exterior fires can transition to attic fires either directly via eave/soffit and wall vents or indirectly by burning through eaves/soffits, exterior walls and/or windows. USFA estimates such source fires and the subsequent exposure fires account for about 30,700 fires, 275 deaths and 875 injuries annually. Furthermore, in fires that that spread beyond the room of origin, structural members or framing were the most common contributing item to flame spread (26%) followed by structural components or finishes (11%) and exterior wall surfaces (10%).”*

This paragraph uses misapplied statistics that result in misleading information. The first sentence claims that the number of residential structure fires originating from the building exterior is increasing. There is no data in either referenced USFA report that support this claim. The 2007 USFA report does not differentiate between residential or commercial structures, nor does it relay any information regarding the rate of exposure fire occurrences over any time period. The cited data is from a single year in 2004 and to state that there has been an increase residential fires from exterior exposures is not supported by the reference. The 2011 USFA report identifies that only 2.5 percent of attic fires (250 fires annually) are caused by exposures, which could originate from either the interior or exterior of the structure. Neither USFA report speaks toward a growing trend of residential fires caused by exterior exposures.

The sentence, “USFA estimates such source fires and the subsequent exposure fires account for about 30,700 fires, 275 deaths and 875 injuries annually,” is factually incorrect. Quite the contrary, the facts presented in the USFA report are that 12,100 fires spread beyond their boundaries (source fires) and that an estimated 18,600 additional fires are caused as a result (exposure fires). The USFA report makes it clear that exposure fires refer to external exposures such as other buildings, vehicles, and outside objects or vegetation such as trash, dumpsters, trees or crops and that these exposures are targets of the source fires. The UL report misinterprets this data and presents it in a manner such that it is the fires originating from the building exterior that are causing an increased number of residential attic fires.

Not only is there no data to support the claims that residential structure fires from external exposures are increasing, there is no solid data presented to quantify this specific problem. Nonetheless, the first test series in the UL study focuses on the specific exposure of an exterior fire on the exterior wall. In this study, the test methodologies of the wall and the eave testing are weighted heavily toward certain construction materials (those that contain plastics and are more combustible than non-plastic products) and may not be fully representative of conditions in the built environment.

It is noted that one of the objectives of the study, as cited on Page 27, states, “Disseminate knowledge gained pertaining to the built environment to stakeholders that are able to impact the code process to improve the safety of the public and the fire service.” This objective appears to conflict with the statement made on Page 22, that “The research proposed herein is not to critique modern construction products and practices that assist in reducing our energy footprint but to understand the impact of these decisions on the dynamics (i.e., fire initiation, growth, spread, etc.) of fires originating either in the attic or on the home exterior and the hazards to firefighters on the scene.”

2.2. Wall Tests

The wall tests employed wall assemblies of various types of construction. Appendix A of the test report provides sketches of the various wall assemblies. The materials used and the specific assembly construction appears to have been chosen by UL.

The report describes “legacy” type exterior walls as having brick, standard stucco or wood-lap siding and fiberglass insulation in the cavities. The “modern” wall assemblies have synthetic materials for the exterior veneer such as vinyl siding and the addition of foam plastic insulation into the wall assemblies. Based on this differentiation, UL’s testing was focused on the “modern” wall assemblies to evaluate flame spread potential.

Additionally, the UL report states on Page 39, “To evaluate the effect these materials have on exterior fire hazards vinyl siding was chosen as it currently dominates the U.S. market with 33 percent of new homes constructed[45] and 30 percent of homes sold in 2012.” As a point of information, the references provided in the report are reversed, but the statistics reported for 2012 are accurate. However, 33 and 30 percent does not represent a “dominating” portion of the principal type of exterior wall materials used on new homes. Tables 1 and 2 provide more detail from the referenced census data that gives a more accurate representative of the distribution of exterior wall materials in new single-family houses. Tables 1 and 2 show that the percent of vinyl siding has decreased over the past 10 years by 8 percent and 7 percent for homes constructed and sold, respectively. In 2014, vinyl siding was used on the exterior of 30 percent of homes constructed, followed by brick (23%), stucco (23%), fiber cement (18%), wood (5%) and other (2%). The percentage of vinyl siding reduced to 28% for homes sold in 2014. There is clearly a decrease in the trend of using vinyl siding on the exterior of single family homes. Additionally, the information presented in the UL report is limited to new single family homes and is not broken down into regions of the country (Northeast, Midwest, South and West).

Table 1 – Principal Type of Exterior Wall Material of New Single-Family Houses Completed (Percent Distribution) [4]

Year	Brick	Wood	Stucco	Vinyl Siding	Fiber Cement	Other
2004	19	7	22	38	(N/A)	15
2005	20	7	22	34	9	7
2006	21	8	22	30	11	7
2007	23	8	23	30	12	5
2008	24	9	21	31	12	2
2009	23	9	19	34	13	2
2010	23	8	17	36	13	2
2011	24	8	17	34	15	2
2012	24	6	19	33	16	2
2013	25	5	22	31	16	2
2014	23	5	23	30	18	2

Table 2 – Principal Type of Exterior Wall Material of New Single-Family Houses Sold (Percent Distribution) [5]

Year	Brick	Wood	Stucco	Vinyl Siding	Fiber Cement	Other
2004	19	5	26	35	(N/A)	16
2005	22	6	25	31	9	7
2006	24	5	22	31	13	5
2007	25	5	24	32	11	3
2008	25	6	23	32	12	2
2009	25	6	22	34	12	1
2010	24	6	22	36	12	1
2011	24	5	23	33	13	1
2012	25	3	26	30	15	1
2013	25	3	26	28	17	1
2014	24	3	26	28	18	1

The wall assemblies consisted of 8 ft. wide x 8 ft. high walls using either 2 x 4 or 2 x 6 wood studs. The various test materials were then installed on and/or in the walls. The types of materials used in the wall construction are summarized in Tables 3, 4 and 5 for siding, sheathing (structural, i.e., plywood and insulating, i.e., foam plastic), and cavity insulation respectively. Vinyl siding was used as the siding material in over half (56%) of the tests. Similarly, polystyrene sheathing was used in 56% of the tests. Fiberglass was predominately used as the cavity insulation (78%). The report did not provide a logic path for the selection of the various construction methods and/or various materials used in the wall assemblies.

Table 3 – Siding Materials used in Wall Experiments

Siding Type	Number of Experiments
Vinyl	18
Wood lap	3
Fiber Cement	1
None	1
Stucco	4
EIFS	4
Aluminum lap	1
Total	32

Table 4 – Sheathing Materials used in Wall Experiments

Sheathing Type	Number of Experiments
Plywood	11
Polystyrene	18
Polyisocyanurate	2
Polystyrene and Plywood	1
Total	32

Table 5 – Cavity Insulation Materials used in Wall Experiments

Insulation Type	Number of Experiments
Fiberglass	25
Open Cell Spray Foam	4
Closed Cell Spray Foam	2
None	1
Total	32

On March 15, 2013, UL convened a “Residential Attic Fire Mitigation and Exterior Fire Industry Technical Panel.” The panel consisted of representatives of various construction material manufacturers, home builders, and the fire service. While this panel had discussions with UL concerning this project, UL did not seek their assistance at a later date to provide input into the construction of the various test assemblies and the materials selected for use.

Thus, the following questions and/or observations are made:

- Wood sheathing - Why was plywood selected as a sheathing material whereas oriented strand board (OSB) is the primary sheathing used in one- and two-family residential construction? The American Wood Council (AWC) reports that the Flame-spread Indices derived from ASTM E 84 testing of various plywood types and OSB are somewhat similar. [6] However, the comparative fire performance of these materials may change when the materials are installed in a vertical configuration and exposed to a different fire source. Thus, the use of OSB may have provided different results or timing of fire growth but this was not investigated.
- Depth of studs – The depth of the studs used to construct the various wall assemblies were not constant. In the majority of the test, 2 x 6 studs were used while in several wall assemblies, 2 x 4 studs were used. No explanation for these variations is provided in the report.
- Differences exist between the constructions of some wall assemblies described in Volume 1 versus the drawings of those wall assemblies in Appendix A. As an example, In Appendix A, Wall Type 9 has R-Board (a polyisocyanurate foam) as the sheathing while in Volume 1 the sheathing is identified as polystyrene foam.
- Use of vinyl siding - Since vinyl siding was used in the majority of the tests, it would have been appropriate to quantify the flame-spread of the vinyl siding by itself with a test over gypsum sheathing. This type of test may have provided some additional insight into the progression of the fire in the various assemblies.
- Open edges on the walls – In reality, wall systems do not have open sides. The sides are closed in some manner. In these tests the edges of the wall systems were not finished and thus the open edges, especially in the vinyl siding tests, could provide air flow into the wall system and this may increase the burning rate or the lateral movement of the flames.
- Foam plastic mounting - For wall types: 8, 9, 10, 11, 12, 13, and 14, the foam plastic insulation was applied directly to the studs instead of over sheathing. When foam plastic insulation is placed directly over the studs, either let-in type wall bracing or end-of-wall bracing with wood structural panels must be used. However, these types of bracing are not commonly used in practice. It is our understanding that the most common application of exterior foam plastic sheathing is over OSB. By eliminating the OSB and using the let-in bracing, UL used an atypical construction technique that is not reflective of current building practice. The use of the OSB sheathing behind the foam plastic insulation may have provided different results.

The ignition source used in the majority of the wall tests was a line burner that was approximately 39-inches wide by 4-inches deep and the top of the burner was approximately 16-inches above the bottom of the wall. It is unclear if the burner was in touch with the wall or spaced some distance away. There is no discussion in the report as to what the line burner exposure is intended to represent, although the configuration of the wide flame directly adjacent to the wall maximizes the potential for ignition of the wall materials.

Various burner outputs were evaluated but the 100 kW heat output was used in the majority of the testing. In some testing, burner outputs of 50 kW, 150 kW, 200 kW and 300 kW were also employed. It appears that the 100 kW fire produced a flame that was approximately 4 ft. high on the test walls. Thus, for combustible materials, the vertical flame spread is only measured over the top 4-ft. of the wall. To provide a better measure of the vertical flame spread, a taller wall might have provided some differentiation.

The 100 kW fire appears to have been selected so as to provide ignition and flame-spread on the base wall assembly of vinyl/Tyvek/plywood. This size of the fire is fairly large and continuous and thus its relationship to actual exterior exposure fires is unclear.

In Test Nos.15 and 16 a propane fired gas grill was used as the ignition source. In the tests, the grill is ignited and it is assumed that the burners were turned to maximum heat output during the tests. In Test No. 15 which involved the vinyl/Tyvek/1-in. EPS assembly, the grill was ignited and placed 2-inches from the wall surface. The test proceeded for 40 minutes during which time the vinyl siding began to melt however no ignition had occurred. At the 40:02 (mm:ss) mark, the gas grill was pushed into contact with the wall surface. After another 5 minutes, the first sign of flames was noted and the fire exhibited vertical flame-spread shortly thereafter but only after the grill was placed in contact with the wall.

In Test No. 16 which involved the same wall construction as Test No. 15 but with plywood in lieu of the EPS, the gas grill was placed in contact with the wall surface. In this test, the vinyl siding began to distort or melt at approximately 5 minutes, and the first sign of flaming occurred at 15:40 (mm:ss). In this test, the fire growth on the wall was limited to less than the height of the wall.

Due to the totally different fire exposures between the two tests, the fire performance between the two tests is not a valid comparison. In fact, when gas grills are typically used, the grill has to be more than 2-inches from the wall for the lid to be opened. In Test No. 15, even with the two inch spacing, the wall assembly showed good fire performance since the grill did not ignite the wall for 40 minutes.

In the report, the wall experiment analysis primarily compares the non-foam plastic containing wall assemblies to the wall assemblies containing foam plastic. Additionally, comparisons are made between wall assemblies that contained vinyl siding versus other claddings.

Overall, the wall experiments indicated:

- Larger ignition sources cause larger and faster fires;
- Combustible foam plastic insulation, when exposed to a large enough fire, will ignite, burn and release heat;
- The use of an exterior veneer that does not melt and expose underlying combustibles will provide longer times to ignition of the underlying combustibles; and,
- More combustibles placed on or in the wall assembly will increase the fire growth and overall heat release of the wall.

These observations were the expected outcomes of the exterior wall testing conducted, based on the configuration of the walls and the size of the ignition source. In essence, combustible wall assemblies will ignite and burn, some more rapidly than others. With vinyl siding as the cladding and with different underlying sheathings, the time to reach 7 ft. flame height varies between 1:19 (mm:ss) for the walls with foam plastic sheathing and 2:25 (mm:ss) for the walls with plywood sheathing. The difference in time of 1:06 (mm:ss) is not that significant. Additionally, as would be expected, the walls with the foam plastic sheathing exhibit higher heat release than the walls with the plywood.

2.3. Eave Tests

The three eave tests evaluated three different wall assemblies to evaluate vertical fire growth and penetration into a simulated attic space via eave vents. The eaves were constructed using vinyl soffits and plastic air baffles. The three tests involved the following wall assemblies:

1. Vinyl/Tyvek/plywood/2x4/R13 insulation/gypsum wallboard
2. Vinyl/Tyvek/1-in. EPS/2x6/R19 insulation/gypsum wallboard
3. Vinyl/Tyvek/1-in. EPS/2x6/SPF in cavity/gypsum wallboard. Additionally, the attic area including the eaves and the underside of the roof deck was sprayed with SPF.

No explanation was provided as to why these assemblies were used for the eave testing, however, the assemblies tested represented wall assemblies that exhibited a range of fire growth from slower to faster.

As expected, based on the wall assembly tests, the wall assemblies with the foam plastic insulations exhibited the faster vertical flame spread. In Test Nos. 1 and 2 flames did enter the attic space and entrance occurred the earliest in Test No. 2. In Test No. 3, as expected, the flames at the eaves were held back from the attic space for a time due to the charring of the SPF. Additionally, Test No. 3 exhibited the most lateral flame spread at the eave are due to the thermoset SPF remaining in place and burning.

The eave tests utilized a worst case condition because the eaves were constructed using vinyl soffits and plastic air baffles. Both of these products will melt rapidly and provide a pathway for the fire to enter into the attic space. Other common eave construction materials such as wood or metal soffits (with varieties of venting methods) were not evaluated. Overhanging eaves without soffits were not tested. Only one overhang depth (1’-6”) was evaluated, while other depths of eave overhangs are common.

The reproducibility of the eave tests is questionable, given that a variety of ignition and flame-spread results occurred. A more reproducible test method that may be more beneficial to the results would consider a burner of variable heat release output positioned beneath the eave overhang.

2.4. Full-scale Attic Tests and Knee Wall & Attic Field Experiments

The portions of the report dealing with the strategic mitigation or suppression of attic fires through full-scale testing and field testing appears to be the most useful and pertinent for the firefighter community. The full-scale attic tests each utilized combustible fuel packages originating within the attic space. The fire spread that was evaluated in the wall and eave tests was not utilized in the full-scale tests, which increases the value of the attic test results from the standpoint of limiting potential test variations.

3. SUMMARY

In general, the report appears to have two different objectives. The first objective is the use of the wall and the eave tests to show the difference in fire performance between “legacy” and “modern” wall constructions. The second objective is to evaluate and develop fire-fighting techniques for the mitigation or suppression of attic fires.

In Section 10.1, UL is correct that there is an increased use of foam plastics in exterior walls so as to meet the new energy efficiency requirements contained in the ICC International Residential Code and the ICC International Energy Conservation Code. These requirements were initiated by the U.S. Department of Energy (DOE). This increase in use of foam plastic insulations may actually increase as ICC, DOE and others push for housing to be even more energy efficient. Currently, the traditional “noncombustible” insulation materials such as fiberglass or mineral wool have significantly less R-value per inch of material and their use alone to meet the energy requirements would dramatically increase the depth of wall studs and the wall itself.

UL states several times (Sections 10.1, 10.1.1) that older homes with brick, stucco, etc. veneers exhibit better fire performance than walls with vinyl siding and foam plastic insulation. They state that this performance will be different even with exposures such as a mulch fire, grill, small trash can or potted plant fire. It is unclear as to how UL came to these conclusions. UL used significant fire exposures in their testing and these types of smaller fires were not evaluated and thus the various wall’s fire performance is unknown.

With the 100 kW ignition source used, it is not unexpected that many of the “modern” exterior wall assemblies ignited, exhibited vertical flame-spread and exhibited higher heat release.

Additionally, the testing showed that some “modern” veneers such a two-coat elastomeric stucco or EIFS provide excellent performance even though the assemblies contain foam plastic insulation.

Attic fires can be initiated by many different paths such as: fire initiated within attic space or fire enters the attic from interior of the house or fire enters the attic through a wall cavity or fire enters the attic via the eaves and the exterior wall or a flame plume exiting a window or another opening in the wall. This study looked at only two of these potential fire scenarios, either via the exterior wall & eaves or within the attic space.

UL states, “The research proposed herein is not to critique modern construction products and practices that assist in reducing our energy footprint but to understand the impact of these decisions on the dynamics (i.e., fire initiation, growth, spread, etc.) of fires originating either in the attic or on the home exterior and the hazards to firefighters on the scene.” However, the wall and eave tests appear to target, and in some instances isolate, specific combustible materials used in exterior wall construction, suggesting that there is a growing problem with the use of “modern” construction materials. Of no question is the fact that attic fires are challenging and can be dangerous to firefighters.

The naming of Section 6.6 as “Most Hazardous Wall Assemblies” is not in keeping with a technical report. In fact, all of the exterior walls except those with stucco or EIFS, ignited and exhibited flame spread to the top of the wall assembly, some faster than others and some producing more heat than others.

In summary, exterior walls in one- and two-family housing are allowed to contain combustible materials by virtue of the building essentially being of Type V Construction. Additionally, the vast majority of the exterior walls are not required to have any fire-resistance rating by virtue of their fire separation distances. Thus, the “modern” exterior walls can potentially exhibit vertical flame spread and the fire may enter into the attic space via the eaves. However, similar fire spread into the attic with brick exterior walls could occur with an interior fire’s flame plume exiting a window, exposing the eaves and entering into the attic.

4. REFERENCES

1. Kerber, Stephen and Zevotek, Robin, Study of Residential Attic Fire Mitigation Tactics and Exterior Fire Spread Hazards on Fire Fighter Safety, Underwriter’s Laboratories, Northbrook, IL on-line published date of April 9, 2015.
2. United States Fire Administration (USFA) Topical Fire Report Series, “Attic Fires in Residential Buildings,” Volume 11, Issue 6, January 2011.
3. United States Fire Administration (USFA) Topical Fire Report Series, “Fires and Exposures,” Volume 7, Issue 2, August 2007.
4. "United States Census Bureau." Characteristics of New Housing Completed. https://www.census.gov/construction/chars/completed.html. 18 Nov. 2015.
5. "United States Census Bureau." Characteristics of New Housing Sold. https://www.census.gov/construction/chars/sold.html. 18 Nov. 2015.
6. Flame Spread Performance of Wood Products Used for Interior Finish, Design for Code Acceptance, American Wood Council, 2015.