January 16, 2013

Betsy Steiner
EPS Industry Alliance
1298 Cronson Blvd. Suite 201
Crofton, MD 21114

Re: Safer Insulation Solution Code Change Resolution Rebuttal

Dear Ms. Steiner:

As per our proposal, we have examined the Code Change Resolution submitted by the Safer Insulation Solution (Ref. 1) and the accompanied paper by V. Babrauskas (Ref. 2). In summary, the referenced documents claim the following:

1) Fire safety will not be decreased by waiving the fire performance of foam plastic insulation in IRC 316.3 in lieu of placing a protective thermal barrier in front of non-FR treated foams for wall and ceiling constructions or where the foam insulation lies on the exterior and below grade of buildings.
2) The ASTM E84 test method does not represent full scale test results for foam plastic insulations.
3) Halogenated FR treated foam plastic insulations are a health hazard that poses a threat greater than the fire hazard of non-FR treated foams when protected as defined above.

With full respect for Dr. Babrauskas as a fire scientist, we disagree with these claims as described below.

On item 1, Ref. 2, it is stated that:

Current codes require foam plastic insulation materials to have both protection by a thermal barrier and compliance with Steiner Tunnel test requirements [. . .] Insulations protected by a thermal barrier are fire safe and the use of flame retardants does not provide any additional benefit [. . .] Changing the building codes could prevent health and environmental harm from the toxicity of these substances without a reduction in fire safety.

We acknowledge that the first statement is in fact true. However, the second and third statements are faulty. It is a logical fact that any building system which incorporates FR treated foam plastic insulation is inherently more fire safe than the same system with non-FR treated foam plastic insulation – regardless of the history used to justify the statement. As an example, the Brown's Ferry Nuclear plant fire was due to untreated polyurethane foam.

The paper later states:

During a room fire under pre-flashover conditions, gypsum wallboard can essentially withstand indefinitely long fire exposure.

This is impossible. A standardized “ASTM” fire test room undergoing a 600 kW fire (pre-flashover) will damage gypsum wallboard in a finite and relatively short period of time (Ref. Personal experience conducting hundreds of room fire tests).
In the section describing the adequacy of thermal barriers, the paper states:

**According to the 2012 IBC Section 2603.4 and IRC Section R316.4, after 15 minutes, the temperature at the interface of the thermal barrier and foam (back of thermal barrier/ front of foam) cannot exceed the criteria of NFPA 275: 121°C (250°F) average with 163°C (325°F) at one peak value thermocouple (NFPA, 2009).**

The paper has not correctly interpreted the allowable temperature rise values. They have taken them to be absolute temperatures, which is not correct. The temperatures stated should be interpreted as a temperature rise above ambient. (i.e., a Delta $T_{\text{avg}}$ of 250°F = 139°C and a Delta $T_{\text{ind}}$ of 325°F = 180°C)

Later, the paper states:

*D’Sousa et al. (1981) ran a full-scale room corner test where a 1/2 inch gypsum barrier protected expanded polystyrene (EPS) foam insulation for 30 min, as judged by the temperature criterion and absence of fire involvement of foam.*

The flaw with the interpretation of this test is that even though the temperature was below the auto-ignition of the EPS, it was well above the melting temperature, so the EPS would have been melted into a pool at the bottom of the assembly. In essence, after a short period, the wall cavity was essentially empty except for a molten pool of EPS at the base of the wall.

In the section which discusses the validity of the Steiner Tunnel test, it states:

*Flame spread ratings by ASTM E84 tunnel test should be disregarded for foamed plastics.*

This ignores the difference between thermoplastics and thermoset foams. A thermosetting foam (i.e., polyurethane and polyisocyanurate) will not melt and drip and hence are correctly evaluated by the E84 test method as currently written. Language is being developed in consensus standards to account for the specialized technique developed by UL for the manner in which thermoplastic foams behave in the Steiner Tunnel. For thermoplastic foam products, the flame spread and smoke measurements are made until the foam begins to burn on the floor of the tunnel. At this point, the time at which this occurs is noted and the test is continued following the procedure as described in the standard. Both sets of results are then calculated and reported (Floor FSI/SDI and Ceiling FSI/SDI). This technique has been in use for several decades and is well accepted by code officials. ASTM Committee E05 on Fire standards has recently (2012) balloted language clarifying this procedure for the ASTM E84 standard.

In the section which discusses fire propagation in wall cavities, it states:

*. . . and concluded that, in the absence of proper firestopping, fire can spread vertically inside wall cavities (Choi & Taylor, 1984) [. . .] that “the flame spread rating of the materials used in the tests was not a significant factor.” Thus, having a lower Steiner Tunnel flame spread test result for the insulation does not improve the fire safety of the cavities.*

While the testing cannot be refuted, what is not discussed is that the size of the fire source has a major impact on these results. For large ignition sources, the statements in the paper may be true. But, in order for fire/heat to penetrate a thermal barrier and cause an ignition, the source must be at or near flashover intensities for an extended duration – in which case the point is moot. Normally, buildings are compromised by the flammability of their contents. Most ignitions in wall cavities are caused by small ignition sources (electric shorts etc.). An FR treated foam insulation will take longer to ignite than non-FR treated foam (Ref. 3, 4). In some cases, depending on the severity of the ignition source (heat flux) and the presence or lack of excess oxygen, ignition may not take place and be sustained at all, in which case the FR treated system clearly outperforms the non-FR treated system (Ref. 5).
In the section describing exposed foam surfaces, the paper describes various studies which show that low flame spread values do not correlate with full scale room fire tests. Specifically, for one study, the paper states:

*The National Bureau of Standards (now NIST) similarly showed that uncovered polyisocyanurate and polystyrene foams having FSI < 25 showed very rapid flashover times when tested in full-scale room fire tests (Lee, 1985). Later NIST studies produced very similar findings for uncovered flame retardant-treated foams: XPS foams produced room flashover in 1.5 min, while EPS foams produced flashover in 1.4 and 1.8 min (Dillon, 1998).*

The paper then cites a list of facts based on these results that the Steiner Tunnel test method is not a good indicator of full scale behavior. It also states that exposed foams (FR and non-FR) not covered by a thermal barrier pose an “unacceptable” fire hazard.

For specific applications using foam plastics insulation covered under the referenced building codes, the use of unprotected foam would be in violation of the code requirements. Those who use non-FR treated foams without a thermal barrier are living with a “more unacceptable” fire hazard. By using FR treated foams, at the very least, the time to ignition of a foam surface will be longer than a non-FR treated foam (Ref. 3, 4). Also, as previously described above, the size of the ignition source is not discussed or compared. The fires used in room corner fire tests consist of two main types – namely wood cribs and gas burners of various intensities and sizes. In all cases, the size of the ignition source is quite severe (40, 160, 160 and 300kW depending on the test method). By comparison, the heat release rate of the Steiner tunnel is 88kW.

What is not discussed is that small ignition sources are what start fires. In the event of a real fire, if an ignition source reaches the heat release values matched by room corner fire test burners, the room will likely go to flashover via the ignition of nearby objects (including walls made of gypsum wallboard). Evidence shows that the paper lining of gypsum wallboard can cause flashover under the right conditions (room size and burner heat release rate). As previously stated, an FR treated foam insulation will take longer to ignite than non-FR treated foam (Ref. 3, 4). In some cases, depending on the severity of the ignition source (heat flux), ignition may not take place at all. FR treated EPS outperforms non-FR EPS by a factor of 10 at 20 kW/m² (Ref. 5).

The statement in the paper also has the opposite argument but is not discussed. We (Howard Stacy and Javier Trevino) have personal experience when employed as test Engineers at various fire laboratories (SWRI, Western Fire Center, Omega Point Laboratories, Intertek Testing) with testing various foam products which produce Class A ASTM E84 results, and perform well in room corner fire tests. Therefore, we can state that there are foam products with FSI < 25 that DO NOT cause flashover in room corner fire tests.

To expand on the discussion about how foams behave in large scale, the descriptions below describe what happens in room corner fire tests on EPS (Based on personal experience witnessing hundreds of room corner fire tests).

**Expected Results for Thin Applications**

In a room corner fire test of EPS, the flames from the burner typically melt the EPS quickly. If the foam is thin, the flames may never really ignite the surface of the foam. In some cases, as the foam melts and drips in the test corner, ignition may occur on the molten material attached to the wall. But if the amount of material is small (for thin applications), the wall flame may be short lived and not readily spread flames upward.

**Expected Results for Thick Applications**

However, for thicker applications, it may be possible to ignite the foam surface if the heat flux is high enough. If ignition of the surface occurs, flames can travel upward rather quickly for high density foams but may melt too fast for flames to travel for low density foams. If the flames reach the ceiling, the flames may cause ignition of ceiling foam (if the ceiling contains foam). However, ceiling foam will melt rather quickly resulting in a large pool of molten material on the floor of the test room. It is unlikely that flames
will spread along the ceiling due to the rapid melting of the material. However, as material melts, if it is in
the form of flaming droplets, a pool of molten material may turn into a floor pool fire. If the pool fire
becomes large enough, the heat release rate can ultimately reach the flashover point based on the heat
release rate per unit area (from cone calorimeter results). In cases where the smoke density is high, if the
heat release rate exceeds approximately 600 kW, ignition of the smoke plume may occur and cause a
rapid transition to flashover.

If the molten EPS from the ceiling is not in the form of flaming droplets (i.e., just molten EPS), a pool
begins to form with the highest concentration on the floor near the burner, then radiating outward. When
molten pools of EPS form on the floor near the burner, the pool may or may not ignite depending on
which test is being conducted. The NFPA 286 burner sits 6 inches from the floor such that burner flames
cannot contact the molten pool and radiation from the flames is insufficient to heat the pool to its ignition
temperature. However, the UL 1715 wood crib can ignite molten pools since it burns close to the floor and
drops glowing embers onto the molten pool as the crib disintegrates. The heat flux from the wood crib
may be high enough to ignite molten pools of EPS in the test corner. In this case, the pool may ignite on
the floor in the test corner and spread radially as the fire grows and increases the heat flux in the room
environment.

**Expected Result for Intermediate Thickness**

For cases where the application is neither thin nor thick (i.e., moderately thick such as 2 inches), an
intermediate result may occur in which there is enough material to spread flames upward and ultimately
form a small pool fire in the vicinity of the test corner. If the amount of material is small enough, flashover
of the room will not occur since the pool will not have enough energy to reach flashover levels or have
enough energy to ignite the smoke plume.

On the subject of the inadequacy of the Steiner Tunnel Test, the paper states:

*The most important reason for the inaccuracy of the Steiner Tunnel test is related to the mounting
geometry. The specimen is placed on the ceiling of a long, tunnel-shaped apparatus, with an exposure
flame directed from one end.*

This is referring to the fact that thermoplastic materials tend to melt and fall to the floor of the tunnel
apparatus – away from the flames. Based on the description above, what happens in the tunnel is the
same as what happens in a gas fire ignited room fire test. Upon ignition of the burner flames, the material
melts and drips away from the ignition source. In fact, the Steiner Tunnel accurately depicts what
happens in full scale room fire tests. The way in which a room flashes over has little to do with surface
flame spread as described above (for thermoplastic foams).

**Note:** UL’s method of separating the "ceiling" and "floor" burning in the E84 test was developed by
comparison to room burns, using EPS foam insulation and other thermoplastic materials. ASTM E05
is currently considering the addition of this separation in calculation methods to the E84 standard,
since it is accepted by the approval agencies.

On the subject of a more accurate test, the paper states:

*Foam plastic insulations treated with flame retardants as typically used in buildings are not able
to achieve the desired flame spread ratings in an accurate test such as ISO 9705 [. . .] typical foam plastic
insulation will exhibit severe fire spread behavior if present in the walls or ceiling of a room and not
covered by a thermal barrier. Thus, an accurate test would indicate this behavior and only tests that
misrepresent the actual performance are able to provide what appear to be acceptable results.*

First, The ISO 9705 test (or any other room fire test) does not give ratings. Results are represented as
heat release, smoke release, ceiling temperatures, floor heat flux, and visual flame spread
approximations. However, as described above, flame spread along surfaces cannot happen for low
density thermoplastic insulations (EPS). For these foams in moderately thin applications, when a gas
burner is used, it is possible for the foam to not ignite at all. Severe fire growth (not the same as surface
flame spread) can only happen if the molten foam on the floor ignites.
The paper later states:

_U.S. fire statistics support the idea that, due to use of thermal barriers, foam insulations very rarely present a fire safety problem. Insulation within a structural area most contributed to flame spread in 2% of U.S. home structure fires, resulting in 0 civilian deaths and 40 injuries (1% of total for the whole U.S.)._

What is not discussed is that the codes require the foam to have a low FSI, which is also contributing to this data.

Dr. Babrauskas, in his paper (Ref. 1), has claimed that the purported health hazards of the use of FR treated foam insulation pose a greater threat than the fire hazard of non-FR foam insulation. In our opinion, this conclusion is unsupported and there is currently no mechanism in place to realistically make such a comparison.

References:

1) Safer Insulation Solution Code Change Resolution to add an exception to IRC R316.3
3) Babrauskas – The Ignition Handbook. pp. 905, Table 172 shows clear evidence of adding FR to plastics increases the time to ignition.
4) Babrauskas – The Ignition Handbook. pp. 1072, Table 18 shows clear evidence of adding FR to EPS increases the time to ignition.
5) Babrauskas – The Ignition Handbook. pp. 908, Table 182 shows clear evidence of adding FR to EPS increases the time to ignition by a factor of 10 at 20 kW/m² heat flux exposure.

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