PRIEST & ASSOCIATES CONSULTING, LLC

January 30, 2017

Tom Harris
Demilec
3315 E. Division Street
Arlington, TX 76011

Re: Engineering Letter 10442
Number of Hatches vs. Volume in Unvented Attics

Dear Tom:

This letter serves to provide a recommended number of hatches vs. volume for unvented attic constructions utilizing Demilec Sealection 500 per EEV 10362B.

Background

According to the IRC section 807, an access hatch must be present if the attic meets certain height and area dimensions. The minimum size required is 22 inches x 30 inches. In unvented attics, pressure builds up in the room and is vented via the downward opening hatch as described in Priest & Assoc. EEV 10362B. For this reason, the attic hatch must be downward opening.

Problem

Builders are asking Demilec for recommendations on how to determine the number of hatches needed for large volume unvented attics. This is a new problem not yet encountered. The current approval (Intertek CCRR 1063) calls for a single downward opening hatch. It is assumed that the minimum size required by code will be used.

Calculations using NUREG 14 (one of a series of Excel spreadsheets which calculate various fire parameters), issued by the United States Nuclear Regulatory Commission indicate that the room pressure in an enclosed room (that has no vents) the same volume as an NFPA 286 room can reach as high as 82 psi during a 30 second 1 MW flashover event. This is more than enough pressure to cause structural damage during a fast fire event in an unvented attic.

Analysis

Roof Uplift Calculation

When performing structural calculations for pressurized attics, the uplift of the roof must consider the strength of the roof/wall connection. As long as the pressure is below the strength of connections, the roof should stay intact. For typical nailed connections and roof sizes, the strength of the roof/wall attachment can withstand an ultimate uplift capacity of 22 psf (1053 Pa). (Ref. Thesis Bagyalakshmi Shanmugam 2011 Clemson University, pg. 20). If an attic is pressurized to 22 psf, the roof will not uplift and detach. Note: The deadweight of most roofs is approximately 15 to 19 psf (Ref. 1), so the pressure must exceed 22 + 15 psf to cause uplift. For this analysis, we use 22 psf as a conservative maximum pressure value.

Ref. 1
http://homeguides.sfgate.com/load-limits-roof-building-68738.html

http://www.bgstructuralengineering.com/BGASCE7/BGASCE7003/BGASCE700302.htm

http://www.structural-design-solutions.com/images/Residential_Design_Loads_and_Construction.pdf

Gypsum Attic Floor Rupture Estimate

Based on the above maximum expected pressures, we resolve the issue if the gypsum board ceiling (attic floor) will or will not experience structural failure before the maximum pressure is reached.

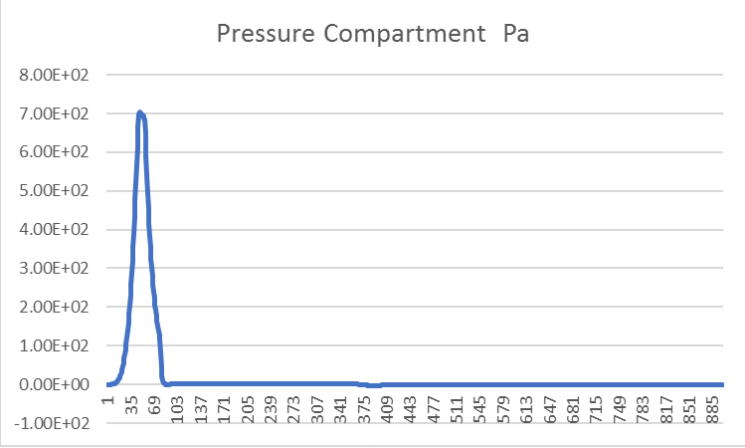
The requirements for gypsum wallboard (ASTM C1396-14 Standard Specification for Gypsum Board, Section 5.3 Nail Pull Resistance) include a minimum nail pull resistance of 80 pounds force for standard ½" gypsum wallboard. Assuming the joists are 24" OC, and the nails fastening the ceiling gypsum in place are spaced 12" OC along the joists, each nail is supporting 2 ft^2 of wallboard. Consequently, from the viewpoint of pulling the fasteners out and releasing the wallboard, it would take a minimum of 40 psf to do so. This exceeds the 22 psf pressure calculation so it is not expected that the attic floor will rupture.

CFAST Pressure Calculations
Definition – 28X Volume. The volume of an NFPA 286 room is 768 cubic feet. This is defined herein as a 1X volume. A 2X volume is 2 x 768 = 1536 cubic feet, 3X = 2304 cubic feet etc., so 28X = 21,504 cubic feet.

According to generic CFAST calculations, the peak pressure in a room is a function of room volume and opening size during a fast fire event. The relationship is not linear – a roughly 9X change in attic volume (from 3X to 28X) results in a hatch opening increase of 4x the area – or a 2X change in each linear dimension of the hatch opening to achieve similar peak pressures. Thus, a doubling of attic volume only requires a small increase in hatch area to maintain a specific peak pressure.

From this, calculations for a 28X volume can be used to determine the number of code compliant hatches (min. size 22 inch x 30 inch) needed for volumes exceeding 28X. By requiring that the number of hatches be directly related to the number of 28X volumes, the linear requirement is conservative (i.e., lower pressures will be achieved).

Using the same Demilec CFAST fire modeling used in EEV 10362B, a 28X room with a 22 inch x 30 inch hatch will reach a peak pressure of approximately 700 Pa (14.6 psf) (see graph below). This provides a factor of safety since the maximum allowed is 1053 Pa (22 psf). All volumes smaller than this will result in lower pressures.



Conclusion
For every 28X volume unvented attic (28 x 768 cubic feet = 21,504 cubic feet) – a hatch measuring a minimum of 22 inches x 30 inches (to meet IRC code) will keep the room pressure below the point where structural failure can occur (1053 Pa or 22 lbf/ft^2) during a fast fire event which causes pressure spikes.

Volumes smaller than 28X should use 1 hatch.

Volumes larger than 28X but smaller than 56X, should use 2 hatches.

Volumes between 56X and 84X should use 3 hatches.

And so forth in 28X increments and hatch number intervals of 1 extra hatch per every extra 28X volume.

We hope this satisfactorily addresses this subject.

Submitted by,

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January 30, 2017

Reviewed and Approved,

Deg Priest
President

January 30, 2017