DESIGN PRESSURE ANALYSIS OF VENTED LOUVERED SHUTTER

(by Michael A. Trapasso, P.E., June 25, 2008)

This report is a basic analysis of the forces, dynamics and testing of the "vented shutter", as compared to the "solid, non-vented type shutter.

The term "vented shutter" in this report refers to shutters with open, free flowing area to total area ratios of at least 50 % or more. The term "solid" or "non-vented" shutter in the report refers to a shutter with no openings, and tightly fitted to the structure.

A vented shutter, that protects a door or window opening, will be subject to pressures from high velocity winds under two different conditions. The first condition, referred to here as "CASE 1", is a condition where the opening has an intact door or window, in an enclosed structure, sealed against air flow. The second condition referred to here as "CASE 2", is a condition where the door or window is either broken or open and air is flowing through the opening.

Please study the attached "CASE 1" and "CASE 2" diagrams, notes A thru O, and the "Shutter Pressure Graph", as this is necessary to understand the following analysis.

In "CASE 1" the pressure equalizes on both sides of the shutter because no air is flowing through the opening. This is the same pressure exerted on the window or door. If the static pressure exceeds the window or door rating, the shutter will be of no consequence to a failure. Thus the vented shutter provides no opening protection from pressure, and therefore is only useful for "impact" protection. The net forces on the shutter from pressure, when the opening is intact, are zero.

In "CASE 2" the window or door is open or has failed and is allowing air to pass through it. The forces on the shutter are a result of several factors as referenced in note"H". The graph depicts differential pressures on the shutter in relation to percentage of the breached area of the opening. The solid shutter is subject to the full differential pressure regardless of the percentage of breached area. The vented shutter is exposed to higher pressures as the volume of airflow increases. The internal pressure coefficient of 18 % is not applicable when air is flowing through the opening. This is in addition to the reduced differential pressure of a free flowing vented shutter. A conservative estimate of 25 percent less differential pressure on the vented shutter in relation to the solid shutter is used for the graph. If the opening is breached by 50 %, the window or door is either open or has failed, and the corresponding differential pressure on the vented shutter is less than 30% of the differential pressure exerted on a solid non-vented shutter.

The above information is based on basic physical science and logical analysis of a real world situation as it applies to the "vented shutter". The graph for "CASE 2" clearly illustrates how the vented shutter is subject to variable pressures, based on air flow velocities, as opposed to a constant differential pressure applied to the solid shutter.

The Florida Building Code TAS 202-94 "Criteria for Testing Impact & Non-Impact Resistant Building Envelope Components using Uniform Static Air Pressure", and The Florida Building Code TAS 203-94 "Criteria for Testing Products Subject to Cyclic Wind Pressure Loading", are not real world tests when applied to a "vented shutter". A breached opening of 50% or more is considered a total failure, and as clearly illustrated in the graph, the vented shutter, at this stage of window or door failure, has a fraction of the load imposed on it, as compared to the load on the solid shutter. The vented shutter only has a load applied to it after the window or door has failed.

The Florida Building Code TAS 201-94 "Impact Test Procedures" is the only test that applies to the "vented shutter". The design of the shutter to pass this test far exceeds the strength required to resist deflection from differential pressure. If the opening being protected is intact, the differential pressure is zero. Once the opening has failed, deflection control of the vented shutter for pressure is of no consequence.

Briscoe Shutters Inc. builds vented shutters for impact resistance only. The full testing procedure has been performed however, as if the vented shutter was solid, & non-vented. This provides us with valuable information as to the relative strength required for the shutter to resist impact as it relates to the shutter to resist pressure from static and cyclic testing. Following is a chart of test results that depict maximum deflections from impact, static, and cyclic tests, with all shutter openings covered with plastic for the pressure tests:

TEST #	MAXIMUM DEFLECTIONS (IN.) LARGE MISSILE IMPACT	STATIC LOAD	CYCLIC LOAD
0288-0611-07 #1		2.620	
0288-0611-07 #1A	1.750		+ 1.600/-4.600*
0288-0611-07 #1B	.900		+1.850/-1.650
0288-0314-08 #2	1.250	.060	+/- .125
0288-0314-08 #3	1.125	.389	+.500/-.688
0288-0314-08 #4	.625		+.375/-.625

* Shutter cracked from impact test, see test report.

From the above comparison chart we can interpolate the results to derive a more accurate analysis of the actual pressures (deflections) exerted on the "vented shutter" due to a failed opening.

Following is a comparison chart depicting large missile impact deflections relative to the actual reduced pressure deflections of a "vented shutter" at 50% of opening failure:

TEST#	LARGE MISSILE IMPACT	29% PRESSURE DEFLECTION (see pressure graph)
0288-0611-07 #1,1A	1.750	.78 (static)
0288-0611-07 #1B	.900	.55 (cyclic)
0288-0314-08 #2	1.250	.03 (cyclic)
0288-0314-08 #3	1.125	.20 (cyclic)
0288-0314-08 #4	.625	.19 (cyclic)

It is evident, from the above comparison, that the strength required of a vented shutter to resist deflection from impact, far exceeds the strength required to resist deflection from pressure differentials at 50% opening failure. This is because air is free to flow through the vented shutter. At greater opening failures the shutter deflects more, however the need for the opening to be protected from excessive deflection increasingly diminishes.

CONCLUSIONS:

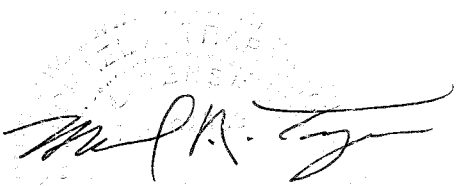
The preceding analysis clearly demonstrates the following facts:

1) The vented shutter provides no protection against static pressure.
2) The vented shutter provides impact protection only.
3) The vented shutter is only subject to differential pressures from a failed opening.
4) The vented shutter cannot, in real world field applications, be subject to pressures as if it were a solid, non-vented shutter.
5) As the deflection increases in the vented shutter, due to opening failure, the need for deflection control to protect the opening decreases.

RECOMMENDATIONS:

The static pressure and cyclic tests are not applicable to this type of shutter because differential pressures can only be exerted on the shutter after the opening has failed. The magnitude of this pressure is directly related to the velocity of air flowing through the shutter, which relates to the percentage the opening is breached. It is neither reasonable nor logical to cover the shutter with plastic and apply tests designed for shutters sealed against air flow. This is not a true representation of the performance of the shutter, and does not exist in field applications.

The testing for shutters defined in this report as "vented shutters" should be for impact resistance only. The Florida Building Code TAS 201-94 "Impact Test Procedures" is the only test that applies, and should be the only test required for "Impact Resistance Only" rated shutters.



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CASE 1

CLOSED WINDOW OR DOOR / FIXED GLASS

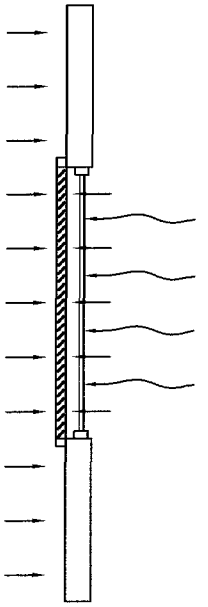
SHUTTER SIDE OF OF OPENING

A) Static pressure build-up from high velociy wind equalizes on both sides of a vented shutter.

B) The net force on the shutter from static pressures is zero at steady wind velocities.

C) Because the volume of air between the window or door & the shutter is so small, rapidly changing pressures due to gusting will equalize almost instantly with open areas between louvers above 50 % of total shutter area.

D) SHUTTER FORCES:
Net Force = 0
Deflection = 0



WINDOW / DOOR SIDE OF OPENING

E) There is no air flow through the window or door.

F) The window or door is subject to full static pressure from the wind plus the internal pressure built up in a closed structure.

G) WINDOW / DOOR FORCES:
Net Force = Static Pressure + Internal Pressure
Deflection = Maximum

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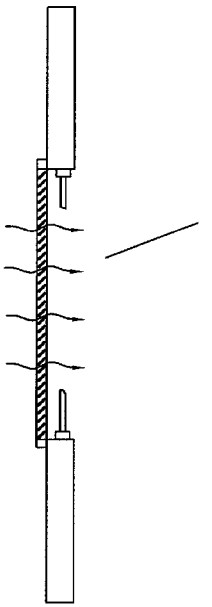
CASE 2

OPEN / BROKEN WINDOW OR DOOR

H) Air flows through the opening and exerts differential pressures on the shutter. The force exerted on the shutter is dynamic and based on the following factors:

1) Ratio of open to total area.
2) Angle of louver blades to direction of air flow.
3) Shape of louver blades
4) Velocity of air moving through the shutter.

I) It is obvious that accurate determination of the forces exerted on the shutter would require wind tunnel testing. The maximum force exerted on the shutter would be a percentage less than the force exerted on a solid, non-vented shutter.



J) Air flowing through shutter

K) SHUTTER FORCES

Net Force = % less than "non-vented shutter"
- (minus) internal pressure

Deflection = % less than "non-vented shutter"
- (minus) internal pressure

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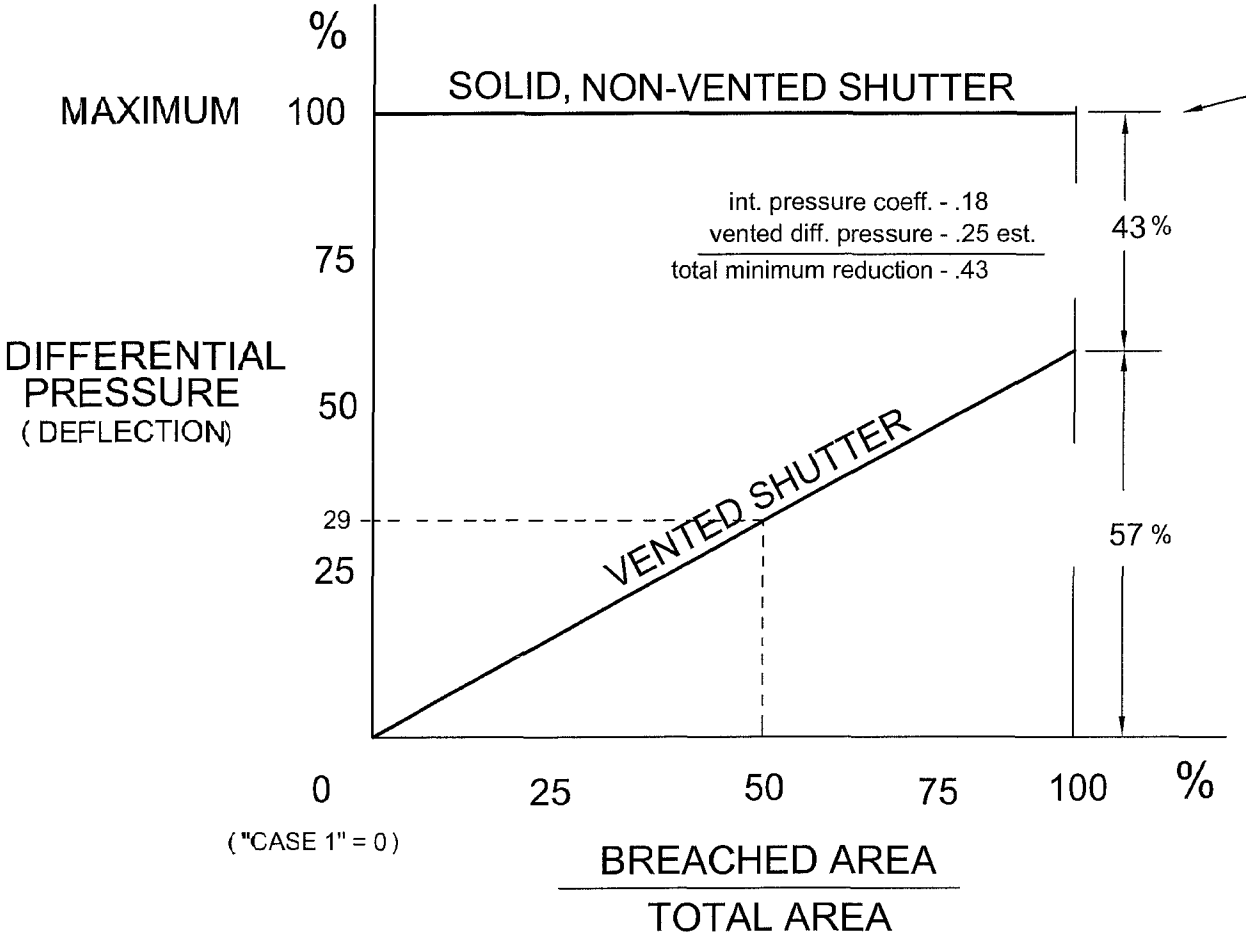
CASE 2

OPEN / BROKEN WINDOW OR DOOR



L) The solid, non-vented shutter is always subject to the full differential pressure because no air is flowing through it. The internal pressure coefficient is added to static pressure.

M) The percentage of breached area of the total opening is directly related to the velocity of air flowing through the vented shutter. The larger the percentage, the higher the velocity. The higher the velocity, the more drag / differential pressure, thus more deflection.

N) The vented shutter with vent openings greater than 50% will have considerably less differential pressure than a solid shutter.
A conservative estimate is 20 to 30 percent less differential pressure.

O) The coefficient of internal pressure (+/- .18) is not applicable when the opening is breached and air is flowing through it.

SHUTTER PRESSURE GRAPH

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DATE: 06/25/08 | PAGE: 3 of 3