Saflex™ and Vanceva™ Security Glazing meeting ASTM F3561[1] "Active Shooter"

The trend toward using more glass in building design has created opportunities to design for enhanced performance in many areas, but a concentration on safety and security are the current focus area for this document. Laminated glass, two or more pieces of glass held together by an interlayer, has long been used as safety glazing however certain configurations are also being designed for security applications while using known and proven interlayer materials. These glass units tend to have more penetration resistance capability than basic laminated safety glass and can range in performance from simple impact to multi-assault resistant glazing.

For interior and exterior glazing, special precautions against injury and loss must be considered. That's because ordinary glass windows can result in serious injuries when broken, causing dangerous flying, or falling shards. Unlike monolithic glass, however, laminated glazing made with Saflex™ and Vanceva™ Color PVB interlayers reduce the risk of injury because glass tends to adhere to the interlayer after impact—this ability for the laminate to break but stay essentially intact also adds to protecting the integrity of the building envelope.

Of course, glass can always be broken by accidental or natural causes. However, today's building and construction professional must also consider protection against manufactured threats, such as forced-entry and forced-exit, ballistics, and blasts—whether caused by nefarious sources or combustible industrial, materials during production or transfer.

While no single product offers complete protection from intentional attacks, laminated glass with Saflex PVB interlayers in properly designed systems can be a critical line of defense. These strong protective interlayers act to deter or delay attackers from gaining entry while protecting people and property from injury and damage. In recent years, interest has continued to grow rapidly especially regarding educational, industrial, government and commercial building applications.

Eastman has completed testing on various Saflex interlayer combinations in accordance with ASTM F3561 **Standard Test Method for Forced-Entry-Resistance of Fenestration Systems After Simulated Active Shooter Attack.** These tests have been performed on glass only in a frame which is specified in the standard. The glazing tested have been primarily conducted on laminates made with glass plies that are annealed and 3 mm (0.125 inch) thick. The test method consists of firing 10 bullets at the glass in a specified order and pattern (**Figure 1**) with the intention of gaining entry or weakening the glass. The laminate is checked after each shot to evaluate the ability to pass an arm through and is checked with a 152 mm (6 inch) solid sphere. If no entry is gained during the ballistic weakening, the laminate is then subjected to impact from a 45 kg (100 lb.) impactor (**Figure 2**) with a rounded nose cone. This is to simulate blunt impact after the glass has been weakened in as an attempt to gain entry. The drop height of the impactor is adjusted upwards for each progressing level of protection; however, the evaluation of each specimen always begins at level 1 and is cumulative. There are a total of 8 performance levels. Each level requires two impacts from impactor at the prescribed height to pass, therefore it takes 16 impacts with the impactor on the same, pre-weakened spot of the laminate to pass level 8, 14 impacts for level 7, 12 impacts for level 6 and so on. See **Table 1** for drop heights and impact energy.

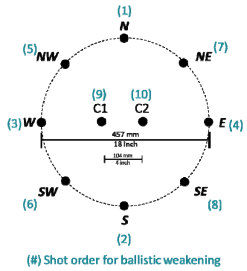

Figure 1: Ballistic Impact pattern

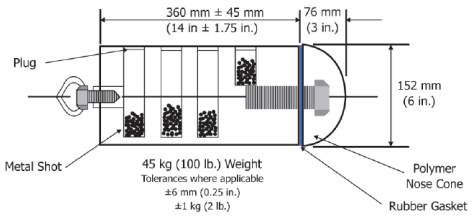

Figure 2: Impactor

[1] ASTM International, 100 Barr Harbor Drive, West Conshohocken PA. www.astm.org

Table 1: Impactor drop heights and energy

Level	Potential Energy		Height of Drop (H)	
	Joules (J)	ft*lb.	mm	ft
1	68	50	155	0.5
2	136	100	305	1.0
3	203	150	460	1.5
4	271	200	655	2.2
5	339	250	768	2.5
6	407	300	920	3.0
7	475	350	1076	3.5
8	542	400	1228	4.0

This method is meant to simulate reach-for-release, or full walk-through entry. In reach-for-release attempts, an opening only needs to be big enough to allow a gloved hand to fit through with little force, thus the 152 mm (6 inch) opening, to release a latched opening in a door or window. In full walk-through conditions, the glass typically vacates the frame creating an opening for full body passage.

The glazing configurations needed for these types of attacks vary with the protection level desired, but typically start with 0.76 mm (0.030 inch) Saflex Clear PVB interlayer and increase in interlayer thickness or are converted to a Saflex composite interlayer type when increased impact resistance is needed. Saflex composite interlayers, like Saflex Storm PVB interlayers, are able to be used as thinner overall interlayers (14-38% interlayer thickness reduction depending upon the level) allowing the glazing to reach similar or higher performance levels than those with conventional PVB interlayers.

Figure 3 shows the thickness trends of Saflex Clear and Saflex Storm (composite) PVB interlayer in meeting the various levels of ASTM F3561. In general, the glass only tests indicate that an additional layer of 0.76 mm Saflex Clear interlayer is needed for each level increase. For example, a level 3 laminate would need 3 layers of 0.76 mm (0.030 inch) or 2.29 mm (0.090 inches) of Saflex Clear PVB interlayer between two plies of 3 mm (0.125 inch) annealed glass. In limited testing, it was determined that Saflex Acoustic, Saflex FlySafe 3D, Saflex DM (HP) and other homogenous Saflex interlayers performed similarly to Saflex Clear. Per the standard, interlayers having color are allowed to be substituted for clear and therefore Saflex Solar, Crystal Clear, Extra Clear and Vanceva Color and Earth Tone interlayers are permitted to be assigned the same levels of performance as Saflex Clear. Saflex composite interlayers like Saflex Storm, have been demonstrated to achieve a level higher in ASTM F3561 glass only ratings than the comparative conventional PVB. **Table 2** provides an interpretation and grouping of the various levels outlined in the standard as they relate to attack. **Table 3** provides glazing system details and their performance levels based on glass only ratings on laminates with 3 mm (0.125 inch) annealed glass plies. It should be noted that in pilot evaluation, double laminated IGU systems were tested and performed to the same level as single laminated units having the same total amount of interlayer.

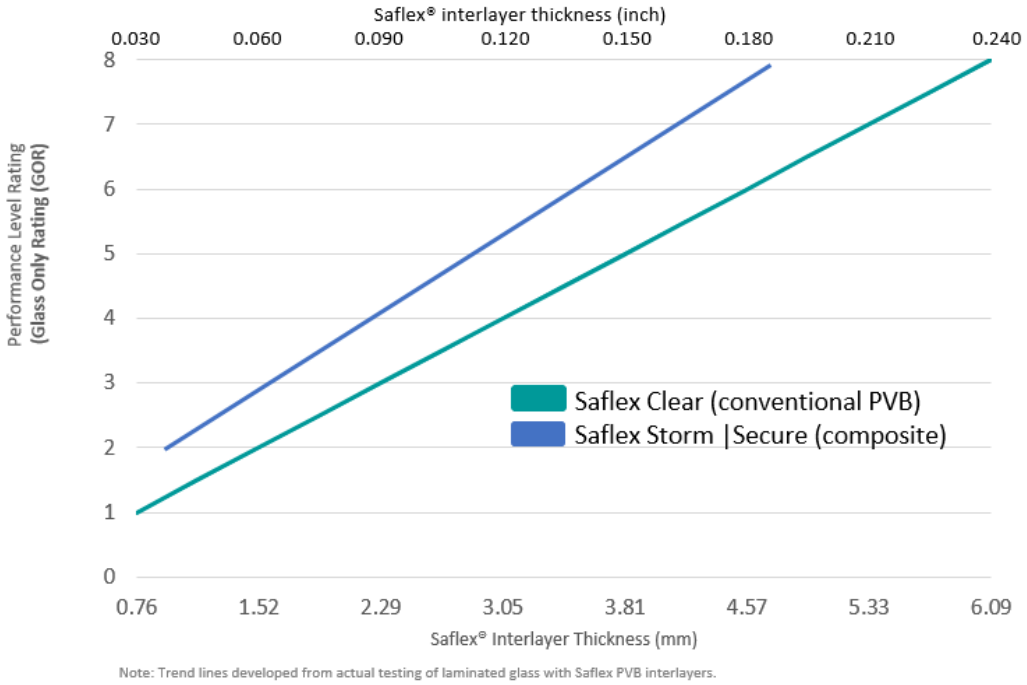

Figure 3: Laminated glass only performance to ASTM F3561

Table 2: Interpretation of ASTM F3561 Performance Levels

ASTM F3561 Level	Interpretation	Adjective
1 - 2	No immediate opening/void for arm penetration; body part impact	Good
3 - 5	Multiple high energy body impacts	Better
6 - 8	Repeated full body impacts for sustained time	Best

Table 3: Laminated Glass Configuration and Glass Only Rating (GOR) Levels

Interlayer	Interlayer thickness mm (inches)	Overall laminate thickness mm (inch)	Accumulated impact energy J (ft*lbf)	ASTM F3561 Level
Saflex Clear	0.76 (0.030)	7.11 (0280)	136 (100)	1
Saflex Clear	1.14 (0.045)	7.49 (0.295)	136 (100)	1
Saflex Clear	1.52 (0.060)	7.87 (0.310)	407 (300)	2
Saflex Storm VS	1.96 (0.077)	8.31 (0.327)	813 (600)	3
Saflex Clear	2.29 (0.090)	8.64 (0.340)	813 (600)	3
Saflex Clear	3.05 (0.120)	9.40 (0.370)	1356 (1000)	4
Saflex Storm VS*2	3.91 (0.154)	10.26 (0.404)	3796 (2800)	7
Saflex Clear	4.57 (0.180)	10.92 (0.430)	3796 (2800)	7
Saflex Storm VS-R_{30}-VS	4.67 (0.184)	11.02 (0.434)	4881 (3600)	8
Saflex Storm VS-R_{60}-VS	5.44 (0.214)	11.79 (0.4640	4881 (3600)	8

To achieve appropriate protection, the selection of glass, glazing details and framing system are important as the performance of the glazed system, as installed, is what delivers the security protection. Specific risks, threats, vulnerabilities, facility design and placement are aspects of security that also need to be considered.

Please consult your Saflex Industry Technical Engagement Manager by emailing glazing@eastman.com or send an inquiry through www.saflex.com for further information.

Keywords: Active Shooter, ASTM F3561, Ballistically weakened, forced entry, laminated, Saflex, Security.