EWFA Technical Paper

Adopted by the EWFA Technical Committee – March 14, 2024

Safety and Security Window Films and Their Installation

This Technical Paper has been produced by the European Window Film Association (EWFA). As the European Chapter of the International Window Film Association (IWFA), the EWFA represents the interests of the window film industry across the European continent and further afield by supporting its members efforts and increasing awareness of the use of window film products.

EWFA members are manufacturers and distributors of window film supplying high performance products for both architectural and automotive applications. Typical architectural applications include small and large residential buildings, commercial buildings (hotels, restaurants, shopping centres, airports), offices, schools, or industrial plants. Typical automotive applications include passenger cars, light commercial vehicles, commercial and industrial transport as well as service vehicles.

The objectives of this Technical Paper are:

- To educate and inform potential project holders on the correct selection and specification of window films in projects that desire improved safety and security performances on existing glazing.
- To guide designers and other project holders in identifying retrofit solutions that improve the safety and security performances of existing glazing systems.
- To provide an unbiased reference for window film professionals to guide project holders and designers in the selection, supply, and delivery of correctly specified and installed safety and security glazing solutions utilizing window film products.
- To assist all levels of window film professionals in understanding the interactions of glass and window films to address potential threats to the existing glazing systems.
- To assist all levels of project holders in identifying test protocols and certifications that are relevant to address any safety and/or security glazing threats.

1. Table of Contents

2. About Window Films

Since the 20th century, glass has increasingly been used in architecture, while the automotive sector has fostered the development of complex glazing, allying glass with other more resistant materials to enhance its properties. Indeed, despite its great qualities of transparency, allowing light and heat from the outside to slip inside buildings or vehicles, glass is a delicate and fragile material and a generally poor insulator.

Laminated glass was invented in the early 1900's, to make the glass itself safer by helping to prevent personal injury from shattered glass. Laminated glass was first elaborated via the insertion of clear liquid plastic between two layers of solid glass. This process was improved with the introduction of a polyvinyl butyral (PVB) film which was inserted between two layers of glass and then autoclaved under heat and vacuum to bond the glass layers together.

Enhancement of glazing systems with window films initiated in the 1960's, when window films were introduced as an aftermarket product installed on architectural glass to control the heating and cooling imbalances often found in buildings.

In their simplest forms, safety window film is composed of a polyester substrate (polyethylene terephthalate, PET) to which a scratch resistant coating is applied on one side; a pressure sensitive adhesive layer and a protective release liner is applied to the other side. When the release liner is removed, the side of the film with the adhesive is applied to the surface of the glass. All components must have high optical quality to allow undistorted vision through the glass and film. A standard window film can be made with multiple layers and undergo several coating and laminating processes to provide a variety of benefits.

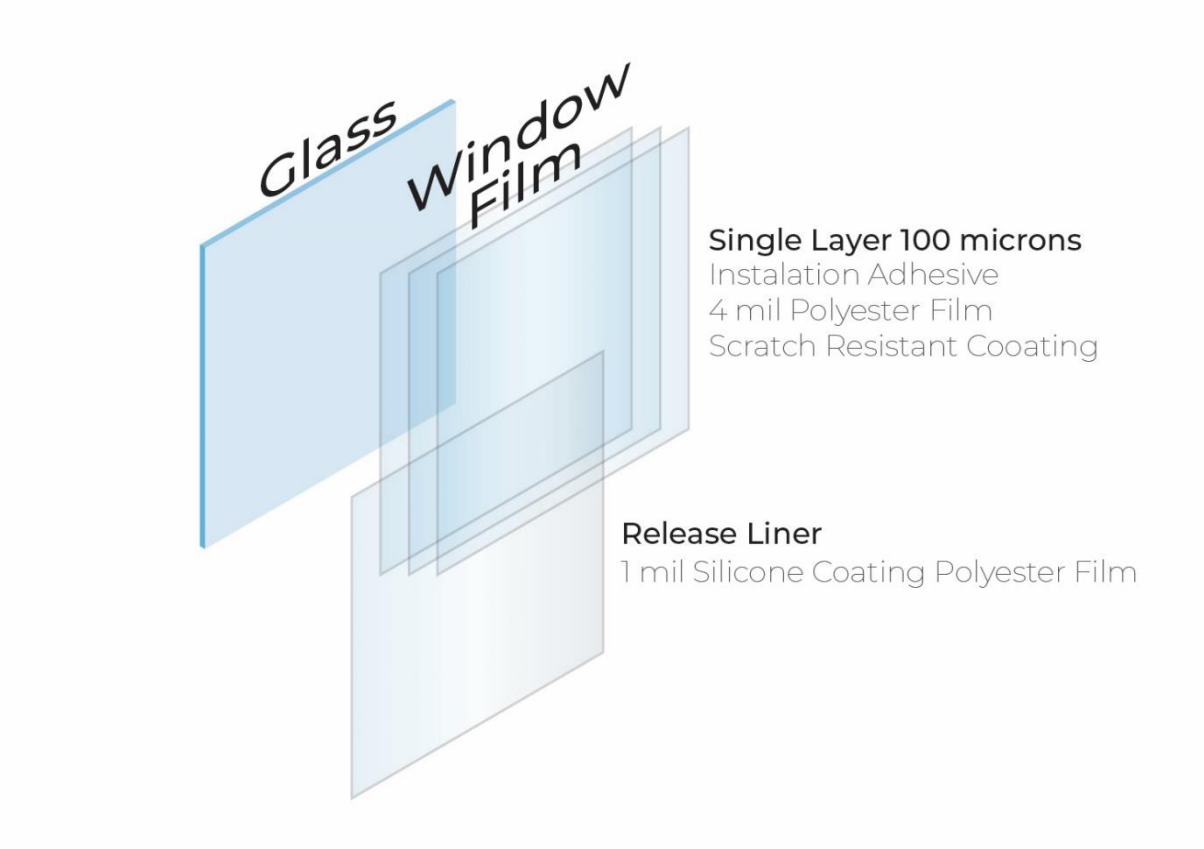

Figure 1 – Composition of a Window Film. Copyright: EWFA.

Did you know?

Important properties imparted by window films applied on glazing include:

- Blocking up to 99 % of harmful UV radiation (some of them recommended by the Skin Cancer Foundation),
- Heat absorption and/or reflection (to improve comfort and to help reduce cooling energy consumption),
- Glare reduction,
- Scratch prevention,
- Improving protection by helping holding glass together in the event of accidental or intentional breakage.
- Window films also come in a wide range of colour and shading choices, while providing increased privacy and protection.

3. What is a Safety or Security Window Film?

Developing from their initial solar control properties, thicker, safety and security window films increase the integrity and shatter resistance of glass and help hold breaking glass in place, minimising the risk of physical injury or damages in both automotive and building applications.

Glass being a fragile material, several conditions can result in accidental or deliberate glass breakage. Below is a list of the most common conditions to which glazing systems are exposed, and for which safety and security window films can be specified:

- Personal impact;
- Spontaneous breakage[2];
- Fragment retention;
- Vandalism/Graffiti mitigation;
- Intrusion/Forced entry;
- Facade pressure loading/High wind
- Blast mitigation.

Safety and security window films help to ensure that breaking glass is held in place and have been manufactured to provide enhanced safety. Indeed, different types of safety and security window films will perform different levels of protection (see box below). Highly tacky, thick, and tear-resistant, tinted, or clear, safety and security films can also reject UVs or be used in combination with other films on the same glazing (thanks to an installation of window films on both sides of the glazing).

Safety and Security Window Films

Safety window films are used in situations where people could potentially get injured by broken glass fragments resulting from an accidental or deliberate glass breakage. Security window films are replying to more specific and higher-level threats, such as anti-vandalism, anti-intrusion, or blast mitigation.

[1] The International Window Film Association (IWFA) has the utmost concern about any written specification or recommendation that would call for the use of any type of window film, such as a safety or security film, as a primary component of a "bullet-resistant glazing". Safety/security films are being used *in conjunction with* various designed and tested bullet resistance glazings, but primarily as a "spall shield" to reduce the "spalling" off of small fragments of the glazings on the interior side in the event of being penetrated by ballistics.
Our industry believes there are adequate and acceptable standards and methods for testing of products as protection against ballistics. Since window films are an addition to a glazing and not intended for use as the glazing itself, we firmly believe that an individual glazing should be tested both with and without film installed on it for any comparison of improvement in total performance. In some cases, we have seen demonstrations or claims that the use of film imparted some bullet resistant value when, in fact, the glazing itself without film had almost those same bullet resistant qualities. Extreme caution should be taken, however, to make sure that any claims about performance due to the addition of a film layer clearly state the specifics of the glazing itself as supplied by the glazing manufacturer, the specifics of the film itself as supplied by the film manufacturer, and all relevant specifics of the ballistics used and the conditions of the test. Any attempt to imply performance due to the application of the film under any other conditions (different manufacturer, different glazing, different ballistics, different conditions), we believe, would be irresponsible as the margin for error could be one of life safety.

[2] Spontaneous glass breakage is a phenomenon which can happen to toughened or tempered glass, at any time of its life, without the need of a specific impact. Using safety film on toughened glass is recommended, as it helps hold glass fragments together.

Figure 2 – Glazing and Safety & Security Window Film. Copyright: EWFA.

"Casualties from explosives are most frequently caused by the fragmentation of structural and other material. Studies on large bombing attacks show that 80 % of victims were killed or injured by primary and secondary fragmentation caused by the explosion. In turn, flying glass fragments were responsible for 80 % of injuries and deaths caused by fragmentation."

Source: UN Department of Safety and Security.

4. Use of Safety and Security Window Films

Whether used for decorative, solar or safety and security purposes, window film is primarily a retrofit product applied to an existing glazing system to improve its performance. The performances and reactions of window films therefore highly depend on the initial performances of the glazing to which it is applied, and its intrinsic thickness and properties.

Safety and security window films' primary use is to act as a "spall shield" and reduce the flying of small fragments in case of breakage.

While traditional window films are made of PET, their thickness can vary, safety or security window films can be installed in multiple interior/exterior combinations to help improve the glass resistance.

Safety and security window film manufacturers must make sure the advertised specifications are representative of the actual performances on a specific glazing. Calling for higher performances if the window films have not been tested on correct conditions are dangerous practices, especially for safety films.

IWFA and EWFA would like to attract the reader's attention on the fact that "bullet-resistant" window films do not exist. A combination of appropriate safety window films, glazings and frame arrangements is the only combination which could potentially lead to interesting "bullet-resistant" performances, which would have to be independently tested and verified before this claim can be made to customers. Demonstrations or laboratory test results performed which use any window construction, glazing, film, or installation method which differs in the type of window construction, glazing, or film that is being recommended to be installed should not be interpreted as evidence that the existing window construction and glazing with a film installed on it will offer the same results as listed in the test results or seen in a demonstration.

5. Safety and Security Window Films Regulations

Safety and security window films properties are highly regulated products. The following standards apply to them in the architectural sector:

5.1 EN 356:1999 - Testing and classification of resistance against manual attack

European standard EN 356:1999 - Glass in building - Security glazing - Testing and classification of resistance against manual attack. EN 356 distinguishes eight resistance classes, P1A - P5A and P6B - P8B, roughly distinguishing between "A" impact resistant and "B" break through resistant.

The standards specifies that "A" classes are determined by a 4,11 kg steel falling ball from different drop heights, and "B" classes by repeated impact loading with a two-kilogram axe and min. 11 m/s or approx. 40 km/h impact speed. Empirical tests[2] using appropriate test setups are used to classify bullet-resistant (C) and explosive-resistant (D) systems, the latter additionally requiring edge bonding or anchoring of the film to the frame.

When tested against EN 356, in favourable testing conditions, window films can reach an "A" class category. A combination of safety and security window films, appropriate glazing and frame arrangements can support increased performances.

5.2 EN 12600:2002 - Impact test method and classification for flat glass

Typical areas of application of this standard: care facilities (Kindergarten), food production facilities.

European standard "EN 12600 - Glass in building - Pendulum test - Impact test method and classification for flat glass" specifies a pendulum impact test method for single flat panes of

[2] Empirical tests are not standardised, and as such do not offer a possibility to compare between situations and products' performances. They can therefore bring to misleading conclusions.

glass for use in buildings (simulating an accidental human impact with glass panes)[3]. The test is intended to classify flat glass products in three principal classes by performance under impact and by mode of breakage. The classification by drop height corresponds to the amount of energy transferred by the impactor.

Impact Levels

Classification	Drop Height (in mm)[4]
Class 3	190
Class 2	450
Class 1	1200

The standard also defines three breakage modes: Type A breakage characterised by large sharp-edged fragments, Type B breakage characterised by the fragments being held together and Type C breakage characterised by the disintegration of the glass into small, less dangerous pieces. Type A is typical of annealed glass; Type B is typical of laminated glass and mirrors with a safety film backing; Type C is typical of toughened glass.

5.3 ISO 16933:2007 - Test and classification for arena air-blast loading

“International standard ISO 16933:2007 - Glass in building - Explosion-resistant security glazing — Test and classification for arena air-blast loading” provides a structured procedure to determine the air-blast resistance of glazing and sets forth the required apparatus, procedures, specimens, other requirements, and guidelines for conducting arena air-blast tests of security glazing.

5.4 EN 13501-1:2019 - Fire classification of construction products and building elements

This standard provides guidance for the classification of construction products by using data from fire tests. This will help to avoid potential safety hazards and ensure that the products used in construction are safe and compliant with applicable regulations.

“EN 13501-1: Fire classification of construction products and building elements - Part 1: Classification using data from reaction to fire tests” ranks construction materials in 7 classes with regard to their reaction-to-fire fire behaviour: A1, A2, B, C, D, E and F.

Euroclass	**Coverage**
A1 and A2	will cover products that do not contribute to the development of a fire.
B	will cover products that have a very little

[3] Both EN 12600 and EN 356 are included and harmonised on the EN 15752-1 Glass in building - Adhesive backed polymeric film - Part 1: Definitions and requirements.
[4] The drop height is the point of release from the centre line of the impactor at rest.

	contribution to fire.
C	will cover products that have a limited contribution to fire.
D	will cover products that have a contribution to fire.
E	will cover products that have a contribution to fire and are only able to resist ignition by a small flame for a short period.
F	is for products that have shown no performance criteria.

Besides this reaction-to-fire classification, the Euroclass classification system will rate also smoke and dripping.

For a Euroclass classification, materials need to be tested and the required classification describes how the material should be tested:

Euroclass	Coverage
A1	EN ISO 1182 and EN ISO 1716
A2	EN ISO 1182 or EN ISO 1716 and EN 13823 (SBI)
B, C, D	EN 13823 (SBI) and EN ISO 11925-2
E	EN ISO 11925-2
F	Fire behaviour not determined/no performance

Source: Euro classification EN 13501-1 - Magma Industries B.V.

5.5 EN 45545:2013 - Fire protection on railway vehicles

Typical areas of application of this standard: EN 45545 addresses manufacturers of railway vehicles, including high-speed trains, regional trains, tramways, metros, and double-decker trains. Typical window film applications in railway vehicles include safety window films, but also solar control or anti-scratch and graffiti mitigation window films.

“EN 45545 - Fire protection on railway vehicles” is a European rail standard which was published in 2013 to harmonise the different train management systems including fire, flammability, and smoke standards. It aims to protect railway passengers and staff against fires on board railway vehicles.

EN 45545 is a mandatory requirement across Europe for materials and products used on railway vehicles as defined in EN 45545-1, as the aim is to achieve an acceptable level of

safety in the event of a fire. If the objectives defined in Clause 4 of EN 45545-1:2013 are met, then there should be a high probability that in the event of a fire, passengers and staff will be able to escape from the fire unaided and be able to reach a place of safety.

5.6 GSA-TS01-2003

Typical requirement of U.S. government-owned buildings throughout the world.

This standard is the American version of EN 16933 (glazing resistance for blast mitigation). GSA-TS01-2003 (General Services Administration / Standard Test Method for Glazing and Window Systems Subject to Dynamic Overpressure Loadings, 2003.

This test standard is intended to ensure an adequate measure of standardization and quality assurance in the testing of window systems including but not limited to glazing, sealants, seats and seals, frames, anchorages, and all attachments and/or secondary catcher or restraint mechanisms designed to mitigate the hazards from flying glass and debris. This standard is the sole test protocol by which blast resistant windows and related hazard mitigation technology and products shall be evaluated for facilities under the control and responsibility of the U.S. General Services Administration (GSA).

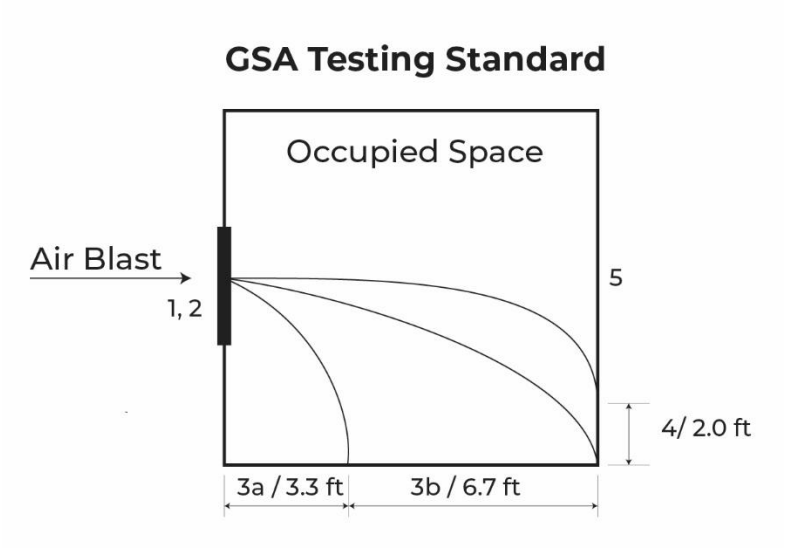

Figure 3 – US GSA Testing Standard. Copyright: EWFA.

6. Best Practises for Safety Window Films Installation

After the appropriate selection of safety or security window films in accordance with their specificities and intended use, installation is the next key step. EWFA has gathered below a summary of best practises from unpacking the chosen window films until the installation is finished.

6.1 Glazing Preparation

The glazing which will receive the window film must be cleaned with distilled water or detergent-free soaps.

6.2 Window Film Preparation

This part can be optional if the window film is already pre-cut/trimmed. For thicker (security) films as well as some safety films, it is recommended to pre-cut the window films and transport them flat or rolled loose with adequate packaging.

6.3 Installation on the Supporting Glazing or Frame

The tools used and squeegee process must be accurate, according to the window film manufacturer's instructions. The adhesion of the window film on the glass is related the force imparted to the film itself during the application process. A fast and rapid application with inadequate tools will not allow reaching the performances declared by the window film manufacturer.

6.4 Frame Bonding or Attachment

Safety window films can also be attached to a frame, reducing the impact in case of blows, storms or forced entry, and supporting for maintaining the glass pieces in place. The main types of attachments usually used are described in the figure below:

- Structural silicone caulking (Dow Corning 995 or similar), which is probably the most widely used type of attachment;
- Angle aluminium;
- Flexible anchoring system.

The performances of the three types of bondings or attachments presented above are usually measured by international standard ISO 16933:2007 Glass in building — Explosion-resistant security glazing — Test and classification for arena air-blast loading.

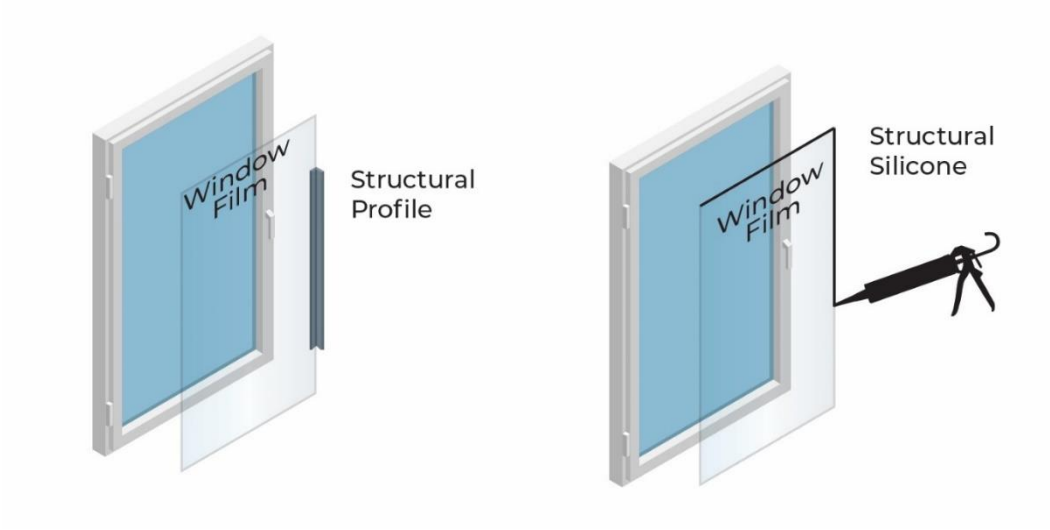

Figure 4 – Frame Bonding or Attachment for Safety & Security Window Films. Copyright: EWFA.

"Internal testing indicates that a window with safety and security film with an attachment system installed approximately doubles the amount of time for an intruder to gain entry compared to a window that has film applied without an attachment system".

Source: Llumar.

6.5 Drying

This step is crucial to allow the best adherence and transparency (no bubbles) in the installed window film. Drying time can differ depending on window film thickness, sunlight, temperature, or humidity. In case the installation involves a silicone attachment, do not clean the film or frame for at least 30 days following installation.

6.6 Marking

An installation mark is not compulsory, but it is good practice in the industry, supporting identification and traceability of the products over longer time periods. In this respect, a safety mark placed in the corner of each glazing pane is recommended.

7. Recommendations

To reach the performances declared by the window film manufacturers, it is recommended to precisely follow the manufacturer's installation recommendations. As responsible entities for the testing and performances of their products, window film manufacturers can also provide you with the necessary information for comparison between products and their performances and reactions.

The performances of safety and security window films are very closely related to their correct installation. EWFA and IWFA therefore recommend that safety and security films are applied by trained specialists or certified installers.

8. Sources

ISO 16933 (2007). Glass in building — Explosion-resistant security glazing - Test and classification for arena air-blast loading. https://www.iso.org/standard/38166.html

IWFA (2023). IWFA Architectural Visual Inspection Standard Window Film. https://iwfa.com/guidelines/

UNE EN 356 (2001). Glass in building - Security glazing - Testing and classification of resistance against manual attack. https://www.une.org/encuentra-tu-norma/busca-tu-norma/norma?c=N0024544

UNE EN 13501-1 (2019). Fire classification of construction products and building elements - Part 1: Classification using data from reaction to fire tests. https://www.une.org/encuentra-tu-norma/busca-tu-norma/norma?c=N0062154