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Factors Affecting Blast Performance of Glass and Glazing Systems

Common issues resulting in reduced blast performance on glass and glazing systems

Physical Security

Introduction

The blast resistance of glazing systems is critically dependent upon:

- a specification that reflects the customer's security requirements
- the correct interpretation of the specification by those involved in the design, supply and installation of the glazing
- the manufacture and assembly of components and assemblies in a factory
- installation of components and assemblies on site
- cleaning and maintenance throughout the life of the product
- maintenance of the glazing during its life.

Any one of these elements can have a potentially significant impact on the level of protection provided. If basic quality control steps are not in place to address the elements above a consequence may be that the glass may not provide the level of protection required from day one. In some cases, even if the right level of protection was installed its performance may be dangerously degraded after a couple of years.

Due to the specialist and complex nature of blast resistant facades, CPNI recommends that a component person is appointed (with both blast and glazing experience) to devise a QA approach to ensure that value for money is achieved whilst safeguarding protection.

The aim of this document

This guidance note is aimed at security managers and project managers who are responsible for the delivery of projects which have glazing systems with a blast design or mitigation requirement.

It provides a summary of the known issues/key items which, if not checked during the project life cycle, may impact the level of protection provide by the glazing system.

This guidance note should be read in conjunction with the suite of guidance notes produced by CPNI on the blast effects of glass and windows, which can be found on the CPNI website.

Items which may affect the blast performance of the glass and glazing system

The following list summarises some of the key items which should be monitored to ensure glass and glazing system will provide and maintain the intended level of blast performance.

- Has the risk from toughened glass fracturing due to inclusions within the glass been considered?
- Where laminated glass is specified, has the correct interlayer been used?
- Has the glass been installed in the correct orientation?
- Have the correct adhesives and sealants been used and installed correctly?
- Can water easily drain from the facade to reduce the risk of delamination and maximise the durability?
- Is the glazing system fixed to the building correctly?
- Is the glazing system being maintained, and are the correct cleaning products being used?

1. The use of toughened (fully tempered) glass within a facade

Toughened glass is a safety glass which is used within many facades and is produced by heating and rapidly cooling float glass. Toughened glass is at risk from spontaneous failure due to the risk from Nickel Sulphide (NiS) inclusions which can be present in the float glass. The inclusions are typically a few hundred microns in diameter and are not visible to the human eye. They are caused by either contaminants within the elements of the float glass, or from the equipment used to produce the float glass. As the float glass is heated and cooled rapidly, the inclusions also heat up but cannot cool down as quickly. Over time the inclusions increase in size which can cause the toughened glass to fracture. The speed at which this happens is dependent upon the initial size of the inclusions, the stress within the glass and the temperature the glass is subject to whilst in service.

Only glass which is toughened/fully tempered is at risk from failure due to the presence of NiS inclusions. It does not present a risk to float/annealed or heat strengthened glass.

When glass is broken, its resistance to blast loads tends to decrease. Hence the speed at which broken glass is replaced is important. The noise generated by toughened glass fracturing may also alarm building occupants as the sound generated maybe mistaken as gunfire which can cause significant safety and security issues.

To reduce the risk of NiS failures, it is recommended that the following measures are considered when specifying the façade glazing:

a) Ensure that all toughened/fully tempered glass is heat soak tested during the production of the glass

A destructive test method, known as 'heat soaking' has been developed for detection and removal of glass which contains nickel sulphide inclusions. During the heat soak test the toughened glass is stacked inside a chamber and heated to between 250 & 290°C. The heat soak process has been developed to accelerate the growth of the inclusions so that NiS failure occurs in the oven and not in service.

Reputable glass processors can heat soak test the glass in accordance with the European standard EN 14179 which defines the appropriate test method. It is recommended that 100% of the toughened/tempered glass is tested and the glass processor must be able to supply evidence of testing in the form of test records as well as confirmation that the heat soak oven has been correctly calibrated.

b) Investigate alternative glass types

In some circumstances, it may be possible to replace the toughened glass with a heat strengthened glass product. Heat strengthened glass is produced by rapidly heating float glass and cooling it slowly, resulting in glass which is 2-3 times stronger than annealed glass but half the strength of toughened glass. Due to the slower cooling process, it is not considered at risk of spontaneous failure due to the presence of NiS inclusions within the glass. Heat strengthened glass is increasingly being used as a replacement for toughened glass (due to this risk), however, unless it is laminated it is not considered as a safety glass product as its break pattern is similar to annealed glass creating large shards. A structural and risk assessment should be conducted to determine if a heat strengthened glass product is a viable alternative to toughened glass.

Where toughened glass has already been installed within a façade, it can be possible to check if the glass has been branded as heat soak tested, by looking at the product standard contained within the branding (or kite mark if registered with the BSI). The branding is typically located in a corner of the glass, and will include the glass processor's name and a list of standards which the product has been processed in accordance with. If the glass has been toughened, it will be branded with either (BS) EN 12150 or (BS) EN 14179. If the glass has been branded to EN 14179, it suggests that it has been heat soak tested and the risk of failure in service due to NiS inclusions should be significantly reduced.

2. Has the correct glass Interlayer been selected and used?

Where there is a blast requirement, usually laminated glass will be specified. There are a number of interlayer types which can be used to laminate glass. Polyvinyl Butyral (PVB) interlayers are the most common and are preferred for applications where blast performance is required.

There are a range of other interlayers which may be selected, depending upon the application and location of the glazing. The designers will consider the requirements of the glass when selecting the appropriate interlayer, for example, safety if it can break at height or security if there is a risk of bomb blast or physical attack. The details of the interlayer should be clearly defined in the specification i.e. interlayer type, grade and thickness.

It is very difficult to identify which type of interlayer has been used after the glass has been processed and installed. Therefore it is essential, that the correct information is clearly transmitted to the glass processor to ensure the correct type of interlayer is used. Where possible an inspection of the glass during fabrication should be conducted to ensure the correct interlayer is used.

3. Has the glass been installed in the correct orientation within the glazing system?

If a double or triple glazed unit or an asymmetric laminate is specified it will be designed for a specific orientation, often with a particular type of glass product on the external surface and another, different glass product located on the internal surface. It is critical to the safety and environmental performance of the façade that the glass is installed using the correct orientation.

Glass which has been installed in the incorrect orientation may not be easy to identify. The easiest way to check is prior to installation when the edge of the glass are visible. Once the glass is on site or installed the following methods can be used to check the orientation of the glass is compliant with the glazing specification:

- Inspect the edges of the glass prior to installation into the frame. The glass thicknesses should be checked against the glazing specification and should all be consistent in orientation.

- Use specialist survey equipment i.e. a glass thickness and toughened glass identification gauge, to check the glass thickness and identify the presence of toughened glass (if specified).

- Check for branding on the glass, which may also be referred to as the Kitemark. This should be visible at one of the corners. The branding should be consistent in location, i.e. always on the inside surface of the glass and located in the same corner. If the branding is inconsistent in its location, it may suggest that the glass has been installed in the wrong orientation.

- Visual checks may provide a clue that a glass has been installed incorrectly. When viewing multiple glass products which should all be manufactured to the same specification, if one or more provides a different appearance then it may provide a clue that the glass has been installed in a different orientation to the rest of the glass. Further checks should be conducted.

Where a blast requirement has been identified and double glazed units specified with a laminated inner pane and a toughened outer pane, it is extremely important that it is installed in the correct orientation. If not, and the toughened glass is inside the room, this may have the opposite affect and create a significant glazing hazard to people inside.

4. Have the correct silicones and adhesives been used?

Within glazing systems silicone may be used for a number of reasons:

1. during the production of insulated glass units (IGUs), or double glazed units, to form a hermetic seal between the individual panes of glass around the perimeter.
2. to structurally secure glass to a supporting frame
3. to form a weather tight seal around the glass.

In all of the uses above, the type and adhesion of silicone to the substrate i.e. glass or frame, is critical to ensure a full strength bond is achieved. The specification of the silicone should be provided within the design. The correct preparation of the surfaces is critical to ensuring the correct adhesion and to give a consistent bonding surface. Both the glass fabricator and façade contractor should be able to prove they are competent in the application of silicones (silicone manufacturers can provide training) and where appropriate understand the requirements of ETAG-002,' Guideline for European technical approval for structural sealant glazing kits (SSGK)'.

If incorrect silicone is used or poor adhesion occurs, it may affect the blast performance of the system, especially if the design is reliant on a fully bonded connection i.e. where the glass is structurally secured to the frame.

5. Can water easily drain from the glazing system?

Facade systems typically utilise internal drainage within the frame to ensure that any water which enters the facade system can escape via drainage holes which are located at the base of the frame/mullion/transom (see figure 1).

Long term contact between the water with the IGUs could cause premature failure of the IGU edge seals and delamination of the glass (See Guidance note: 'Influence of delamination of laminated glass on its blast performance', CPNI EBP 04/13: July 2013)

Most proprietary systems include some form of drainage; however, this should be checked during the design and specification of the system. During installation and whilst in service, the drainage holes should be checked to ensure they are unobstructed and allow free drainage of the system. Debris can collect within the system which may need to be cleared from the drainage holes.

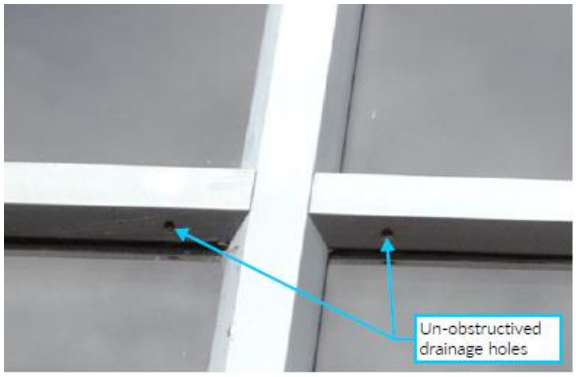

Figure 1: Photo showing un-obstructive drainage holes in a window frame.

Most glazing systems hold the glass in place via the edges of the pane. Against a blast threat it is this connection which is securing the glass to the frame. When subject to blast loads it is this connection which is securing the glass to the frame. Deterioration of the laminated glass edges due to delamination, may reduce the effectiveness of the connection to hold the glass in position and therefore impact the level of protection expected.

6. The connections from the facade to the building

Brackets or spigots are used to connect a façade to the host structure. It is important that the connections are adequate to support the loads imposed onto the façade as well as the weight of the façade. Calculations should be provided which confirm the suitability of the connections which connect the façade to the structure. Against a blast threat the outward forces i.e. rebound of the system towards the threat, can severely challenge components that have been designed for conventional dead and inward wind loads.

Compliance of the support and fixings to the structure should be checked during manufacturing and installation on site. Any deviations to the design (which have not been approved by the blast engineer) may result in a significant reduction of performance and level of protection.

7. Training/approvals

Many façade manufacturers provide training to ensure that operatives who are installing the systems are fully conversant with the assembly of each façade system. This is particularly important for high performance facades, especially blast enhanced systems.

The façade manufacturer should be consulted to check if they have an approved installer scheme, and if so, installers should be used who are trained and familiar with the façade they have been tasked with installing.

Good workmanship and correct installation is very important in achieving the designed protective measures.

8. Cleaning the glass system

Mild chemicals are typically used to clean glass, and specific cleaning products will generally be recommended by the glass processor and/or the installer of the system. These will have been carefully selected to ensure all the components which will be in close proximity, e.g. silicone, gasket and interlayer, are compatible to avoid premature failure.

If an alternative cleaner is used, it is important to ensure that it is compatible with the glazing system.

What documentation should be provided after the glass has been processed and installed?

1. Calculations should be provided which confirm the suitability of both the glass and the framing system to withstand the applicable loads, which may include wind, occupancy and even blast. These can be used as a reference when checking compliance of the system during processing and installation.

2. Where toughened glass has been specified and heat soaking included in the process, the glass processor must provide records which confirm that all the glass has been tested, confirmation of the oven temperature as well as the number of glass panels which failed during the testing. Confirmation that the oven has been calibrated should also be provided.

3. Where glazing systems utilise silicones, the company which applied the silicone should be able to provide assurance that the application has followed the manufacturer's guidelines. For structurally bonded glass the applicator should provide assurance that the silicone followed the requirements of ETAG-002, 'Guideline for European technical approval for structural sealant glazing kits (SSGK)' (item 3).

The documentation can be provided in either electronic or paper format.

How and when to check the key issues

	Specification of heat soaking for toughened glass.	Has the correct interlayer layer been specified/used?	Has the glass been installed the right way round?	Have the correct adhesives and sealants been used?	Are there clear drainage routes within the glazing systems?	Is the glazing system fixed to the building correctly?	Do the installers have the correct training?	Is the correct cleaning product being used?	Comments
Procurement	✓	✓		✓		✓	✓		Check bid is compliant with the design specification.
Fabrication/ Processing	✓	✓		✓	✓				Are factory production controls in place and correct for the products which are being supplied. A factory visit may be required.
Installation			✓	✓	✓	✓	✓	✓	Regular inspection during the installation phase required, ideally before elements are covered up i.e. sealant joints.
In service checks				✓	✓			✓	Periodic checks to monitor condition of the glazing system.

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