Technical Note No 54

Self-cleaning glass

Introduction

This Technical Note explains how self-cleaning glass works, gives guidance on the use of self-cleaning glass and highlights some of the factors that will need to be considered when specifying self-cleaning glass on commercial and high-rise residential buildings. References to relevant manufacturer’s publications are also given at the end of the Technical Note.

Self-cleaning glass is a relatively recent development having been commercially available since 2001. The glass is designed to reduce the frequency of cleaning and improve the appearance of glazing. Currently its main use is in the domestic and domestic refurbishment markets.

In the future there is expected to be demand from clients and building developers to use the glass on commercial and high-rise residential buildings as they increasingly become aware of its potential benefits. Its use will also be driven by the need to improve health and safety by reducing the need for regular access for cleaning. This may however be offset by a general requirement for powder coatings to have a maximum three-monthly cleaning cycle.

How self-cleaning glass works

Self-cleaning glass consists of float glass with a neutral, durable and hard polycrystalline coating of titania (TiO₂). The coating is applied to the non-tin side of the float glass during glass manufacture and is designed to:

- Break down organic dirt that accumulates on the glass surface by photodegradation, and
- Reduce the build-up of dirt and dust particles on the glass surface due to its hydrophilic (water attracting) nature.

The coating’s ability to photo-degrade organic material arises from the thin titania coating reacting with oxygen and water molecules in the atmosphere to produce free radicals after exposure to ultraviolet radiation. These free radicals break-up organic material adsorbed on the glass surface into volatile molecules. This helps to reduce the dirt’s adhesion enabling surface water to more easily wash away organic dirt along with any inorganic dust that may be attached.

The coating’s hydrophilic nature causes surface water to spread out over the glass surface to form a sheet of water. This
Self-cleaning glass sheet, when moving, washes away organic dirt along with any inorganic dust that may be attached. The sheeting effect will also allow clearer vision through the glass in wet conditions, and cleaner looking glazing in dry conditions, as more dirt will be removed and water droplets are less likely to leave spots on the glass surface. It may also reduce the occurrence of condensation on the external face of the glazing. Drying is faster as water evaporates more quickly when spread out in a thin sheet.

Self-cleaning glass

Self-cleaning glass has the potential to:

- Reduce the need for the manual cleaning of externally exposed glass surfaces
- Improve the visual appearance of glazing.

Reduced manual cleaning will lead to reduced cleaning costs and lower safety risks as cleaners will be required to work at height less often. Less frequent manual cleaning may have other benefits such as reduced scratching of the glass surface. Reducing the need to wash glazing will also reduce the use of clean water and reduce environmental pollution due to smaller amounts of cleaning materials being used.

Improved appearance will increase building aesthetics and vision through the glass. The former will increase clients’ satisfaction. The latter has the potential to increase safety, such as on air traffic control towers, increase spectator enjoyment, such as at sporting events, or increase marketing effectiveness, such as on shop fronts.

Sufficient water needs to run across the glass surface for cleaning to be effective and compatibility with sealants should be assessed to prevent unwanted effects, such as the masking of self-cleaning performance.

The high hardness and durability of the self-cleaning coating enables manufacturers to predict that the coating will last for the life of the glazing. The high durability also means that leaching from the coating will be small and unlikely to cause contamination of water run-off.

Should the coating become chemically or mechanically damaged it is not repairable and this will necessitate the replacement of the glass pane if performance is to be maintained.

‘Easy to clean’ glass

Self-cleaning glass should not be confused with glass that is surface-treated after manufacture to reduce the need for glass cleaning. These treated glasses are called ‘easy-to-clean’ and several different proprietary formulations are on the market. In essence a hydrophobic (water repelling) film, such as a polymer or silane, is manually applied or sprayed on to the glass surface, either in a factory or on-site.

The surface treatment causes water to form beads that run off the glass surface washing away any loosely attached dirt. These glasses do not break down organic dirt on the glass surface and are therefore unlikely to be as effective as self-cleaning glasses. They could also lead to spots forming on the glass surface after drying. They may be less durable than self-cleaning glass, necessitating periodic re-application of the coating to maintain performance.

Warranties are provided by the applicator with typical predicted service lives of 3-10 years subject to requirements for cleaning/maintenance. It is also possible to apply a hydrophilic (water attracting) coating in a similar manner.

Easy to clean glass may, however, be cheaper and more versatile in that the treatment can be applied on a greater variety of glasses as well as on other materials such as ceramics and granite. The treatment can be applied in-situ to existing glazing and does not need to receive ultraviolet radiation and moisture to work. Repair may be easier and cheaper as it is not necessary to replace the whole glass pane. The treatment is normally guaranteed against discolouration, loss of adhesion, etc.

As with self-cleaning glass, sufficient water needs to run across the glass surface for cleaning to be effective and compatibility
Self-cleaning glass with sealants should be assessed to prevent unwanted effects, such as loss of adhesion. Currently, there are no specific standards concerning the cleaning performance of these surface treated glasses.

Standards

There is no specific standard for self-cleaning glass but it does comply with the requirements of a Class A coated glass when tested in accordance with BS EN 1096, the product standard for coated glass.

This Standard does not assess the self-cleaning performance of the glass. It is consequently difficult to ascertain how effective self-cleaning is, the variables that might affect self-cleaning performance, its long-term durability and performance, and any cost benefits from using the glass. These issues have been recognised and tests are in development with research being led by two major float glass manufacturers. It is intended that these tests will form the basis for a future European Standard on self-cleaning glass. It is not known when this standard will be published.

Self-cleaning glass is mentioned in BS 8213-1 which gives recommendations for the safe design, construction, operation and cleaning of windows.

In Annex C.2 it states that:

'The degree of dirtying upon the glazing differs according to the locality, the angle of inclination of the surface, its texture, and whether it is exposed to the washing action of the rain. If it is not possible to provide windows that can be safely cleaned on both sides from within the building, self-cleaning glass should be used in situations where satisfactory cleaning is likely to result. However, unless the design permits sufficient flow of water over the whole glazed surface, it is likely that manual cleaning will be necessary to remove all dirt. Window frames also need manual cleaning.'

The intention of BS 8213-1 is to reduce safety risks by reducing the frequency at which contractors need to carry out window cleaning at height. Note that use of self cleaning glass will not completely remove the need for access to the outside of building as access will be needed to ensure that other parts of the building envelope are cleaned and maintained. Access may also be required for inspection of the glazing, removal of heavy soiling and replacement of failed glazing.

It is expected that a similar clause will be incorporated into Building Regulations Approved Document N4 when it is revised. The Work at Height Regulations 2005 also has requirements for the minimisation of work at height.

Self-cleaning performance

In order for self-cleaning glass to function effectively it requires moisture and ultraviolet radiation to activate the coated surface. It will also require regular wetting with sufficient quantities of water to enable breakdown of organic dirt (including bird droppings, tree sap, industrial and transportation pollution) and for dirt and dust to be washed away. The orientation of sloping or vertical glazing should have little effect on self-cleaning performance provided thorough wetting occurs during use.

Inorganic debris, such as salts from seawater splashes or mortar run-off, will not be broken down by the coating though they may be partially washed away aided by the hydrophilic action of the coating. The sheeting action of the coating may also help to dissolve inorganic deposits.

The need for regular thorough wetting may impose limitations on building design as wetting will be affected by features such as overhangs, deep window recesses and orientation with respect to the prevailing wind. Such limitations could be overcome by occasional hosing down, if access is available, or use of water spray systems. These solutions also enable the glass to be cleaned during periods of low rainfall or when the glass has become excessively dirty.

Self-cleaning glass clearly requires the coating to face externally. In the unlikely event of self-cleaning glass being installed the wrong way round this should become visually obvious once completely wetted due to more water droplets forming on the
Self-cleaning glass

Glass surface and the greater dirt accumulation over time. There may also be a slight difference in appearance from correctly glazed glass. The position of the coating can be assessed prior to installation by:

- Labelling fixed to the uncoated surface,
- Use of a detector available from the glass manufacturer,
- Use of specially developed meters.

An ultraviolet light which causes the tin side of the float glass (which does not have the self-cleaning coating) to fluoresce can also be used - it does not however show that a self-cleaning coating is present.

Once installed the self-cleaning coating will need up to seven days before its self-cleaning properties become effective. The exact time depends upon the amount of UV radiation the glass receives to activate the coating. This in turn is determined by the season and glazing orientation, with activation taking longer in winter and on north facing elevations. North-facing elevations may also have reduced self-cleaning performance because of reduced UV radiation received. Once activated the self-cleaning coating will continue to work in shaded areas, on cloudy days and during the night.

The normal extremes of temperature which occur within the UK (-20 to +90°C) have not so far been found to impair self-cleaning performance.

The long-term effectiveness of the self-cleaning coating is unknown as the self-cleaning glass has only been used since 2001. Manufacturers have however carried out a wide range of accelerated ageing tests which have shown that the permanent and durable nature of the coating means it may last for the life of the glazing with little or no loss in performance. Nevertheless, in areas where the self-cleaning coating is likely to become obscured by hydrophobic compounds, chemically removed through corrosion or mechanically removed by abrasion, self-cleaning performance could visibly deteriorate over time.

Hydrophobic compounds such as silicones can be removed by specialist chemical removers. A physically damaged self-cleaning coating is not, however, possible to repair as the coating is applied during manufacture. This will necessitate replacement of the glass pane if building envelope performance is to be maintained.

Compatibility with sealants, gaskets and glazing compound

To prevent any unwanted visual effects, self-cleaning glass must be compatible with the sealants, gaskets and glazing compounds used during manufacture and installation.

Silicone weather sealants are not normally used with self-cleaning glass as hydrophobic compounds may be leached from the silicone and spread out over the glass surface interfering with the self-cleaning action. These hydrophobic compounds do not damage the self-cleaning coating but mask its performance thereby preventing water from forming a sheet. Affected areas become visible due to dirt accumulation, particularly in a band around the perimeter of the glass. They are not readily broken down by the self-cleaning coating or removed by normal cleaning and will hence remain on the glazing for long periods of time. It should be noted that silicone compounds can also affect the surface of ‘ordinary’ float glass, but the effect is less prominent.

Similar masking of the coated surface of the self-cleaning glass may occur if the coated surface comes into contact with other sources of silicone lubricants including gaskets, rubber or silicone gloves and silicone contamination of handling equipment. Hydrophobic materials are far less likely to be leached from cross-linked silicones. Care should be taken to ensure that silicones do not come in contact with self-cleaning glass at any stage from manufacture, processing, installation to final building use. This will not be easy to achieve due to the widespread use of silicone. Silicone free gloves must always be used by personnel handling the glass.

If contamination occurs it is possible to remove silicone using a specialist silicone remover. These compounds remove existing material from the surface but will not stop further contamination of the glass
Self-cleaning glass

if a source of silicone remains near to the glass.

 Manufacturers are aware of these potential problems with using silicone and have undertaken extensive tests on sealants, gaskets and other glazing materials for compatibility with self-cleaning glass. As a result, there are several alternative materials available which include the use of MS (modified silicone) polymer sealants in wet glazing systems and EPDM gaskets in dry silicone free glazing systems as detailed in Pilkington Activ™ Customer Technical Update June 2005 and Saint-Gobain ‘SGG BIOCLEAN® Self-cleaning glass Customer Technical Guide April 2005’. Alternative gaskets should comply with BS EN 12365-1 while alternative sealants should comply with BS EN ISO 11600.

Manufacturers have also been working closely with polymer suppliers and formulators to develop products that are similar to silicone in terms of performance, but without the ‘leaching’ effect. Several potential solutions have been developed and are expected to be launched in the near future.

PVCU frame manufacturers have begun to supply frame and bead sections with glazing gaskets as an integral part of the system by either co-extruding or rolling the gasket in. This eliminates the use of silicone.

When selecting alternatives to silicone, consideration should be given to the effects on long-term building performance and maintenance. For instance, silicone sealants are advantageous in that they have large movement accommodation, maintain their appearance for longer and have the longest predicted service life of all the common sealant materials.

For structural sealant glazing, long-term performance should be investigated and care taken to ensure that photo-degradation on the self-cleaning coating does not create products which migrate and cause loss of adhesion of the structural sealant. To date long-term tests that have been carried out to investigate this effect have shown no evidence of loss of adhesion.

Silicone sealants that are used as the secondary seal of an insulating glass unit and as structural sealants in structural sealant glazing are not normally seen as a problem. This is because in a well designed drained and ventilated system they do not come into direct contact with water which would be necessary to cause leaching from the silicone to occur. However in a poorly designed and constructed system there is the potential for silicones to be leached from the bottom edge of an IGU if standing water accumulates in the frame to a sufficient depth that it contacts the unit. Should the water then drain from the system it may fall onto glass panes causing surface contamination which in the case of self-cleaning glass will mask its performance. This would also have a detrimental affect on the long-term performance of the IGU.

Glass selection

Self-cleaning glass is available in thicknesses of 3, 4, 6, 8 and 10 mm, and in glass sizes up to 6000 x 3210 mm. It can be processed like other glasses by toughening, bending, laminating, insulating glass unit fabrication, etc though the glass processor should be consulted on capabilities.

It is not possible to produce self cleaning glass with a reflective hard coating for environmental control as both the self cleaning coating and hard environmental control coating would have to be applied to the non-tin side of the glass.

Environmental control may be achieved by applying the coating to a body tinted glass but availability is limited. Environmental control can also be achieved by using a laminated glass with either a tinted PVB interlayer or a tinted glass. Alternatively, a dual coated glass consisting of a self-cleaning coating applied to the non-tin surface of the float glass and a soft environmental control coating applied on the tin side can be used.

Silkscreen printing is possible but will reduce the effectiveness of the self-cleaning coating if printed on the same surface. Printing is therefore normally applied on the uncoated surface. It is also possible to paint or silkscreen print a
ceramic frit onto the uncoated surface to provide self-cleaning opaque glass panels.

The glass is not normally acid etched or sandblasted due to the potential for removal of the self-cleaning coating.

Self-cleaning glass can also be laminated with patterned glass for decoration.

The glass can be combined with other glasses in an IGU to achieve optimum glazing functionality, such as thermal insulation, solar control and noise control.

**Coating durability and handling**

Self-cleaning glass meets the highest requirements for durability of coated glass, achieving a Class A classification when tested in accordance with BS EN 1096. A Class A classification is required for coated glasses to be used on the external surfaces of buildings. However, as with any glass, consideration should still be given to the potential for run-off from adjacent surfaces, such as concrete or lead flashings, to cause corrosion and staining of the glass surface. The coated self-cleaning surface has a slightly higher roughness than an uncoated surface and it may, at least in theory, have a greater potential to be stained by run-off.

Care is needed during processing, handling and installation to reduce the likelihood of damage and contamination of the coated glass surface. This is standard practice for coated glasses and if in doubt manufacturer’s guidance should be followed. Damage to the self-cleaning coating may however be less likely than with conventional coated glasses due to the higher hardness and chemical durability of the titania coating. If handling dual coated glass, extra care should be taken to prevent damage to both the coated surfaces. Good practice is to minimise contact where possible but if contact is needed this should occur on the harder and more durable self-cleaning coating.

**Visual appearance**

Self-cleaning glass, like all neutral-coated glass, will reduce both the light and energy transmission through the glass by a small amount. It also has a slight blue tint.

The appearance of the building envelope may be compromised if self-cleaning glass is used for only part of the glazing. Differences in water behaviour may become noticeable in wet conditions while differences in surface dirt accumulation may become noticeable during dry conditions. In addition, slight differences in the appearance of coated and uncoated glass may be apparent under some lighting conditions if both are used in the same façade.

The appearance of the glazing may be adversely affected by the presence of the coating. Coatings often contain small imperfections that do not normally have a significant effect on appearance but on rare occasions can be so numerous that they produce ‘haze’. Similarly, variations in coating thickness can on rare occasions become apparent. Dual coated glasses which have a coating on each glass surface may be more likely to have imperfections than glass with a single coating. Imperfections may also be more obvious in low-level glazing where people look at or through the glass from close distances.

These imperfections can arise due to the difficulty in uniformly coating flat glass particularly while it is moving during manufacture as with hard coated low-E glass. Glass manufacturers always endeavour to minimise the affect on appearance by high manufacturing standards which include ensuring visual appearance meets the requirements of BS EN 1096. This standard has acceptance criteria for appearance but allows defects that are not ‘visually disturbing’. Such a term is subjective and its interpretation will vary from one person to another. It can therefore be the subject of dispute if control samples and acceptance criteria are not properly clarified during glass specification.

**Manual cleaning**

The need for manual cleaning of glazing and other cladding components will depend upon a number of factors, such as location, building use and the degree of cleanliness desired. The effect of these
factors on self-cleaning performance and on cleaning costs should be considered when selecting self-cleaning glass for use on commercial and high-rise residential buildings.

Where self-cleaning glass is used manual cleaning may still be required to:

- Achieve optimum glass appearance and vision,
- Clean other parts of the building envelope such as glazing materials and frame finishes,
- Remove graffiti.

The frequency of building envelope cleaning will depend upon the nature and texture of the materials being cleaned, warranty requirements, the degree of cleanliness required and the local environment. For example:

- Glazing materials such as gaskets and sealants slowly accumulate dirt over time leading to a band of dirt along the edges of glass panes that if not cleaned will affect the appearance of the glazing. This occurs with all glass panes but may become more obvious if self-cleaning glass is used and regular cleaning is not undertaken.
- Frame finishes have specific warranty requirements for cleaning which will depend upon the nature of the finish and the local environment. For example, powder coatings may need to be cleaned at three monthly intervals so reducing the cost savings from the use of a low maintenance self-cleaning glass. Alternatively, anodised finishes which require less frequent cleaning, such as annual intervals, will give greater cost savings from the use of a low maintenance self-cleaning glass.
- Frame finishes with surface texture will be more likely to trap dirt requiring more frequent cleaning.
- In local environments where dirt or corrosive residue accumulation is high, more frequent cleaning of the building envelope may be required. Manual cleaning may also be required during periods of low rainfall particularly if dry spells become more common in the UK due to climate change.

Where hard water is used to clean the building, limescale may be deposited as water evaporates and a solvent-free detergent may be added to minimise this effect. Where very hard water is used it is recommended that a softener is added. Glass manufacturers’ guidance should be sought where this is an issue.

Summary

Self-cleaning glass may be increasingly used in commercial and high rise residential buildings due to the potential benefits it offers including reduced building cleaning, better vision through the glass and improved glazing appearance. These benefits should lead to reduced cleaning costs, safer buildings and improved building aesthetics.

Consideration should however be given during building design and glass specification to the following factors:

- Self-cleaning performance (eg. effect of building design, location and environment)
- Compatibility with glazing materials (eg. gaskets, sealants)
- Manual cleaning requirements (eg. glazing materials, frame finishes, warranties)
- Glazing system (eg. framed, structural, structural sealant)
- Glass selection (eg. glass thickness, solar control)
- Visual appearance (eg. use of coated glass)
- Coating durability (eg. resistance to corrosive residues, handling).

It should also be noted that self-cleaning glass is a new product and as with all such products the longer-term pitfalls with its use may not yet be known despite rigorous, extensive and on-going testing carried out by glass manufacturers.

Bibliography and References

BS EN 1096, Glass in building - Coated glass
Part 1: 1999 Definitions and classification
Part 2: 2001 Requirements and test methods for class A, B and S coatings
Part 3: 2001 Requirements and test methods for class C and D coatings

BS 8213-1: 2004, Design for safety in use and during cleaning of windows, including door-height windows and roof windows - Code of practice.


BS EN 12365-1: 2003, Building hardware - Gasket and weatherstripping for doors, windows, shutters and curtain walling - Part 1: Performance requirements and classification.


STREP project brochure ‘SELF-CLEANING GLASS: Nano-structured self-cleaning coated glasses: modelling and laboratory tests for fundamental knowledge on thin film coatings, EC normalisation and customer benefits’.