Technical Bulletin

ATS-193
2013-08-01

4th surface Low-E coatings: Guidelines for use

Summary

All windows can benefit from higher insulation values (lower U-factor) in all climates and all seasons. Use of 4th surface Low-E coatings in a double glazed unit provides a simple way of improving insulation whilst keeping the dimensions of the window frame the same.

Adding a Low-E coating on the 4th surface of a unit with any type of Low-E coating on surface #2 will provide a U-factor improvement of approximately 20%. A number of glazing combinations are discussed below illustrating the improved design options using this technology. The coating on the 4th surface is exposed on the room side of the window and pyrolytic Low-E coatings provide the advantage of being very durable and difficult to damage with a track record of use in these types of application for well over 10 years. Detailed recommendations on cleaning are provided in this document to ensure successful use of the coating.

IMPROVING THE PERFORMANCE OF LOW-E GLAZING

The advantages of using Low-E coatings in the air gap of a double glazed unit are well known and described in Architectural Technical Bulletins ATS-116 and ATS-138. Main points on the use of Low-E coatings are as follows

- Surface #2 or surface #3: Low-E coatings should be first placed within the sealed air/gas space to reduce radiant heat transfer
- Surface #2: A Low-E coating on surface #2 will result in a lower SHGC than one on surface #3
- Surface #1: Low-E coatings are not significantly effective because heat transfer is dominated by the natural air convection flow of the ambient wind

In order to improve the glazing energy efficiency further we can consider two main options:

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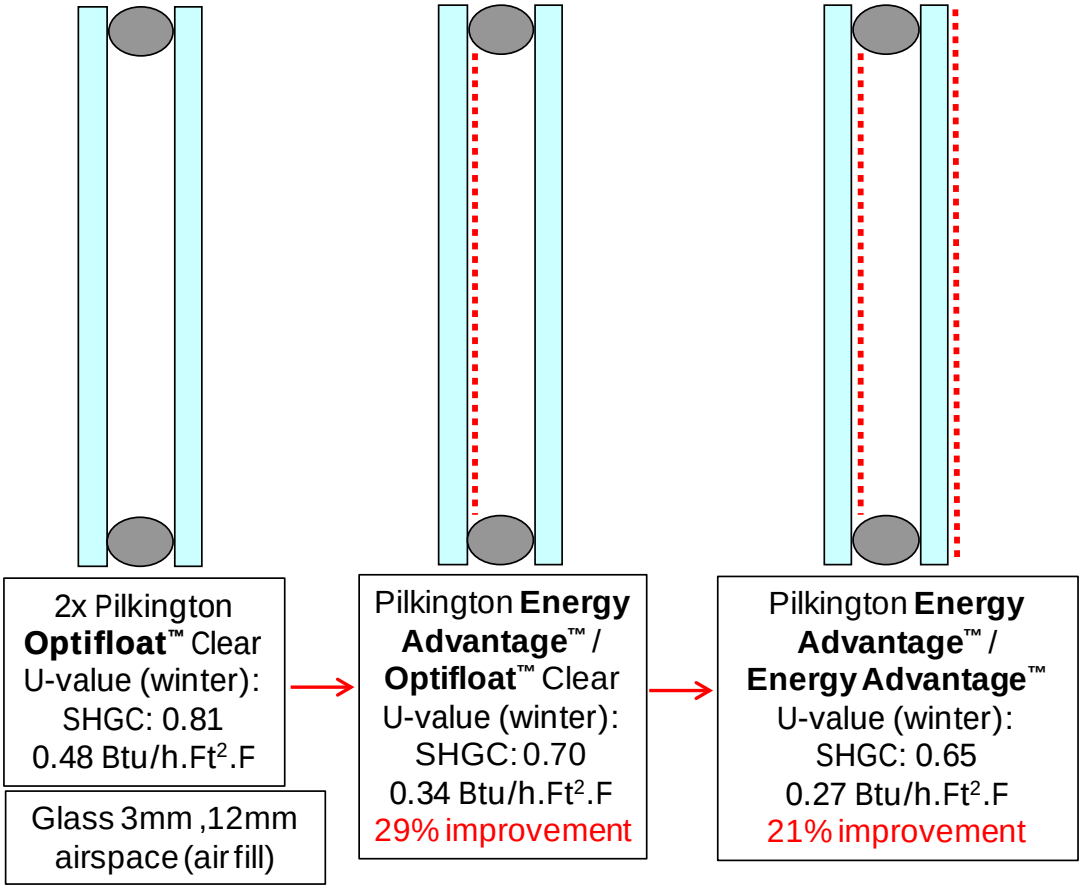
1. Triple Glazing: Effective method, however this may increase the overall IG thickness and cost significantly. It will also increase the reflectivity of the window and potentially introduce more distortion

2. Additional Low-E coatings: As described above, a Surface #1 coating is ineffective and adding an additional coating in the air gap will give only a small U-factor improvement
   - Use of Low-E coatings on Surfaces #2 and #4 surfaces means more infrared heat (room heat) is reflected back into the building, reducing the radiant heat loss through the glass
     - Thermal performance is improved due to a ~20% lower U-Factor
   - The effect of Low-E coating(s) is illustrated below with center of glass U-Factor being reduced by 45%, compared to an IGU with two panes of uncoated glass

In applications where a higher solar heat gain is required, use of Pilkington **Energy Advantage**™ on surfaces #2 and #4 would be recommended and this is shown in the first situation below. Such a unit would give excellent energy rating values for residential glazing due to the passive solar gain and low U-factor.

The second glazing construction is desirable for situations where lower SHGC is desired and here a Pilkington **Solar E**™ Plus Graphite Blue in combination with Pilkington **Energy Advantage**™ on the 4th surface give low U-value and a reduced SHGC for improved indoor comfort.



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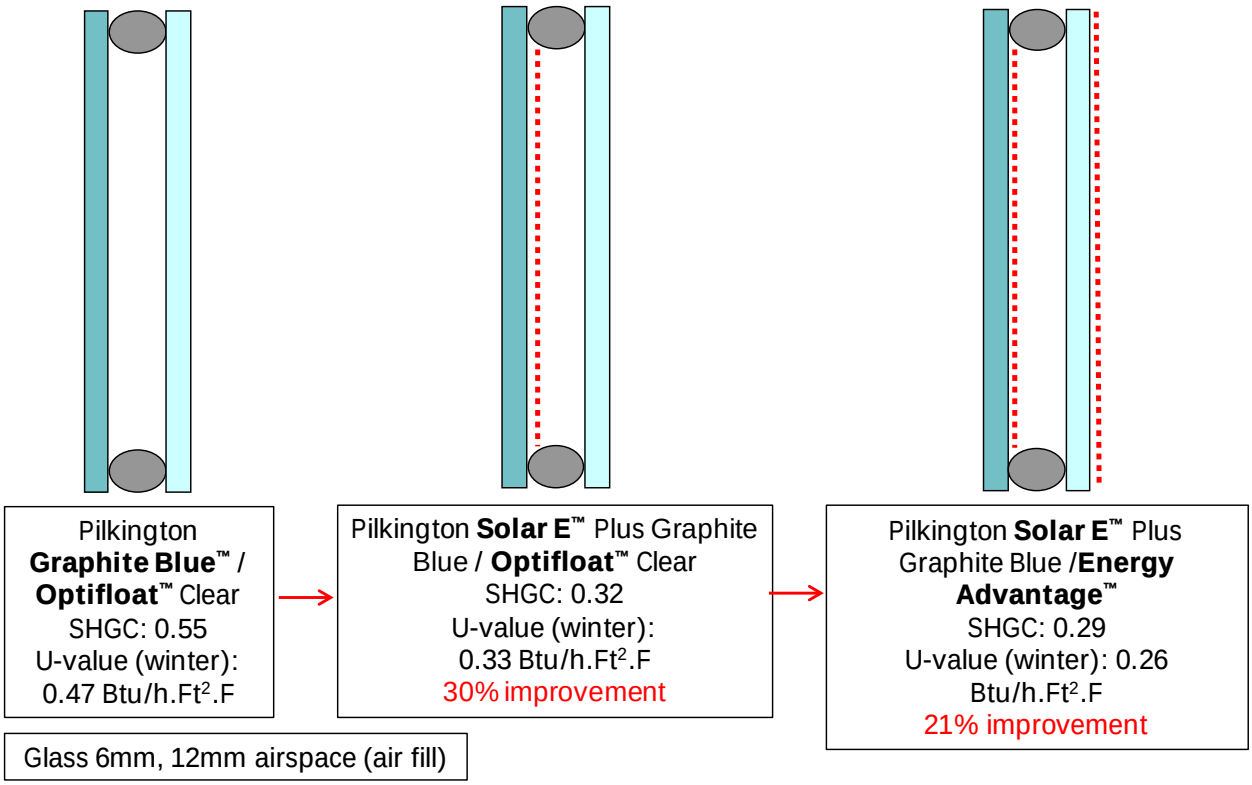

Architectural Technical Bulletins ATS-138D provides more detail on the use of multiple Low-E coatings in an insulated glass unit. See Pilkington website "Sun Management Calculator" at http://www.pilkingtoncalculators.com/smc.php for performance values of double glazing with low-e coatings on multiple surfaces.

VISUAL APPEARANCE OF 4TH SURFACE COATINGS

Improvements made to the Pilkington **Energy Advantage**™ coating have significantly reduced visual haze, giving unrivalled clarity in a pyrolytic product as shown below. These improvements are detailed in Architectural Technical Bulletins ATS-137.

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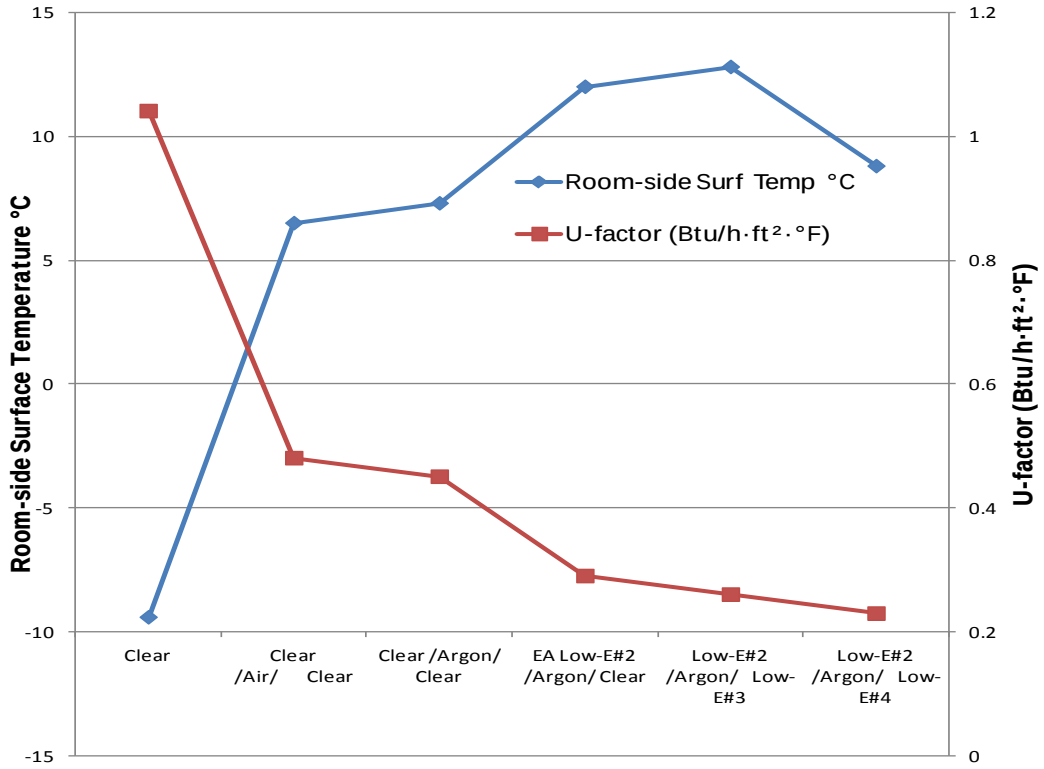
Using extreme lighting conditions for the reflected images of a typical window, the residual haze of the older (2010 and earlier) product can be seen in the left hand IG unit of the following photo. The IG unit on the right hand side of the original photo below barely shows the miniscule amount of haze that can be found in 2011 production of Pilkington **Energy Advantage™**.

GLASS TEMPERATURES AND CONDENSATION ON THE ROOM-SIDE SURFACE

It should be noted that use of an additional Low-E coating on Surface #4 will reduce the temperature of that surface. This is illustrated in the chart below, which shows the Relative U-Factors (no units) and the room-side surface temperatures (°C) under ASHRAE/NFRC standard winter conditions of -18°C (0°F), and 5.5 m/s (12.3 mph) wind for different coating

combinations. The graph shows the significant further gain in U-Factor achieved by the addition of a second low-e coating to an IGU.



An optimum combination of a generic double silver soft sputtered Low-E on surface #2, Ar fill and a Pilkington **Energy Advantage™** Low-E on surface #4 results in a U-Factor improvement of 81%, as compared to the single glazed case. Whilst the #4 surface glass temperature falls to 8.8°C (48°F) this is still 2°C (4°F) warmer than the case of a non-coated, air-filled, double glazed unit. Such a unit has been demonstrated over the years to be warm enough to prevent center of glass condensation in normal residential winter conditions in North America.

Whether the temperature drop shown results in condensation on Surface #4 depends on a number of factors; outside and inside temperature, interior humidity and also the quality of the construction of the IG unit. Based on the above chart, interior humidity would have to rise to 46% RH before condensation appears in the central glass area:

#4Surface Temp.	Relative Humidity at 21°C (70°F) (RH)	Dew Point (Condensation (100% RH))
8.8°C (48°F)	46%	8.8°C (48°F)

This RH is well above most typical living space humidity levels in winter, except perhaps in a non-ventilated bathroom. 30% RH is a common and comfortable indoor level, at 21°C (70°F) in winter. If winter condensation is seen on the #4 surface of sealed units, low-e coated or not, it first occurs at the coldest areas, typically near the glass edges (within 50 mm (2 in.)) where the cold glass temperature is primarily determined by the lesser insulation values of the IG spacer and window frame materials rather than by any coating on the glass.

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So although in extreme climates the drop in Surface#4 temperature has potential to cause condensation, for most climate zones and living conditions this will not be an issue.

COATING DURABILITY

As the coating on the 4th surface is exposed on the room side of the window, its durability is critical. Pyrolytic Low-E coatings are very durable and difficult to damage and Pilkington products have a track record of use in these types of application through many installations in Australia of residential, single glazed, patio doors with a solar control layer under the same top surface low-e coating. This application has now proven to be successful for more than 10 years installed life. Recent improvements in the haze levels of the Pilkington **Energy Advantage™** coating, as detailed above have resulted in improved coating smoothness. In fact the coating has been in use for more than 6 years in the North American market as a 4th surface low-E product.

Pilkington **Energy Advantage™** has been successfully tested to the European EN 1096-2 standard for exposed coatings. This standard includes sections on resistance to abrasion; acid rain; condensation and salt spray cycling, illustrating the durability of the coating.

MAINTENANCE & CLEANING

Although the coating itself is resistant to most chemicals, the nature of the coating surface makes cleaning operations slightly different compared to those for uncoated glass. Do not use razor blades, steel wool or other metallic objects on the coated surface. This would not damage the coating but fine metal marks, looking like scratches in sunlight, could easily be left on the coating. Such marks would need special cleaning techniques to remove them and these are described later in this document.

Hand cleaning a pyrolytic low emissivity coating, to visibly remove accumulated dust or fingerprints, can be accomplished by using a number of different cleaning products which are readily available from domestic supply, grocery and hardware stores. Follow the manufacturer's recommended handling procedures for each product listed.

Recommended Routine Cleaning Products

- "Sparkle Glass Cleaner", clear liquid available from grocery stores, produced by A.J. Funk & Co., Elgin, IL. Contains 2-Butoxyethanol.
- "Windex® Advanced Glass & Multi-Surface", blue liquid, by SC Johnson & Son, Inc., Racine, WI. Contains 2-Hexoxyethanol and Isopropyl Alcohol.
- "Hi-SHEEN", aerosol spray Glass Cleaner by Sommer & Maca Industries Inc., Cicero, IL. Contains Diacetone Alcohol.
- "Windex® Multi-Surface Vinegar Cleaner", clear liquid by SC Johnson. Contains: 2 Hexoxyethanol, Acetic Acid.
- Mixture of one part clear vinegar with one to ten parts clean water.
- Commercially available vinegar-based glass cleaners have generally demonstrated an ability to provide a clean, streak-free coated surface

Pilkington North America, Inc. does not recommend the use of ammonia or alcohol based glass cleaners because these products could leave faint (not permanent) streaks on the coating.

Routine Cleaning Procedure for Pilkington Energy Advantage™:

- Flood the coated surface with a spray-on cleaning solution or with a cloth saturated with the cleaning solution, to thoroughly wet the surface and remove any grit particles. Be generous with the amount of solution applied
- Rub the wetted surface with a clean, lint free towel or cloth, to fully dissolve any dirt on the coating
- Wipe dry with a dry, clean, lint free towel or cloth. It is preferable not to use a squeegee on the low emissivity surface, simply to avoid the possibility of drag marks from the corners of a soft blade abrading against the hard coating
- To prevent streaking, stop wiping when the glass is almost dry and there is still a uniform, thin film of moisture left on the glass surface. This film will quickly evaporate leaving a clean surface
    - Note: streaking is simply the re-deposition of smears of non-uniform dirt, and detergent from the cleaning solution if there was too much dirt and too little volume of cleaning or rinsing solution

Detailed Cleaning Procedure to Remove Large Amounts of Dirt:

- If the coated surface is heavily contaminated with dirt, such as during installation on a construction site, use a water spray from a hose or garden spray pressure bottle to flush away insoluble particulate matter without risk of creating fine scratches
- Flood the coated surface with a spray-on cleaning solution or with a cloth saturated with the cleaning solution. Be generous with the amount of solution applied
- Rub the wetted surface with a clean, lint free towel or cloth, to fully dissolve any dirt on the coating
- Wipe dry with a dry, clean, lint free towel or cloth. It is preferable not to use a squeegee on the low emissivity surface. To prevent streaking - stop wiping when the glass is almost dry and there is still a uniform thin film of moisture left on the glass surface. This film will quickly evaporate leaving a clean surface
    - Note: streaking is simply the re-deposition of smears of non-uniform dirt and detergent from the cleaning solution if there was too much dirt and too little volume of cleaning solution
- If, after the above procedure, and under critical viewing, the glass does not appear clean then a rinse with distilled water should be made after detergent washing - before the cleaning solution has had time to evaporate - to remove the dirt contaminated detergent solution
    - When properly done this allows the final evaporation of a thin film of pure, clean rinse water which cannot leave any visible deposits

Spot Cleaning

Occasional spot cleaning may be required to remove stubborn dirt or foreign materials that have adhered to coated surface. Spot cleaning products containing organic solvents, or a one-time gentle hand application of very fine abrasives, can be used to remove markings from grease, oil, tape adhesive, and crayons or other waxy materials as well as paint and rub-off marks from plastics. Overly aggressive application of abrasives will rub a permanent bright spot into the coating.

Recommended Spot Cleaning Products:

- "Soft Scrub® with Bleach Cleanser", mild abrasive cleaner, produced by The Clorox Co., Oakland, CA. Contains: Calcium Carbonate and Sodium Hypochlorite
- "Bar Keepers Friend Liquid®", produced by Servaas Laboratories, Indianapolis, IN. Contains: Oxalic Acid and fine abrasive powder
- "Goof-Off" from Valspar Corp., Wheeling, IL and Lilly Industries Inc., Grand Rapids, MI 49512. Contains Xylene and Ethyl Benzene
- Denatured Alcohol, Methyl Ethyl Ketone, Acetone or other organic solvents available from hardware stores

Spot Cleaning Procedure:

- Use a cloth saturated with a routine cleaning solution to thoroughly wet the surface and to remove any grit particles
- Apply a small quantity of one of the cleaners listed above to a clean, wet cloth or towel
- Rub on areas of coating needing spot cleaning
- Take particular care to prevent solvents, such as those listed above, from contacting glass sealants, framing and adjacent paintwork
- Wipe clean using a dry, clean, lint free towel or cloth and immediately follow with the rinsing procedure given above in "Detailed Cleaning Procedure"

Specialized Cleaning

If metallic objects have contacted the coated surface, a thin layer of metal removed from the object may be deposited onto the coating which results in a discolored stain or mark the looks like a scratch. Such marks cannot be removed using the normal cleaning procedures given above but do require the specialized techniques below.

Recommended Specialized Cleaning Products for Removal of Metal Marks, etc.:

- "Lime-A-Way", by Reckitt Benckiser Inc. Contains Sulfamic Acid, Isopropyl Alcohol and Hydroxyacetic Acid
- Muriatic Acid, (available from hardware stores). 20% Hydrochloric acid solution in water
- "Acid Magic™", Muriatic Acid Replacement (available from hardware stores), produced by Universal Chemicals & Supplies Inc., Div. of Certol International LLC, 6120 E. 58th. Ave., Commerce City, CO. Tel 800 843 3343. Contains: Hydrochloric Acid

Specialized Cleaning Procedure:

- Use a cloth saturated with a routine cleaning solution to thoroughly wet the surface and to remove any grit particles
- Apply a small quantity of one of the specialized cleaning products listed above to a wet, clean cloth or towel
- Rub only on the areas of glass needing cleaning. Do not allow splashing onto adjacent glazing frames, etc
- Wipe clean using a dry, clean, lint free towel or cloth. Follow with the rinsing procedure given above in "Detailed Cleaning Procedure"

For the suitability of cleaners not discussed here, or for further information, please contact the Architectural Technical Services Department of Pilkington North America, Inc. at 419 247 4448.

IG FABRICATION

As detailed in ATS Fabrication Bulletin #135, Architectural Technical Bulletins , the pyrolytic coating is hard and durable. However dragging metal tape measures, rubber suction cups, or sliding the coating on rollers or insulating glass (IG) press equipment could be expected to make deposit type marks on the very fine texture of the coating which will need to be removed. Direct contact with rollers, suction cups, press platens etc., will not create such marks.

Similarly, applying adhesive labels to the very fine texture of the hard pyrolytic coating will not damage the coating, but could create cleaning issues if the adhesive can separate from the label and lodge into the valleys of the surface texture. Organic solvents can be used to remove such adhesive residues without any damage to the hard coating but it is obviously preferable to avoid applying such labels unnecessarily to the coated surface. If labels are used on the coated surface they should only be in place for the least time needed. They should not be left in place when sunlight can shine through the glass to the adhesive material causing it to change. Labels should be thoroughly tested for ease of complete removal after time.

IG TRANSPORT

Transportation should be made without any sliding action occurring between the coated surface and any packing materials.

INSTALLATION

Either install the glass after other cement, mortar, plastering and painting trades have completed their work, or protect the coated surface from splashing and overspray of these materials. Such materials will typically not damage the pyrolytic coating, but their effective removal may be difficult resulting in glass and coating scratching or marking.

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