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The Systematic Cleaning and Restoration of Architectural Glass

Introduction

Glass has long been admired for its functionality as well as longevity and distinctive aesthetic qualities. Day-to-day experience is replete with evidence that glass is undeniably a stable, enduring material which can be relied upon for generations, if not centuries, of consistent service. This point is illustrated by the fact that original glass installations can still be found in medieval cathedrals as well as municipal and residential structures dating from the colonial era. However, there are situations where both the aesthic features and functionality of glass can be severely challenged by factors that exist in many ambient environments. For example, airborne particulates, runoff from concrete facades and spotting from hard water sources represent three common forms of contamination that can affect glass. Each of these elements can act either individually or in combination with the others to severely degrade glass surface quality and compromise performance characteristics. What is perhaps less well known is the fact that particulates contain components that are harder than glass and thus maintain the potential for causing scratches in specific circumstances. In addition, both concrete runoff and certain types of water spots can chemically bond to glass surfaces. As a consequence, the lack of systematic washing and maintenance often leads to situations in which eventual glass cleaning procedures become more labor intensive and commensurately more expensive than normal. In severe cases, even higher priced restorative techniques may be required in order to refurbish soiled glass to its original brilliance and lustre.

The following paragraphs present a number of real-life examples where glass installations have been significantly affected by one or more of these adverse factors. The intent in so doing is to emphasize that such situations need not be endured by neither commercial property managers nor homeowners. Furthermore, the examples cited serve to develop a rationale for the regular cleaning and maintenance of glazing installations by experienced professionals in order to effectively prevent such conditions from occurring in the first place.

It is worth pointing out before proceeding that the importance of establishing systematic cleaning preventive maintenance programs for glass has not gone unnoticed among building owners and managers. For example, in a recent article entitled “Pay Now or Pay Later” which appears in The BOMA Magazine issue of May/June 2012, it is highlighted that a preventive maintenance program for windows is an integral part of overall exterior building maintenance.[1]

Dust and Particulates

Glass that appears dirty and soiled is often affected by an accumulation of particulates that are characteristic of the everyday environment and not necessarily composed of exotic airborne pollutants. For example, the soiled door shown in Figure 1 exhibits an accumulation of ordinary dust and grime that originated from a relatively commonplace environment.

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Figure 1: Entrance door on a municipal building located within 30 feet of a busy roadway.

Figure 2: Close-up view of municipal building entry door reveals a significant accumulation of dirt and soil.

A close-up view of the door in question is displayed in Figure 2 and provides a more detailed view of what appears to be a significant amount of dirt and soiling. While this particular view of dirty glass does not appear to be inherently unusual, a different perspective is unveiled by examining this same grit and grime with the aid of a scanning electron microscope. Such a view is presented by the photograph presented in Figure 3.

The left hand frame of Figure 3 was taken at a magnification of 250X and reveals the dirty glass of interest to be littered by a variety of irregularly shaped particulates. Many of these measure less than 100 microns in either length or diameter (0.1 millimeters or 4/1000 of an inch). However, more important than size is the chemical composition of the particulates. For example, the right hand frame in Figure 3 focuses on a sharp-edged entity magnified 1200 times for which the compositional analysis reveals the presence of silicon oxide (SiO_2). In other words, a particle that can be more commonly identified as a grain of sand.

Although small in size, the presence of sand particles is not a trivial matter since SiO_2 is harder than glass and thus has the potential to initiate surface scratches. However, surface scratching is not necessarily a forgone conclusion if particulate removal is undertaken by a skilled window cleaning and maintenance specialist.

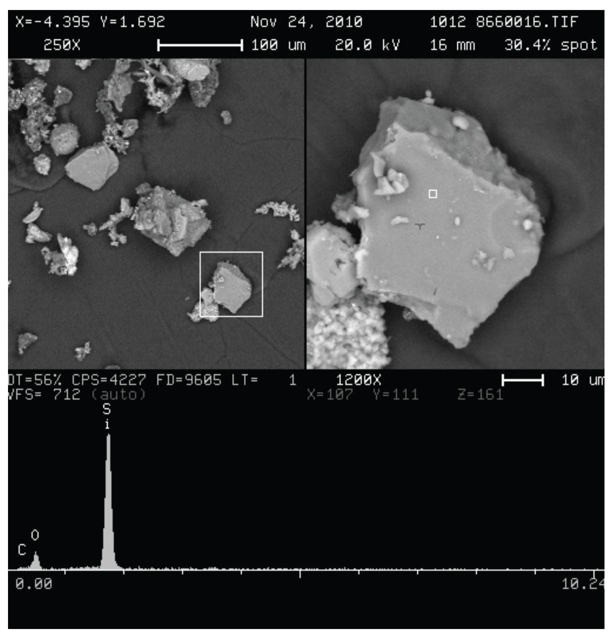

Figure 3: Microscopic view of particulates sampled from municipal building entry door which include entities that are composed of silica (sand). Left hand frame shows particles magnified 250 times (250X) while frame on right is shown at 1200X.

A second example of the accumulation of soils and dust on a window glass installation warrants consideration in order to demonstrate that the results cited in the first example are not necessarily unique. In this instance, attention is focused on the vacation home pictured in Figure 4 which is located in the mountains of northwest Virginia. Here again, as was the case with the municipal building door, some significantly soiled glass can be identified as illustrated in Figure 5.

When examined with the aid of a scanning electron microscope, the dust and dirt in this example reveal the interesting physical features that are shown in Figure 6. As in example 1, the observed window dirt is an assembly of numerous irregularly shaped particles that are on the order of 100 microns or less in size.

Compositional analysis in this example also reveals the presence of silicon oxide (sand grains) as well as alumino silicate material which are both harder than commercial flat glass. As a consequence, each of these materials has the potential for initiating surface scratching when removed from a glass surface without the appropriate precautions that are employed by window cleaning-professionals.

Fig. 4: Vacation home in the mountains of Virginia.

Fig. 5: Close-up view of dirt and soil on window at Virginia vacation home.

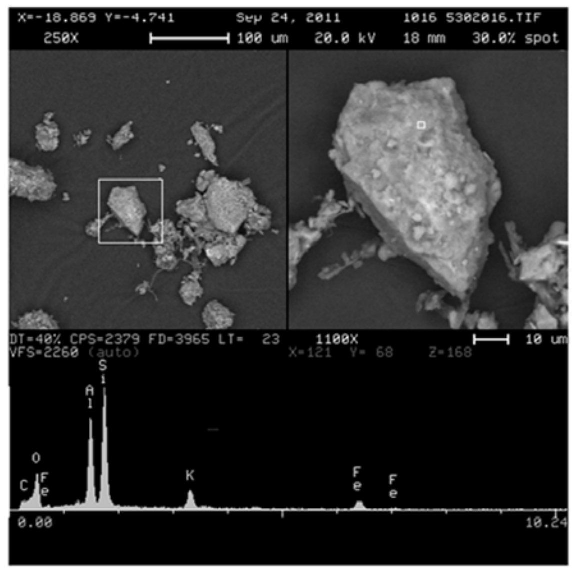

Figure 6: Particulates from Virginia window magnified 1100 times via a scanning electron microscope

The photographs presented to this point indicate quite convincingly that the glass examples of interest were not participants in any regularly scheduled cleaning and maintenance regimens. While the decision not to engage in such programs remains the prerogative of the building owners or managers, such choices do not come without the possibility for adverse consequences occurring at some future date. This contention is supported by the several observations noted here that dust and dirt normally found on glass are likely to include particulate materials that are harder than glass. If the populations of these are allowed to increase to intensities similar to those represented in Figures 2 & 5, the probability is enhanced that some degree of scratching *might* occur during subsequent efforts at cleaning unless appropriate procedures are implemented. Therefore, it is very important to secure the services of a knowledgeable and experienced professional in order to successfully address such challenging cleaning projects as those portrayed by the examples presented to this point.

Figure 7 presents an example of a window unit that exhibits a variety of small surface scratches. The significant population of these suggests that a large number of minute, relatively hard particulates were moved in a circular motion over the glass surface in question. However, the key point here is not necessarily the damage done to this particular unit, but, rather, consideration of the fact that had a skilled professional been engaged in this project, there would be little or no discussion of post-cleaning damage. A second example for which numerous scratches appear on glass is presented in Figure 8. Once again, the observed scratches are indicative of an absence of sufficient care and diligence having been exercised during cleaning.

The incidents of glass scratching illustrated in these examples place renewed emphasis on the inherent wisdom in engaging the regular services of a professional window cleaning contractor, such as a member of the International Window Cleaning Association (IWCA), as part of a damage mitigation and preventive maintenance strategy.

In scenarios involving initial or post-construction window cleaning projects, the accumulation of dust and dirt from building materials can be particularly challenging. Relevant information that advises both building owners and construction contractors in preparing for and coping with these unique situations can be found in the joint IWCA/GANA Bulletin entitled, "Construction Site Protection and Maintenance of Architectural Glass."[2]

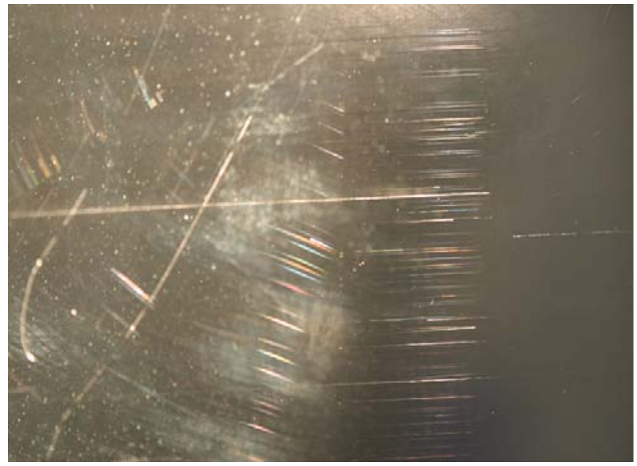

Figure 7. Close up view of a previously soiled window surface after cleaning. The observed scratches suggest that washing was undertaken by someone lacking the skills of an experienced professional window cleaner.

Figure 8: Another example of a window glass surface where the observed scratches are indicative of cleaning in the absence of an experienced professional.

Concrete Runoff

Runoff from rainwater cascading over concrete components of building facades presents another distinct challenge to maintaining clean and aesthetically pleasing fenestration (window) surfaces. The consequence of this occurrence has long been a source of apprehension among individuals associated with the glass manufacturing and window cleaning industries. The focal point of concern has been the typical inability to restore the affected glass to its original condition by means of basic cleaning techniques. For example, the window shown in Figure 9 provides a graphic illustration of the typical outcome associated with such attempts. The close up view of concrete runoff deposits presented in Figure 10 reveals the characteristic pattern associated with this problem.

Figure 9: Visible gray haze due to deposits on glass from concrete runoff. Implementation of conventional cleaning procedures failed to remove deposits.

For many years, conventional wisdom has maintained that runoff from concrete surfaces damages glass due to an alkaline etching or erosion of the surface. However, more recent scientific study has shown concrete runoff to be characterized by deposits of amorphous materials that reside on the glass surface.[3] Whenever rainwater makes contact with a concrete surface, small amounts of silicate materials are dissolved with concentrations of 4 to 8 parts per million being quite common. Upon coming to rest on glass, these dissolved silicate materials gradually become more and more concentrated as the runoff droplets evaporate. Finally, a point is reached where formation of water insoluble polymers begins. This same reaction also results in chemical bonding to the glass substrate. In addition, experiments have shown this process to be significantly more rapid than either glass surface corrosion or true alkaline etching.[4] In fact, prior work has shown the reaction to reach completion at the point when the water carrier evaporates to dryness. This could take hours or as little as a few moments to occur depending upon environmental conditions.

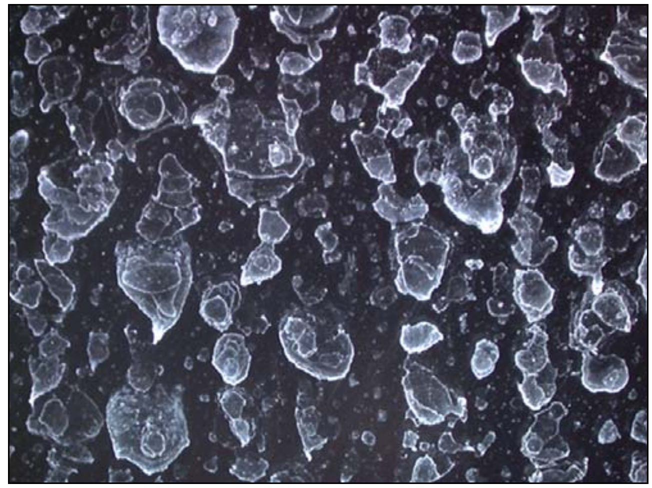

Figure 10: Close up view of typical concrete runoff deposits on glass. These deposits begin to react with glass upon evaporation of the runoff droplets resting on the glass

Figure 11 offers a view of concrete runoff obtained with the aid of a scanning electron microscope. The magnified image clearly shows the deposit to be residing on top of the glass. There is no evidence of erosion or pitting that would be observable had chemical etching occurred. In addition, previous studies (See reference 1.) have shown these deposits to be glass-like with respect to both structural and solubility attributes.

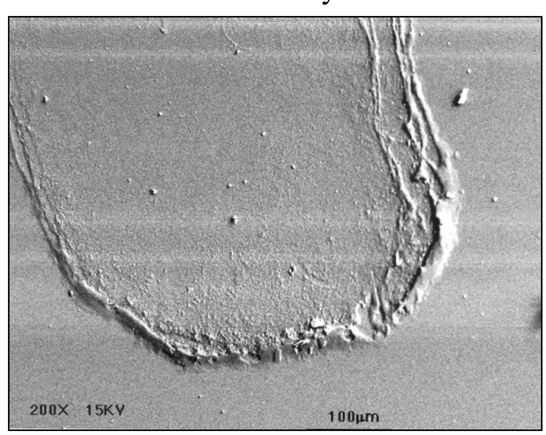

Figure 11: Magnified view of concrete runoff deposit on glass taken with scanning electron microscope; 200X.

It is important to note that concrete runoff can also have an adverse effect on glass that bears a first surface coating. The same mechanism that produces glass-like deposits on uncoated glass can generate similar entities on coated surfaces with equal facility. Figure 12 reveals the outcome of concrete runoff accumulating on glass with a solar reflective coating on the No. 1 surface. A magnified view is presented in Figure 13. The glass in question had been removed from an existing glazing installation due to suspicions that the coating was defective as a consequence of compromised durability. These reservations arose when it was observed that conventional cleaning failed to restore the glass to its pristine condition. However, subsequent investigation identified the deposits to be silicate residue from concrete runoff

Figure 12. Concrete runoff deposits on coated glass unit removed from an existing glazing installation. Note the line of demarcation at point where glass was protected by framing.

The net result of concrete runoff accumulating on glass is the formation of tenacious, glass-like deposits that defy removal by means of conventional cleaning practices. In essence, a “glass-on-glass” residue is created. If this process is allowed to continue unabated, future cleaning and restoration become simultaneously more challenging, more labor intensive and more expensive. In the case of coated glass surfaces, successful outcomes are even more elusive since such coatings are very thin and often not amenable to polishing or chemical cleaning. However, a preferred approach is to preempt such events by having an experienced

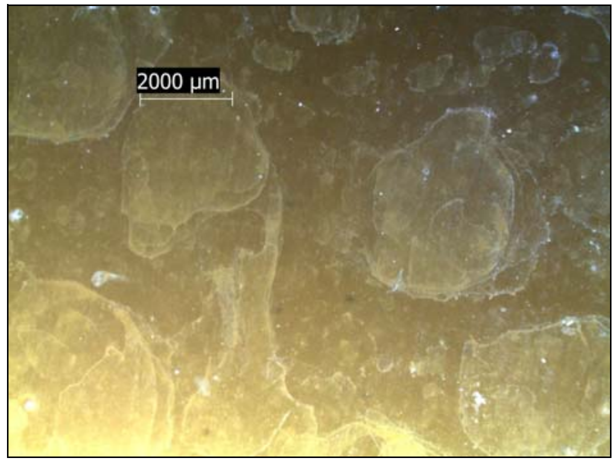

Figure 13: Magnified view of silicate residue from concrete runoff on a coated glass surface; shown at 10X.

IWCA professional engage in an ongoing and consistent program of cleaning and maintenance in order to minimize the potential for permanent fenestration damage. In those situations where concrete runoff has been allowed to amass on glass, any effective cleaning strategy that includes restoration will require specialized procedures and cleaning agents that also bear added costs. However, there is no simple or fool proof approach to successfully reversing the degradation of windows that have been the object of neglect. Once again, such projects are best addressed by an experienced IWCA professional.

Hard Water Spots

Another topic that warrants consideration focuses on events that often affect glazing installations situated in suburban settings where glass and decorative landscapes reside in close proximity. In these settings it is not uncommon to observe sprinkler heads that deliver tap water from public or private sources to the ornamental flowers and shrubbery on a regular basis. An example of such an arrangement is shown in Figure 14 where the close proximity of glass and landscape components is clearly illustrated. Hidden from view are pop-up sprinkler heads that rise periodically to irrigate the surrounding area. In these situations, it is not uncommon for the irrigation zone to also include the nearby windows. However, this seemingly uneventful sequence of events can, in some cases, yield problems for subsequent attempts at removing the hard water spots that form. The reason for such behavior emanates from the fact that not all hard water spots are alike. More specifically, this depends upon the chemical nature and concentration of various minerals dissolved in the water.

Fig. 14 Hotel window with adjoining decorative garden and hidden pop-up irrigation system.

A majority of individuals are likely to be familiar with the impact that hard water deposits can have on daily experience whether it be calcium carbonate build up (lime scale) in a tea kettle or the unsightly spots that accumulate in a shower enclosure. In addressing these situations, it is normal practice to use weakly acidic household cleaners to remove water spots from bathroom surfaces or employ vinegar to dissolve lime scale from kitchen vessels. As a consequence, these limited successes serve to create the impression that hard water deposits always respond to relatively simple cleaning procedures. However, in the case of window glass surfaces, the removal of hard water deposits may not be so easy.

Typical household concerns regarding the minerals commonly found in tap water focus on dissolved calcium and magnesium salts and sometimes iron. Nevertheless, there is a less conspicuous and often overlooked component in tap water that, depending upon concentration levels, can create significant difficulty when it comes to removing spots from glass. The "often overlooked" material in question includes the entire family of dissolved silicates which behave quite differently from calcium and magnesium based residues.

In a manner similar to the process involved in formation of concrete runoff deposits, whenever hard water droplets containing dissolved silicates evaporate, these materials become increasingly more concentrated as the liquid volume decreases.[5,6] Eventually, the silicates begin to bond with one another as well as the glass surface producing what is akin to a "glass-on-glass" deposit. Just like concrete runoff, these glass-like entities fail to respond to common household cleaning agents. Vinegar and other weakly acidic solutions will not dissolve the silicate deposits. A good example of this is shown in Figure 15 which presents a close up view of the window shown in Figure 14. In this instance, repeated contact with hard water droplets from an adjacent lawn sprinkler has created a significant build up of silicate material.

Figure 15 Hard water spots containing silicate materials after normal attempts at cleaning.

The general condition of the window under consideration here suggests that a regularly scheduled program of cleaning and maintenance had not been implemented by the time the photograph was taken. Of course, the preferred course of action is to prevent such conditions from developing in the first place by consistently employing the services of a window cleaning professional.

As mentioned previously, the problems associated with removal of silicate deposits from glass are not restricted to uncoated surfaces. Figure 16 presents a view of a suburban office building with adjacent lawn and garden features similar to those observed in Figure 14. However in this instance the glazing system incorporates a reflective coating on the outer or No. 1 surface. Nevertheless, silicate deposits that emanate from hard water spots are equally resistant to removal as illustrated in the close up view shown in Figure 17.

Figure 16 Suburban office building with glass coated on #1 surface.

Figure 17: Close up view of silicate deposits on a coated glass surface arising from repeated contact with hard water droplets.

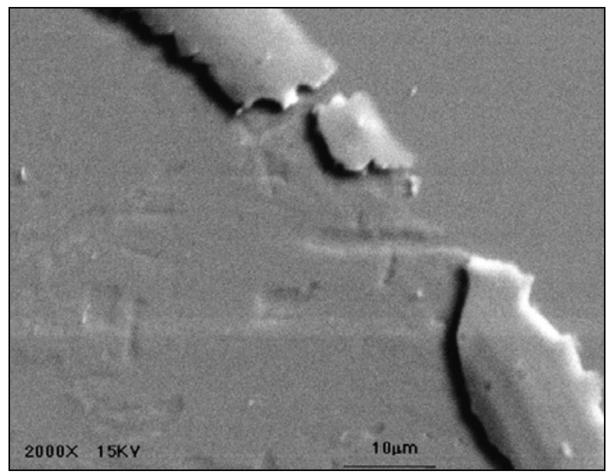

Figure 18: Glass-like silicate deposit on glass magnified 2000 times with an electron microscope.

With the aid of an electron microscope, one is able to discern that silicate residue from hard water is similar in physical appearance to deposits from concrete runoff. This characteristic is displayed in Figure 18 which presents a silicate deposit magnified 2000 times. The glass-like silicate residue lies on the substrate surface and extends a small distance above the point of contact. There is no evidence that chemical erosion or etching has occurred.

In a manner similar to concrete runoff, the task presented in removing silicate deposits caused by hard water sources is even more difficult for coated surfaces than in the case of non-coated glass. This situation arises from the fact that the structural layers within the family of first surface coatings are quite thin and often vulnerable to the extraordinary mechanical and chemical cleaning procedures required to remove silicate bearing residues. As a consequence, implementation of such cleaning procedures is best left to the skilled professional.

Frequency of Cleaning and Maintenance

This cursory overview of three of the most common sources of soiling and fouling of window glass obviously begs the question as to how often one must engage in cleaning and maintenance in order to maintain glazing system aesthetics and prevent potential glass surface damage. The answer to this query will necessarily depend upon factors that characterize the particular environment in which the glass is located. For example, the rate at which dust particles accumulate on glass, among other influences, may hinge upon intensity of prevailing winds and the concentration of air borne particulates. Thus the frequency of noticeable soiling will differ from one location to another.

The time frame over which concrete runoff presents a problem can be affected by factors such as the age of masonry-based building components as well as average annual rainfall. In a similar vein, issues related to hard water spots can be influenced by the frequency of sprinkler head operation and the nature of dissolved minerals in the water. Here again, the degree and rate of soiling will vary from site to site.

In view of the location-dependent influences cited in the previous paragraphs, the answer to the original question regarding the frequency of cleaning and maintenance may appear to remain somewhat elusive. However the solution to this quandary can perhaps be found by taking a second glance at Figures 2,5,10,12,14 and 16. Each of these images presents an example of severe glass surface soiling due to either particulate build up, concrete runoff or hard water spotting. Each of these also represent a situation where the glass in question ought have been subjected to cleaning and maintenance *before* the conditions portrayed in the photographs had developed.

It should be evident at this point that an effective program for the care and preservation of glass at any given building site have as a primary objective the prevention of the conditions presented in the several examples offered during the progression of the current discussion. Of course, the actual time frames that elapse between necessary repetitions of washing and upkeep will vary. However, some excellent insight regarding the topic of "frequency of cleaning" can be found in a recent e-book published by the Building Owners and Managers Association International (BOMA). Bearing the title, "BOMA International Guide to Exterior Maintenance Management,"[7] this guidebook points out that the necessity of exterior glass surface cleaning may vary from two to four, or more, iterations per year depending upon the specific environment. In view of this advice, an operative approach to identifying reasonable time frames between cleaning events can be facilitated by direct involvement of building management personnel engaging in regular site evaluations. This process can be further enhanced by including a window cleaning and maintenance professional who has access to the full array of resources and support offered by International Window Cleaning Association (IWCA)

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2. *"Construction Site Protection and Maintenance of Glass." Glass Association of North America. TD 03-1003. 2010.* <www.glasswebsite.com>

3. *Düffer, Paul F. "Where Masonry, Glass and Concrete Meet; The Interactions and Ramications of Concrete Runoff on Glass", US Glass, Metal & Glazing, May 2008: 52-62*

4. *Düffer, Paul F. "How to Prevent Glass Corrosion," Glass Digest 65 [12](1986): 77- 84*

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6. *Düffer, Paul F. "The Surface Chemistry of Float and Lead Crystal Glass," Glass, March/April 2008: 32-34*

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This bulletin has been commissioned by the Glass Committee of the International Window Cleaning Associating and authored by Paul F. Düffer Ph.D., Educational Program Adjunct to the Glass Committee; Paul D. West, Chairman.

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