Destruction of glass surfaces:

Inevitable or preventable?

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All surfaces are subjected to a weathering process that reduces their performance, damages their appearance and makes their maintenance increasingly difficult. Protective systems are commonly specified for most materials used, such as metals. Unfortunately, in most cases there is still one material that is left unprotected: glass

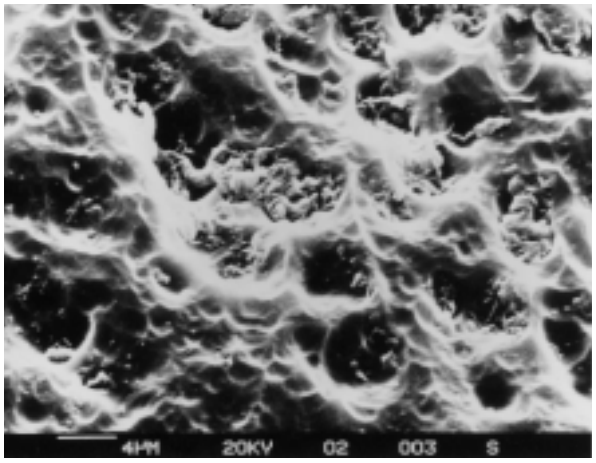


Figure 1

New glass is bright and sparkling, easy to see through and easy to clean and keep clean. Contrary to popular belief, the surface of the glass is not completely smooth. It has what glass manufacturers call 'lattice' or 'honeycomb' patterns. Under a microscope, as illustrated in figure 1, glass reveals a rougher surface made of peaks and potholes. Organic and inorganic contaminants fill these potholes and react chemically with the glass, firmly bonding to its surface. As a result, glass easily becomes stained and discoloured, difficult to see through and difficult to clean and keep clean. The surface of the glass also possesses hydrophilic properties and is over time subjected to a corrosion process that will make its surface rougher and therefore its damage greater, in some cases irreversibly.

This has great implications on the property owner and any other users of glass, increased costs and efforts in maintenance, renovation or replacement, and in all cases a reduction in the expected performance.

DESTRUCTION OF GLASS SURFACES: THE CAUSE

Just as metal rusts, glass is subjected to a corrosion process caused by reactions between the glass surface and gases in the atmosphere. It is commonly associated with moisture or vapour attack through condensation, or reaction with an alkaline solution.

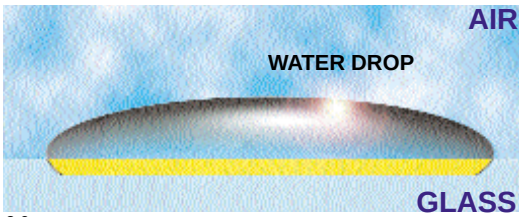
Glass is hydrophilic, meaning it attracts and holds moisture. All glass has a molecular layer of moisture on the surface. When this layer increases because of humidity or rainfall, it can obscure visibility and create a risk to comfort or safety. But most of all, it participates greatly to the destruction of the surface of the glass.

There are two distinct stages to the corrosion process, occurring together or separately. The first stage is aqueous corrosion, caused by moisture. It is referred to as ion exchange or alkali extraction (leaching). An ion exchange occurs between sodium ions from the glass and hydrogen ions from the corrosion solution. The remaining components of the glass are not altered, but the effective surface area in contact with the solution is increased. This increase in surface area leads to extraction or leaching of the alkali ions from the glass, leaving a silica-rich layer on the surface. As silica (SiO_2) concentration in the glass goes down, surface area increases through dissolution of the glass surface. The pH of the solution in contact with the glass will greatly affect the corrosion process. A rapid pH increase will cause a rapid breakdown of the glass surface.

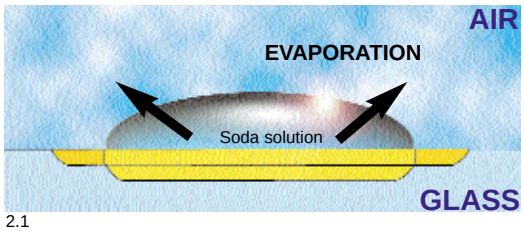
There are two types of aqueous corrosion, static and dynamic. Static aqueous corrosion is caused by an entrapment of moisture on the surface of the glass. In dynamic aqueous corrosion, the corrosion solution is replenished due to condensation run-off. Even a single droplet of moisture on unprotected glass, as described in figure 2, can produce sufficient damage to be visible in good lighting.

The second stage of corrosion is a process of destruction of the leached surface layers of glass. Glass is resistant to most acids but is highly susceptible to attack by alkaline materials, especially a concentration of $(OH)^-$ ions giving a pH greater than 9.0. The result is an attack of the network forming silica-oxygen (Si-O) bonds, leading to dissolution of the glass surface.

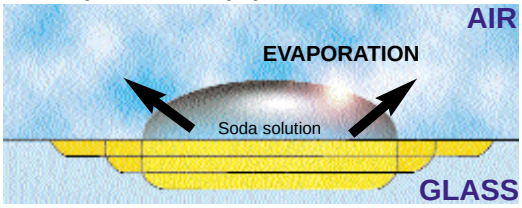
Alkaline cleaning products are readily available and widely used, sometimes indiscriminately, in surface maintenance. Damage to the glass can also be caused by improper and abrasive cleaning methods.



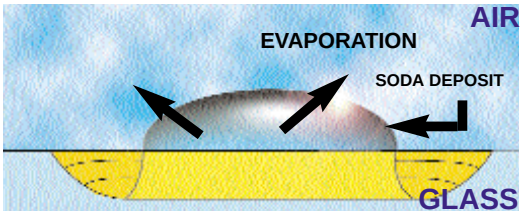
2.0
Soda being dissolved over highlighted area



2.1
Soda being dissolved over highlighted area



2.2
Droplet now saturated. As evaporation continues soda must deposit out



2.3
Results in a 'silica-rich' surface with a spot of 'soda-rich' material in its centre

Figure 2. Evaporation of a water droplet on new glass surface

Allowing even a single drop of clean water to fall on a new glass surface and evaporate off in this way can produce sufficient damage to be visible in good lighting. Once the damage is there it is likely to increase through further corrosion.

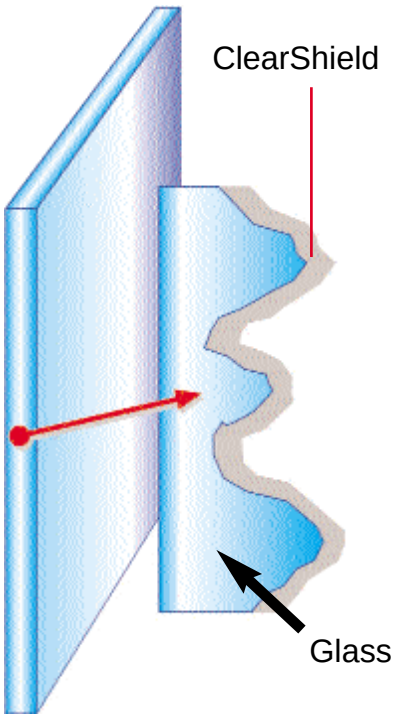


Figure 3. Surface of ClearShield 'Non-Stick' Glass

Renovation

Ritec International pioneered surface protection for the flat glass industry with its 'non-stick' surface technology starting back in 1982. Extensive research and experience have resulted in the understanding and expertise in the renovation of glass. The ClearShield System removes all contaminants without creating further abrasion on its surface following the corrosion process described above.

Organic and inorganic contaminants summarised in table 1 deposit on glass and bond firmly to its surface. Ritec has developed a full range of innovative solutions to efficiently remove such contamination. Through work carried out in many

Other sources of alkalinity, summarised in table 1, react chemically with glass in the presence of moisture. They will attach firmly to the surface and cause general degradation. At first, the damage will show as marks or staining but within a very short time can progress to physical damage or etching.

DESTRUCTION OF GLASS SURFACES: A FULL RANGE OF INNOVATIVE AND DURABLE SOLUTIONS

The ClearShield System is a unique system that provides a wide range of solutions to all types of glass, in the factory or on-site. The expertise provided covers renovation for glass whose performance has already been greatly reduced through staining and discolouration, and protection and maintenance for new or renovated glass as a preventative measure.

Type of contaminants		Source of contamination	
		Marine environment	Land based environment
Inorganic	Limescale	Seawater	Hard water Building materials Cement dust Mortar Building run-off from Concrete Brickwork Stonework
Inorganic	Metal oxides	Rust (iron oxide) from framework	Aluminium, lead, metal and iron oxides from framework Metal dust from rails & brake pads
Inorganic	Silicone sealants		Run-off from sealant
Organic	Hydrocarbon pollution	Deposits from ship's funnel	Traffic film & industrial pollution Jet engine exhaust in airports

Table 1. Type of contaminants that chemically bond to glass

Above: Pictures 1-4

different types of environments, from marine vessels to buildings in different climates, renovation has been made possible by breaking the bond between the contamination and the glass, avoiding as much as possible the use of abrasive compounds and methods.

Many glazed areas have benefited from the process, bringing glass to an 'as new' condition. Its intended performance of visibility, clarity and cleanliness restored, as illustrated by photographs 1 to 4.

Protection

ClearShield, a special polymeric resin, provides the protection. It reacts chemically with the glass at a molecular level to modify its surface properties as illustrated in figure 3.

ClearShield possesses special cross-linking properties that ensure the durability of the protection it provides. When applied, the polymer forms a very strong chemical bond with the glass and with itself, creating a new multi-molecular surface that becomes part of the glass. The multi-molecular surface was confirmed following surface analysis carried out by the ISST (Institute of Surface and Technology) using an Auger electron spectrometer. This machine allows elemental analyses and measures compositions with atomic layer resolutions on extremely small areas of the glass surface.

ClearShield follows the contours of the glass and is less than a micron thin. It is also important to note that ClearShield will not bond to any surfaces other than vitreous. It washes off other surfaces with normal cleaning methods, such as soap and warm water.

Unprotected, high-maintenance glass is now converted into ClearShield 'Non-Stick' Glass. The surface of ClearShield Glass is totally inert when cured. The Clear-Shield surface therefore acts as a barrier against the bonding of contaminants, and is more resistant than ordinary glass against the attack of moisture and alkalinity. The result is greater ease of cleaning and a durable resistance to staining. ClearShield Glass also effectively resists microbial adhesion for a higher hygiene.

PRACTICAL IMPLICATIONS TO GLASS MANUFACTURERS AND PROCESSORS

Destruction of the surface of glass is therefore not inevitable. Performance is crucial when selecting a glass surface protection

Flamm-ability	**Flash point**	Flashpoint test using the Abel closed cup test method which conforms to IP (Institute of Petroleum) 170/95 Section 9.1 – **unable to obtain a Flash point**
Weather	**Humidity**	Temperature cycles from 30°C to 70°C for 8 days then held for 14 days at 70°C all at 100% RH – **significantly less weight loss than on untreated co samples**
	Salt spray	100 hour test – **pass**
	Weatherometer	To BS 3900: Methods of test for paints; 2000hrs - **pass**
Mechanics	**Coefficient of friction**	Measured on inclined surface – **significantly less friction on treated samples**; 60-70% of friction on untreated samples
	Mechanical abrasion	Specially designed test rig with rubber blade rotated under controlled pressure against samples of glass immersed in abrasive slurry – **demonstrated exceptional wear resistance**
Chemical	**Alkali attack**	ISO 695 – **significantly less weight loss than on untreated samples**
	Migration	**No migration from treated to untreated areas after curing**
Biological	**Algae/lime deposits**	Beaker tests for 5 weeks **Treated sample – algae and lime scale easily removed with soft cloth and detergent** Untreated sample – algae removed with much scrubbing; lime scale required scouring powder
Heat	**Autoclave**	To ISO 4802 – **pass**; no difference between treated and untreated samples
	Freeze/thaw cycles	From -15°C to + 20°C; 20 cycles – **pass**
	Thermal shock	Infrared radiation for 8 hrs then cold water spray; 20 cycles – **pass**
Light	**Light transmission**	**No detectable reduction on treated samples**
Comp-atibility	**Paint adhesion**	BS 3900: Methods of test for paints, cross cut test: **no difference in paint adhesions on timber and metal after warm detergent wash**

Table 2. Performance tests carried out by independent laboratories on ClearShield glass

system. Just as important are the practical implications of the application.

First and most important are health and safety, and the versatility and safety in application, which are related issues. The toxicity and flammability of the solvents used by the system are crucial for the user and for the environment.

Some solvents are extremely harmful by ingestion as well as inhalation, placing the applicator at risk, and may have environmental restrictions.

ClearShield is not toxic or harmful, only classified as irritating to skin and eyes. Committed to an environmentally responsible policy, Ritec is continuously researching to always use solvent systems that are the least aggressive to users and the environment.

Application of products with very low flash points can be very dangerous, whether manually or by spray. Static electricity, generation of power and other potential sources of spark represent real dangers. In certain ratios of vapour to air, the risks of explosion are high. The surrounding area also has to meet safety regulations such as spark-proof and anti-static. Even mobile phones can be restricted.

As reported in table 2, ClearShield has no flash point, so it can safely be applied manually or by spray, avoiding the cost of spark proof equipment and environment. A range of spraying machines, from manual to fully automatic, exists to adapt to any level of production.

ClearShield Glass does not require any special protection during handling. On the contrary, when the excess polymer is left on the glass, it provides an extra protection during construction.

ClearShield has an unlimited shelf life, reducing considerably the risk of wastage or questionable quality.

Compatibility with sealants used in architectural glazing, windows and conservatories or shower enclosures must be assured. A number of leading sealant manufacturers such as Dow Corning, Ego, Sika, Wacker Chemie, Otto Chemie and Simson have already approved the use of some of their sealants on ClearShield Glass. Please contact Ritec for more details.

(left) Visual Control Tower at Schipol Airport, Amsterdam

(below) Lloyds of London Building

A PROVEN TECHNOLOGY FIT FOR ITS PURPOSE

As described above, the risks of glass surface destruction, staining and difficult cleaning highlight the need for glass surface protection. As for all technologies, the solution provided must be fit for purpose for all involved.

Long term performance and durability is a key requirement of any glass protection system but is very difficult to simulate in accelerated test conditions. Throughout the last sixteen years, various independent laboratories and glass companies have carried out many tests on ClearShield Glass.

A laboratory test frequently quoted is the contact angle of water droplets as a measure of water repellency. British Glass (previously The British Glass Industry Research Association) carried out contact angle tests on glass protected by The ClearShield System. The measured contact angle on the samples varied from 95 to 105, with a mean of 98. The result therefore showed a high level of water repellency.

Accurate measurement of contact angle is nevertheless difficult and is affected by surface roughness and chemical heterogeneity. While contact angle can be used as a broad indicator of the effectiveness of the initial application, the relationship with long term durability and protection performance if any is unclear.

Natural weathering, which really determines the durability of a surface protection, is the result of separate or combined actions of sun, rain, frost and atmospheric pollution. This includes the effects of corrosion, ultraviolet (UV) radiation, infrared heat, oxidation and airborne contamination.

For these reasons, although ClearShield is not a coating but a conversion of the glass surface, all standard laboratory tests for surface coatings have been carried out in order to further estimate its resistance to weathering. As illustrated in table 2, ClearShield passed all of these tests.

However Ritec's experience is in line with the views expressed by many technical organisations in the glass and coating industries that the main value of such tests is for assessing the relative merits of different systems rather than predicting performance in actual conditions; even then results in actual service conditions and test rankings are not always consistent.

Factory conversion to ClearShield glass before installation, Tsuyama City.

For example, the Corning Museum of Glass, New York State, USA (Ref 1) comments that " Many factors influence the rate of corrosion and no laboratory test to date is capable of predicting service behaviour under all conditions". Similarly EPMA, the Swiss Federal Laboratories for Materials (Ref 2) states "Generally applicable interrelations between ageing resulting from artificial and natural weathering are not to be expected due to the large number of parameters and the often complicated decomposition processes. However, the tests are suitable for comparing the ageing characteristics of various products".

There is no performance test than can replace field experience. Ritec International has always based its warranties on its experience in the field, extending the warranted durability over the years.

A great number of companies, in more than 30 countries worldwide, have placed their trust in The ClearShield System in areas such as architectural glazing, decorative glass, shower doors and enclosures, windows and conservatories and marine vessels. The two case studies below illustrate the satisfaction provided by users of ClearShield 'Non-Stick' Glass.

VISUAL CONTROL ROOM OF SCHIPOL AIRPORT, AMSTERDAM

In 1991, ClearShield Glass panels were installed in the control tower of the Schipol Airport in Amsterdam. The high specification and expensive panels, produced by St Gobain were treated in the factory prior to installation.

Contaminants such as unburned hydrocarbons create a very aggressive environment for glass in airports. The corrosion of the glass caused by such contamination and atmospheric attack leads to a marked reduction in visibility, jeopardising safety and making cleaning much more difficult.

When the initial treatment was carried out by Ritec Benelux, the service interval was expected to be five years. The durability of the protection varies depending upon the exposure of the glass. Since installation, the panels have been cleaned approximately once a month.

Ten years on, the airport authorities requested that the panels be inspected to assess the current performance of the glass and if necessary carry a new application to prevent the loss of benefits provided by ClearShield which may have been affected due to years of abrasion on the glass surface. Following tests it was determined that a re-application of the system was unnecessary. The results showed that l0 years on, the system was still performing to its original expectations, and re-application was not yet necessary. Many other airports in the world today benefit from a similar protection.

LLOYDS OF LONDON LANDMARK BUILDING IN LONDON

During routine inspections in the early 1990's, the owners of the Lloyds Building found that the paint on the frame around the atrium was shedding and plating onto the glass, and was beginning to adhere to the surface. This was making the cleaning extremely difficult. The glass was successfully converted into ClearShield Glass. Today, the paint still flakes, but thanks to the "non-stick" surface it is still easily wiped off, there has been no long term staining and conventional cleaning methods are still sufficient to maintain the glass.

Roy Parrish, Lloyds Building Facilities Manager said, "we are very impressed with the ClearShield System, it has been extremely beneficial to our facilities management operation and we intend to carry on with the aftercare regime".

In order to ensure such results are obtained, basic requirements to obtain a satisfactory protection on the glass surface therefore are:

- strong chemical bond making the glass protection an integral part of the surface;
- multi-molecular instead of mono-molecular protection, for stronger performance and greater durability;
- strong protection against static and dynamic aqueous corrosion, attack from alkalinity and prevention of bonding of both organic and inorganic contaminants;
- safety in application, e.g. non-flammable and non-toxic;
- unlimited shelf-life;
- ease of application, either in the factory or on site, and adaptability to all volumes of production;
- easily washes off from other surfaces than glass;
- does not require any special protection during handling;
- durable and easily re-applied when necessary;
- track records under all types of operating conditions, indoors as well as outdoors. ■

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