justlook

magazine of window films

EWFA
EUROPEAN WINDOW FILM ASSOCIATION

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Editorial

Dear Reader,

The aim of this magazine is to introduce you to the world of window films.

People often have misconceptions about window films as they associate them with dark or mirrored-tint on vehicles and buildings. However, by reading these various articles, you will realise that this is not the case.

Window films are now manufactured using increasingly high-tech processes and their use with existing and, in some cases, new glazing systems, can enhance your every day working and living environment.

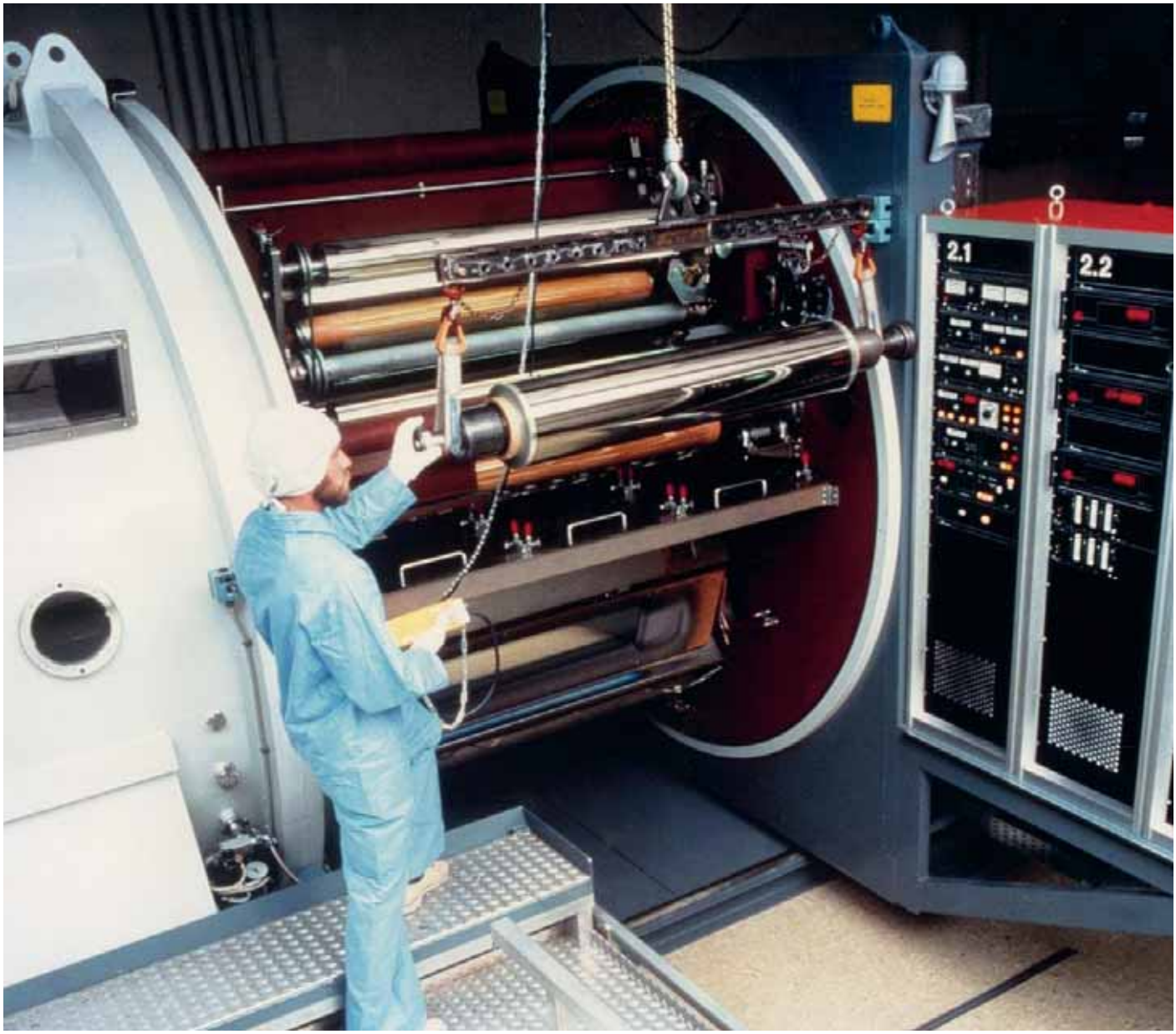
Architects and designers today are using glazing systems in buildings and vehicles as a major part of the construction and window films can enhance these systems to provide cost-effective solutions for energy savings all year-round (solar gain, UV protection), provide more safety / security (protection in the event of accident, vandalism, explosion or glass failure) and enhance privacy.

With best regards,

David Cox
President
European Window Film Association

Window film technology

AN INTRODUCTION



Coating and lamination of two polyester films in a clean room during window film manufacture

THE COMMENT "WINDOW FILM IS SIMPLY A STICKY PLASTIC" MAY HAVE BEEN TRUE THIRTY YEARS AGO. TODAY HOWEVER, THE COMPLEX AND DEMANDING TECHNOLOGIES USED BY THE INDUSTRY IS PRODUCING HIGH QUALITY AND HIGH PERFORMANCE WINDOW FILMS.

An insight into manufacturing

Whether a window film is used to reduce solar heat gain, improve safety and security, or to reduce fading, it is essential that high quality is provided to the end-user. This requires strict quality control of the raw materials, manufacturing processes, final product, packaging and warehousing. The number and types of tests verify that the window film is fit for purpose. Quality control has to be even stricter compared to some industries because window film will be used as part of the glass/glazing. The human eye can see defects as small as 25 microns (0.025 mm or 0.001 inches), so optical quality is essential for an unobstructed view through the glass + film.

Window Film Technology – Components

The performance and durability of window films is determined by the type and quality of the component used in the film and the construction used. The essential components include:

➜ Protective Release Liner
A film, usually polyester, which is used to cover the adhesive and protect it from contamination before installation.

➜ Adhesive
High quality, low or zero distortion adhesives that adheres the polyester film to glass; types used for automotive installations retain high adhesion even on double curved glass.

➜ Polyester Film
A strong, high clarity, high quality plastic film – more than one layer may be used with a laminating adhesive to produce a multi-layered structure.

➜ Scratch Resistant Coating
A hard acrylic coating that provides protection for the polyester against scratching and abrasion.

➜ Dyes, metals, alloys and UV inhibitors are added to produce the specific properties desired.

All components must have high optical quality to allow undistorted vision through the glass + film. Figure 1 shows a multi-layer window film sample that has gone through several manufacturing processes; quality control of raw materials, manufacture and end product adds further to these processes.

Window Film Technology – Manufacturing Processes

Very precise processes are required to ensure high quality. They include:

➜ Coating (Figure 1)
Adhesives and scratch resistant coatings are transferred from a container to a roller and then rolled onto the surface of the polyester.

➜ Laminating
A film coated with adhesive is adhered to a second uncoated film, using a roller system to press the two films together.

➜ Metallising (Figure 2)
Polyester film is wound round a water-cooled roller in a large metal vacuum chamber. Metal – usually aluminium – is evaporated onto the cold surface of the film.

➜ Sputtering (Figure 3)
Using similar equipment, a metal or alloy target is bombarded with positive ions to knock (sputter) atoms of metal out of the target and onto the cold film surface. A larger number of different metals and alloys can be sputtered and some, such as nickel, may also have extra resistance to corrosion. Slower but more precise than metallising.

➜ Colouring (Figure 4)
The colouring of window film may be achieved in several different ways. The adhesive may be coloured before coating it on the film or a laminating layer may be coloured. The use of dyes or pigments may be used to colour the actual polyester base film after it is manufactured or during the extrusion process itself. The manufacturer of any specific film would be able to explain the process used in its construction and the reasons, uses and benefits that may result.

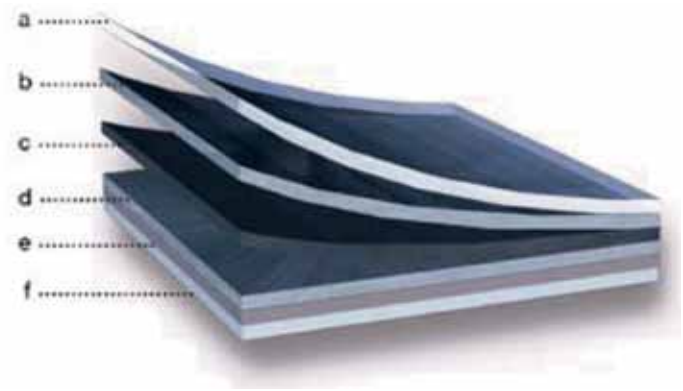


Figure 1:
Structure of a typical window film
a) release liner with silicone coating;
b) adhesive layer with UV inhibitor;
c) clear or tinted polyester film;
d) adhesive layer;
e) metallised layer for heat rejection on clear polyester film;
f) scratch-resistant coating.
Layer c may have added UV inhibitors for extended durability

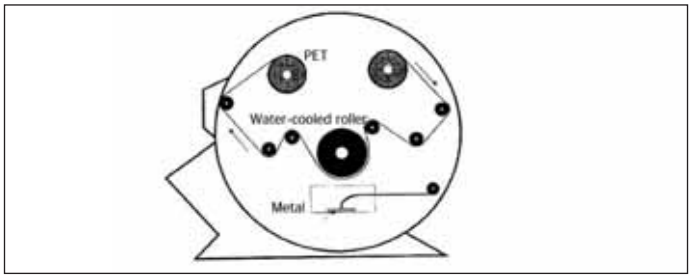


Figure 2:
Metallising of polyester (PET) film

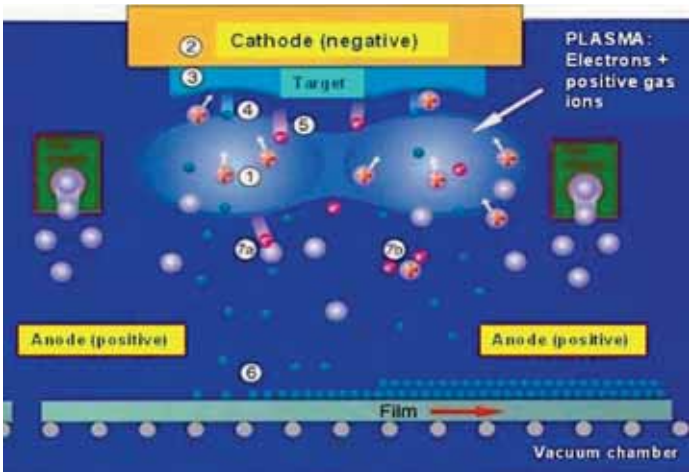


Figure 3:
Sputtering of polyester (PET) film

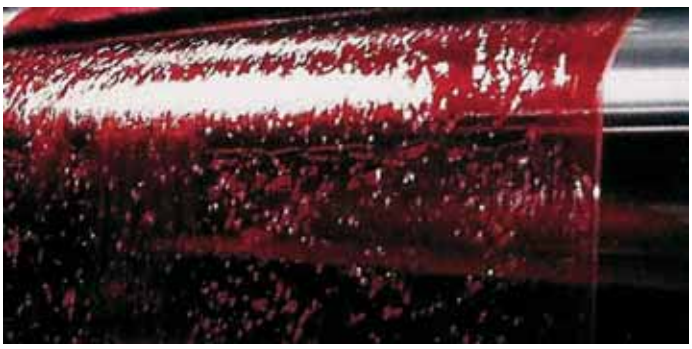


Figure 4:
Deep dyeing of polyester film –
the finished film must be a high clarity, low distortion product

Quality and durability

THE MANUFACTURING PROCESS

TECHNOLOGY: IT TRANSFORMS OUR LIVES. BUT SOMETIMES WE DO NOT RECOGNISE THE TECHNOLOGY USED TO PRODUCE APPARENTLY SIMPLE MATERIALS. FOR EXAMPLE, UP TO 230 DIFFERENT LAYERS ARE USED IN SOME WINDOW FILMS TO CREATE THEIR ADVANCED PROPERTIES. ADVANCED TECHNOLOGY MAKES WINDOW FILMS HIGHLY DURABLE, QUALITY PRODUCTS. QUALITY WINDOW FILMS COMPLEMENT AND ENHANCE THE BENEFITS OF GLAZING.

Window film during the coating and laminating process undergoes quality control inspections as shown in this equipment that utilises laser inspection technology

Quality and Durability from Film Construction

It is important to ensure that the product selected comes from a high quality, world-class manufacturer because film constructions and the materials and process controls used by the manufacturer strongly affect quality and durability. For example, good quality manufacturers will be concerned about constituents such as:

➜ UV Protection

Adding UV protection to the adhesive and to the polyester film enhances durability. The test shown on page 12 is for 2 500 hours accelerated weathering – about 4-5 years in hot-humid locations such as Florida. The bottom blue line shows the UV transmission for a film with UV absorbers in the adhesive and in the polyester film. The top red line shows the UV transmission for a film with UV absorbers in the adhesive only.

➜ Location of colours

As described in the previous article, the colour in a film may be provided by different constituent parts and in different locations within the construction. Such variations can provide a variety of effects both in performance and in durability and it is worth checking with the manufacturer of any particular film on how the film is made, how it will perform and how long it may be expected to last.

➜ Coating uniformity

Coatings such as metallising must be uniform; high quality manufacturers carefully control coating processes – for example, many sputtered coatings can be controlled to within 1% of the performance specification. Non-uniform coatings not only look bad but often do not have the properties claimed.

Quality from Clean Technology

Window film manufacturers take advantage of modern technologies to make high quality products by carrying out certain important production processes in ultra-clean environments. A clean room controls and limits the number and size of airborne particles. Particles of ≥ 0.010 mm (i.e. 10 microns – smaller than the full stop at the end of this sentence) are filtered out. A Class 10 000 clean room has no more than 10 000 of these size particles per cubic metre of air compared with the millions of larger-sized particles per cubic metre of air in our normal environment. Adhesives used in window films are also filtered to eliminate particles of more than a few microns. Machine operators wear clean clothes and hair nets.

Quality from Quality Control Testing

Window film manufacturers test their products for a wide variety of properties to monitor and control the properties and quality of the finished product, for example:

- Adhesion to glass
- Tear strength
- Colour
- Tensile strength
- Metallisation variation
- Lamination strength
- Scratch resistance
- Solar-optical properties such as solar energy rejection, glare reduction, visible light transmission and UV resistance.

In addition, good quality, high performance window films are manufactured with three essential attributes:

- The film layer(s) used are of high-strength and are made from optcally clear polyester
- Laminating adhesives must strongly bond individual film layers together and have good optical properties
- The adhesive bonding the film to the glass must have the correct coat weight on safety / security films in order to keep broken glass pieces together in event of glass breakage.

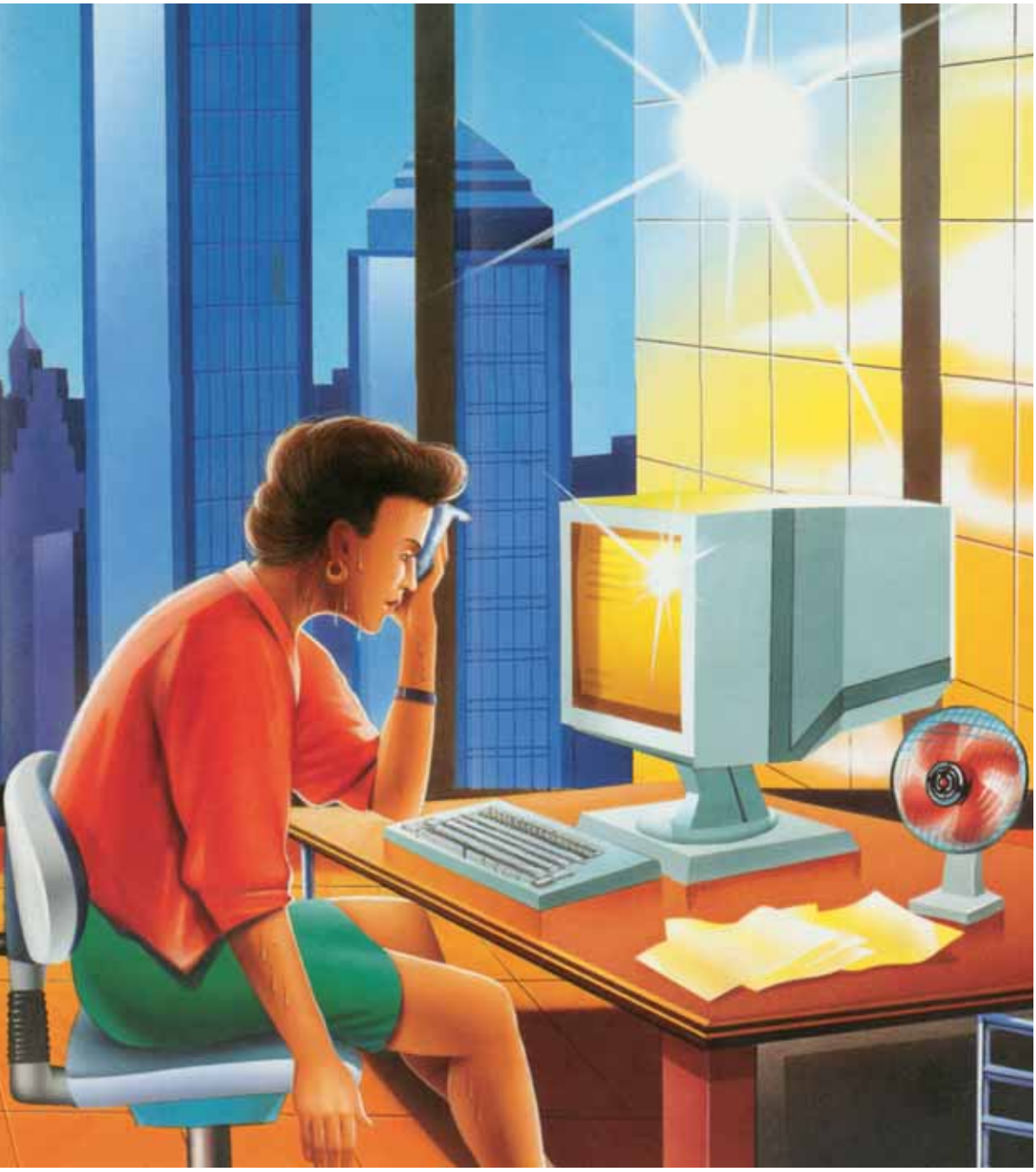
Durability from Resistance to Weathering Testing

Window film manufacturers routinely test window film products for resistance to weathering. Over the years, window film manufacturers have developed a very good understanding of weathering testing as their products are constantly exposed to the rays from the sun through the glass. Weathering resistance is essential for window films because they are continuously exposed to the sun. Sunlight contains damaging Ultra-Violet radiation; less well known is the fact that visible light and Infra-Red energy from the sun can also damage materials – so window films must resist both the degradation and the daily cycles of heating and cooling caused by solar energy. Accelerated weathering simulates high levels of solar energy (including UV), humidity, etc. found in hot and humid locations where degradation of the film is expected to be the worst. Testing is also done in 'real world' conditions in hot-humid and hot-dry locations. Only when the manufacturer is satisfied that the window film has the required durability is the product launched onto the market.

Durability – Warranty

Window films have progressed rapidly over the last decade and have long since gained their reputation for extended lifetime, good scratch resistance and high performance. Warranties may vary in their criteria of coverage depending on the film type and its function, the geographical location and the films construction. Furthermore the periods of the warranties may vary from two years to fifteen years. The most important thing to look for is that it is a warranty from the manufacturer themselves.

Improving the ene



CONCERNED ABOUT THE COST OF ENERGY FOR COOLING YOUR BUILDING? WORRIED ABOUT GLOBAL WARMING FROM EMISSIONS OF CARBON DIOXIDE INTO OUR EARTH'S ATMOSPHERE, A SO-CALLED 'GREENHOUSE GAS'? WANT TO KNOW AN EASY WAY TO REDUCE CARBON DIOXIDE EMISSIONS USING 'HIGH-TECH', COST-EFFECTIVE WINDOW FILMS AND SAVE MONEY?

Global Warming – the European Union Viewpoint

Global warming from carbon dioxide emissions and the cost of energy are major topics of discussion around the world. The European Union and European Governments are committed to reducing carbon emissions and improving energy usage with a particular focus on energy in buildings. In 2007, the European Commission organised a conference on the best implementation of the Energy Performance of Buildings Directive in the context of the EU sustainable Energy Week and identified energy efficiency in buildings as the most decisive contribution to improve energy efficiency. Energy efficiency in buildings is also at the heart of the Energy Efficiency Action Plan published by the Commission in October 2006 and part of the Strategic Energy Review presented in January 2007.

The Growth in Air Conditioning

In the ten years to 2000, Germany had a 250% increase in air conditioned floor area and the UK had an increase of about 60%. Unsurprisingly, the number of air conditioned buildings continues to rise across Europe. In this context, it is important to note that cooling buildings often consumes significantly more energy than heating. All this is in addition to energy demand caused by the revolution in computer and communications technology. The result? An escalation in demand for energy that seems never ending. This escalation adds to the attention given to energy efficiency. The most obvious source of high temperatures in buildings is the energy from the sun. In fact research by the Building Research Establishment (BRE) in the UK shows that on average, 40% of the load placed on air conditioning in offices comes from direct solar gain through windows. As events in recent times indicate, the cost of fuel is very unlikely to fall in any significant way and so such sources of energy consumption cannot be ignored.

The Business Perspective

Responsible employers want to

play a part in reducing global warming, and, naturally, they also want to keep staff happy while controlling capital expenditure and operating costs. In addition, European businesses and other organisations are required by EU Directive and legislation to maintain workplace comfort for employees, including ensuring temperatures in workplaces are neither too hot nor too cold – and energy is expended in cooling or heating buildings. This creates an apparent contradiction: save energy according to legislation or expend energy keeping workers comfortable according to legislation.

The Solution

Using modern high technology solar control window films, the cooling loads demanded by air conditioned buildings can be substantially decreased, giving business managers the possibility of significant savings in energy costs and maintain workplace comfort, as well as contributing to reducing carbon dioxide emissions.

Solar Control Window Films – Performance

The article "Thermal Comfort in Buildings" gives details of how these high technology films work. The fundamental requirement is to ensure the solar control window film reflects high levels of solar radiation back to the outside, before this solar energy can be absorbed by or enter into the building. Table 1 gives just a few examples of the performance of some solar control window films compared to selected glass types. With g values[1] of as little as 1/4 that of the glass itself and total solar energy rejection values as high as 81% the solar control performance of glass can be improved considerably. This shows that the range of solar control window films work well for various types of glazing. Typically, the metallised films, using aluminium, copper and silver, along with certain specific spectrally selective films have higher performances. Neutral films, using nickel or stainless steel, have more moderate performance and are more suited to clear glazing and older style buildings. External solar control films also provide high performance protection and can be used on virtually any glazing type.

Solar Control Window Films – Payback Time

So what is the typical performance of solar control window films in reducing energy costs? Understandably, the actual results depend not only upon the film selected but also upon the glazing specification and building construction. However, it is possible to save thousands of Euros a year in energy costs, even in moderate climates. Payback times of less than 3 years are achievable.

How do I select the best film?

It may appear that selecting the correct solar control window film for the type of glazing is not always straightforward. There are specialist window film installation companies across Europe to provide assistance in window film specification. These experts must understand glass and glazing as well as the window film itself. They will check your glass / glazing and ensure that the correct product is specified with respect to both your requirements and to the glazing system. They may even be able to provide a model for your cooling energy demand and an analysis of the predicted energy savings compared with current use, based upon the internationally recognised DOE-2 simulation software.

Glazing system	Direct solar transmittance	Direct solar reflectance	g value	Total Solar Energy Rejected
Clear 4 mm glass				
Glazing only	0,81	0,07	0,84	14%
+ 20% metallised 'silver' film	0,12	0,55	0,20	79%
+ 20% bronze sputtered film	0,14	0,43	0,25	73%
+ 35% neutral sputtered film	0,35	0,17	0,47	52%
+ 60% Spectrally Selective film	0,31	0,28	0,41	58%
+ 35% metallised external grade film	0,22	0,50	0,28	71%
Clear 4/16/4 Insulating glass unit (IGU)				
Glazing only	0,67	0,12	0,74	25%
+ 20% metallised 'silver' film	0,11	0,45	0,31	68%
+ 20% bronze sputtered film	0,12	0,37	0,36	63%
+ 35% neutral sputtered film	0,29	0,18	0,57	42%
+ 60% Spectrally Selective film	0,27	0,22	0,51	48%
+ 35% metallised external grade film	0,17	0,50	0,23	76%
Bronze tinted 4 mm glass				
Glass only	0,60	0,06	0,70	28%
+ 20% metallised 'silver' film	0,09	0,31	0,26	73%
+ 20% bronze sputtered film	0,10	0,26	0,28	71%
+ 35% neutral sputtered film	0,26	0,10	0,45	53%
+ 60% Spectrally Selective film	0,22	0,15	0,39	59%
+ 35% metallised external grade film	0,14	0,49	0,25	73%
Bronze tinted 4 mm outer glass / 16 mm space / 4 mm clear inner glass IGU				
Glazing only	0,49	0,09	0,59	40%
+ 20% metallised 'silver' film	0,08	0,26	0,27	72%
+ 20% bronze sputtered film	0,09	0,22	0,31	68%
+ 35% neutral sputtered film	0,22	0,12	0,46	52%
+ 60% Spectrally Selective film	0,19	0,15	0,41	58%
+ 35% metallised external grade film	0,12	0,49	0,19	81%

Table 1:
Performance of solar control window films – examples of upgrading and modifying glass

[1] The total amount of solar energy that goes to the inside of the building by reflection and by absorption / re-radiation.

Thermal comfort in buildings

ARE YOU TOO HOT IN YOUR OFFICE SITTING IN THE SUN? WISHING THE AIR CONDITIONING WOULD WORK BETTER? THE PROBLEM OF OFFICES OVERHEATING ON SUNNY DAYS IS FOUND ACROSS THE WORLD. EMPLOYEES WHO ARE HAPPY AND COMFORTABLE AT WORK ARE AN IMPORTANT FACTOR TO BUSINESS COMPETITIVENESS AND EFFICIENCY. ONE COST-EFFECTIVE METHOD TO REDUCE SOLAR OVERHEATING IS USING THE MICRO-THIN, HIGH PERFORMANCE TECHNOLOGY OFFERED BY SOLAR CONTROL WINDOW FILMS.

What is Solar Overheating?

Heat flows from hot to cold by radiation, conduction or convection, or by a combination of these processes, for example:

- The sun warms the earth by radiation – its temperature is about 5500° C compared to less than 40° C for the earth
- A metal bar heated at one end will become hot at the other end because heat transfers to the other end of the bar by conduction
- A wind will occur when one part of the earth is warmer than another – the heat is transferred by convection via the air.

Buildings gain heat from many sources including lighting, electrical equipment, building occupants, and the sun.

We all know the power of solar energy – it is so strong that buildings can reach high temperatures after a short period of time. Air conditioning systems can reduce the problem but then building managers can find themselves in the predicament that part of the building is at satisfactory temperatures but other areas are too hot or too cold. Added to this, direct solar energy causes surface temperatures – doors, walls and furniture – to become particularly hot. Worse still, people sitting in direct sunlight experience the full force of the sun, heating both them and their surroundings.

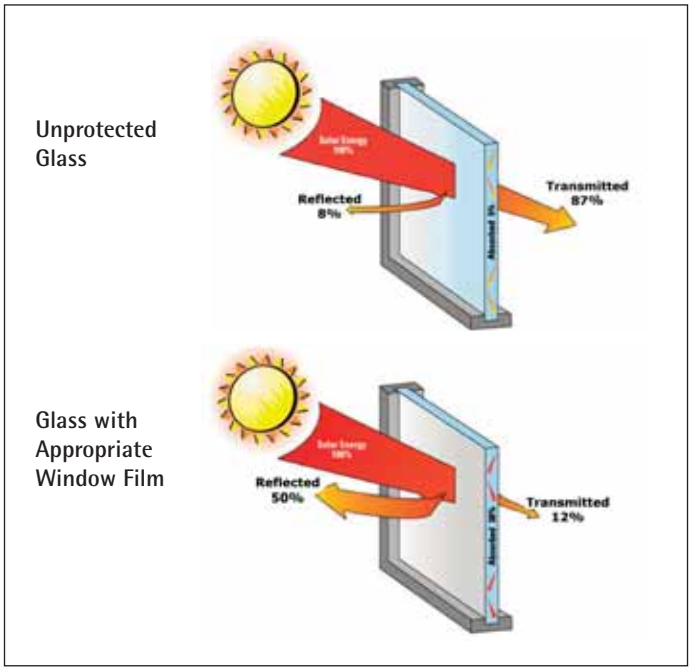
The Effects of Solar Overheating

There are three aspects to consider:

- Building occupants prefer stable workplace temperatures of typically 20-23° C. It has been shown that as workplace temperatures rise above 24° C workers concentration drops by 30-50%; in factories, above 25° C, staff can become more vulnerable to accidents and mental performance declines, causing productivity and quality to suffer. Trade Unions and staff organisations may draw the attention of managers to the high room temperatures, adding to the impetus for a solution to solar overheating
- However, not only is a reasonable room temperature needed, but it should be realised that comfortable workplace conditions are also influenced by changes in temperature and by the speed of such a change. In real life, environmental conditions will always be changing, so buildings will never be at constant temperatures. If the temperature is acceptable and then a change in environmental conditions is slow, or if the change is small, then workplace comfort will change slowly or not significantly and people will generally remain content. But a fast and large change in room temperature will also cause workplace comfort to change quickly.

The Solution

Reducing solar energy transmitted by glazing before it enters the building by installing solar control window films is often the best solution. This helps to reduce solar heat gain, workplace room temperatures, and the rate of temperature change.



See the difference in Solar Energy transmission when comparing clear glass and glass with appropriate window film.

Glare reduction

WE LOVE THE SUN, BUT IT CAN CAUSE UNWANTED GLARE. GLARE IS EITHER TOO MUCH LIGHT OR INTRUSIVE LIGHT; TWO EXAMPLES WILL HELP TO RECOGNISE THESE DIFFERENT DEFINITIONS OF GLARE:

1. **YOU ARE WORKING AT YOUR DESK BUT SUNLIGHT ENTERING THROUGH THE GLAZING MAKES IT DIFFICULT TO SEE YOUR COMPUTER SCREEN, PAPERWORK, ETC. THIS IS EXCESS DIRECT GLARE WHICH TENDS TO BE MORE PREVALENT IN THE WINTER AND SPRING AS THE SUN IS LOWER.**
2. **YOU ARE DRIVING YOUR VEHICLE AND YOU LOOK OUT THE WINDOW AND SUDDENLY THE SUN IS RIGHT THROUGH THE WINDOWS OF THE VEHICLE. THIS IS CONTRAST GLARE. SOME SITUATIONS CAN CAUSE PARTICULARLY CHALLENGING PROBLEMS WITH GLARE SUCH AS WHEN WORKING AT A COMPUTER SCREEN AND THE WINDOW IS SEEN REFLECTED OFF THE SCREEN INTO YOUR EYES – THE AMOUNT OF REFLECTED LIGHT CAN BE MUCH GREATER THAN THE LIGHT GIVEN OFF BY THE SCREEN.**

Reducing Direct Glare

There is one important point to understand: to reduce excess direct glare it is essential to reduce the visible light transmission of the glazing – it is impossible to have a clear, transparent window or window film that also reduces glare. Most glare problems can be solved by window films. Glare reduction, the percentage reduction in visible light transmission compared to a clear 4 mm annealed glass pane, is a good measure of the effectiveness of a window film product.
A good guide to finding the amount of Glare Reduction you need is to consider how glare affects you:

Reducing Contrast Glare

Contrast glare often occurs with direct glare, and in such cases the same method as for reducing direct glare should be used. Where contrast glare occurs on its own then a diffusing film can be used. This type of product can allow high Visible Light Transmission levels of 65% or more and, because light is diffused, also can provide privacy to people seeing in through the glazing.

Working Conditions	Specify minimum Glare Reduction
Comfortable	No glare reduction needed
Slightly uncomfortable	Minimum 30% required
Uncomfortable	Minimum 60% required
Distressing	Minimum 80% required
Disabling	Minimum 90% required
Glare from computer screen	Minimum 90% – often more – is required

ANTI-GRAFFITI

COST-EFFECTIVE SOLUTIONS

GLASS IS A VERY EASY TARGET FOR GRAFFITI: GLASS IS EASILY ATTACKED. CHEMICALS THAT ETCH THE GLASS OR SMALL, EASY-TO-CONCEAL TOOLS THAT SCRATCH THE GLASS ARE COMMON EXAMPLES OF THE VANDAL'S PREFERENCES. THE ETCH MARKS AND SCRATCHES ARE DIFFICULT TO REMOVE AND BECOME A MOVING ADVERTISEMENT OF THE DAMAGE CAUSED BY THE GRAFFITI 'ARTIST'.

The cost-effective answer – Sacrificial window film

This special type of film is made to cover and protect glass surfaces from deliberate or accidental damage. The film is 'sacrificed' to keep the glass looking good. Of course, a virtually invisible appearance after professional installation allows a choice to be made from either optically clear film, or from tinted or coated film to modify the glass to a solar control product.

Is there an alternative?

Apart from glass replacement and sacrificial window film, scratches can be removed by polishing the glass. But this reduces glass thickness and introduces distortion into the glass; reduced glass thickness can also mean reduced glass strength. And if the glass is scratched again the window has to be replaced anyway.

Graffiti doesn't affect glass very much, does it?

Graffiti on glass is not only annoying, it obstructs vision view through glass and destroys the aesthetic appearance of windows. It makes people feel uncomfortable about using the trains and buses that have graffiti on the glass. Worse still, 'graffiti attracts graffiti' – once there is some graffiti present, more graffiti will often appear nearby. Thousands of train windows in Germany are replaced every year because of this type of damage and the problem is being seen across Europe.

It is expensive to replace the glass

In addition to looking bad, it costs a lot of money to replace damaged glass. High performance glazing in buildings can cost hundreds of Euros per window to replace.
Ask any train or bus operator, especially in the large cities. Some of these organisations will spend hundreds of thousands of Euros a year on replacing glass that has been defaced by graffiti – profits that cannot then go to shareholders and pension funds, or money that local and national governments have to pay out from their tax and other revenues. This is often a hidden cost for our public transport systems that we don't always appreciate. Also, consider how a glass pane has to be replaced in, for example, a train:
➜ Take the train out of service and move it to a safe location, often the train engineering warehouse ➜ Remove the fixings that keep the glass window in place ➜ Have the complete glass pane removed from the train using a crane or pulley ➜ Winch the new glass into place ➜ Replace the fixings ➜ Put the train back into service – at least 2 hours later, and more if there are several windows to replace ➜ All this costs money, and uses highly skilled train engineers who could be doing other more productive and satisfying work.

Sacrificial Window Film

If the film is damaged, replacement by professionally trained staff is quick and easy. The train or bus can be out of service for no more than a few minutes and does not have to be moved far from its normal place of work. For buildings, the disruption caused by replacing a window is avoided. And the cost is much lower than replacing the complete piece of glass. Glass stays looking good for longer. Better still, the adhesive can hide mild scratching, saving the cost of replacing some damaged glass! The film provides protection against a variety of attacks: scratching, felt tip pen, paint and even glass etching chemicals.

Protecting property against fading

SUN ATTACK!

THE SUN CAN DESTROY THE COLOUR OF PICTURES, PHOTOS, CURTAINS, CLOTHES AND FURNITURE. IT CAN ALSO CAUSE DAMAGE TO PAINT, WOOD AND OTHER MATERIALS BE IT AT HOME OR IN YOUR SHOP DISPLAY WINDOW.

UV is Not the Only Cause of Damage

Fading is usually thought to be caused by Ultra Violet light in sunlight. In fact, fading is caused by all parts of the solar energy reaching the earth: UV, Visible Light and solar heat all cause fading and damage. Figure 1 gives approximate contributions to fading and damage by the UV (40%), visible light (25%) and solar heat (25%) in sunlight, which mean that approximately 90% of fading and damage is from solar energy.

Miscellaneous factors (10%) include air humidity, indoor lighting and fabric quality.

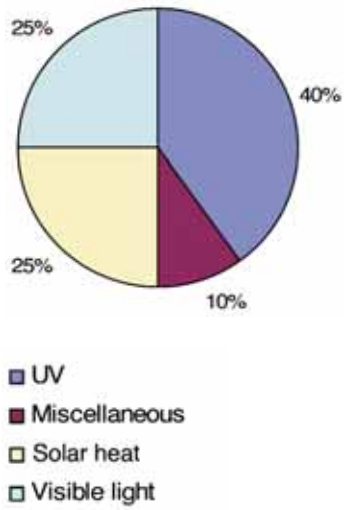


Figure 1:
Causes of fading and damage from solar energy (estimated figures)

Who can benefit by protecting goods and materials from fade and damage?

Museums can protect their paintings and other works of art, artefacts, clothing, etc. from damage caused by solar energy – and can provide a good optical environment for conservation work without distortion of colours. Businesses can protect their investments in furniture and office equipment as well as carpets, curtains, etc. Shop and home owners can reduce damage to valuable goods and merchandise.

How much slower will materials fade with UV protection film?

As a guide, specialist UV filtering films often halve the rate of fading, or, in other words, window films double the time taken for the same amount of fade / damage. However, it is essential to remember that different materials react in very different ways. The types of materials, fabrics, dyes and colours used to manufacture your product strongly influence the extent of fading and damage resulting from solar energy; natural fibres (such as silk) and natural colours tend to fade and be damaged quicker than synthetic materials. And fading is no respecter of the cost or value of the goods – some expensive products can fade remarkably quickly.

Key points

- Fading cannot be stopped although in the majority of cases it can be reduced
- UV is the most important part of solar energy to filter, but filtering visible light and/or infra-red energy may also be needed
- Delicate or valuable items require more protection from sunlight than other items.

Therefore it is essential to ensure the best choice of window film is selected.
Specification of window films for fade reduction is relatively easy and advice is available from manufacturers, distributors and authorised dealers.

How to Specify the Correct Film

➜ General

It is important to ensure that the selected film will continue to offer protection from fading and damage over a number of years. Fact Sheet 1 shows the UV transmission of UV filtering windows films after accelerated ageing – the performance of the two types clearly demonstrates the very significant difference in the protection offered. The good durability UV reducing film shows only a small increase in UV transmission after the equivalent of several years' exposure to sunlight, compared to the high UV transmission of the other film.

➜ Conservation of Valuable Items: Museums, Art Galleries, etc.

UV: museums and similar institutions require the UV to be reduced to very low levels. A special measure of the quantity of UV in visible light is used, called microwatts per lumen (or µW/lumen). It is usually required for the UV to be < 75 µW/lumen and sometimes < 10 µW/lumen. Many window films will provide < 75 µW/lumen; specialist films will reduce UV to < 10 µW/lumen or even < 5 µW/lumen.

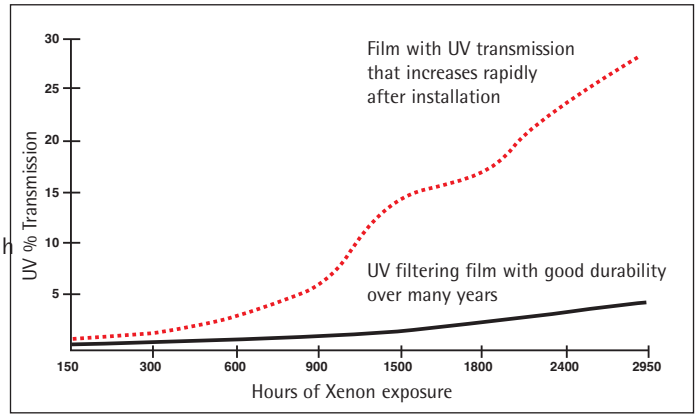


Figure 2:
UV Transmission % of UV filtering window films with accelerated ageing

Clear films:	
UV Transmission (UVT)	≤ 0,5%, preferably ≤ 0,1% < 75 µW/lumen or < 10 µW/lumen as required
Visible Light Transmission (VLT)	≤ 85%
Direct Solar Energy Transmission (SET)	< 90%
Additional requirements:	UV transmission at low level for ≥ 7 years Colour Rendering Index > 90, preferably > 95
Metallised, sputtered and tinted films:	
UV Transmission (UVT)	≤ 0,5%, preferably ≤ 0,1% < 75 µW/lumen or < 10 µW/lumen as required
Visible Light Transmission (VLT)	≤ 40%, as required for the specified lux levels
Direct Solar Energy Transmission (SET)	≤ 55%, preferably ≤ 35%
Additional requirements:	UV transmission at low level for ≥ 7 years Colour Rendering Index ≥ 80, preferably ≥ 90 No large colour change in the film after 7 years

Fact Sheet 1

Visible Light: the amount of visible light allowed in the museum depends upon the sensitivity of objects to visible light. A Scottish Museum gives recommendations for maximum light levels (Fact Sheet 1):

- 50 lux for sensitive items
- 200 lux for moderately sensitive items, and
- 300 lux for insensitive items

These recommendations mean that some areas may need little reduction in the amount of visible light transmitted by the glazing while other areas need a very high reduction in visible light transmission. The 50 lux value may require visible light transmission to be reduced to much less than 5%.

Infra-red energy: The requirement for filtering Infra-Red (IR) energy also depends upon the type of object being protected. Objects that are subject to thermal stress damage or to drying out (which then causes damage) will obviously require better protection than non-IR sensitive items.

Specification for UV, Visible and IR: All three aspects, UV, Visible Light and IR, need to be considered according to the objects being protected. A simple method of selecting the appropriate film is to choose between specifying a clear film or a solar control film.

➜ Offices and Other Workplaces

Many offices suffer from solar gain and glare related problems. By using solar control window films, you can resolve these issues and reduce UV and infra-red transmissions that can cause damage to property and health.

➜ Shops and Homes

Many shops and homes require maximum light transmissions through their glass; a slight tint is acceptable, but often no more. It is essential to reduce UV light to very low levels while reducing a little of the visible light and direct infra-red energy transmission can provide extra protection.

Safety and security

GLASS IS A VERSATILE MATERIAL. IT IS USED TO ALLOW LIGHT AND WARMTH TO BRIGHTEN OUR BUILDINGS AND IMPROVE THE AESTHETICS. IT IS EVEN USED AS PART OF THE STRUCTURAL STRENGTH OF BUILDINGS. HOWEVER, SOMETIMES IT CAN BE A HAZARD WHEN BROKEN OR IS THE WEAK POINT FOR DELIBERATE ATTACK. FORTUNATELY, QUALITY SAFETY FILM PROVIDES AN EASY METHOD OF MODIFYING PLAIN GLASS FOR RESISTANCE TO ACCIDENTAL IMPACT. HIGH PERFORMANCE SECURITY FILM CAN IMPROVE RESISTANCE TO EXPLOSIVE, BULLET OR REPEATED IMPACT ATTACK.

Figure 1:
Security film on ordinary glass: EN 356 uses the steel ball impact test to represent deliberate attack. A 4,11 kg steel ball is dropped repeatedly from a specified height onto the security glazing. The EN 356 classification depends upon the drop height and number of impacts:

- 1.5 m, 3 impacts = Class P1A
- 3.0 m, 3 impacts = Class P2A
- 6.0 m, 3 impacts = Class P3A
- 9.0 m, 3 impacts = Class P4A
- 9.0 m, 9 impacts = Class P5A

➜ Security Glazing
glazing material that passes a suitable test; there are several tests that can be used for security performance of glazing including:
- *EN 356: Glass in building – Security glazing – Testing and classification of resistance against manual attack (steel ball simulated attack)*
- *Explosion testing: Governments – such as the UK – have developed systems of hazard assessment for glazing resistant to explosive attack*
- *EN 1063: Glass in building – Security glazing – Testing and classification of resistance against bullet attack*

Security Film Specification

For all specification of security films it is essential to obtain professional advice. The following guidance is intended to help you only as a preliminary source of information for security film specification. The performance and type of security film required often varies considerably from one project to another.

Characteristics of security film

➜ Manual attack

In order to resist the steel ball attack test, the security film has certain attributes:

- The adhesive must bond strongly to the glass to hold broken glass pieces together – acrylic pressure sensitive adhesive is most commonly used
- The base film used must resist stretching, puncture, and tearing – polyester (PET) film is used for this purpose, which, in addition, has excellent optical properties
- The security film must be a laminate consisting of two, three or more separate layers or micro-layers of PET film - laminated structures perform better than single ply materials; the layers are adhered together using acrylic pressure sensitive adhesive.

➜ Explosive attack

Many explosion resistant security films are single ply, but the highest performing films are laminated multi-ply or micro-layered products with similar characteristics as above.

➜ Bullet attack

Depending upon the type of security glazing the security film may be single or may be multi-ply with similar characteristics as above.

All types of safety and security film have a high adhesive bond to the glass. The adhesive retains broken glass fragments and helps to absorb some of the energy of the attack.

Security Glazing Performance – Resistance to manual attack – EN 356

EN 356 is the recognised test standard for assessing the resistance to manual attack of security glazing. The first part of EN 356 uses a 4.11 kg hardened steel ball; the sample of security glazing is positioned horizontally and the steel ball is dropped vertically onto it. Five samples of the security glazing must pass the test; the drop height and number of impacts then determine the final EN 356 classification. Figure 1 shows the effects of the steel ball dropping from 3 metres onto 4 mm glass + security film; the glass breaks but a barrier remains against forced entry. The EN 356 classifications for the steel ball drop test are also shown.

The velocity the steel ball strikes the security glazing test piece ranges from about 20 kph to almost 50 kph; the impact energy ranges from 60 Joules to 363 Joules. These values demonstrate the high resistance the security film + glass must have to the impact from the hardened steel ball. Remember: the glass used above to demonstrate the effectiveness of security film is ordinary 4 mm float glass, which is not even a safety glass let alone a security glass. Most security films are designed to reach EN 356 Class P2A, but window film manufacturers are constantly developing the technology of security films. It is possible that EN 356 Class P3A will be reached in the near future with Class P4A following some time later.

Security Film Specification – Resistance to manual attack

Specify the EN 356 class you want to achieve with security film on annealed glass, either P1A or P2A.

Security Glazing Performance – Resistance to explosions – Hazard Ranking

A common method of assessing security film on glass for resistance to explosions is via a hazard ranking assessment. This method was developed by the UK Government in the 1980's as a result of the terrorist explosions being experienced and it has been adapted by the USA Government in the US General Services Administration (GSA) Standard Test Method for Glazing and Glazing Systems Subject to Airblast Loadings. It is being written into forthcoming EN standards. Figure 2 gives details of the current UK Hazard Ranking system. Security film, installed with a small edge gap, will upgrade plain float glass to hazard level 2 or hazard level 3, depending upon the type of film used and the glazing construction.

Hazard level 2 may be obtained by using security film with an appropriate edge retention system. An edge retention system is simply an attachment that bonds to both the film and to the frame; it may be a structural silicone, a galvanised and powder coated steel section (e.g. in an L shape, Z shape, etc. as required by the frame), or similar system. In an explosion, the security film retains broken glass fragments and the edge retention system bonds the film to the frame. This reduces both the risk of broken glass fragments entering into the building and the hazard level. Typical areas that may be treated with both security film and with an edge retention system are escape routes out of a building, safe assembly areas, personnel offices, and computer suites.

Security Film Specification – resistance to explosions

Usually security film is specified for explosion resistance by thickness and EN 12600 impact resistance because these factors are related to the hazard level achieved.

Security Glazing Performance – Resistance to bullets – EN 1063

Bullet resistant glass may be improved with security film, but the performance of ordinary glass is unlikely to improve. Bullet resistant glazing is classed either as NS (No Splintering) or S (Splintering); splintering is where particles of glass break away from the surface of the glass opposite the side where the bullet impacted. Security film will usually upgrade an NS type glass to an S type glass. The increasing technology used in security films means it is possible that one will be developed that will upgrade a non-bullet resistant glass to a true bullet resistant glass. However, the current window film technology of upgrading to an S type glass from NS is an advantage, because some S type glass can become scratched over time – if the security film (which has a hard scratch resistant coating) is scratched then it can easily and quickly be replaced without having to replace the complete – and very expensive – bullet resistant glass.

UK Hazard Ranking	USA Hazard Ranking
1	1 – no glass breakage
	2 – glass breaks; no fragments inside
2	3a – glass breaks; fragments inside ≤ 3.3 ft from window
3	3b – glass breaks; fragments inside ≤ 10 ft from window
4	4 – glass breaks; fragments inside ≤ 2 ft up witness panel at 10 ft from window
5	5 – complete failure

Figure 2: Hazard Ranking System from UK Government. For comparison, the approximate USA Hazard Rankings. 1ft = 0.3048 m

Safety Films

➜ Safety Glazing
Safety glazing is defined as a glazing material that passes a standardised impact test; the European impact test is EN 12600 (Figure 2).

Figure 1
Typical break pattern for safety film on 4 mm float glass. The film upgrades the glass to a safety glazing material by keeping the broken pieces of glass together and provides a barrier against falling through the glass.

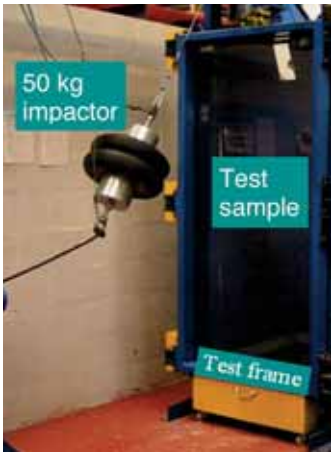


Figure 2
EN 12600 test equipment

Figure 3
Drop height for EN 12600

Safety Glazing – EN 12600 Impact Test

Impact tests use an impactor to strike the glazing material and assess if it safely resists impact. EN 12 600 also assesses whether it can reduce the risk of someone falling through the glass. The impactor is 50 kg in weight and is suspended on a steel wire. Figures 2 and 3 show a setup for the EN 12 600:

- Figure 2 shows a glazing sample (clear safety film + 4 mm float glass) ready for testing
- The impactor is pulled away from the glass sample until it has increased in vertical height, as shown in Figure 3; this is called the drop height
- The impactor is released and allowed to strike the centre of the glazing sample once (also see Figure 1).

Safety Glazing – EN 12600 Classification and Specification

a Impact Resistance depends upon the drop height:
Class 1 = impact resistance at 190 mm, 450 mm and1 200 mm;
Class 2 = impact resistance at 190 mm and 450 mm;
Class 3 = impact resistance at 190 mm.

ß Breakage Type:
A = like annealed glass;
B = like laminated glass;
C = like tempered glass.

y Containment performance / reduced risk of falling through the window: EN 12 600 allows no split in the glazing material through which a 76 mm sphere can pass with a force of 25N.
Class 1 = containment performance at 190 mm, 450 mm and 1 200 mm drop heights;
Class 2 = containment performance at 190 mm and 450 mm drop heights;
Class 3 = containment performance at 190 mm drop height.

Safety film type	Glass type	EN 12600 Classification, αβγ	Impact energy
100 micron clear	3 mm to 6 mm float	2B2	221 Joules
100 micron clear	Wired glass: 6 mm clear or 7 mm opaque	3B3	93 Joules
175 micron clear	3 mm to 6 mm float	1B1	588 Joules
175 micron clear	Wired glass: 6 mm clear or 7 mm opaque	2B2	221 Joules
100 micron solar control	3 mm to 6 mm float	2B2	221 Joules
200 micron solar control	3 mm to 6 mm float	1B1	588 Joules
275 micron clear security	3 mm to 6 mm float	1B1	588 Joules
375 micron clear security	3 mm to 6 mm float	1B1	588 Joules

Examples of using safety film to make plain float glass safe

Specification Process:

➜ Specify the EN12600 performance level according to local Glazing and/or Building codes. If you are unsure about the glass type or Glazing/Building codes relevant to your situation, contact your local specialist window film installation company or window film manufacturer (see contact details on the back page) to get the best professional advice.

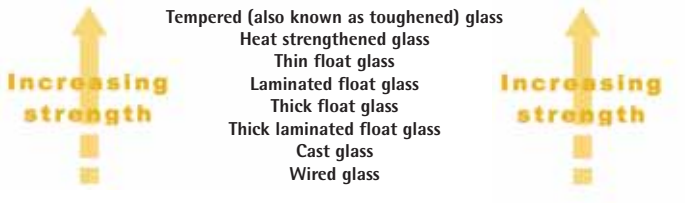
➜ It may be that a Glass survey is required to identify the type of glass and understand whether any upgrade or enhancement is needed to meet the required performance levels and if so, which films are to be used.

➜ To achieve the required EN12600 performance level, the type of glass and film combined must be taken into account. For example, if a Level 2B2 performance is required, the table shows that ordinary annealed glass between 3mm and 6mm thick, with a standard 100 micron thick safety film applied to it, will meet this level.

Film-to-glass compatibility

THERMAL STRESS

WILL GLASS BREAK IF WINDOW FILM IS INSTALLED TO GLAZING? GLASS CAN ALWAYS BREAK WHETHER WINDOW FILM IS INSTALLED OR NOT. HOWEVER, THE RISK OF BREAKAGE FROM THERMAL STRESS IS USUALLY VERY LOW WHEN THE GLASS IS IN GOOD, UNDAMAGED CONDITION AND COMPLIES WITH THE APPROPRIATE EUROPEAN AND NATIONAL STANDARDS.



How is thermal stress caused?

Thermal stress in a glass pane is caused by a temperature difference in one part of the glass sheet compared to another part. The greater the temperature difference, the greater the thermal stress. Solar energy is the single major cause of temperature difference in glass; the process of thermal stress breakage is shown in Figures 1 to 3.

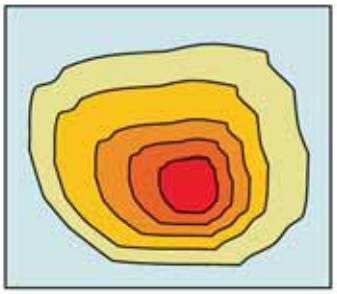


Figure 1
Solar energy warms the centre of the glass pane, which rises in temperature. The glass edges are hidden by the frame so remain cooler.

Tempered glass should never suffer from excess thermal stress (except in an actual fire) due to the manufacturing process. **Heat strengthened glass** is also highly unlikely to suffer from thermal stress. On the other hand, **ordinary annealed glass** may suffer and fail in some circumstances. Applications of solar control window film are always acceptable on tempered glass and mostly on heat strengthened glass. However, a little more caution should be used when considering the application of solar control film to annealed glass. Read on to understand what to look for and how to proceed.

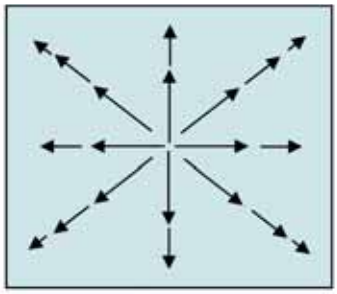


Figure 2:
The centre area of the glass expands more than the edges; the edges are then under stress to expand = thermal stress.

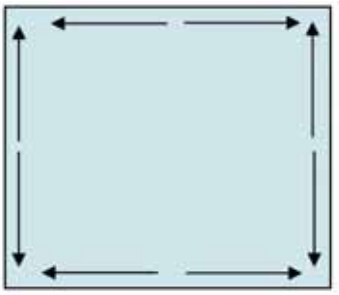


Figure 3:
If this thermal stress meets or exceeds the breaking strength of the glass, thermal stress fracture of the glass pane occurs.

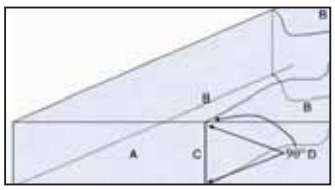


Figure 4:
Characteristics of thermal stress fracture in float glass.
Key: A = edge of float glass B = surface of float glass C = origin of fracture (not near a corner) D = angles the thermal stress fracture makes with the glass edge and surface = 90°

What does a thermal stress breakage in glass look like?

Figure 4 shows the characteristics of thermal stress breakage in float glass. If a crack has all these characteristics then it is likely to be caused by thermal stress; if the crack does not have all these features then it is nomaly not caused by thermal stress.

Window film compatibility with glass – thermal stress factors to consider

The aim of correctly specifying window film is to keep the risk of thermal stress breakage to a low level. factors to consider: glazing and environmental factors involved in the thermal compatibility of window films with glass include film type, glass quality, glass specification, glass thickness, glazing type, pane size, external / internal shading, frame type, altitude and solar energy intensity. In particular, glass / glazing must be in good undamaged condition (including undamaged edges) and meet relevant National and European standards. Window film should never cause thermal stress breakage with tempered glass, and is highly unlikely to cause thermal stress breakage with heat strengthened glass. Incorrectly specified window film can increase the risk of thermal stress breakage of float glass. Factors to consider: properties of the film are its solar energy transmission, reflection and absorption, the most important being solar energy absorption. Solar-optical properties of window film vary according to the film selected and the glazing system construction (glass type, thickness, etc.). Solar energy transmission, reflection or absorption values for one glazing system + window film can give different information on compatibility compared with other glazing system using the same window film. Window film manufacturers have developed film-to-glass thermal stress compatibility recommendations for the most common glazing systems, generally making the assessment process quick and easy for the trained professional.

How to keep the risk of thermal stress breakage to a low level?

A professional thermal stress compatibility assessment is highly recommended, which will consider all the relevant factors such as those given above. As long as the window film installation has been professionally assessed for compatibility with the glass/glazing according to these types of factors, the risk of thermal stress breakage will remain low. The window film manufacturer, distributor or installer should always be consulted for specific checks on thermal stress and film-to-glass compatibility and for advice on which films are suitable for your glass and glazing.

Automotive applications

STYLING AND PROTECTION

AUTOMOTIVE WINDOW FILM – OFTEN KNOWN AS AUTOTINT FILM – IS AN EASY WAY OF INSTANTLY UPGRADING GLASS IN VEHICLES. AUTOMOTIVE WINDOW FILM CAN ADD AESTHETIC APPEAL, REDUCE THE SOLAR HEAT GAIN AND INCREASE PROTECTION BY BOOSTING THE SAFETY AND SECURITY FEATURES OF YOUR GLASS.

Four Uses of Autotint Films

1. Aesthetic

There are two important points to consider: visible light transmission and colour. Autotint film comes in various grades from very light to very dark. It is always important to ensure that the film you choose complies with the local laws. With such a variety of light, medium and dark films along with different colours and shades, there is a wide range of choices for the modern motorist.

Type of use:
Aesthetic

Objective:
To make your vehicle look fantastic!

How to Specify

• Visible light transmission

Glass either side or in front of the driver: no tint allowed; clear safety, security and UV filtering films may be permitted but check what your national laws allow.

Glass behind the driver: most people choose a product between 15% and 50% visible light transmission; 5% transmission is used in some European countries. Anti-glare strip at top of windscreen: 15% to 50% is used;

Note: Local laws in some countries may restrict the use of anti-glare strips.

• Colour

The most popular colours are smoke, grey, charcoal, neutral and bronze.

2. Solar Control

High temperatures inside a vehicle can significantly reduce comfort levels as well as negatively impact concentration levels and reaction times. Factors that can impact the temperature in the vehicle can be the presence and effectiveness of any air-conditioning, the geographical location and length of journey time and the time of day or season. Autotint films can provide a very effective solution to the build-up of such temperatures. Unwanted excess light or glare as it is known, can also be reduced with the use of autotint films reducing visible light transmission.

Type of use:
Solar Control

Objective:
To reduce the effects of solar energy entering into your vehicle.

How to Specify

• For both temperature and glare issues, review the different performance figures available for the different films in terms of the percentage of heat and light reductions, and then select the most effective film that has the most suitable appearance for the way you wish your vehicle to look.

3. Fade Reduction

Ultra Violet Light (UV), Visible Light (VL) and Infra Red energy can all cause vehicle interiors to fade although the most damaging factor is the UV. Preserve the value of your vehicle by installing high-quality window film.

Type of use:
Fade Reduction

Objective:
To reduce fading and other damage to the interior of your vehicle caused by sunlight.

How to Specify

Select an autotint film with at least 98% UV rejection.

Note: Do not forget the limitation against using tinted films in front of or either side of the driver.

4. Safety/security

Safety/security autotint films have a thicker construction than standard autotint films. Depending on where the films are applied or what is the desired performance or appearance, the films may be clear or tinted.

Type of use:
Safety/Security

Objective:
To improve the resistance of vehicle glazing against shattering through accidental or deliberate breakage.

How to Specify

• Check with the local specialist installer or window film manufacturer that the particular film is a thicker safety/security film and that it is legally able to be installed on any particular vehicle windows.

➜ What are automotive window films?

Automotive window films are products that when fitted to your car increase comfort and safety, create a stylish look and provide privacy.

Installation quality

Application of window film to the curved glass in vehicles is the most difficult application of all. To ensure that you have the best looking application and the best performing windows in your vehicle, it is very advisable to have the installation carried out by a fully trained authorised specialist in such applications. Such installers will have attended a formal training course and then have practised for some considerable time in order to get the appropriate standard expected by the owner of the vehicle.

European Window Film Association

The EWFA is an international not-for-profit organisation founded under Belgian law in 2000. It represents the manufacturers, converters, distributors and industry suppliers of automotive window films. It counts the following companies as manufacturer members 3M, Bekaert Specialty Films LCC, CPFilms Inc., Johnson Window Films, Madico. In addition, it counts 20 associated members that are established in different European countries.

The EWFA represents its members towards public authorities such as the United-Nations/Economic Commission for Europe, the European Union institutions and National Governments. It addresses all regulatory issues that are of interest and/or concern to its members, most notably the requirements regulating the use of automotive window films in certain EU Member States and the growing need for Governments to save energy.

The EWFA maintains close working relationships with the International Window Films Association (IWFA) and the UK Glass and Glazing Federation. It is furthermore a member of CLEPA, the European Association of Automotive Suppliers.

For further information, please visit www.ewfa.org.

Manufacturing Members

3M

www.3M.com/UK/Windowfilm
e-mail: Wfilm@mmm.com

Johnson Window Films

www.johnsonwindowfilms.com
e-mail: info@johnsonwindowfilms.com

BEKAERT better together

www.bekaertfilms.com
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