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INTERNATIONAL CONFERENCE of SCIENTIFIC PAPER
AFASES 2011
Brasov, 26-28 May 2011

IMPACT OF LOW-E GLASS AND INSULATING SPACERS ON CONDENSATION

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Abstract: *Low-emittance (low-E) coatings are microscopically thin, virtually invisible, metal or metallic oxide layers deposited on a window or skylight glazing surface primarily to reduce the U-factor by suppressing radiative heat flow. Different types of low-E coatings have been designed to allow for high solar gain, moderate solar gain, or low solar gain. Condensation happens when moisture in the air suddenly cools and condenses on a cold window. Although it is difficult to prevent this on the outside of a window, by installing well insulated double glazing window (Low E), condensation problems on the room-side can be greatly reduced. Condensation is defined as the physical process by which a gas or vapour changes into a liquid. If the temperature of an object (e.g. grass, metal, glass) falls below what is known as the 'Dew Point' temperature for a given relative humidity of the surrounding air, water vapour from the atmosphere condenses into water droplets on its surface. An improvement that can be made to the thermal performance of insulating glazing units is to reduce the conductance of the air space between the layers. Originally, the space was filled with air or flushed with dry nitrogen just prior to sealing. In a sealed glass insulating unit, air currents between the two panes of glazing carry heat to the top of the unit and settle into cold pools at the bottom. Filling the space with a less conductive, more viscous, or slow-moving gas minimizes the convection currents within the space, conduction through the gas is reduced, and the overall transfer of heat between the inside and outside is reduced.*

Keywords: *Low-E, condensation, spacer, argon-gas, high performance, window*

1. INTRODUCTION

Low-emittance (low-E) coatings are microscopically thin, virtually invisible, metal or metallic oxide layers deposited on a window or skylight glazing surface primarily to reduce the U-factor by suppressing radiative heat flow. The principal mechanism of heat transfer in multilayer glazing is thermal radiation from a warm pane of glass to a cooler pane. Coating a glass surface with a low-emittance material and facing that coating into the gap between the glass layers blocks a significant amount of this radiant heat transfer, thus lowering the total heat flow through the window. Low-E coatings are transparent to visible light. Different types of low-E coatings have been designed to allow for high solar gain, moderate solar gain, or low solar gain.

In heating-dominated climates with a modest amount of cooling or climates where both heating and cooling are required, low-E coatings with high-, moderate- or low-solar-gains may result in similar annual energy costs depending on the house design and operation. While higher solar-gain glazings perform better in winter, lower solar-gain glazings perform better in summer. In cooling-dominated climates, the priority is to lower solar gains. [4]

2. WINDOW TECNOLOGIES: LOW-E COATINGS

2.1 Double-Glazed with High-Solar-Gain Low-E Glass

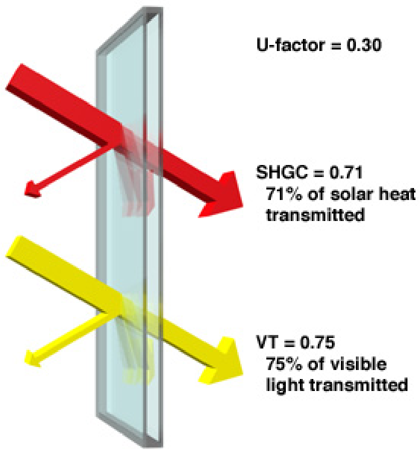

Fig.2.1.Characteristics of a typical double-glazed window with a high-solar gain low-E glass with argon gas fill

This figure illustrates the characteristics of a typical double-glazed window with a high-solar gain low-E glass with argon gas fill. These windows are designed to reduce heat loss but admit solar gain. High-solar-gain low-E glass products are best suited for buildings located in heating-dominated climates and are the product of choice for passive solar design projects. High-solar-gain low-E glass is often made with pyrolytic low-E coatings, although sputtered high-solar-gain low-E is also available. [2,4,5]

2.2 Double-Glazed with Moderate-Solar-Gain Low-E Glass

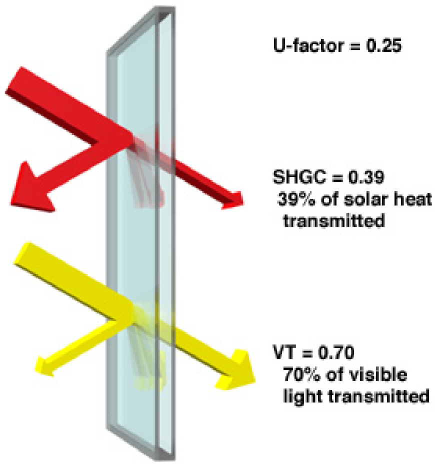

Fig.2.2.Characteristics of a typical double-glazed window with a moderate-solar-gain low-E glass with argon gas fill

This figure illustrates the characteristics of a typical double-glazed window with a moderate-solar-gain low-E glass with argon gas fill. These windows are often referred to as spectrally selective low-E glass due to their ability to reduce solar heat gain while retaining high visible transmittance. Such coatings reduce heat loss and let in a reduced amount of solar gain making them suitable for climates with both heating and cooling concerns. Moderate-solar-gain low-E glass is often made with sputtered low-E coatings, although pyrolytic moderate-solar-gain low-E is also available. [2,4,5]

2.3 Double-Glazed with Low-Solar-Gain Low-E Glass

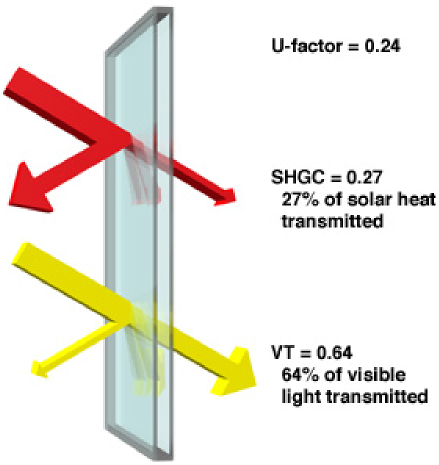

Fig.2.3. Characteristics of a typical double-glazed window with a low-solar-gain low-E glass with argon gas fill

This figure illustrates the characteristics of a typical double-glazed window with a low-solar-gain low-E glass with argon gas fill. As with moderate-solar-gain low-E glass, these windows are often referred to as spectrally selective low-E glass due to their ability to reduce solar heat gain while retaining high visible transmittance. Compared to most tinted and reflective glazings, this low-E glass provides a higher level of visible light transmission for a given amount of solar heat reduction. Variants on low-solar-gain low-E coatings have also been developed which may appear slightly tinted. This type of low-E product reduces heat loss in winter and substantially reduces solar heat gain both in winter and in summer. Thus, low-solar-gain low-E glazings are ideal for buildings located in cooling-dominated climates. Low-solar-gain low-E glass is typically made with sputtered low-E coatings consisting of either two or three layers of silver (also called double-silver or triple-silver low-E). [2,4,5]

2.4 Window Technologies: Argon or Krypton Gas Fills. An improvement that can be made to the thermal performance of insulating glazing units is to reduce the conductance of the air space between the layers. Originally, the space was filled with air or flushed with dry nitrogen just prior to sealing. In a sealed glass insulating unit, air currents between the two panes of glazing carry heat to the top of the unit and settle into cold pools at the bottom. Filling the space with a less conductive, more viscous, or slow-moving gas minimizes the convection currents within the space, conduction through the gas is reduced, and the overall transfer of heat between the inside and outside is reduced. Manufacturers have introduced the use of argon and krypton gas fills, with measurable improvement in thermal performance. Argon is inexpensive, nontoxic, nonreactive, clear, and odorless. The optimal spacing for an argon-filled unit is the same as for air, about 1/2 inch (11-13 mm). Krypton is nontoxic, nonreactive, clear, and odorless and has better thermal performance, but is more expensive to produce. Krypton is particularly useful when the space between glazings must be thinner than normally desired, for example, 1/4 inch (6 mm). The optimum gap width for krypton is 3/8" (9mm). A mixture of krypton and argon gases is also used as a compromise between thermal performance and cost. [3,4]

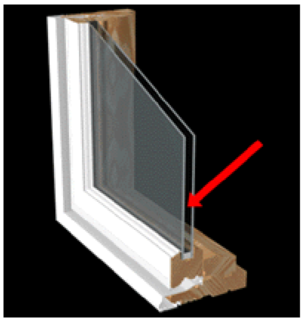

Fig.2.4. Gas fills

2.5 Window Technologies: Low Conductance Spacers. The layers of glazing in an insulating unit must be held apart at the appropriate distance by spacers. Because of its excellent structural properties, window manufacturers started using aluminum spacers in the 1960's and 1970's. Unfortunately, aluminum is an excellent conductor of heat and the aluminum spacer used in most standard edge systems represented a significant thermal "short circuit" at the edge of the insulating glass unit (IGU), which reduces the benefits of improved glazings. In addition to the increased heat loss, the colder edge is more prone to condensation. To address this problem, window manufacturers have developed a series of innovative edge systems to address these problems, including solutions that depend on material substitutions as well as radically new designs. One approach to reducing heat loss has been to replace the aluminum spacer with a metal that is less conductive, e.g. stainless steel, and change the cross-sectional shape of the spacer. These designs are widely used in windows today. Another approach is to replace the metal with a design that uses materials that are better insulating. The most commonly used design incorporates spacer, sealer, and desiccant in a thermoplastic compound that contains a blend of desiccant materials and incorporates a thin, fluted metal shim of aluminum or stainless steel. Another approach uses an insulating silicone foam spacer that incorporates a desiccant and has a high-strength adhesive at its edges to bond to glass. The foam is backed with a secondary sealant. Both extruded vinyl and fiberglass spacers have also been used in place of metal designs. There are several hybrid designs that incorporate thermal breaks in metal spacers or use one or more of the elements described above. Some of these are specifically designed to accommodate three-and four-layer glazings or IGUs incorporating stretched plastic films. All are designed to interrupt the heat transfer pathway at the glazing edge between two or more glazing layers. Warm edge spacers have become increasingly important as manufacturers switch from conventional double glazing to higher-performance glazing. For purposes of determining the overall window U-factor, the edge spacer has an effect that extends beyond the physical size of the spacer to a band about 64 mm wide. The contribution of this 64mm wide "glass edge" to the total window U-factor depends on the size of the window. Glass edge effects are more important for smaller windows, which have a proportionately larger glass edge area. For a typical residential-size window (0.8 by 1.2 meters), changing from a standard aluminum edge to a good-quality warm edge will reduce the overall window U-factor by approximately .02 Btu/hr-sq ft-°F.

A more significant benefit may be the rise in interior surface temperature at the bottom edge of the window, which is most subject to condensation. With an outside temperature of 0°F, a thermally improved spacer could result in temperature increases of 6-8°F (3-4°C) at the window sightline--or 4-6°F (2-4°C) at a point one inch in from the sightline, which is an important improvement. As new highly insulating multiple layer windows are developed, the improved edge spacer becomes an even more important element. [3,4]

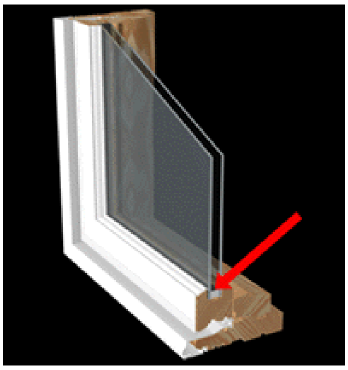

Fig.2.5. Low Conductance Spacers

3. CONDENSATION

Condensation happens when moisture in the air suddenly cools and condenses on a cold window. Although it is difficult to prevent this on the outside of a window, by installing well insulated double glazing window (Low E), condensation problems on the room-side can be greatly reduced. As the room facing pane of an insulated double glazing window stays warmer, the air that comes into contact with it does not cool and condense.

There are three main ways to improve thermal insulation, and thus reduce condensation, in a double glazing window :

- By using Low-E glass;
- By upgrading from an aluminium edge spacer to a warm edge spacer bar;
- By substituting a dehydrated air cavity filling with an inert gas, such as argon.

Condensation is defined as the physical process by which a gas or vapour changes into a liquid. If the temperature of an object (e.g. grass, metal, glass) falls below what is known as the 'Dew Point' temperature for a given relative humidity of the surrounding air, water vapour from the atmosphere condenses into water droplets on its surface. This "dew point" varies according to the amount of water in the atmosphere (known as humidity). In humid conditions condensation occurs at higher temperatures. In cold conditions condensation occurs despite relatively low humidity.

The principal cause of condensation on glass on the inside of a building is a high internal humidity level coupled with a low outside temperature which cools the inside surface to below the dew point, particularly around the edges. Bathrooms, kitchens and other areas where humidity levels are high are particularly susceptible to this problem. In order to control this form of condensation, consideration should be given to improving the heating and ventilation in these areas. Condensation forms on the outdoor surface of glass when its temperature drops below the outdoor dew point temperature. [1,5]

4. BENEFITS: LESS CONDENSATION

High performance windows with new glazing technologies not only reduce energy costs but make homes more comfortable as well. High-performance windows create warmer interior glass surfaces, reducing frost and condensation. High-performance windows with warm edge technology and insulating frames have such a warm interior surface that condensation on any interior surfaces is significantly reduced under all conditions. [1,4]

4.1 Impact of Low-E Glass and Insulating Sacers on Condensation

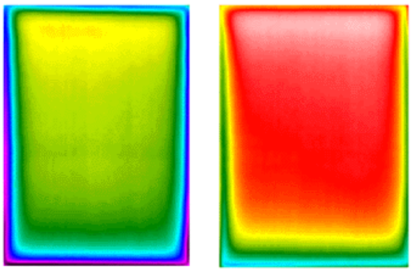

Fig.4.1. Comparison between a conventional clear double glazing and Low-E glass

The adjacent images show interior surface temperature patterns of a clear double glazed unit (left) and an energy-efficient Low-E insulated glazing unit with an improved spacer (right). Under typical winter conditions, (i.e. 20°F outside), condensation on the glass under typical humidity levels is shown by purple and blue. With a conventional clear double glazing (left), condensation occurs in a band a couple inches wide along the edge of the sightline, with more condensation along the bottom than at the top. With the energy-efficient Low-E insulated glass unit (right), condensation will be greatly reduced (a small strip less then 1" high along the bottom). Under extreme winter conditions (i.e. 0°F outside), condensation is shown by purple, blue and green. With clear double glazing, there is condensation over the entire unit. With energy-efficient Low-E glazing, there is only condensation on a band along the bottom and up along the edges. [1,4]

4.2 Impact of Temperature, Humidity and Glass Choice on Center-of-Glass Condensation

The graph shows condensation potential on the center of glass area (the area at least 2.5" from the frame/glass edge) at various outdoor temperature and indoor relative humidity conditions. Condensation can occur at any points that fall on or above the curves. As the U-factor of windows improve, there is a much smaller range of conditions where condensation will occur. These values are based on center-of-glass temperatures. Condensation may occur at lower humidity levels on the glass edge. [1,4]

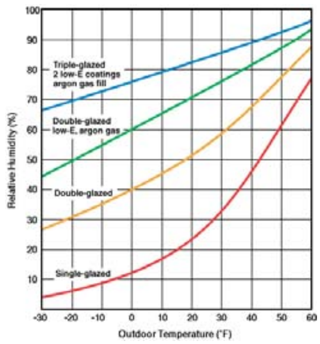

Fig.4.2. The graph for condensation

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