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# Electrochromic glass vs. fritted glass: an analysis of glare control performance

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**Abstract**

Today's modern architecture is characterized by the use of large area glasses which maximizes daylight admission and connection to outside; however, such a design concept often leads to major visual and thermal discomfort. The present paper focuses on comparing performance of two different strategies for controlling glare: fritted glass and electrochromic (EC) glass. For this purpose daylighting and glare simulations were conducted to compare the performance of the EC glazing versus fritted glass on two different case studies, one with skylight and one with vertical glass. The simulation results shows electrochromic glass with appropriate zoning can control the glare more effectively while the view to outside is maintained.



*Keywords:* electrochromic glazing, fritted glass, glare control, daylighting

## 1. Introduction

A frit is an opaque ceramic material that has been fused onto the surface of a piece of glass during the heat treatment process. Different extents of coverage of frit on glass surfaces (defined as a percentage) and different patterns can be

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specified depending on the aesthetics and performance desired. Architects use fritted glass for reducing solar heat gain, glare control and creating patterns [1, 2].

Electrochromic (EC) glazing varies its visual and thermal properties by electric field. It can switch from a clear state with a maximum of 60% visible light transmittance (VLT) to a fully darkened state with 1%VLT and can be held at some specific intermediate tinted states. EC windows always remain transparent and thus preserve outside views while controlling transmitted light, glare, and solar heat gains. EC glass is made up of five layers of coating on glass. When electricity is applied, the EC glazing darkens as lithium ions and associated electrons transfer from the counter electrode to the electrochromic electrode layer. By reversing the voltage, the ions and associated electrons return to their original layer and EC glazing returns to the clear mode. This solid state electrochromic reaction is controlled through a low-voltage DC power supply [3].

This paper compares the daylighting performance of fritted glass and electrochromic glazing using two different case studies, one skylight application and one vertical glass application.

## 2. Simulation

Daylight performance of the EC glass and fritted glass were compared using RADIANCE and DAYSIM daylight simulation within the DIVA-for-Rhino interface. Modeling Electrochromic glazing is challenging due to the variation in daylight properties of glazing in each zone and point in time. The EC tinting operation was modeled with a control algorithm developed in Grasshopper using DIVA and Ladybug plugins [4, 5]. This algorithm has two daylight control and glare control components measuring daylight level and Sun angle for every time-step and generate the optimum tinting pattern for the multi zone EC configuration [6, 7, 8].

Modeling optical properties of Fritted glass has its own complexity as well. Frit has the optical characteristic that the incident light passing through it has both a specular component (that goes straight through construction) and a diffuse component (that scatters in many different directions) [1]. Different approaches have been used for modeling frit glass in earlier studies to evaluate qualitative and quantitative effect of these products [1, 2, 9 and 10]. In this study Radiance "trans material" was used as an approximation for fritted glass to capture both the specular and diffuse quality of frit [11, 12].

## 3. Case Study 1, Skylight

In the first case study, the glare control performance of EC glazing (60%-2% visible light transmission range), a double silver low-e insulating glass with a 50% frit coverage (44% visible light transmission) and a standard double silver low-e insulating glass (70% visible light transmission), were compared as glazing options for the glazed dome of the Old Parkland Pavilion located in Dallas, Texas. Annual daylight availability and daylight glare probability metrics were used to assess daylight and glare performance of the space below the skylight.

### *3.1. Data Analysis*

The annual glare analysis shown in Figure 1 provides an indication of the potential glare in the space for the low-e, fritted low-e and SageGlass EC cases. The red bars show the percentages of occupied hours that the space below the skylight receives excess illumination (Useful Daylight Illuminance_UDI over 2000 Lux). Glazing the dome area with low-e glass has a high risk of glare for 35% of the occupied hours. Adding 50% frit coverage to the low-e glass reduces the risk of glare to 17% percent of occupied hours, but there is still a considerable risk of glare.

EC glazing significantly reduces the risk of glare to only 4% of occupied hours. Figure 2 shows the annual daylight availability for double silver Low-e, double silver low-e with a 50% frit and SageGlass EC glazing across the floor plan. Areas with high glare potential have been shown in a purple color. As can be seen there is a significant risk for over-lighting with both the low-e glass and the low-e glass with 50% frit. The addition of frit does not significantly reduce the potential for over-lighting.