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A Thermal Modelling Comparison of Typical Curtain Wall Systems
Introduction

Today’s Aim
• To understand the meaning of a ‘U’ value and window energy ratings
• Discuss the drivers for energy efficiency in Europe

Today’s Objective
• Outline the study details of generic curtain wall systems
• Review the study results and discuss how this affects energy efficiency

Today’s Outcome
• Provide a greater insight into how system choice can affect energy consumption
Agenda

• What is a ‘U’ value?
• What are window energy ratings and how are they communicated?
• Drivers for energy efficiency in Europe
• Compare the U façade value of typical curtain wall systems used in commercial construction
• Compare energy usage of typical curtain wall systems
• Summary and conclusion
• Question & answer session
What is a ‘U’ Value?

• A ‘U’ value is a measurement that represents the ability of a window assembly to resist heat transfer

• The ‘U’ value is the overall heat transfer coefficient – a measure of how thermally efficient an installation is

• The lower the ‘U’ value, the more efficient the installation
What is Window Energy Rating?

- **U value**: heat losses and gains from conduction, convection and radiation arising from all the components of the window (frame and gaskets as well as double glazed units) for a specific size and design of window. Lower U-value = less energy loss.

- **Solar factor g**: heat gain from solar radiation, $0 < g < 1$ (more solar heat gain).

- **L**: heat losses from air infiltration through the window.
Window Energy Rating

- CO₂ reductions – energy savings
- Difficulty to compare efficiency of different systems
- U values suited for opaque buildings

Window Ratings

- **Easy** assessment of the energy efficiency of competing window products
- Identify the best performing window as a whole system
- **Comparisons** of windows, no absolute values
- Independent of manufacturer’s claimed values
- Recognizable logo
- Incentives and grants
- Domestic windows

Energy Index (kWh/m²/year)
Energy consumption for a specific application will depend on the building, the local climate and the indoor temperature.

The climate zone is:

<table>
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<tr>
<th>Manufacturer Model</th>
<th>More Efficient</th>
</tr>
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<td>G</td>
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UK, Denmark, Finland, Sweden
Energy Efficiency in Europe - a hot topic!

European drivers:
- Energy prices and security of energy supply
- Economics (EuroACE)
- Climate changes

Several actions:
- Action plan for energy efficiency: realizing the potential: “The largest cost effective savings potential lies in the residential and commercial buildings sector”
- Energy performance building directive: certification of entire buildings by end 2008: [www.epbd-ca.org](http://www.epbd-ca.org)
- European Window Energy Rating System SAVE project 2000-2003
Thermal Modeling Comparison of Typical Curtain Walling Systems

Goal of Study

• Calculate and compare the $U_{\text{fa}}$ value of different generic curtain wall systems used in commercial construction

• Compare energy usage of different curtain wall systems
Façade Systems Compared

• Mechanically fixed system
  with new and aged gasket

• Structurally glazed system
  with dry sealing (gasket) and wet sealant

• Hybrid ‘toggle’ system
Structural Glazing

- Structural Silicone Glazing = structurally bonding units (glass, stone, metal sheets,...) to the supportive frame with a specially designed structural silicone
- Strong and long term adhesive properties, UV resistance, longevity and durability of Silicones
- Glass, Ceramics, Metals, Stone and Composite panels
- Satisfies Essential requirements for a Construction as defined in Europe and Globally
- Used for New building and Renovation
Material Specifications

- For the insulating glass spacer bars, aluminium, stainless steel and desiccated silicone foam (warm edge) were installed

- Silicone sealants were used for the structural glazing, insulating glazing and weather sealing applications

- Mechanically fixed gaskets were designed using EPDM

* For the Hybrid curtain wall system, only aluminium IG spacer was used
System Specifications

Frame:
- Frame of 75mm by 125mm with a thickness of ±3mm
- ‘Poor’ frames on thermal performance
- Alternations in system unavoidable

Glass:
- 6mm – 15mm - 6mm glass airfilled
- Low E coating (4% emissivity) on # 3 of glass
- IG silicone sealant joint of 6mm x 15mm
- PIB 0.2mm x 6mm
- Spacer bar 6mm x 15mm
- \( U_{\text{glass}} \) value: 1.393W/m\(^2\)K

Structural Glazing Joint:
- Silicone sealant; 6mm by 12mm ; with 6 x 6mm urethane foam tape

The façade consists of glass units of 1m by 2m
Mechanically Fastened System

- Aluminium frame of 75mm by 125mm by ±3mm
- EPDM rubber gasket
- PVC
- Airfilled IG unit 6-15-6mm
- 6mm by 15mm spacer
- 6mm by 15mm silicone secondary sealant
Structurally Glazed System

- Wet silicone weathersealant
- Structural silicone joint
- Urethane foam tape
- Dry EPDM gasket weathersealant
Hybrid System

- Wet silicone weathersealant
- Silicone joint
- Toggle
- Anodised Aluminium spacer bar profile
The Test Method

- Winsol 2D software was used to thermally model the various designs already described
- The study uses interior temperatures of 20°C and an exterior temperature of -5°C
Results - Mechanically fixed

New Gasket
T frame: 16.4°C

Aged Gasket
T frame: 14.1°C
Results - Structurally Glazed

Wet weathersealant
T frame: 18.2°C

Dry Gasket weathersealant
T frame: 17.9°C
Results- Hybrid system

T frame: 16.2°C

T = +20°C

T = +8.12°C

T = +16.2°C

T = -5°C
<table>
<thead>
<tr>
<th>Results</th>
<th>U Value Frame W/m²°K</th>
<th>IG Spacer Design</th>
<th>Interior Profile Temp °C</th>
<th>Interior Glass Temp °C</th>
<th>U Value Façade W/m²°K</th>
<th>Overall Rating**</th>
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Results

System comparison:
- The structurally glazed system clearly showed the lowest U value.
- Hybrid system has slightly lower U value compared to a mechanical fixed system (with the same IG spacer).
- The effect of the ageing of the gasket for the mechanically fixed system is significant.

Dry sealing versus wet sealing:
- Wet sealing gives better U-values than dry sealing, although structurally glazed, dry sealed systems are performing well.

IG spacer bars:
- Desiccated silicone foam warm edge spaces are highest performing followed by stainless steel spacers and then aluminium spacers.
## Results – Energy Usage

<table>
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<tr>
<th>Ranking</th>
<th>U Façade Values</th>
<th>Watts/m² required at 20°C differential</th>
<th>Watts required at 20°C differential for 1000 m² facade</th>
<th>Watts/m² required at 40°C differential</th>
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</table>
Energy Usage

• The best performing system (SG with warm edge and wet sealing) consumes less than half of the energy of the worst performing system (mechanically fixed, aluminium spacer, failing gasket)

• Influence of ageing gasket in mechanically fixed system; consumes 44% more energy than a new gasket

• Chosen system does impact energy usage (thus energy cost)!
Summary and Conclusions

• The structural glazing systems studied provide the best thermal performance

• Wet sealing has a positive impact on thermal performance

• The use of silicone gaskets in mechanically fixed systems will reduce the degradation of the U-value

• Desiccated silicone foam warm edge spacers do demonstrate improved thermal performance

• By choosing the correct façade system, up to 50% of the energy can be saved
Question & Answer Session