Fixed Vertical Glazing Energy Performance Design Considerations for New Construction

2014 High Performance Building Standard (HPBS)

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Preface by State Energy Program Director

It is imperative that the design team understand the significant role of the glazing design on building performance over the anticipated 50 plus year life of State buildings. Unfortunately, this guide is in response to many recent projects that have failed to provide adequate attention to the performance aspects of glazing design. Aesthetic drivers of the building design must be balanced with functional performance requirements set forth by State Standards as well as project budget constraints. When done properly the design ensures that the investment into each State building by tax payers, donors, and agencies is maximized and will provide value, comfort, and energy efficiency for decades.

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Introduction

According to the U.S. Department of Energy (DOE) Buildings Energy Data Book 2012, energy consumption of commercial and institutional buildings, related to space heating & cooling, accounts for 31% of the total energy consumption, as projected for the year 2015[1]. Space heating & cooling is a direct function of the envelope design, with the glazing design having the greatest impact on the overall envelope thermal/energy performance. As such, particular attention must be paid to all the energy performance related considerations of any glazing design approach.

When proper attention is given to balancing all the design considerations of a building's glazing scheme, the following tangible benefits are realized.

- Energy & Energy Cost Savings
- Reduced HVAC Equipment Size & Cost
- Improved Occupant Thermal Comfort
- Improved Daylighting Potential
- Reduced Frost/Condensation Maintenance & Repair
- Reduced Fading of Furniture & Surface Materials

This document is intended to provide general discussion points regarding the design of fixed vertical glazing assemblies used for commercial and institutional new construction, regarding energy and energy cost performance.

As related topics, some discussion points touch upon issues of horizontal glazing assemblies, daylight harvesting, and thermal comfort, but these topics are not addressed comprehensively.

Additionally, discussion points are provided to assist the designer with proper definition of design intent in construction documents, and energy code compliance reporting. But, is not comprehensive, as other criteria, not directly relevant to this document, is required to fully define/specify glazing and glazing assemblies (i.e. condensation resistance, structural performance, acoustical performance, security, etc.)

[1] http://buildingsdatabook.eren.doe.gov/ChapterIntro3.aspx

HPBS Requirements

- HPBS Section 5.1(B)(1) requires “glazing orientation, and glazing amount” be evaluated through simplified energy modeling, during the schematic design (SD) phase. Exceptions are permitted through approval of the Energy Program Director.

- HPBS Section 5.5(C)(1) requires that glazing performance (U-value & Solar Heat Gain Coefficient (SHGC)) conform to the more stringent minimum requirements of either the International Energy Conservation Code 2012 (IECC) or ASHRAE 90.1-2010. I.e. no trade-off is permitted with the thermal/energy performance of other building envelope components. (Glazing requirements are specified by location, and are not identical for all locations within the state.)

- HPBS Section 5.5(C)(3) requires, by reference to IECC Section C402.3.1, that total glazing area does not exceed 30% of above grade gross wall area (horizontal skylights may not exceed 3% of gross roof area). Spandrel sections are not considered toward the calculation of glazing percentage, but must meet the insulation/thermal performance requirement(s) of other typical opaque wall assemblies.

Glazing U-value

- U-value primarily describes the glazing’s ability to resist heat transfer via thermal conduction.

- The lower the U-value, the better the glazing is at resisting, or reducing, the thermal conduction, i.e. heat loss or gain.

- U-value becomes increasingly more important to energy performance and thermal comfort, as the climate becomes colder (i.e. Box Elder, Cache, Carbon, Daggett, Duchesne, Morgan, Rich, Summit, Uintah Counties). This, in part, is due to the fact that conductive heat transfer is a function of temperature difference, i.e. the absolute temperature difference between the ambient outdoor temperature and the indoor (conditioned space) temperature.

- U-values can be used to define/describe the glazing only, or the entire glazing assembly.

- Glazing only U-value is typically referred to as Center-of-Glass (SOG) U-Value. This value is provided by the glass manufacturer (i.e. PPG, Guardian, Pilkington, Viracon, etc.) and is used, in part, to define the glazing (only) performance, typically Specification 08 80 00 - Glazing. (Also see Glazing Specifications & Glazing Energy Code Compliance, below.)

- Assembly U-value, in reference to glazing, describes the thermal conductance performance of the entire glazing assembly, i.e. frame, mullions, glass, gas fill, thermal break, etc. Assembly U-value is always greater than (performs worse than) SOG U-value, due to fact that the conductance of the framing is greater than that of the glazing, alone. This U-value must be determined through standardized testing and/or calculations, per National Fenestration Rating Council (NFRC) or American Architectural Manufacturers Association (AAMA). Assembly U-value is used, in part, to define the

glazing assembly performance in construction documents, typically Specification 08 41 13 – Aluminum-Framed Entrances & Storefronts, and Specification 08 44 13 – Glazed Aluminum Curtain Walls. Assembly U-value is also the appropriate quantity used for energy code compliance reporting, i.e. COMcheck. (Also see Glazing Specifications & Glazing Energy Code Compliance, below.)

- Considering the fact that the framing of a glazing assembly has a higher conductance than the glass, it follows that minimizing the framing dimensions and use of mullions, and maximizing the glass-to-frame area ratio, will result in improved glazing assembly U-value performance. Additionally, glazing assemblies should strive toward achieving length-to-width ratio equal to 1.0, i.e. avoid thin strips of glazing, where possible.

- Shading devices have no appreciable influence on either the SOG U-value or glazing assembly U-value.

- Surface orientation has no appreciable influence on either the SOG U-value or glazing assembly U-value.

Glazing SHGC

- SHGC describes the glazing's ability to resist heat transfer via solar radiation, i.e. the sun.

- The lower the SHGC, the better the glazing is at resisting, or reducing, the thermal radiation allowed to interior spaces due to solar exposure.

- SHGC becomes increasingly more important to energy performance and thermal comfort, as the climate becomes warmer (i.e. Washington County).

- SHGC will have a greater impact, than U-value, on energy cost, due to the fact that space cooling is a function of electric energy consumption, which per unit of energy, is greatly more expensive than fossil fuel consumption.

- Similar to U-values, SHGC can be used to define/describe the glazing only, or the entire glazing assembly.

- SOG SHGC is also provided by the glass manufacturer, and is used, in part, to define the glazing (only) performance, typically Specification 08 80 00 - Glazing. (Also see Glazing Specifications & Glazing Energy Code Compliance, below.)

- Assembly SHGC describes the solar radiation performance of the entire glazing assembly, and is always slightly less than (performs better than) SOG SHGC, due to fact that the assembly's framing provides some minimal shading to the glazing, itself. The assembly SHGC must be determined through standardized testing and/or calculations, per National Fenestration Rating Council (NFRC). Assembly SHGC is used, in part, to define the glazing assembly performance in construction documents, typically Specification 08 41 13 – Aluminum-Framed Entrances & Storefronts, and Specification 08 44 13 – Glazed Aluminum Curtain Walls. Assembly SHGC is also the appropriate

quantity used for energy code compliance reporting, i.e. COMcheck. (Also see Glazing Specifications & Glazing Energy Code Compliance, below.)

- Shading devices are capable of having a pronounced impact on the effective SHGC, by limiting the direct incident solar contact on a glazing assembly. Particularly in warmer climates, consider utilizing light shelves, in order to preserve daylight harvesting potential, while minimizing incident solar radiation on glazing assemblies.

- Glazing SHGC is tested/calculated with consideration that the solar heat gain is a direct function of the angle of incident solar radiation, i.e. the angle at which the sun hits the window. Therefore, surface orientation should be considered as part of the design, where North (and somewhat South) exposures are less important, as the angle of incidence is lower, and East and West exposures are more important, having more direct angle(s) of incidence. Additional attention should be paid regarding the seasonal changes of the solar path, with regard to the glazing surface orientation, and incorporation of shading devices and/or light shelves.

Glazing Visible Light Transmittance (VLT)

- VLT (sometimes shortened to visible transmittance (VT)) describes the glazing's ability to allow the transfer of visible light.

- The higher the VLT, the more visible light that is allowed to pass, and the greater the potential for daylight harvesting.

- VLT is also provided by the glass manufacturer, and is used, in part, to define the glazing (only) performance, typically Specification 08 80 00 – Glazing. VLT is not applicable to description of glazing assemblies.

- Typically, the higher the VLT (potential for daylight harvesting), the higher the SHGC (adverse impact of incident solar radiation). Projects should be evaluated on a case by case basis to determine the relative impact(s) of these, somewhat, conflicting consequences of this glazing design parameter.

- As eluded to under Glazing SHGC, shading devices are capable of having a pronounced impact of the ability to let visible light pass through glazing, toward daylight harvesting.

Glazing Air Leakage

- Air Leakage describes how much outside air is permitted through a glazing assembly. (Air leakage is not applicable to glazing independent of an assembly.)

- The lower the leakage rate, the lower the flow of unwanted outside air infiltration and/or exfiltration.

- Glazing air leakage describes the glazing assembly, only, and does not consider air leakage that may occur at the transition(s) from the glazing assembly to other neighboring building envelope components.

- Air leakage (rate) is used, in part, to define the glazing assembly performance in construction documents, typically Specification 08 41 13 – Aluminum-Framed Entrances & Storefronts, and Specification 08 44 13 – Glazed Aluminum Curtain Walls.

Glazing Specifications

- SOG thermal/energy performance data, as described above and provided by the glass manufacturer, is appropriate only for the glazing specification, typically Specification 08 80 00 – Glazing.

- Assembly thermal/energy performance data, as described above, is required for all glazed building envelope assemblies, typically Specification 08 41 13 – Aluminum-Framed Entrances & Storefronts, and/or Specification 08 44 13 – Glazed Aluminum Curtain Walls. These specifications will reference the glazing specification (08 80 00), for the glass to be used in the assemblies.

- The glazing assembly U-value & SHGC must be determined by the standardized tests and/or calculations indicated above, and are the responsibility of the glazing assembly product representative and/or installer to provide. These standardized tests and/or calculations are performed using standardized sample (glazing assembly) sizes/dimensions, and therefore, will not necessarily correlate with the glazing assembly thermal/energy performance data used for whole building energy performance assessment (i.e. energy models per ASHRAE 90.1 Appendix G). This is due to the fact that whole building energy performance protocol allows the designed glazing assembly performance to be defined/calculated per the actual dimensions/configuration, not necessarily per standardized test sample size/dimensions.

- Assembly U-value & SHGC should be edited correctly in the appropriate construction documents, such that the basis of design is accurately represented, to ensure that the as-built performance meets the design intent.

- Do not rely on using energy code/standard minimum allowable window assembly thermal/energy performance criteria in construction documents (specifications). Even if the glazing specification (08 80 00) accurately represents the glass-only basis of design, the use of energy code minimum performance criteria in the glazing assembly specifications will allow the glazing assembly contractor/installer leeway regarding the performance of the framing members provided, in terms of thermal performance. As such, the design intent regarding thermal/energy performance of glazing assemblies will likely be compromised.

Glazing Energy Code Compliance

- Energy code compliance reporting (i.e. COMcheck) provides three options for the reporting of glazing assembly thermal/energy performance data. All three options require glazing assembly thermal/energy performance data, not SOG data.

- NFRC Site-Built Certified Product. This option requires that the glazing assembly being installed/reported has been previously tested, in the as-built condition, and is listed in the

Certified Products Directory (CPD) of the NFRC. This option requires reporting of the CPD identification number, otherwise, this option for reporting compliance is prohibited.

- Product Performance Evaluated in Accordance with NFRC. This option, which is most typically used, requires that the glazing assembly be evaluated in accordance with NFRC 100 & 200 (for U-value & SHGC respectively), and are typically the same values used in glazing assembly specifications. An identification number is also required, which should be provided with the NFRC test results/report.

- Energy Code Defaults. It is important to note that, for this option, Code Defaults are not the same as the code minimum allowable values provided in the envelope requirement tables of the IECC or ASHRAE 90.1. In this case, the Defaults are much worse, in terms of thermal performance, than the code minimum allowable values in the envelope requirement tables. This option is used when no appropriate testing or calculations have been performed in order to determine the glazing assembly thermal/energy performance data, and demonstrating energy code compliance for the entire envelope, and hence the entire project, will be very difficult.

- Shading devices can benefit the demonstration of energy code compliance for glazing assemblies, utilizing Projection Factor; a method to describe the contribution to improved SHGC with use of shading devices, which is permitted.

Resources

- First and foremost, all UT DFCM new construction and major renovation projects are provided an energy engineer, employed by the DFCM, for utilization by the design team. The energy engineer will consult qualitatively, regarding the discussion points above, and for major new construction projects, will provide energy models and life cycle cost analysis for glazing design options, specific to each project. Appropriate leverage of this resource, with an integrated design approach, will provide the best overall glazing design, while minimizing the explicit burden on the design team.

- Prescriptive minimum criteria for glazing assemblies (U-value & SHGC) are provided in the IECC Section C402 (v. 2012 see Table C402.3) and ASHRAE 90.1 Tables 5.5-1 thru 5.5-8 (all versions).

- The following institutions & organizations provide a plethora of resources and educational information related to glazing design approach options and implications.

    - National Fenestration Rating Council - http://www.nfrc.org/
    - National Institute of Building Sciences - http://www.wbdg.org/design/env_fenestration_glz.php
    - Efficient Window Collaborative - http://www.commercialwindows.org/
    - U.S. Department of Energy (white paper) - https://windows.lbl.gov/pub/selectingwindows/window.pdf

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