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California Energy Commission

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Dear California Energy Commission and T-24 Code Development Team,

I applaud the CEC's inclusion of references to the National Fenestration Rating Council's (NFRC) new NFRC 203-2014 Measurement and Ratings "Procedure for Determining Visible Transmittance of Tubular Daylight Devices" in the new proposed language for the California Title 24, Part 6 Energy Code. I am concerned, however, that the current references do not accurately apply this new product rating.

The new NFRC 203-2014 procedure outlines a radically-new daylighting product rating that is able to characterize the annual performance of an optical daylighting system's light transmittance over the course of a solar year. While the term "visible transmittance" is common with the traditional method by which visible transmittance is reported for traditional window and skylight products, the new "Annual Visible Transmittance" (VT_{annual}) rating is, in fact, fundamentally different. To produce this new metric, the National Fenestration Rating Council (NFRC) embarked on a multi-year, cross disciplinary research and development project using experts from the fenestration, research (led by Lawrence Berkley National Laboratory), and architectural product testing industries to identify and establish a new testing and rating protocol for the new breed of advanced, optically-complex fenestration equipment. The end result, the NFRC 203-2014 procedure, establishes a robust product testing protocol for creating a new, revolutionary, annual visible transmittance rating (VT_{annual}) that has been implemented, and is in the process of being adopted by the fenestration industry. This new testing and rating protocol marks a significant advancement in optically-complex product evaluation, and fortells the future path of product testing and evaluation for daylighting products.

The benefits of this new rating were outlined in my June 10, 2014 article published by the American architectural Manufacturers' Association (AAMA), entitled "the Dawn of a New Day for Visible Light Transmittance Ratings." This article outlined the need for this new rating as follows.

"...Until now, VT ratings have been based on testing and rating products under direct-normal illumination (a vertical beam of light directed perpendicular to a test sample of glazing). But, this only measures the direct-normal transmittance of planar glazing elements. This method has obvious shortcomings when one considers the different light transmission performance introduced by varying solar angles and the orientation of the glass in the building itself; clearly, direct normal testing is deficient when employed for

both vertically-oriented windows and horizontally-oriented skylights. Simple VT ratings derived in this manner thus do not provide for accurate representation of real-life performance.

In addition, direct-normal measurement of VT is inadequate to quantify the performance of new, highly-engineered fenestration technologies that diffuse, reflect, partially block or selectively collect, redirect and deliver useful visible light. These complex products may use a combination of refractive, reflective, and filtering elements to selectively harvest and control light, allowing the VT to intentionally vary over the course of a day and/or a year for a given building location and climate.

A new, more meaningful rating is required which accounts for the variable angularity inherent in real-world incidence of solar light at a building site as well as for the precise, selectable, and tunable optics and optical performance of modern, highly-engineered, complex optical fenestration technologies and products.

The NFRC Tubular Daylighting Device (TDD) Task Group has been working for several years in conjunction with Lawrence Berkeley National Laboratory, to develop a new meaningful rating for the ever-growing family of optically complex fenestration products. The result is a new annualized visual transmittance rating (VT_{annual}) protocol, which is implemented in 2013 within Section 8 of the new NFRC 203-2014, *Procedure for Determining Visible Transmittance of Tubular Daylighting Devices*.

NFRC 203 specifies ASTM E1175, Standard Test Method for Determining Solar or Photopic Reflectance, Transmittance, and Absorptance of Materials Using a Large Diameter Integrating Sphere, as the test method for determining (through physical measurement) the visible transmittance (VT) of Tubular Daylighting Devices (TDD/HTDD) at an NFRC predetermined set of 18 representative annual solar incidence angle pairs.

As defined by NFRC 203, the two new key elements of the VT_{annual} rating are as follows:

- Visible Transmittance, Annual (VT_{annual}): The ratio of visible radiation passing through the fenestration product to the incident visible radiation, expressed as a single dimensionless value between 0 and 1 or as a percentage.
- Zonal Time, ZT: Zonal Time weighting factors report the percentage of time that the sun spends within each of 18 specific Sky Zones, relative to the time that Solar Altitude angles are between 15° and 75°, and Solar Azimuths are between +/- 75° from true south, for a site located in Middle America represented by 40° North Latitude. The ZT factors are generated by calculation using existing data for the sun's solar position at 30-second intervals for an entire solar year. (Equations for calculating solar altitude are given in the 2009 ASHRAE Handbook of Fundamentals, Chapter 14 [Reference 2]). Each sky zone ZT is calculated at the specific solar altitude, β , and surface-solar azimuth, γ , where each angle represents median of a 10-degree range of solar angles. For example, the range of 15 to 25 degrees is defined as 20 degrees.

The VT_{annual} rating (for a specific latitude) is calculated by summing the products of each measured zonal VT value and the associated Zonal Time Weighting Factor for each of 18 different sky zones. The approach mimics what a building sees during the traditional 8:00

AM to 5:00 PM period of actual use, without considering the extreme low angles of incidence that occur early and late in the day.

VT_{annual} is expressed as the sum of 18 different VTs applicable to the sky zones multiplied by ZT weighting factors.”

As a result, the new VT_{annual} rating provides an assessment for a product’s performance over the course of a year given the sun’s actual movement through the sky, and the interaction of light with a product’s particular optical design to selectively harvest the daylight resource. Thus, unlike the traditional VT ratings, the VT_{annual} rating provides a single number that accounts for the actual time-weighted path that the sun transverses over the course of the year. This marks a huge advancement in optical, daylighting product ratings that provides meaningful performance data that enables architects, engineers, code officials, and consumers to make better-educated decisions between advanced daylighting products.

Thus, VT and VT_{annual} product ratings have distinctly different meanings, and cannot be used interchangeably. Due to its very nature, a VT_{annual} rating of 0.35 to 0.4 represents a very high-performing, and optically-advanced daylighting product. The proposed revisions to California Title 24, Part 6 uses the two metrics interchangeably, which is incorrect. Since this new VT_{annual} rating is the only rating metric suitable for optically-advanced daylighting products, such as the Tubular Daylighting Device, I would request that the California Energy Commission work to develop language for a new code exception for TDDs that allows this new, and innovative rating data to be supported by and applicable to California’s daylighting initiatives within the California Title 24 Energy Code. Without it, application of these new, incredibly advanced optical daylighting technologies is greatly limited, and application of these technologies can only be supported by direct communication with code officials for projects on a case-by-case basis, an activity that is time consuming and difficult for all involved.

I look forward to the day when California’s Title-24, Part 6 standard is able to fully and effectively embrace these robust optical daylighting technologies.

Sincerely,

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