PO-6 New Product Evaluation and Rating Protocols are Needed for Optically-complex Fenestration

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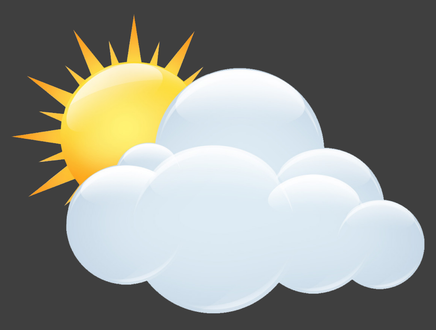
DAYLIGHT & DAYLIGHTING

The Application of a Dynamic Light Source



The Daylight Resource is available from…

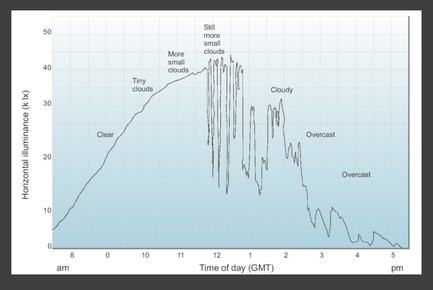
- The Solar Disk (sun)
- The Diffuse Sky Vault

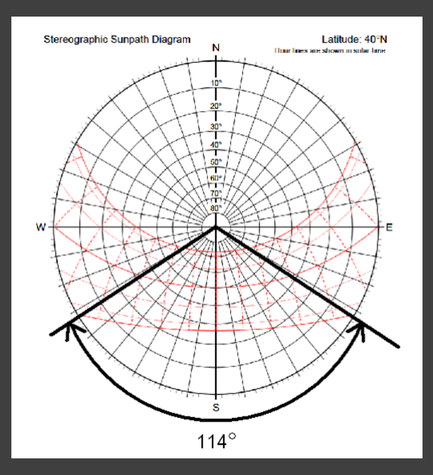
In real-life application, the daylight resource is dynamic, varying with time of day, day of year, and sky condition.

Daylighting is the artful application of the Daylight Resource (Sky + Sun) for...

- Task Illuminance for visibility, and/or
- Illumination for Visual Effect

The performance of a building's daylighting solution is therefore driven by the building location, the local climatic conditions, the fenestration/ product's orientation, and the occupant-based illumination objective (See Figures 1 & 2).





Figures 1 & 2: The daylight light source is highly variable, with the resource driven by the geographical location, fenestration/ product orientation and climatic conditions.

What we know…

- Today's daylighting solutions are dynamic.
  - Modern Daylighting Technologies are "Smart".
  - Modern Daylighting Technologies are Optically Complex, supporting the need for Dynamic Daylight Harvesting.
  - Occupant comfort and the resulting "activity" drives annual system performance.
- Yesterday's Single Point-in-Time and/or Single Test Condition metrics do not tell the performance story for either optically-complex fenestration OR occupant satisfaction.
- Modern Design & Evaluation trends support dynamic, annual analysis, metrics, and ratings that address the daily and seasonal variations of daylighting system performance due to occupancy schedules, annual solar path, and climate data.

NEW ENLIGHTENED MEASUREMENT AND RATING, AND EVALUATION PROTOCOLS ARE REQUIRED

Visible Transmittance (VT or Tvis): Old Single Measurement Product Rating:

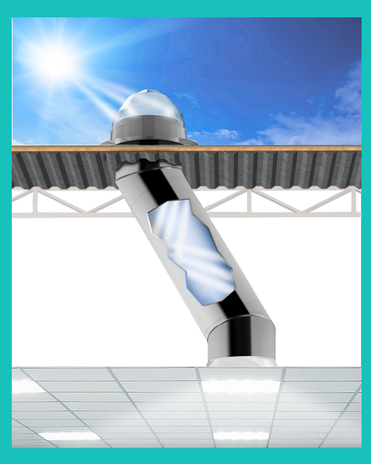
- Visible Light Transmittance is a key performance factor used by architects, engineers, code officials, and consumers to compare fenestration product options and daylighting designs.
- As a single, direct-normal rating, a single VT cannot indicate a product's performance under varying solar angles and/or fenestration orientation, and cannot provide for accurate representation of real-life system performance.
- Direct-normal measurement of VT cannot represent the performance of new, highly-engineered fenestration technologies that selectively collect, redirect, and deliver useful visible light. These complex products may use a combination of refractive, reflective, and filtering elements to selectively harvest light, allowing the VT to intentionally vary over the course of a day and/or a year for a given building location and climate.

New Enlightened Measurement and Rating Protocols Are Required That...

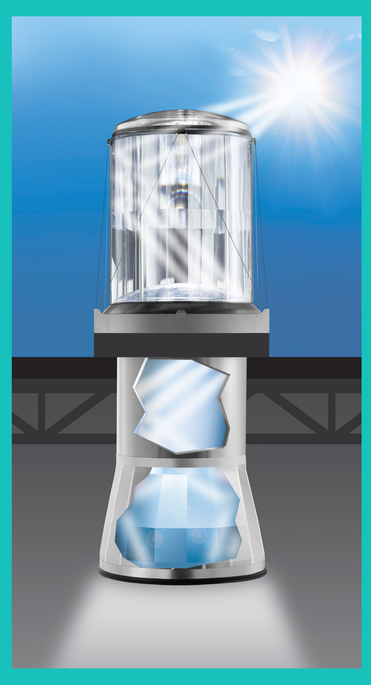
- Use Multi-point Measurements to characterize Annual Performance.
- Allow Products and solutions to be compared based upon real-world performance driven by location, climate, and product design.
- Support an improved daylighting design and evaluation decision process.

Annual Visible Transmittance (VT_{annual}): New Multi-Measurement Rating for Annual Performance:

- A new, more meaningful rating that 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.
- NFRC 203-2014 specifies ASTM E1175, as the test method for determining (through physical measurement) the visible transmittance (VT) of Tubular Daylighting Devices (TDD/HTDD) at a set of 18 representative annual solar incidence angle pairs (6 solar Altitude angles (20, 30, 40, 50, 60, & 70 Degrees) measured at 3 Azimuthal planes (0, +/- 30, +/- 60 Degrees)).
- The new VT_{annual} provides a single number that represents a product's annualized clear-sky visible transmittance given the sun's actual time-weighted annual movement through the sky and it's interaction with a products' optical system that provides selective daylight harvesting from beneficial portions of the sky vault.



VT_{normal} = 0.41
$VT_{max\ (20,0)}$ = 0.66
VT_{annual} = 0.47



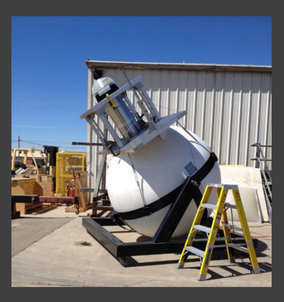
VT_{normal} = 0.69
$VT_{max\ (20,0)}$ = 1.35
VT_{annual} = 1.03

NFRC 203-2014

An Advanced Annual Rating In Practice

NFRC 203-2014 - Annual Visible Transmittance (VT_{annual})

- NFRC 203-2014 uses two new key data sets to determine the VTannual rating of a product:
  - VT: An array of 18 Visible Transmittance factors are Measured under CIE Clear Sky conditions for 6 Solar Altitude Angles (20, 30, 40 , 50, 60, and 70 degrees) in three Azimuthal Planes (0, +/- 30, and +/- 60 degrees).
  - Zonal Time, ZT: Zonal Time weighting factors are used that report the percentage of time that the sun spends within each of the 18 VT-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 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 (ZT) for each of 18 different sky zones, and represents the effective visible transmittance relative to a space occupied from roughly 8:00 AM to 5:00 PM throughout the year.



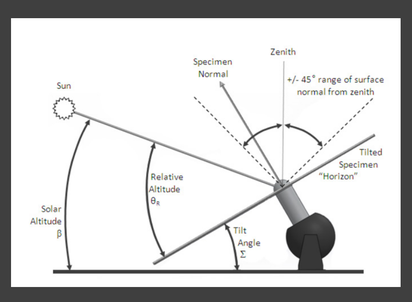


Table 1: Zonal Time Factors used in NFRC203-2014 for a Northern Site Latitude of 40 Degrees.

Relative Solar Altitude Angle (RSALT), θ_R	Surface-Solar Azimuth Angle,γ 0°	30°	60°
20°	0	0.106	0.084
30°	0.074	0.097	0.072
40°	0.034	0.064	0.068
50°	0.026	0.053	0.078
60°	0.023	0.051	0.074
70°	0.029	0.055	0.012

CIE

CIE Must Be a Part of the Rating Revolution

- CIE should be part of this annualized metric development process.
- The use of annual product testing and rating protocols and the application of annual system evaluation metrics are a critical part of supporting improved annual daylighting system performance analysis & whole building energy modeling.
  - Improved annualized energy modeling is a critical step in effectively integrating advanced daylighting solutions into future net-zero energy buildings.