

REFERENCE: NFRC PROJECT NUMBER 05-105-DR4
PROPONENT: COMPLEX PRODUCT VT RESEARCH TASK GROUP

Introduction:

In addition to the investigation concerning VT rating conditions for TDDs and to determine if the goniophotometers can be used by NFRC to determine the NFRC-ratable VT, the Task Group developed a VT Algorithm to allow calculation of the Yearly VT Average.

Scope/Approach

The VT Algorithm will use the VT measurements obtained from NFRC designated instrumentation (goniophotometers or integrating sphere) and approved procedure, in conjunction with percentage of the time spent in different zones, based on SALT angle.

The VT Algorithm is based on using as source:

- <http://www.esrl.noaa.gov/gmd/grad/solcalc/>
 - o This is a NOAA/ESRL's Global Monitoring Division's web site which allows calculation of sun location at any date and time for any location in the world.
 - o It calculates
 - Solar elevation
 - Azimuth
 - Solar noon
 - Sun rise and Sunset

The spreadsheet:

- Is using the solar position calculator for the 21st of each month for each given location.
- Data details
 - o Calculate the time that the sun enters and exits each zone (i.e. 15-25 degrees)
 - Include time at end of day as sun sets
 - o This amount of time is added together then multiplied by the number of days in the month
 - It gives weighted average for the month
- Calculate the percentage of the year spent by the sun in each zone
 - The percentage is calculated using the weighted time for each zone, for each month and the total of the number of hours above minimum SALT angle for entire year (i.e. for Option # 2 the minimum SALT is 10°).

The proposed algorithm will

- o Calculate the yearly efficiency
 - Based on measured visible transmission at 10, 20, 30, 40, 50, 60 and 70 degrees solar angle

- Yearly Efficiency =
 $(Vt10*ZT10)+(Vt20*ZT20)+(Vt30*ZT30)+(Vt40*ZT40)+(Vt50*ZT50)+(Vt60*ZT60)+(Vt70*ZT70)$

Using visible transmission and multiplying by percent of time spent in the zone over the year. The sum of these calculations is the annual visible light transmission.

The TG is proposing two options, based on SALT angle one for 10° and one for 15°.

Also, is proposing to get VT measurements starting with 10° and ending up with 70°.

Both suggestions are subject to review and approval by PMTG and NFRC.

The TG proposed and verified that using 3 locations within North America the average is still matching the Denver yearly average efficiency, as shown in the attached files.

V_t Algorithm

LOCATION: MIAMI

Legend

V_{t20} = Visible Transmission at 20 degrees solar altitude (i.e.)

ZT₂₀ = Zonal Time, percent of time spent in zone that number falls into (i.e. ZT₂₀ is for 15-25 range from chart)

Miami Data

$$V_t \text{ Yearly} = (V_{t10} \cdot ZT_{10}) + (V_{t20} \cdot ZT_{20}) + (V_{t30} \cdot ZT_{30}) + (V_{t40} \cdot ZT_{40}) + (V_{t50} \cdot ZT_{50}) + (V_{t60} \cdot ZT_{60}) + (V_{t70} \cdot ZT_{70})$$

Hypothetical V _t data		OPTION #1 (sunrise to sunset)		OPTION #2 (10° to 10°)		OPTION #3 (15° to 15°)	
SALT	V _t	SALT range	ZT	SALT range	ZT	SALT range	ZT
10	0.20	<15°					
20	0.25	15°-25°		10° - 25°	0.231	15°-25°	0.168
30	0.35	25-35		25-35	0.166	25-35	0.179
40	0.38	35-45		35-45	0.211	35-45	0.229
50	0.42	45-55		45-55	0.145	45-55	0.156
60	0.45	55-65		55-65	0.114	55-65	0.124
70*	0.48	>65°		>65°	0.133	>65°	0.144
			0		1		1

OPTION # 1

Yearly efficiency (sunrise) = (0.20*0)+(0.25*0)+(0.35*0)+(0.38*0)+(0.42*0)+(0.45*0)+(0.48*0) =

0.00

OPTION # 2

Yearly efficiency (10 deg) = (0.25*0.231)+(0.35*0.166)+(0.38*0.211)+(0.42*0.145)+(0.45*0.114)+(0.48*0.133) =

0.37

OPTION # 3

Yearly efficiency (15 deg) = (0.25*0.168)+(0.35*0.179)+(0.38*0.229)+(0.42*0.156)+(0.45*0.124) +(0.48*0.144)=

0.38

NOTE 1:

Yearly efficiency starting at different points of day, depending on levels of usable amount of light

NOTE # 2:

70*

we could use the efficiency for 60° SALT if agreeable, in order to reduce the cost of the tests
Presently we considered only 5 data points for V_t (20, 30, 40, 50 and 60)

NOTE # 3:

For the second Zonal Time, the lower range is 10° to 25° , using V_{t20} and combined ZT₁₀+ZT₂₀

V_t Algorithm

LOCATION: DENVER

Legend

V_{t20} = Visible Transmission at 20 degrees solar altitude (i.e.)

ZT₂₀ = Zonal Time, percent of time spent in zone that number falls into (i.e. ZT₂₀ is for 15-25 range from chart)

Denver Data

$$V_t \text{ Yearly} = (V_{t10} \cdot ZT_{10}) + (V_{t20} \cdot ZT_{20}) + (V_{t30} \cdot ZT_{30}) + (V_{t40} \cdot ZT_{40}) + (V_{t50} \cdot ZT_{50}) + (V_{t60} \cdot ZT_{60}) + (V_{t70} \cdot ZT_{70})$$

Hypothetical V _t data		OPTION #1 (sunrise to sunset)		OPTION #2 (10° to 10°)		OPTION #3 (15° to 15°)	
SALT	V _t	SALT range	ZT	SALT range	ZT	SALT range	ZT
10	0.20	<15°	0.247				
20	0.25	15°-25°	0.176	10° - 25°	0.307	15°-25°	0.234
30	0.35	25-35	0.1895	25-35	0.2275	25-35	0.252
40	0.38	35-45	0.1365	35-45	0.164	35-45	0.182
50	0.42	45-55	0.111	45-55	0.133	45-55	0.147
60	0.45	55-65	0.086	55-65	0.103	55-65	0.114
70*	0.48	>65°	0.054	>65°	0.065	>65°	0.072
			1		0.9995		1.001

OPTION # 1

Yearly efficiency (sunrise) = $(0.20 \cdot 0.247) + (0.25 \cdot 0.176) + (0.35 \cdot 0.1895) + (0.38 \cdot 0.1365) + (0.42 \cdot 0.111) + (0.45 \cdot 0.086) + (0.48 \cdot 0.054) =$

0.32

OPTION # 2

Yearly efficiency (10 deg) = $(0.25 \cdot 0.307) + (0.35 \cdot 0.2275) + (0.38 \cdot 0.164) + (0.42 \cdot 0.133) + (0.45 \cdot 0.103) + (0.48 \cdot 0.065) =$

0.35

OPTION # 3

Yearly efficiency (15 deg) = $(0.25 \cdot 0.234) + (0.35 \cdot 0.252) + (0.38 \cdot 0.182) + (0.42 \cdot 0.147) + (0.45 \cdot 0.114) + (0.48 \cdot 0.072) =$

0.36

NOTE 1:

Yearly efficiency starting at different points of day, depending on levels of usable amount of light

NOTE # 2:

70*

we could use the efficiency for 60° SALT if agreeable, in order to reduce the cost of the tests
Presently we considered only 5 data points for V_t (20, 30, 40, 50 and 60)

NOTE # 3:

For the second Zonal Time, the lower range is 10° to 25° , using V_{t20} and combined ZT₁₀+ZT₂₀

V_t Algorithm

LOCATION: WINNIPEG

Legend

V_{t20} = Visible Transmission at 20 degrees solar altitude (i.e.)

ZT₂₀ = Zonal Time, percent of time spent in zone that number falls into (i.e. ZT₂₀ is for 15-25 range from chart)

Winnipeg Data

$$V_t \text{ Yearly} = (V_{t10} \cdot ZT_{10}) + (V_{t20} \cdot ZT_{20}) + (V_{t30} \cdot ZT_{30}) + (V_{t40} \cdot ZT_{40}) + (V_{t50} \cdot ZT_{50}) + (V_{t60} \cdot ZT_{60}) + (V_{t70} \cdot ZT_{70})$$

Hypothetical V _t data		OPTION #1 (sunrise to sunset)		OPTION #2 (10° to 10°)		OPTION #3 (15° to 15°)	
SALT	V _t	SALT range	ZT	SALT range	ZT	SALT range	ZT
10	0.20	<15°					
20	0.25	15°-25°		10° - 25°	0.414	15°-25°	0.32
30	0.35	25-35		25-35	0.201	25-35	0.233
40	0.38	35-45		35-45	0.165	35-45	0.191
50	0.42	45-55		45-55	0.133	45-55	0.134
60	0.45	55-65		55-65	0.088	55-65	0.102
70*	0.48	>65°		>65°	0	>65°	0
			0		1.001		0.98

OPTION # 1

Yearly efficiency (sunrise) = $(0.20 \cdot 0) + (0.25 \cdot 0) + (0.35 \cdot 0) + (0.38 \cdot 0) + (0.42 \cdot 0) + (0.45 \cdot 0) + (0.48 \cdot 0) =$ **0.00**

OPTION # 2

Yearly efficiency (10 deg) = $(0.25 \cdot 0.414) + (0.35 \cdot 0.201) + (0.38 \cdot 0.165) + (0.42 \cdot 0.133) + (0.45 \cdot 0.088) + (0.48 \cdot 0) =$ **0.33**

OPTION # 3

Yearly efficiency (15 deg) = $(0.25 \cdot 0.32) + (0.35 \cdot 0.233) + (0.38 \cdot 0.191) + (0.42 \cdot 0.134) + (0.45 \cdot 0.102) + (0.48 \cdot 0) =$ **0.34**

NOTE 1:

Yearly efficiency starting at different points of day, depending on levels of usable amount of light

NOTE # 2:

70* we could use the efficiency for 60° SALT if agreeable, in order to reduce the cost of the tests
Presently we considered only 5 data points for V_t (20, 30, 40, 50 and 60)

NOTE # 3:

For the second Zonal Time, the lower range is 10° to 25° , using V_{t20} and combined ZT₁₀+ZT₂₀