

# Energy Efficient Windows and Building Design \* Software Workshop \*

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Sponsored by:    *U.S. Department of Energy (DOE)*  
                      *National Fenestration Rating Council (NFRC)*  
                      *Center for Energy Efficiency and Renewable Energy at the*  
                      *University of Massachusetts (CEERE)*

# OVERVIEW OF COMPUTER PROGRAMS

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- WINDOW
- THERM
- OPTICS
- RESFEN
- OVERALL INTEGRATION



# WINDOW

- Current version WINDOW 5.1
- Calculates center of glass and total product U-factors.
- Relies on THERM (or compatible) program to determine frame and divider U-factors.
- Incorporates libraries of glass products, gas fillings and environmental conditions
- Has Certified (NFRC) mode and Design mode
- Stores data in MS Access database format



Window Library (C:\User\BEEP\_Shared\Round Robins\TRR99\TRR99\_W5-T5\w502b.mdb)

File Edit Libraries Record Tools View Help

List

Calc

New

Copy

Delete

Save

Report

Dividers

Dividers

Display mode: Normal

ID # 11

Name Al Winter

Mode NFRC

Type Casement - Doubl >>

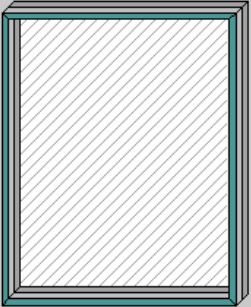
Width 47.244 inches

Height 59.055 inches

Area 19.38 ft2

Tilt 90

Environmental Conditions NFRC 100-2002



Total Window Results

U-factor 0.456 Btu/h-ft2-F

SHGC 0.642

VT 0.675

CR N/A

Detail...

Detail...

Click on a component to display characteristics

Glazing System

Name Al\_winter

ID 12 Ucenter 0.351 Btu

Layers 2 SC 0.809

Area 13.99 ft2 SHGC 0.702

Edge area 3.32 ft2 Vtc 0.756

For Help, press F1 Mode: NFRC

W5 - Glass Library (C:\User\BEEP\_Shared\Round Robins\TRR99\TRR99\_W5-T5\w502b.mdb)

File Edit Libraries Record Tools View Help

Detailed View

Calc

New

Copy

Delete

Find ID

Advanced...

1038 records found.

Import

Export

Report

Print

NFRC only

Glass Library (C:\User\BEEP\_Shared\Round Robins\TRR99\TRR99\_W5-T5\w502b.mdb)

ID	Name	ProductName	Manufacturer	Source	Mode	Color	Thic
100	BRONZE_3.DAT	Float Glass	Generic	Optics 5 v11.. #	#		0.
101	BRONZE_6.DAT		Generic	Optics 5 v11.. #	#		0.
102	CLEAR_3.DAT	Float Glass	Generic	Optics 5 v11.. #	#		0.
103	CLEAR_6.DAT	Float Glass	Generic	Optics 5 v11.. #	#		0.
104	GRAY_3.DAT		Generic	Optics 5 v11.. #	#		0.
105	ONE.DAT		Generic	Optics 5 v11..			0.
106	ZERO.DAT		Generic	Optics 5 v11..			0.
700	B120.AFG	Silver-Blue on Clear	AFG Industries	Optics 5 v11.. #	#		0.
701	B130.AFG	Silver-Blue on Clear	AFG Industries	Optics 5 v11.. #	#		0.
702	B140.AFG	Silver-Blue on Clear	AFG Industries	Optics 5 v11.. #	#		0.
703	B220.AFG	Silver-Blue on Green	AFG Industries	Optics 5 v11.. #	#		0.
704	B230.AFG	Silver-Blue on Green	AFG Industries	Optics 5 v11.. #	#		0.
705	B240.AFG	Silver-Blue on Green	AFG Industries	Optics 5 v11.. #	#		0.
706	B320.AFG	Silver-Blue on Gray	AFG Industries	Optics 5 v11.. #	#		0.
707	B330.AFG	Silver-Blue on Gray	AFG Industries	Optics 5 v11.. #	#		0.
708	B340.AFG	Silver-Blue on Gray	AFG Industries	Optics 5 v11.. #	#		0.
709	B420.AFG	Silver-Blue on Bronze	AFG Industries	Optics 5 v11.. #	#		0.
710	B430.AFG	Silver-Blue on Bronze	AFG Industries	Optics 5 v11.. #	#		0.
711	B440.AFG	Silver-Blue on Bronze	AFG Industries	Optics 5 v11.. #	#		0.
712	B520.AFG	Silver-Blue on Blue	AFG Industries	Optics 5 v11.. #	#		0.

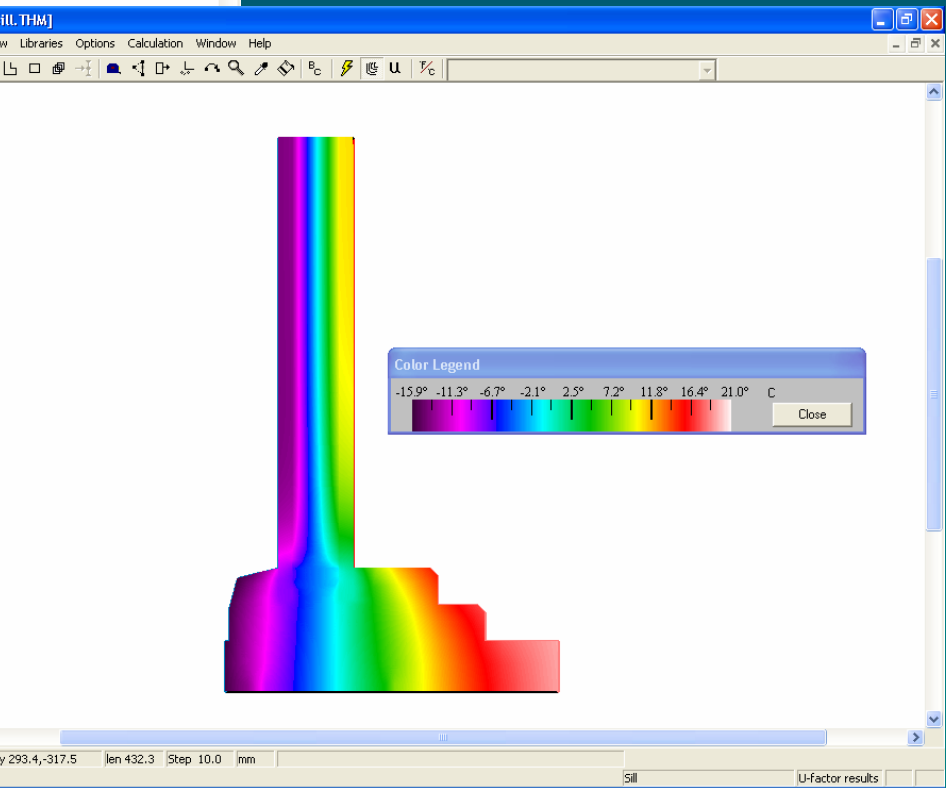
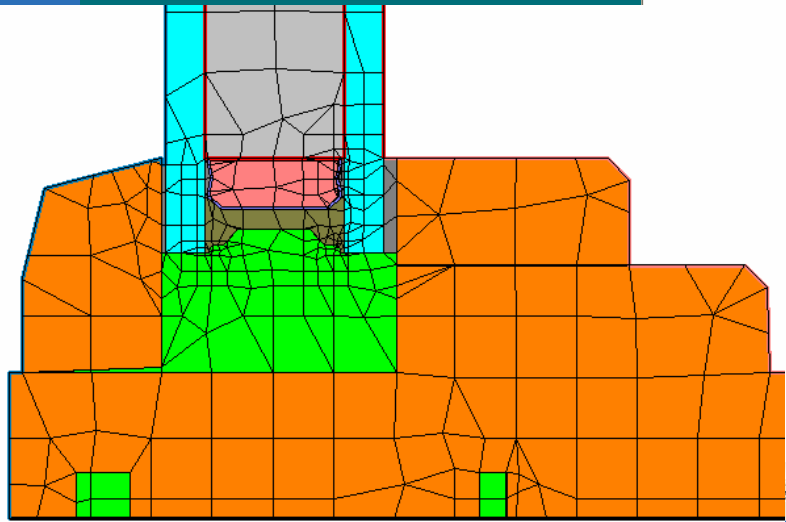
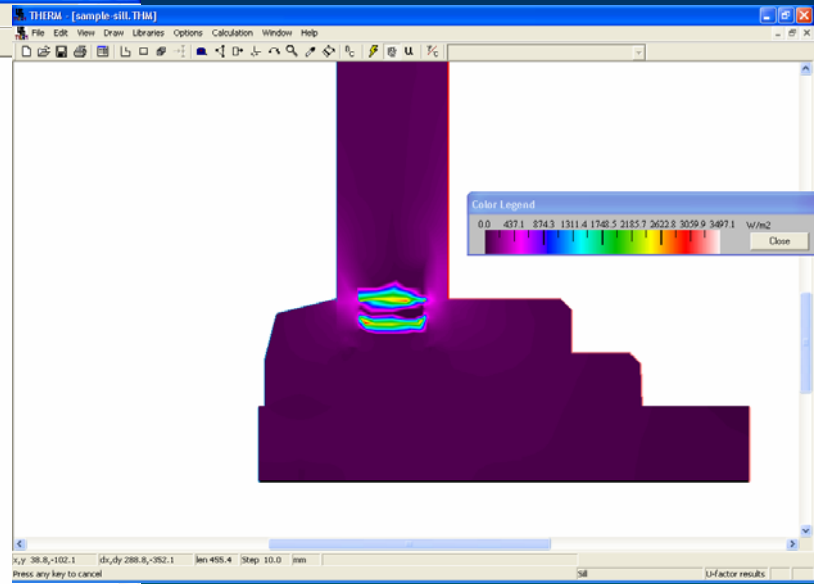
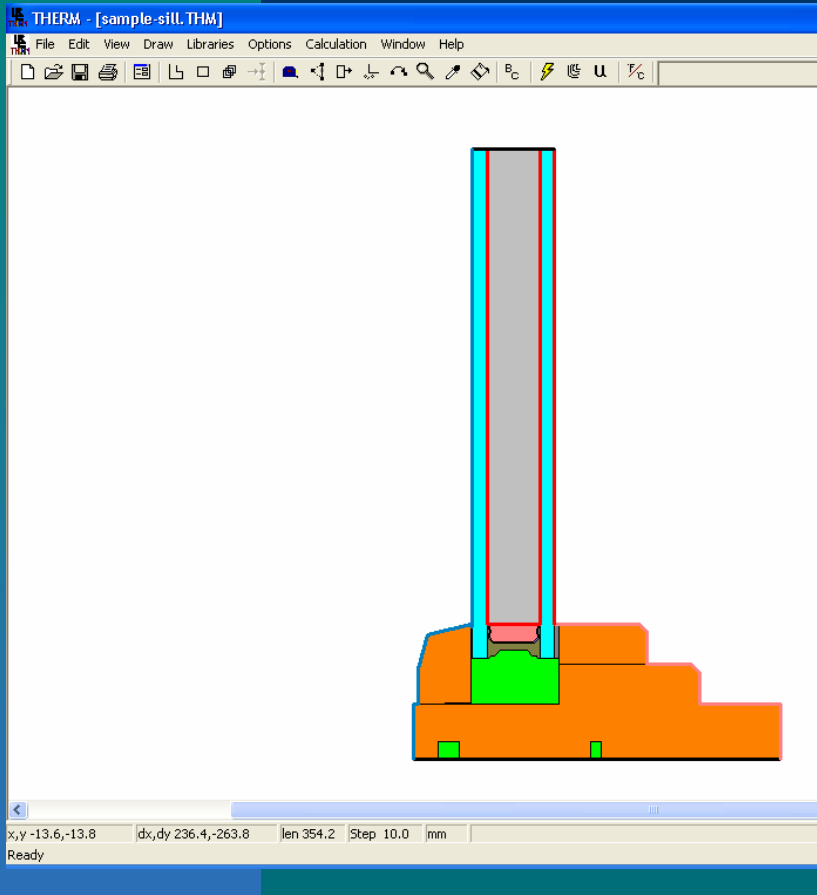
For Help, press F1 Mode: NFRC IP



# THERM

- Current version 5.1
- Two-Dimensional conduction and radiation heat transfer program
- Finite Element Method (FEM)
- Glazing cavity convection modeling (correlat.)
- Powerful drawing tool for preparing model geometry
- View-factor radiation modeling
- Automatic meshing
- Error estimation and auto re-meshing





# OPTICS

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- Current version 5.1
- Virtual Glass Laboratory
- Hundreds of records of glass products with detailed solar-optical properties
- Change glazing thickness
- Switch glazing coating
- Construct glazing with applied films
- Construct glazing with laminate
- International glass product database



**Optics**

File Edit Database View Tools Graph Help

Main Database (IGDB)

Glazing System Laminate

Layer:	#1	#2	#3	System
Filename	CMFTE	CLR_3		GlzSys.
solar, T	0.695	0.859		0.604
solar, Rf	0.115	0.079		0.156
solar, Rb	0.101	0.078		0.154
photopic, T	0.830	0.904		0.755
photopic, Rf	0.096	0.077		0.149
photopic, Rb	0.087	0.077		0.148
EmitF	0.204	0.840		0.204
EmitB	0.840	0.840		0.840

3.1 mm

Type	FileName	ProductName	Nominal (m...)	Nominal (in)	Thickness	Manufacturer	NFRC...
Monolithic	118MCW.ATO	Plexiglas® MC	3 mm	double - 1/8 "	2.9972	ATOFINA C...	2602
Monolithic	177MC.ATO	Plexiglas® MC	N/A	no match	4.4958	ATOFINA C...	2603
Monolithic	236MC.ATO	Plexiglas® MC	6 mm	1/4 "	5.9944	ATOFINA C...	2604
Monolithic	ARCBL10.LOF	Arctic Blue™	10 mm	3/8 "	9.4488	Pilkington N...	9929
Monolithic	ARCBL4.LOF	Arctic Blue™	4 mm	5/32 "	3.937	Pilkington N...	9927
Monolithic	ARCBL6.LOF	Arctic Blue™	6 mm	1/4 "	5.6388	Pilkington N...	9928
Monolithic	ASBRNZ6.PGL	Pilkington Optiflo...	6 mm	1/4 "	5.9	Pilkington	4001



**Optics**

File Edit Database View Tools Graph Help

Main Database (IGDB)

Glazing System Laminate

Layer:	#1	#2	#3	Lamin
Filename	G714.A	30PVB6	CLR_6	s1 lam.
solar, T	0.055	0.946	0.801	0.051
solar, Rf	0.646	0.000	0.069	0.646
solar, Rb	0.137	0.000	0.069	0.121
photopic, T	0.140	0.996	0.883	0.134
photopic, Rf	0.488	0.000	0.076	0.487
photopic, Rb	0.299	0.000	0.076	0.276
EmitF	0.155	0.000	0.840	0.155
EmitB	0.840	0.000	0.840	0.840

5.7 mm

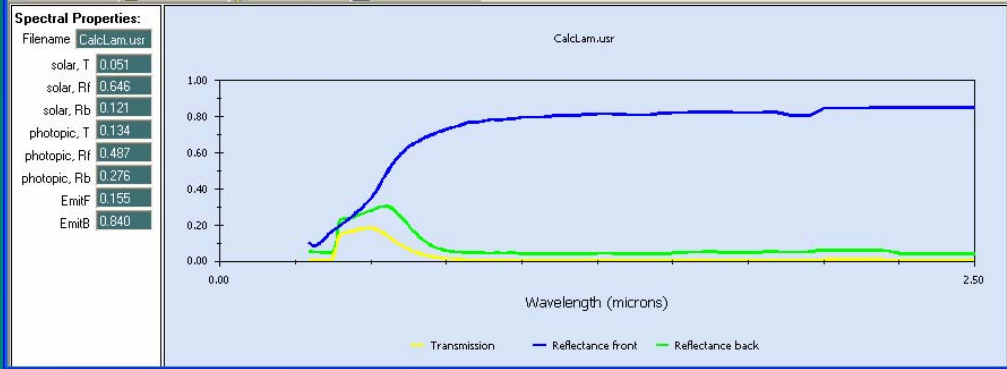
0.8 mm

5.7 mm

**Spectral data**

Wl. (µm)	T	Rf	Rb
0.300	0.000	0.099	0.049
0.305	0.000	0.093	0.049
0.310	0.000	0.087	0.049
0.315	0.000	0.084	0.048
0.320	0.000	0.086	0.048
0.325	0.000	0.090	0.047
0.330	0.000	0.095	0.047
0.335	0.000	0.102	0.047
0.340	0.000	0.109	0.046
0.345	0.000	0.117	0.045
0.350	0.000	0.128	0.045
0.355	0.000	0.137	0.044
0.360	0.000	0.146	0.044
0.365	0.001	0.153	0.044
0.370	0.003	0.160	0.044
0.375	0.024	0.167	0.050
0.380	0.047	0.174	0.068

OK



# RESEFEN

- Current version 3.1
- Calculates energy impacts of residential fenestration systems
- Uses DOE2.1E simulation engine
- Library of default house constructions
- Built-in HVAC systems
- Interface to WINDOW program
- Economic analysis of various fenestration options
- Graphical output of energy use and cost



### RESFEN - default.RSF

File Edit Library Calculate View Options Help

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#### House Data

Location: MN Minneapolis

House Type: 1-Story New Frame

Foundation Type: Basement

HVAC System Type: Gas Furnace / AC

Total Area Floor (ft<sup>2</sup>): 2000  
Window (ft<sup>2</sup>): 300

Elec Cost: \$/kWh: 0.084  
Gas Cost: \$/Therm: 0.45

Description: Base Case House

#### Window Data

	North	East	South	West	Skylight
Window Type	W311	W311	W311	W311	W311
Window (ft <sup>2</sup> )	75.00	75.00	75.00	75.00	0.00
U-factor	0.49	0.49	0.49	0.49	0.49
SHGC	0.56	0.56	0.56	0.56	0.56
Cfm/ft <sup>2</sup>	0.30	0.30	0.30	0.30	0.30
Solar Gain Reduction	Typical	Typical	Typical	Typical	None

### Results

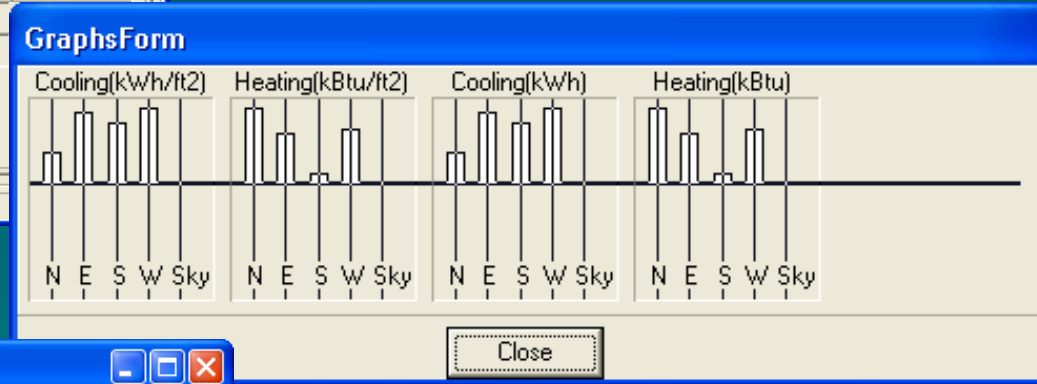
Whole House | Window Annual Energy | Window Energy Cost | Window Peak Energy

Energy Totals		Total Cost	
Cooling	715 (kWh)	Cooling (\$)	60.09
Heating	98.98 (MBtu)	Heating (\$)	445.39
Energy per ft <sup>2</sup>		Total (\$)	
Cooling	0.36 (kWh/ft <sup>2</sup> )	505.48	
Heating	49.49 (kBtu/ft <sup>2</sup> )		

#### Results

Whole House | Window Annual Energy | Window Energy Cost | Window Peak Energy

	North	East	South	West	Skylight
Cooling(kWh/ft <sup>2</sup> )	1.17	2.63	2.27	2.81	0.00
Heating(kBtu/ft <sup>2</sup> )	96.86	63.64	14.16	69.58	0.00
Cooling(kWh)	87	197	170	211	
Heating(MBtu)	7.26	4.77	1.06	5.22	



### Window Library

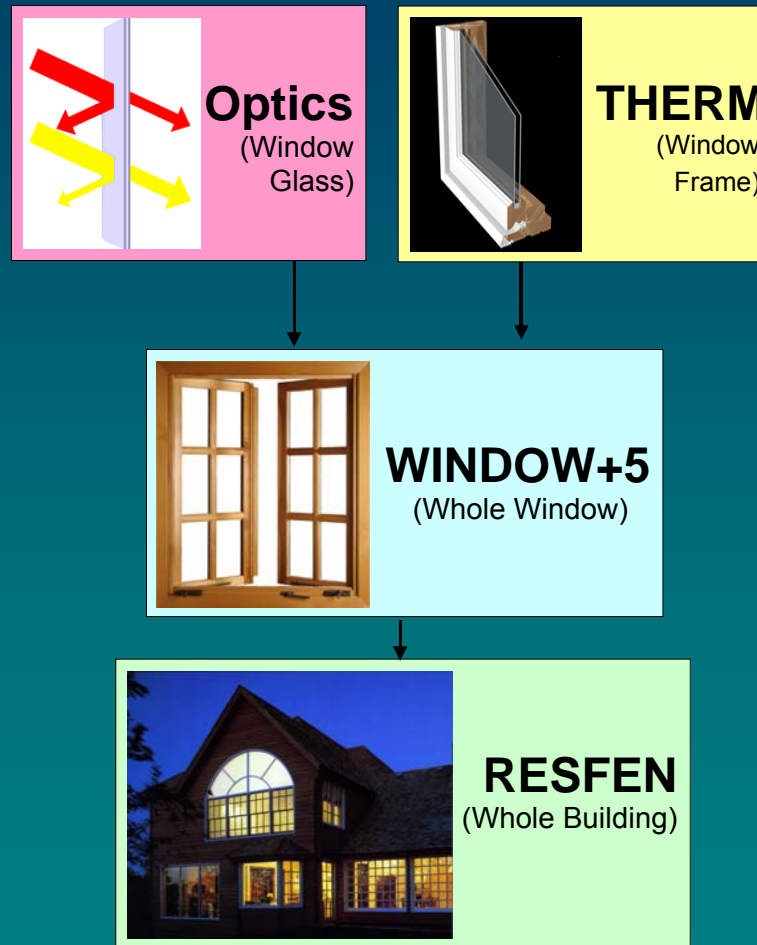
ID	Name	Typ	Width	Height	U Factor	SC	SHGC	VT
221	ATB 2 PY Low-E	1	2.00	4.00	0.52	0.67	0.58	0.57
231	ATB 2 SP Low-E	1	2.00	4.00	0.49	0.56	0.45	0.58
241	ATB 2 SS Low-E	1	2.00	4.00	0.48	0.39	0.34	0.53
301	W/V 1 Clear	1	2.00	4.00	0.90	0.73	0.63	0.64
302	W/V 1 Bronze	1	2.00	4.00	0.90	0.62	0.54	0.48
311	W/V 2 Clear	1	2.00	4.00	0.49	0.65	0.56	0.58
212	W/V 2 Bronze	1	2.00	4.00	0.49	0.54	0.45	0.44
311	W/V 2 Clear	1	2.00	4.00	0.49	0.65	0.56	0.58

File Name

Cancel OK



# Overall Integration



# Scope of the Workshop

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- Installation and setup
- Introduction to all programs and simple exercises
- WINDOW 5.1 Training
- THERM 5.1 Training
- In-class exercise
- Q&A



# INSTALLATION AND SETUP

---

... Proceed to installation of programs on every computer and their setup ...



# WHAT IS WINDOW

- WINDOW is a MS Windows based program, designed for Win95/98/ME, WinNT/2000/XP,
- WINDOW performs calculations of solar-optical and thermal properties of glazing systems according to ISO 15099 methodology,
- WINDOW uses MS Access database format for data handling and storage
- WINDOW calculates total product U-factor, SHGC, VT and FR, by area weighting center of glass and frame/edge of glass (THERM)
- WINDOW outputs results in several standard formats



# HOW TO USE WINDOW 5.1 - EXAMPLE PROBLEM

- Obtain description of the glazing system,
- Check for availability of glass products,
- Create gas mixtures if necessary,
- Create custom boundary conditions, if necessary
- Enter glazing system library
- Specify number of glass layers, gap width(s), gas filling, glass products, coating(s) facing, and boundary conditions
- Simulate,
- View results (U-factors, SHGC, VT, FR)



**Glass library**

W5 - Glass Library (C:\User\BEEP\_Shared\Round Robins\TRR99\TRR99\_W5-T5\w502b.mdb)

File Edit Libraries Record Tools View Help

Detailed View

Calc

New

Copy

Delete

Find

ID

Advanced...

Records found.

Import

Export

Report

Print

NFRC only

For Help, press F1

Mode: NFRC IP

ID	Name	ProductName	Manufacturer	Source	Mode	Color	Thickness	Tsol
							inches	
100	BRONZE_3.DAT	Float Glass	Generic	Optics 5 v11.	#		0.1230	0.646
101	BRONZE_6.DAT		Generic	Optics 5 v11.	#		0.2260	0.486
102	CLEAR_3.DAT	Float Glass	Generic	Optics 5 v11.	#		0.1200	0.834
103	CLEAR_6.DAT	Float Glass	Generic	Optics 5 v11.	#		0.2250	0.771
104	GRAY_3.DAT		Generic	Optics 5 v11.	#		0.1230	0.609
105	ONE.DAT			Optics 5 v11.			0.2362	1.000
106	ZERO.DAT			Optics 5 v11.			0.2362	0.000
700	B120.AFG	Silver-Blue on Clear	AFG Industries	Optics 5 v11.	#		0.2220	0.140
701	B130.AFG	Silver-Blue on Clear	AFG Industries	Optics 5 v11.	#		0.2210	0.227
702	B140.AFG	Silver-Blue on Clear	AFG Industries	Optics 5 v11.	#		0.2220	0.319
703	B220.AFG	Silver-Blue on Green	AFG Industries	Optics 5 v11.	#		0.2280	0.091
704	B230.AFG		AFG Industries	Optics 5 v11.	#		0.2300	0.140
705	B240.AFG	Silver-Blue on Green	AFG Industries	Optics 5 v11.	#		0.2270	0.199
706	B320.AFG	Silver-Blue on Gray	AFG Industries	Optics 5 v11.	#		0.2200	0.079
707	B330.AFG	Silver-Blue on Gray	AFG Industries	Optics 5 v11.	#		0.2200	0.130
708	B340.AFG	Silver-Blue on Gray	AFG Industries	Optics 5 v11.	#		0.2200	0.182
709	B420.AFG	Silver-Blue on Bronze	AFG Industries	Optics 5 v11.	#		0.2200	0.088
710	B430.AFG	Silver-Blue on Bronze	AFG Industries	Optics 5 v11.	#		0.2200	0.144
711	B440.AFG	Silver-Blue on Bronze	AFG Industries	Optics 5 v11.	#		0.2190	0.205
712	B520.AFG	Silver-Blue on Blue	AFG Industries	Optics 5 v11.	#		0.2320	0.085
713	B530.AFG	Silver-Blue on Blue	AFG Industries	Optics 5 v11.	#		0.2310	0.131

**Glass ID**

**Manufacturer**

**Product name**



Gas library

The screenshot shows the 'Gas Library' application window. The title bar reads 'Gas Library (C:\User\BEEP\_Shared\Round Robins\TRR99\TRR99\_W5-T5\w502b.mdb)'. The menu bar includes 'File', 'Edit', 'Libraries', 'Record', 'Tools', 'View', and 'Help'. The toolbar contains various icons for file operations and data manipulation. The main area displays a table with 8 records found. The table columns are: ID, Name, Type, Conductivity, viscosity, Cp, Density, Prandtl, and Comments. The data rows are as follows:

ID	Name	Type	Conductivity	viscosity	Cp	Density	Prandtl	Comme
1	Air	Pure	0.013907	0.355130	0.240469	0.080670	0.7197	
2	Argon	Pure	0.009446	0.438690	0.124746	0.111240	0.6704	
3	Krypton	Pure	0.005006	0.480470	0.059296	0.233351	0.6717	
4	Xenon	Pure	0.002981	0.438690	0.037845	0.365620	0.6542	
6	Air (5%) / Argon (95)	Mix	0.009652	0.438690	0.129000	0.109711	0.6731	
7	Air (12%) / Argon (22)	Mix	0.006639	0.480470	0.077129	0.188165	0.6403	
8	Air (5%) / Krypton (9)	Mix	0.005311	0.480470	0.062534	0.225717	0.6640	
9	Air (10%) / Argon (90)	Mix	0.009859	0.438690	0.133376	0.108183	0.5758	

Callouts point to the following fields:

- Gas ID: Points to the 'ID' column header.
- Gas name: Points to the 'Name' column header.
- Gas mix ID: Points to the 'ID' cell of the first gas mix row (ID 6).
- Gas mix name: Points to the 'Name' cell of the first gas mix row (Air (5%) / Argon (95)).
- Gas/Gas mix properties: Points to the 'Cp' cell of the first gas mix row (0.129000).

On the left side of the interface, there are buttons for 'Calc', 'New', 'Copy', 'Delete', 'Find', 'Advanced...', 'Import', 'Report', and 'Print'. The 'Find' section has a dropdown menu set to 'ID' and a search box. The status bar at the bottom indicates 'For Help, press F1' and 'Mode: NFRC IP'.

Gas/Gas mix properties



Gas library

Gas Library (C:\User\BEEP\_Shared\Round Robins\TRR99\TRR99\_W5-T5lw502b.mdb)

File Edit Libraries Record Tools View Help

Gas Library

ID #: 10

Name: Air 5% / Kr 95%

Gas Mixture Add Delete

	ID	Name	Percent
Gas 1	1	Air	5.0%
Gas 2	3	Krypton	95.0%

Properties at STP

Conductivity 0.013907 Btu/h-ft-F

Viscosity 0.359655 lb-s/ft2

Specific Heat 0.240469 Btu/lb-F

Density 0.080670 lb/ft3

Prandtl 0.7197

Property Calculator

Comment:

Protected

For Help, press F1

Mode: NFRC IP

Gas mix tool

Property calculator at user specified temperature

Add new components to gas mixture

Gas Property Calculator

Temperature 50 F

Pressure 101 psi

Conductivity 0.006 Btu/h-ft-F

Viscosity 0.568 lb-s/ft2

Specific Heat 0.063 Btu/lb-F

Density 0.2 lb/ft3

Prandtl 0.665

Close



Environmental condition library

Boundary condition ID

Boundary condition name

Create New BC

Boundary condition values

The screenshot shows the 'Environmental Conditions Library' window. The title bar indicates the file path: 'C:\User\BEEP\_Shared\Round'. The window contains a table of boundary conditions and a sidebar with various actions.

ID	Name	U-factor Tin	U-factor Tout	SHGC Tin	SHGC Tout	SHGC Solar
		F	F	F	F	Btu/h-ft2
1	NFRC 10J-2002	69.8	-0.4	75.2	89.6	248
2	NFRC 100-2002 Winter	69.8	-0.4	69.8	-0.4	0
3	NFRC 100-2002 Summer	75.2	89.6	75.2	89.6	248
4	CEN	68.0	32.0	77.0	86.0	158
5	NFRC 100-1997	70.0	-0.0	75.0	89.1	248

The sidebar on the left includes buttons for 'Detailed View', 'Calc', 'New', 'Copy', 'Delete', 'Find', 'Advanced...', 'Import', 'Export', 'Report', and 'Print'. The 'Find' section has a dropdown menu set to 'ID' and an empty text input field.



W5 - Environmental Conditions Library (C:\User\BEEP\_Shared\Round Robins\TPR99\...

File Edit Libraries Record Tools View Help

Environmental Conditions Library

ID #:

Name: default

U-factor: Inside | U-factor: Outside | SHGC: Inside | SHGC: Outside

Inside Air Temperature

Convection Model: ASHRAE/NFRC Inside

U-factor: Inside | U-factor: Outside | SHGC: Inside | SHGC: Outside

Outside Air Temperature

Direct Solar Radiation

Convection Model: ASHRAE/NFRC Outside

Convection Coef.

Outside Wind Speed

Wind Direction

Radiation Model: ASHRAE/NFRC

Effective Sky Temperature

Effective Sky Emissivity

U-factor: Inside | U-factor: Outside | SHGC: Inside | SHGC: Outside

ASHRAE/NFRC

Effective Room Temperature

Effective Room Emissivity

U-factor: Inside | U-factor: Outside | SHGC: Inside | SHGC: Outside

Inside Air Temperature

Convection Model: ASHRAE/NFRC Inside

Radiation Model: ASHRAE/NFRC

Effective Room Temperature

Effective Room Emissivity

U-factor: Inside | U-factor: Outside | SHGC: Inside | SHGC: Outside

Outside Air Temperature

Direct Solar Radiation

Convection Model: ASHRAE/NFRC Outside

Convection Coef.

Outside Wind Speed

Wind Direction

Radiation Model: ASHRAE/NFRC

Effective Sky Temperature

Effective Sky Emissivity

Outdoor BCs for SHGC calc.

Indoor BCs for U-factor calc.

Outdoor BCs for U-factor calc

Indoor BCs for SHGC calc.

U-factor: Inside | U-factor: Outside | SHGC: Inside | SHGC: Outside

Outside Air Temperature

Direct Solar Radiation

Convection Model: ASHRAE/NFRC Outside

Convection Coef.

Outside Wind Speed

Wind Direction

Radiation Model: ASHRAE/NFRC

Effective Sky Temperature

Effective Sky Emissivity

U-factor: Inside | U-factor: Outside | SHGC: Inside | SHGC: Outside

Inside Air Temperature

Convection Model: ASHRAE/NFRC Inside

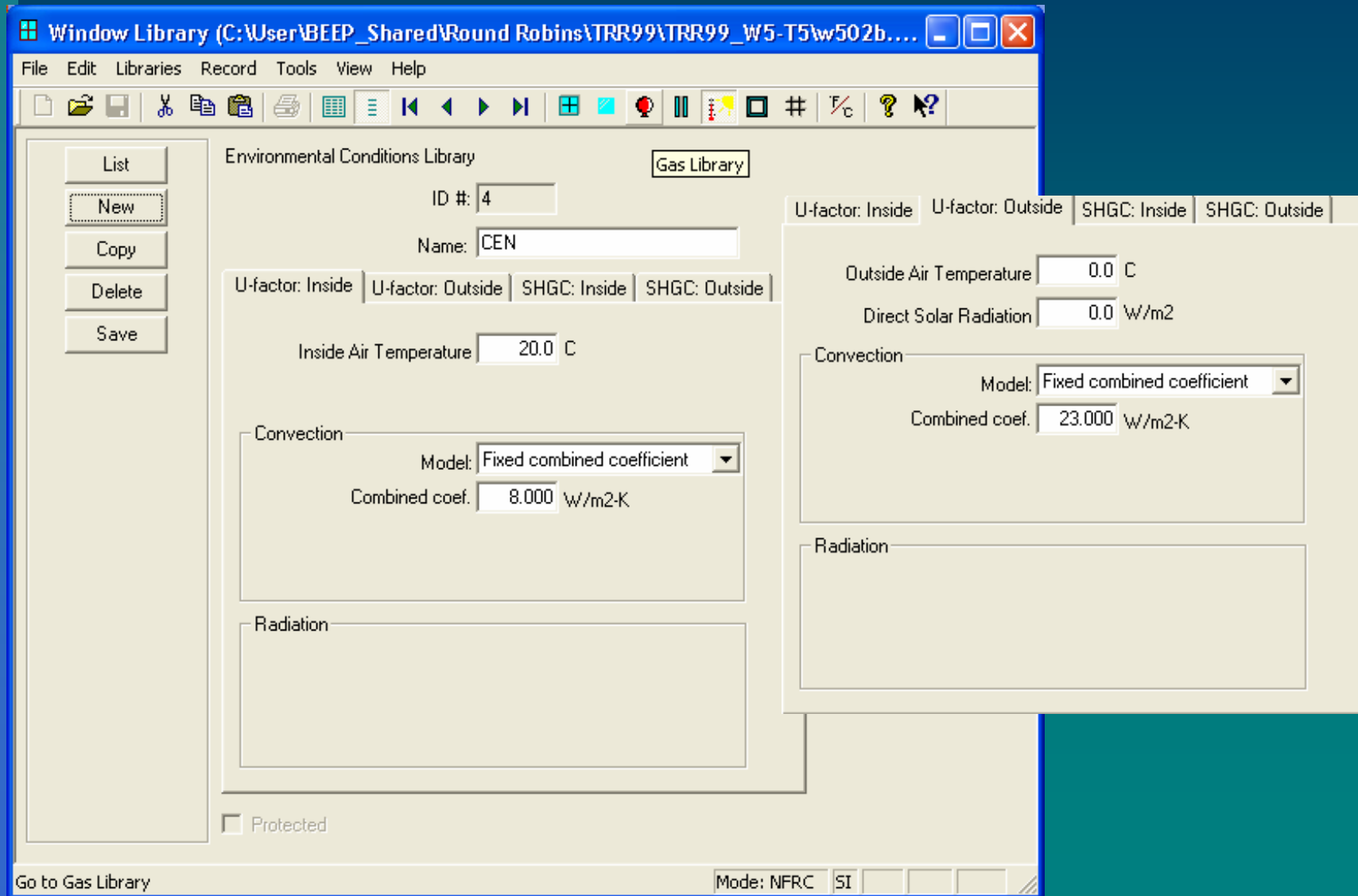
Radiation Model: ASHRAE/NFRC

Effective Room Temperature

Effective Room Emissivity



# EXAMPLE OF CEN BOUNDARY CONDITIONS



Calculate button

Glazing system library

Graphical representation of glazing system

Glazing system ID

Coating position

Number of layers

Environmental conditions used

Glass ID

Glass name

Glass thickness

Summary of glass solar-optical data

Gas filling

Gap thickness

Calculated results (after pressing Calc button)

The screenshot shows the 'Glazing System Library' software interface. At the top, there is a menu bar (File, Edit, Libraries, Record, Tools, View, Help) and a toolbar. The main window is divided into several sections:

- Left Panel:** Contains buttons for 'List', 'Calc', 'New', 'Copy', and 'Save'. The 'Calc' button is highlighted with a callout.
- Form Fields:**
  - Glazing system ID:** ID # 1
  - Name:** TRR99
  - Number of layers:** # Layers: 3
  - Environmental conditions used:** Environmental Conditions: NFRC 100-2002
  - Comment:** Test round robin 99
  - Overall thickness:** 19.050 mm
  - Tilt:** 90°
- Graphical Representation:** A diagram showing a cross-section of a three-layer glazing system with layers labeled 1, 2, and 3. Arrows point to the 'Coating position' on each layer.
- Table 1: Glass Properties**

	ID	Name	Mode	Thick	Flip	Tsol	Rsol1	Rsol2	Tvis	Rvis1	Rvis2	Tir	E1	E2	Cond	Comment
Glass 1	9909	CLEAR_3.PPG		3.3	<input type="checkbox"/>	0.827	0.076	0.077	0.898	0.086	0.086	0.000	0.840	0.840	0.900	
Gas 1	1	Air		6.2												
Glass 2	9942	HMSC75.cust		0.1	<input type="checkbox"/>	0.375	0.460	0.467	0.754	0.128	0.105	0.000	0.772	0.088	0.140	
Gas 2	1	Air		6.2												
Glass 3	9944	S500CL_3.cust		3.3	<input type="checkbox"/>	0.705	0.126	0.108	0.833	0.113	0.109	0.000	0.230	0.840	0.900	
- Table 2: Summary of glass solar-optical data**

Ufactor	SC	SHGC	Rel. Ht. Gain	Tvis	Keff	Gap 1 Keff	Gap 2 Keff
W/m2-K			W/m2		W/m-K	W/m-K	W/m-K
1.753	0.399	0.346	266	0.581	0.0321	0.0405	0.0263



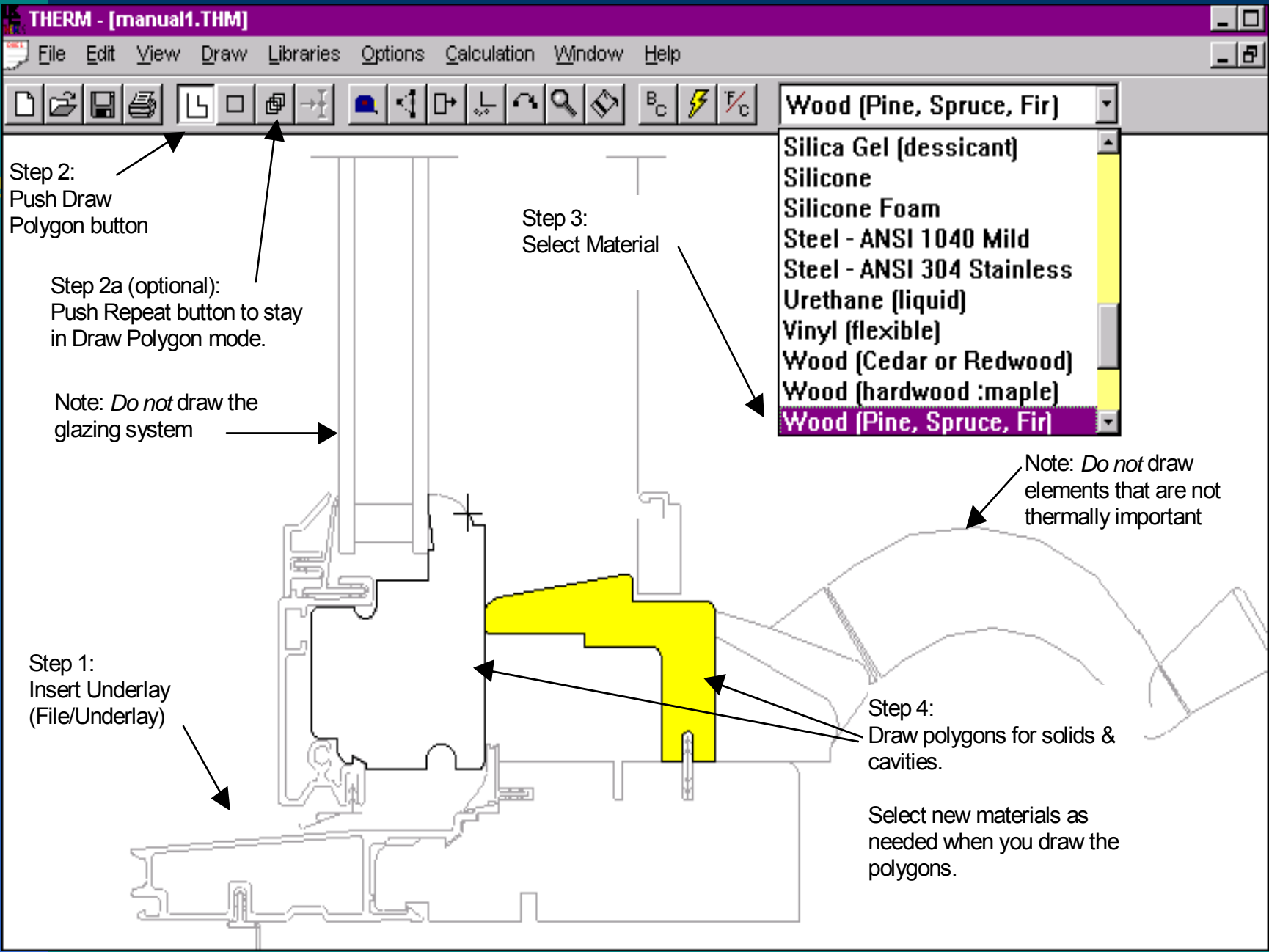
# WHAT IS THERM

- THERM is a MS Windows based program, designed for Win95/98/ME, WinNT/2000/XP
- THERM uses a finite element solution technique to solve the steady state energy equation in accordance with the ISO15099.
- THERM imports dxf files and bitmaps and has extensive drawing capabilities.
- THERM has an automated adaptive mesh generator which guarantees the quality of the mesh.
- THERM displays/prints/exports results in terms of U-factors (used in WINDOW 5.1).

# HOW TO USE THERM 5.1 - EXAMPLE PROBLEM

- Obtain a representation of the cross section either as dxf file, bitmap or dimensioned dwg.,
- Model the cross section using polygons and rectangles and specify material properties,
- Import glazing system from WINDOW,
- Specify boundary conditions and U-factor tags (completes mathematical formulation),
- Simulate,
- View Results (Isotherms, Local Temperatures, U-factors, On-Screen Report).
- Export results to WINDOW.





Step 2:  
Push Draw  
Polygon button

Step 2a (optional):  
Push Repeat button to stay  
in Draw Polygon mode.

Note: *Do not* draw the  
glazing system

Step 3:  
Select Material

- Wood (Pine, Spruce, Fir)
- Silica Gel (dessicant)
- Silicone
- Silicone Foam
- Steel - ANSI 1040 Mild
- Steel - ANSI 304 Stainless
- Urethane (liquid)
- Vinyl (flexible)
- Wood (Cedar or Redwood)
- Wood (hardwood :maple)
- Wood (Pine, Spruce, Fir)

Note: *Do not* draw  
elements that are not  
thermally important

Step 1:  
Insert Underlay  
(File/Underlay)

Step 4:  
Draw polygons for solids &  
cavities.

Select new materials as  
needed when you draw the  
polygons.



**THERM - [manual.thm]**

File Edit View Draw Libraries Options Calculation Window Help

Frame Cavity [NFRC Simplif

Step 2: Push the Fill toolbar button

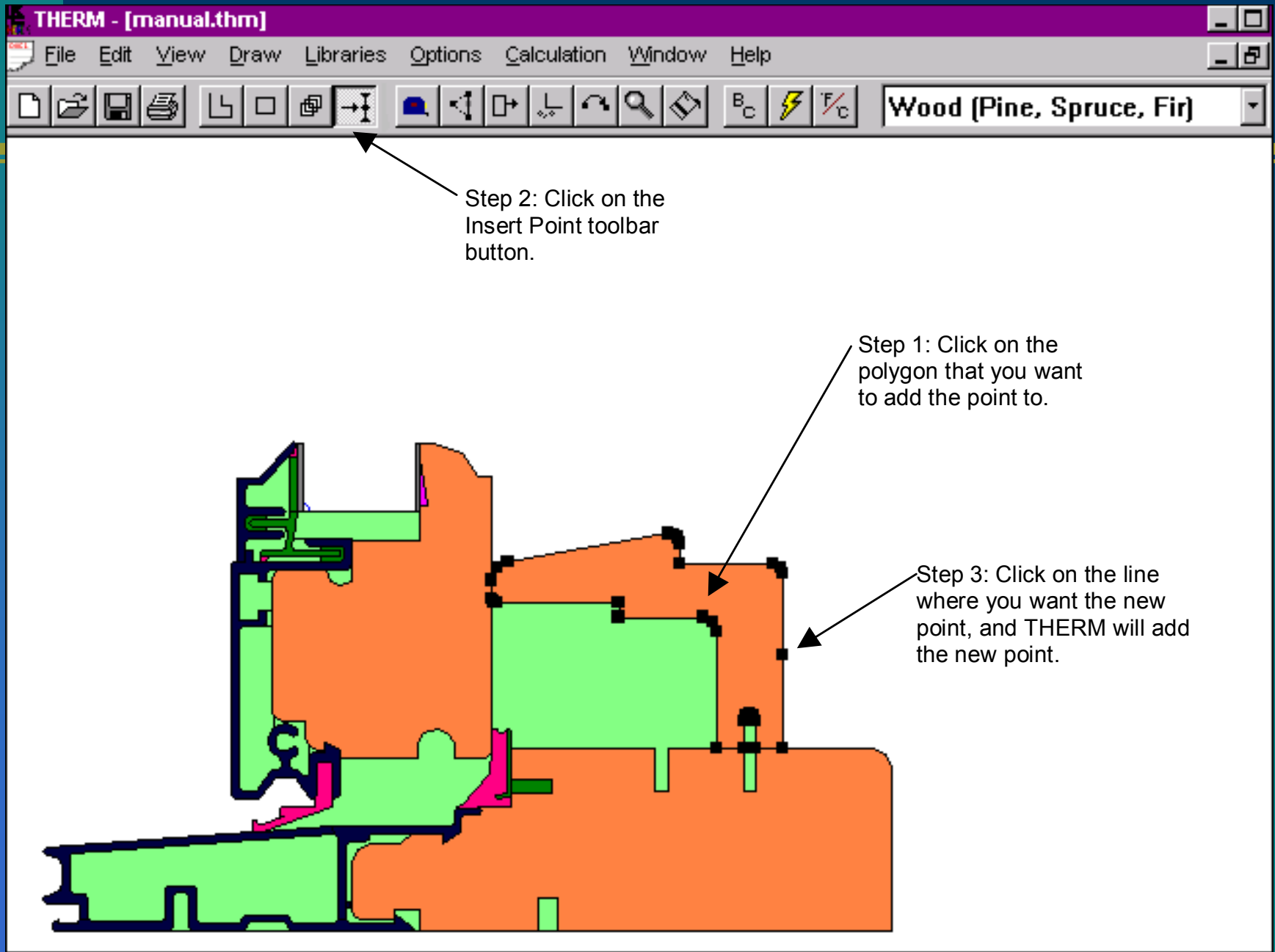
Step 1: Select the Material you want "fill" with, in this case a Frame Cavity Material

This drawing has many areas that are surrounded by polygons. These areas can be "filled" automatically by the program.

Step 3: You will see a Fill cursor. Place that cursor in the vacant area you wish to fill. The area must be completely bounded by other polygons.

Step 4: Click the left mouse button, and the area will be automatically filled.

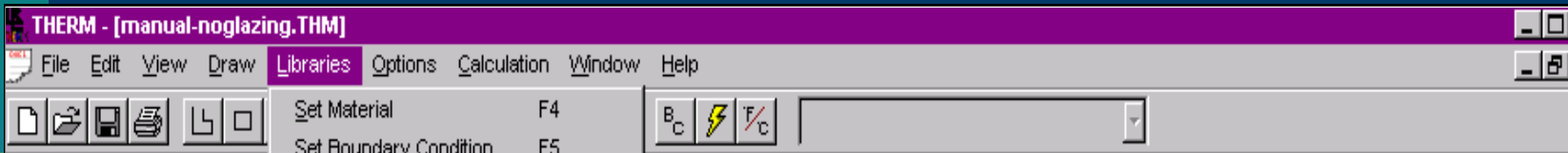




Step 2: Click on the Insert Point toolbar button.

Step 1: Click on the polygon that you want to add the point to.

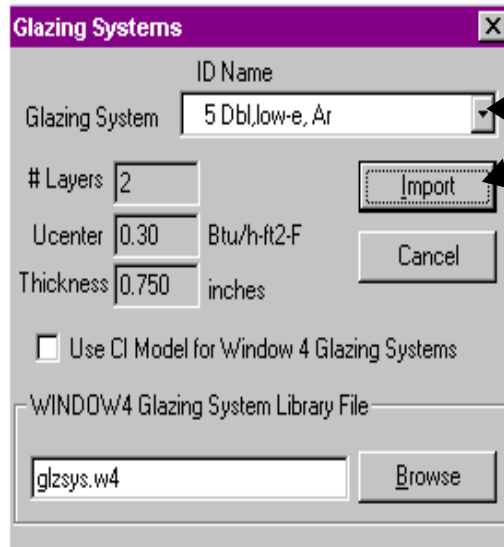
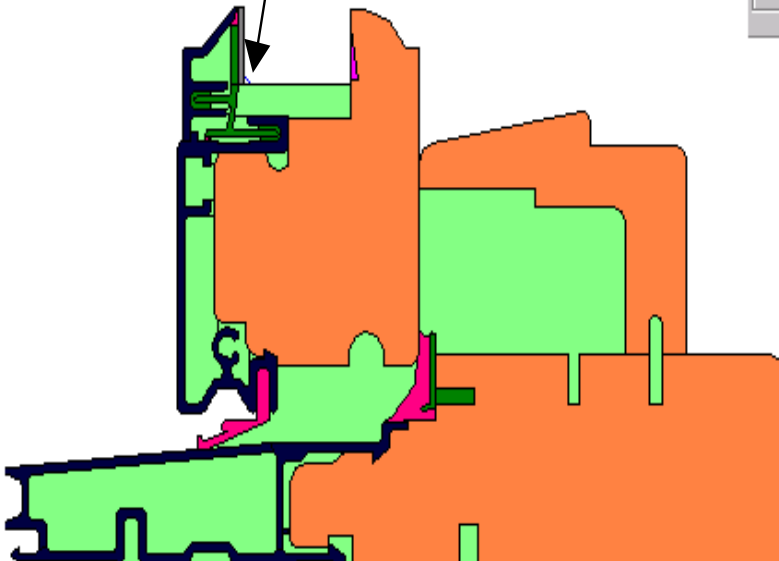
Step 3: Click on the line where you want the new point, and THERM will add the new point.



Step 3:  
Choose Libraries/Glazing System menu choice.

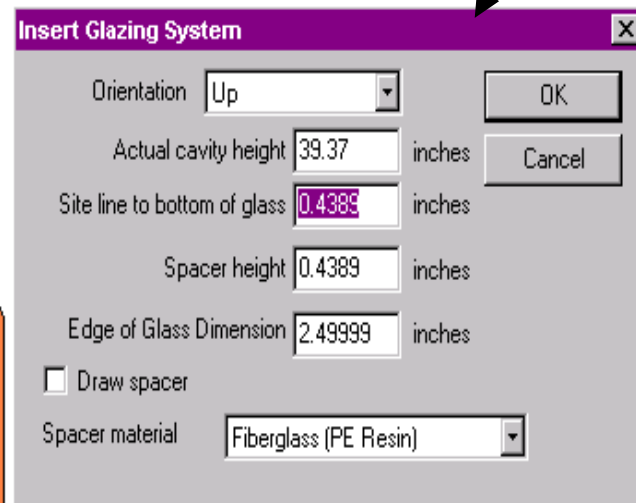
Step 1:  
Draw polygon to represent glazing tape on left side.

Step 2:  
Select Draw/Locator menu choice, place cursor at lower left corner where glazing system will be inserted and click the left mouse button. Locator circle will appear.



Step 4:  
Pick the Glazing System. Press Import

Step 5:  
Enter the cavity height, site line, and spacer height dimensions in the Insert Glazing System dialog box.



You can use the Tape Measure toolbar button to measure these spaces while the Insert Glazing System dialog box is open.



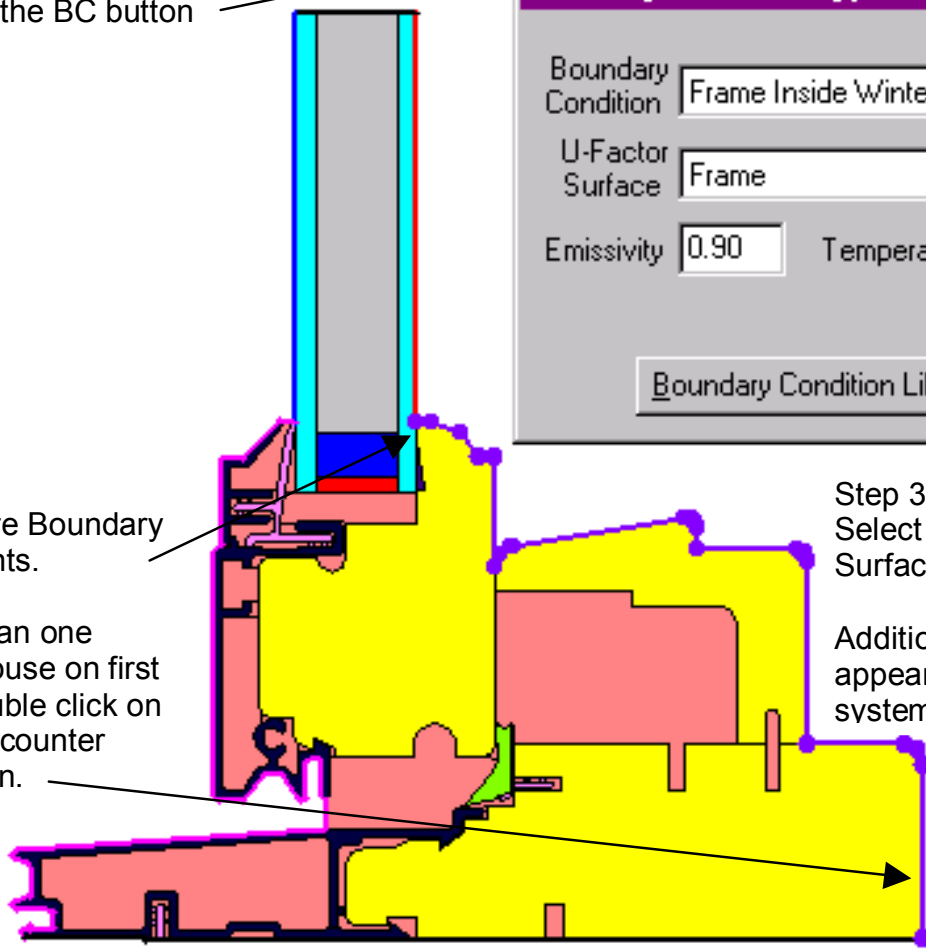
Step 1:  
Press the BC button

### Boundary Condition Type

Boundary Condition	<input type="text" value="Frame Inside Winter"/>	<input type="button" value="OK"/>
U-Factor Surface	<input type="text" value="Frame"/>	<input type="button" value="Cancel"/>
Emissivity	<input type="text" value="0.90"/>	Temperature <input type="text" value="70.0"/>

Step 2:  
Select one or more Boundary Condition segments.

To select more than one segment, click mouse on first segment then double click on last segment in a counter clockwise direction.



Step 3:  
Select Boundary Condition & U-Factor Surface values.

Additional boundary condition options will appear in the list based on the glazing system inserted.



THERM - [manual.thm]

File Edit View Draw Libraries Options Calculation Window Help

Calculation F9  
 Display Options Shift+F9  
**Show U-factors Ctrl-F9**  
 Calc Manager  
 Background Calc  
 Add to queue

Select "Show U-factors" to see the U-factor results.

Checking "Background Calc" allows you to do other computer tasks while the calculations are being performed.

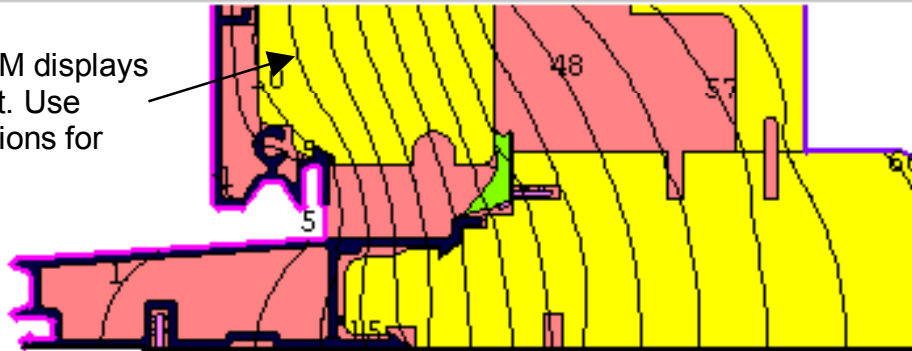
**U-Factors**

	U-Factor Btu/h-ft <sup>2</sup> -F	delta T F	Length inches	
Edge	0.535	102.0	2.49999	Projected Y
Frame	0.401	102.0	3.15628	Projected Y

% Error Energy Norm N/A

Export OK

After calculating, THERM displays the isotherms by default. Use Calculation/Display Options for more results options.



# HOW TO USE WINDOW 5.1 - EXAMPLE WHOLE PRODUCT

- Import results into the frame library from THERM,
- Assemble window in window library from frame sections and glazing units,
- Press calculate,
- View results (U-factors, SHGC, VT, FR, CRI),
- Produce standardized reports for NFRC certification or for use in building energy simulation programs.
- Simulate dividers



Frame Library (C:\User\BEEP\_Shared\Round Robins\TRR01\Tr01\_w5-T5\w502b.mdb)

Summary listing of frame cross section in a library

Frame library

Detailed view button

Open

Import

Format: Therm file

Avoid creating duplicate records in export database by searching for identical records

Import THERM results

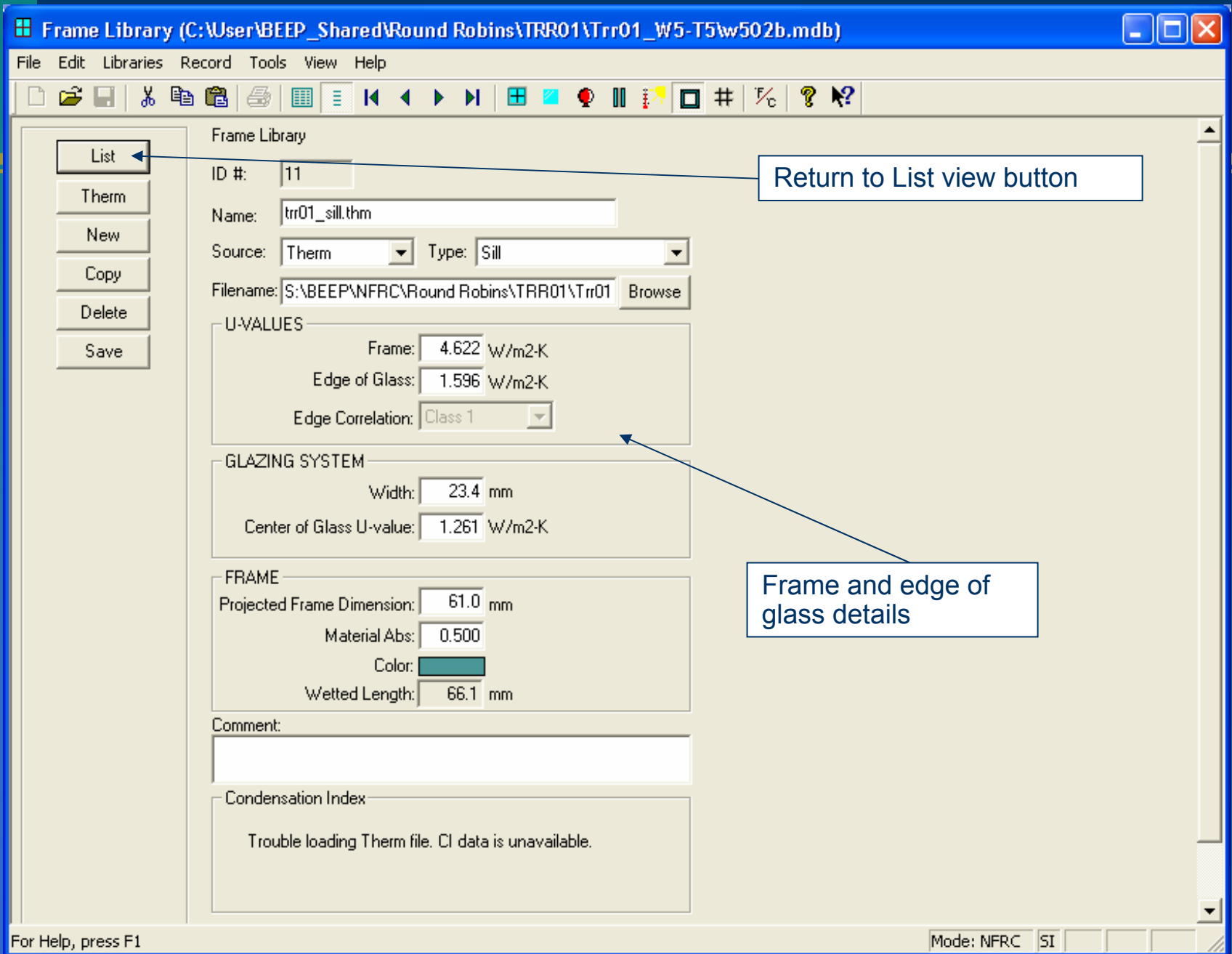
ID	Name	Source	Type	Frame Uvalue W/m2-K	Edge Uvalue W/m2-K	Edge Correlation	Glazing Thickness mm	Pfd mm	Abs	Color
1	Al flush	ASHRAE	N/A	5.680	n/a	Class1	n/a	57.2	0.90	
2	Al flush	ASHRAE	N/A	3.970	n/a	Class1	n/a	57.2	0.90	
3	Wood	ASHRAE	N/A	2.270	n/a	Class1	n/a	69.8	0.90	
4	Vinyl	ASHRAE	N/A	1.100	n/a	Class1	n/a	69.8	0.90	
11	trr01_sill.thm	Therm	Sill	4.100	1.589	n/a	23.4	61.0	0.30	
12	trr01_head.thm	Therm	Head	4.100	1.589	n/a	23.4	61.0	0.30	
13	trr01_jamb.thm	Therm	Jamb	4.100	1.589	n/a	23.4	61.0	0.30	
16	trr01_sill_liq-ur.thm	Therm	Sill	5.606	1.589	n/a	23.4	61.0	0.30	
25	trr01_liqJamb_09N_et.THM	Therm	Jamb	5.373	1.633	n/a	23.4	61.0	0.30	
26	trr01_liqSill_09NCl_rev_frame-hc.THM	Therm	Sill	5.408	1.589	n/a	23.4	61.0	0.30	
27	trr01_liqHead_09NCl_rev_frame-hc.THM	Therm	Head	5.406	1.589	n/a	23.4	61.0	0.30	
28	trr01_liqJamb_09N_rev_frame-hc.THM	Therm	Jamb	5.606	1.589	n/a	23.4	61.0	0.30	

19 records found.

For Help, press F1

Mode: NFRC SI





Return to List view button

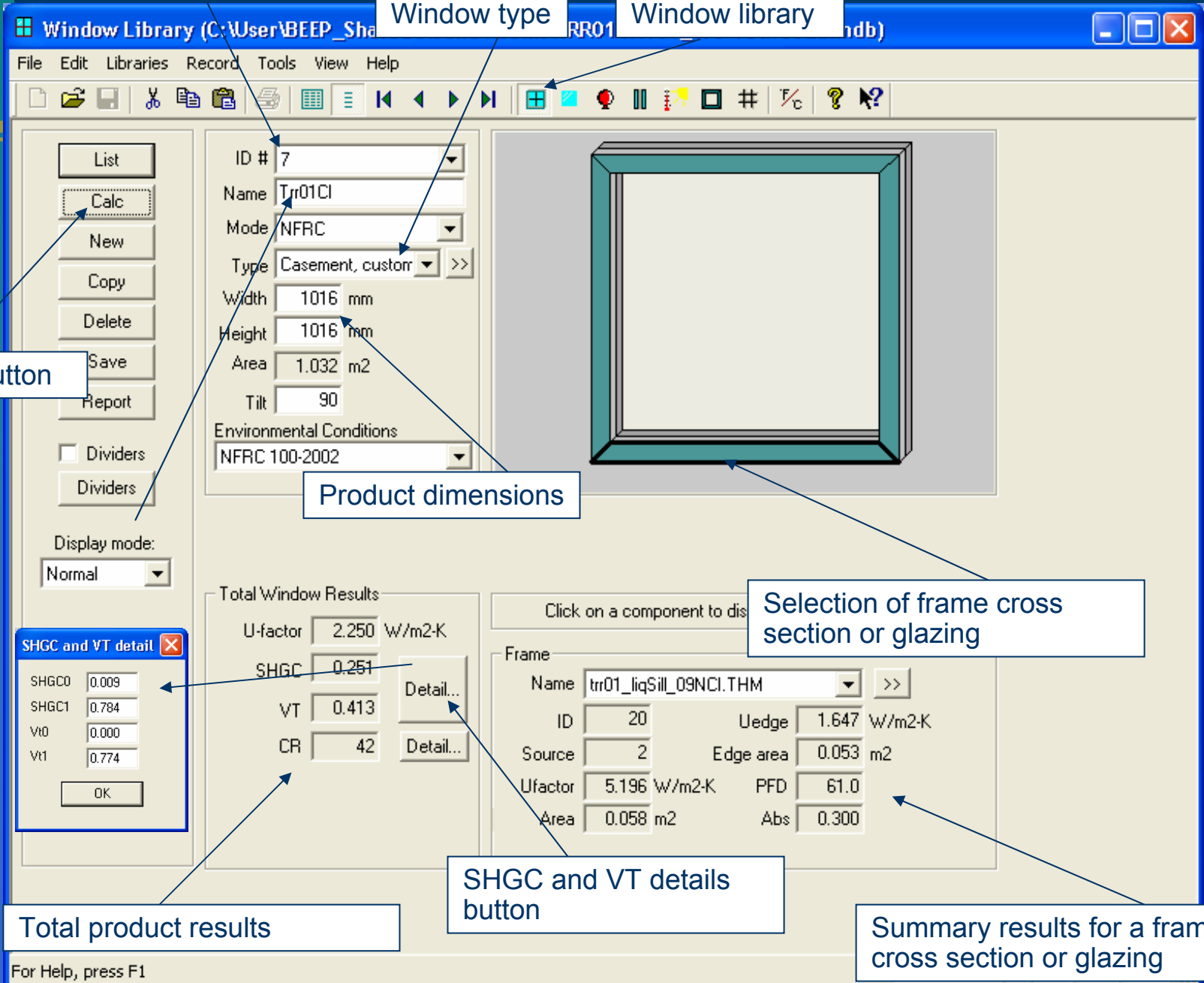
Frame and edge of glass details



Product ID

Window type

Window library



Calculate button

Product dimensions

Selection of frame cross section or glazing

Total product results

SHGC and VT details button

Summary results for a frame cross section or glazing



### Report

Report type:

OK Cancel

### Report

Report type:

OK Cancel

### Dialog

Close Print Save As

Window 5.1 v5.1.00 Report Page 1 11/21/02 19:15:53  
 ID: 7  
 Name: Trr01CI  
 EnvCond: 1 NFRC 100-2002

Type: Casement, custom  
 Tilt: 90  
 Size: 0  
 Width: 1016.0 mm  
 Height: 1016.0 mm  
 Area: 1.03 m<sup>2</sup>

U-value: 2.250 W/m<sup>2</sup>-K  
 SHGC: 0.251  
 Vt: 0.413  
 CI: N/A

Data for Glazing Systems

ID	Name	COG Area m <sup>2</sup>	#Lay	Tilt	Uc W/m <sup>2</sup>	SCc	SHGCc	Vtc	RHG
10	Trr01N	0.588	3	90	1.263	0.36	0.31	0.53	238

Glass and Gas Data for Glazing System '10 Trr01N'

ID	Name	D(mm)	Tsol	1 Rsol	2 Tvis	1 Rvis	2 Tir	1 Emis	2 Keff
Outside									
9942	CMFTE2_3_AFG	3.1	.686	.101	.124	.830	.088	.096	.000
1	Air	8.6							.055
9943	HM5C75_SWT	0.1	.370	.460	.467	.754	.128	.105	.000
1	Air	8.6							.028
9942	FCMFTE2_3_AFG	3.1	.686	.124	.101	.830	.096	.088	.000
Inside									

### Dialog

Close Print Save As

Window5 Data File for EnergyPlus  
 Window 5.1 v5.1.00  
 Date : Thu Nov 21 19:16:24 2002  
 Window name : 7 Trr01CI  
 Description : Casement, custom

# Glazing Systems: 1

GLAZING SYSTEM DATA: Height Width nPanes Uval-center SC-center SHGC-center Tvis-center  
 System1 : 894 894 3 1.263 0.360 0.312 0.534

FRAME/MULLION DATA: Width OutsideProj InsideProj Cond EdgeCondRatio SolAbs VisAbs Emiss Orient'n (null)

	L Sill	R Sill	L Head	R Head	Top L Jamb	Bot L Jamb	Top R Jamb	Bot R Jamb	Mullion
	61.0 25.4 25.4 29.303 1.411 0.300 0.300 0.90	61.0 25.4 25.4 29.303 1.411 0.300 0.300 0.90	61.0 25.4 25.4 28.946 1.418 0.300 0.300 0.90	61.0 25.4 25.4 28.946 1.418 0.300 0.300 0.90	61.0 25.4 25.4 36.462 1.398 0.300 0.300 0.90	61.0 25.4 25.4 36.462 1.398 0.300 0.300 0.90	61.0 25.4 25.4 36.462 1.398 0.300 0.300 0.90	61.0 25.4 25.4 36.462 1.398 0.300 0.300 0.90	None

Average frame: 61.0 25.4 25.4 32.793 1.407 0.300 0.300 0.90

DIVIDER DATA : Width OutsideProj InsideProj Cond EdgeCondRatio SolAbs VisAbs Emiss Type #Hor #Vert  
 System1 : 0.0 0.0 0.0 0.000 0.000 0.000 0.000 0.000 0.000 None 0 0

GLASS DATA : Layer# Thickness Cond Tsol Rfsol Rbsol Tvis Rvis Rbvis Tir EmissF EmissB SpectralDataFile  
 System1 : 1 3.10 0.900 0.69 0.10 0.12 0.83 0.09 0.10 0.00 0.84 0.20 CMFTE2\_3\_AFG  
 2 0.08 0.140 0.37 0.46 0.47 0.75 0.13 0.10 0.00 0.76 0.05 HM5C75\_SWT  
 3 3.10 0.900 0.69 0.12 0.10 0.83 0.10 0.09 0.00 0.20 0.84 CMFTE2\_3\_AFG

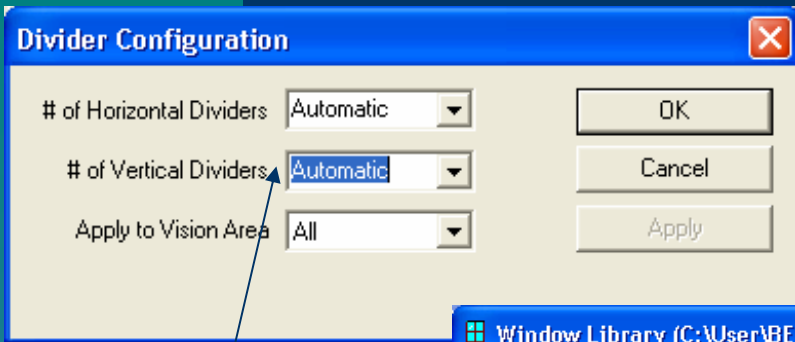
GAP DATA : Gap# Thick nGasses  
 System1 : 1 8.59 1  
 2 8.59 1

GAS DATA : GasName Fraction MolWeight ACond BCond CCond AVisc BVisc CVisc ASpHeat BSpHeat CSPHeat  
 System1 Gap1 : Air 1.0000 28.97 0.002873 7.76e-005 0 3.723e-006 4.94e-008 0 1002.74 0.012324 0  
 Gap2 : Air 1.0000 28.97 0.002873 7.76e-005 0 3.723e-006 4.94e-008 0 1002.74 0.012324 0

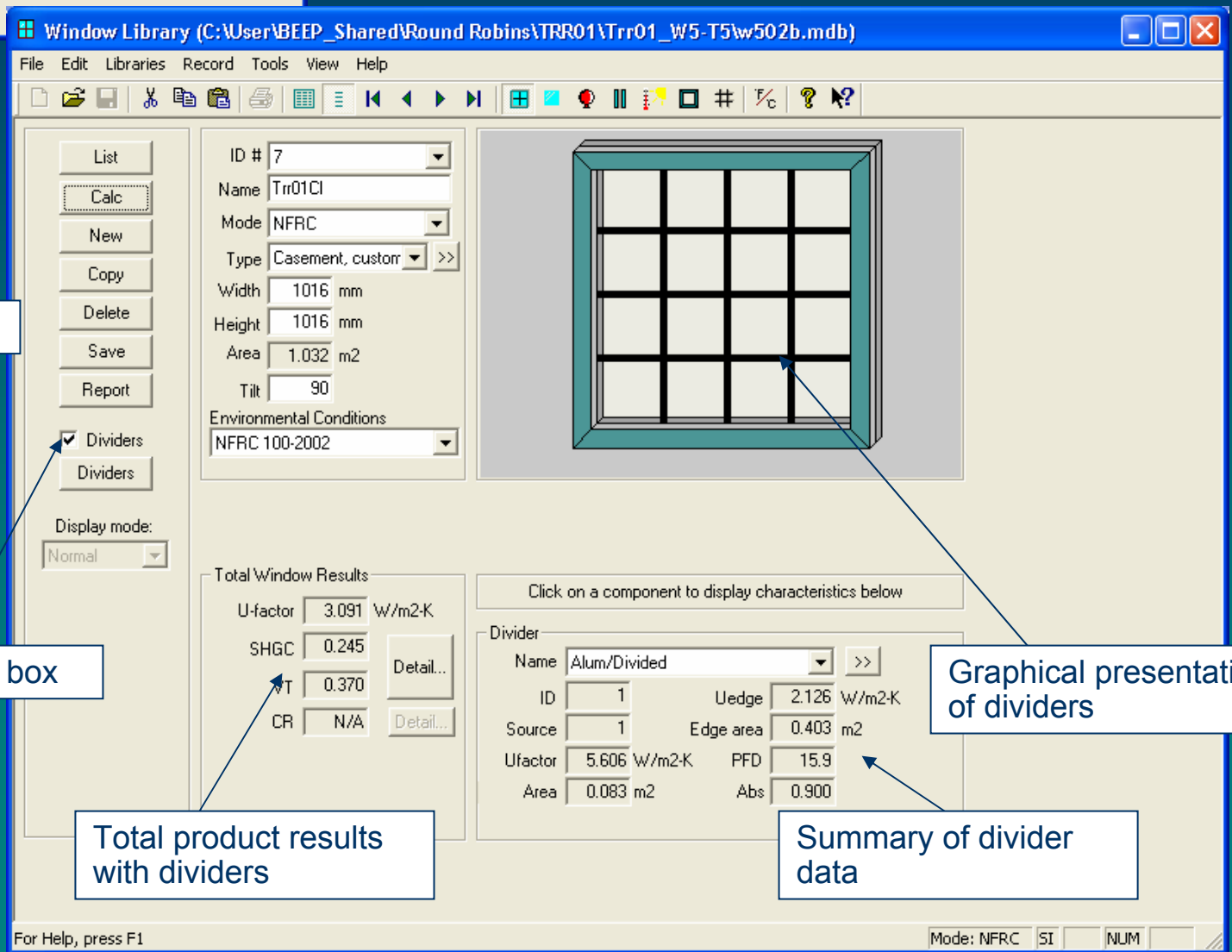
GLAZING SYSTEM OPTICAL DATA  
 Angle 0 10 20 30 40 50 60 70 80 90 Hemis  
 System1  
 Tsol 0.196 0.196 0.196 0.196 0.196 0.196 0.196 0.196 0.196 0.196 0.196  
 Abs1 0.279 0.279 0.279 0.279 0.279 0.279 0.279 0.279 0.279 0.279 0.279  
 Abs2 0.129 0.129 0.129 0.129 0.129 0.129 0.129 0.129 0.129 0.129 0.129  
 Abs3 0.054 0.054 0.054 0.054 0.054 0.054 0.054 0.054 0.054 0.054 0.054  
 Rfsol 0.340 0.340 0.340 0.340 0.340 0.340 0.340 0.340 0.340 0.340 0.337  
 Rbsol 0.344 0.344 0.344 0.344 0.344 0.344 0.344 0.344 0.344 0.344 0.340  
 Tvis 0.534 0.534 0.534 0.534 0.534 0.534 0.534 0.534 0.534 0.534 0.529

Energy Efficient Windows and Building Design





Divider selection screen



Divider selection box

Graphical presentation of dividers

Total product results with dividers

Summary of divider data



# THERM 5.1 Interactive Tutorial

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## ■ Menus:

- File
- Edit
- View
- Draw
- Libraries
  - ❖ Material
  - ❖ Boundary conditions
  - ❖ Glazing systems
  - ❖ U-factor

# THERM 5.1 Interactive Tutorial

## – Cont.

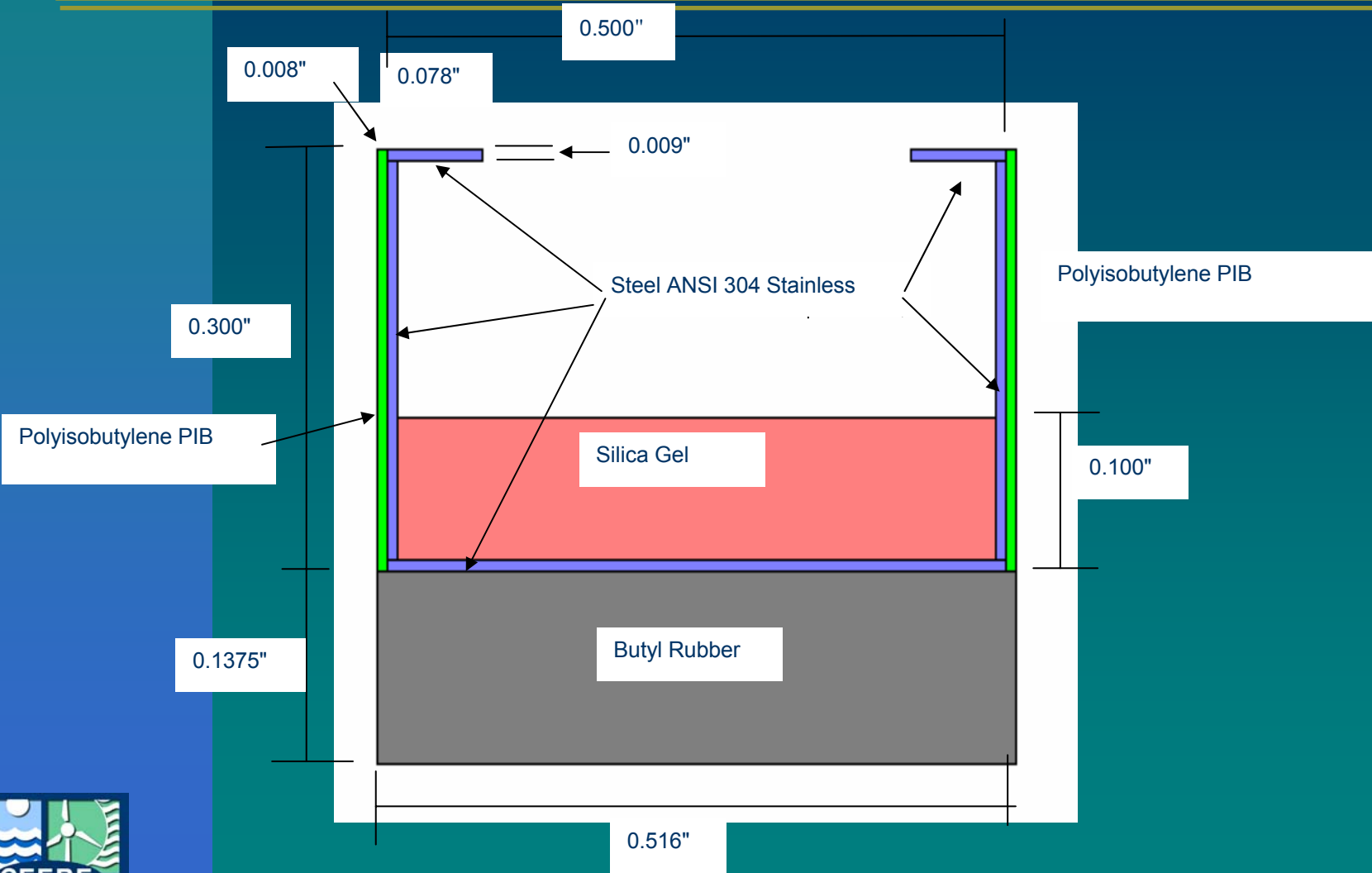
- **Menus (Cont.):**
  - Options
    - ❖ Preferences
    - ❖ Simulation
    - ❖ File options
    - ❖ Snap settings
  - Calculation
    - ❖ Display options
    - ❖ Show U-Fcators
    - ❖ Calculation Manager
  - Window
  - Help

# THERM 5.1 Training

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- Toolbar
- Modeling Exercise
  - Options
    - ❖ Preferences
    - ❖ Simulation
    - ❖ File options
    - ❖ Snap settings
  - Calculation
    - ❖ Display options
    - ❖ Show U-Fcators
    - ❖ Calculation Manager
  - Window
  - Help

# Drawing with the Keyboard:



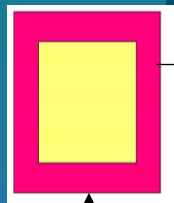
Energy Efficient Windows and Building Design



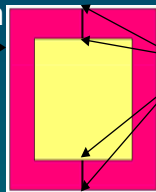
www.ceere.org

# "Donuts"

"Donut"

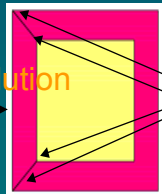


Poor Solution



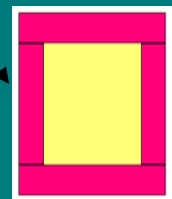
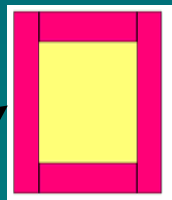
New points have been introduced

Better solution



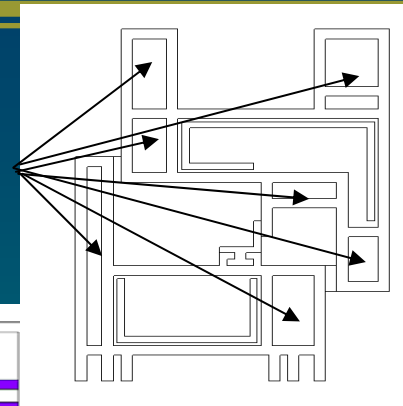
No new points have been introduced, 45° angles are ok.

Best solutions

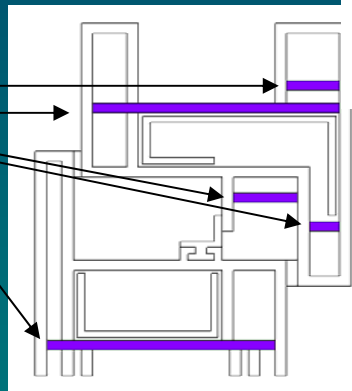


# Breaking Up Donuts:

These areas are "donuts" and must be broken up.



Draw a few well-placed rectangles to break up the donuts in the extrusion dxf file



Then follow the dxf file underlay to trace the rest of the polygons for the extrusion.

