5. MODELING CENTER-OF-GLAZING WITH WINDOW

5.1. Overview

The WINDOW program calculates the center-of-glazing U-factor (U_c), Solar Heat Gain Coefficient ($SHGC_c$), Visible Transmittance (VT_c) and Fading Resistance (FR) according to the following standards:

- *NFRC 100: Procedure for Determining Fenestration Product Thermal Properties*
- *NFRC 200: Procedure for Determining Fenestration Product Solar Heat Gain Coefficients at Normal incidence*
- *NFRC 300: Procedure for Determining Solar Optical Properties of Simple Fenestration Product*
- *NFRC 500: Procedure for Determining Fenestration Product Condensation Resistance Values*
- *ISO 15099: Thermal Performance of Windows, Doors and Shading Devices – Detailed Calculations*

The WINDOW User's Manual, *WINDOW 5: Program Description, A PC Program for Analyzing the Thermal Performance of Fenestration Products* contains detailed information about how to use the program, and can be used to become familiar with the program before reading this manual.

For NFRC simulations, the procedure for calculating the center-of-glazing U-factor in WINDOW is:

- Verify that the **Glass Library** entries are from the currently approved International Glazing Data Library associated with the Optics program (the following website contains current updates: http://windows.lbl.gov/software and click on the Optical Data Library link)
- Create a glazing system for the product to be modeled which is composed of entries from the **Glass** and **Gas Libraries**
- This Glazing System can then be imported into THERM to calculate the frame and edge-of-glazing values
- The Glazing System is also used in WINDOW when constructing the whole product in the Window Library.

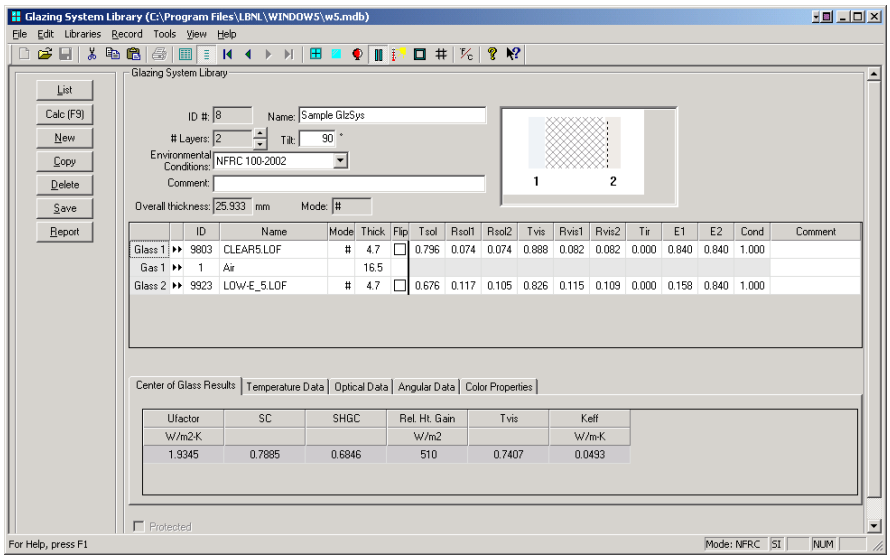


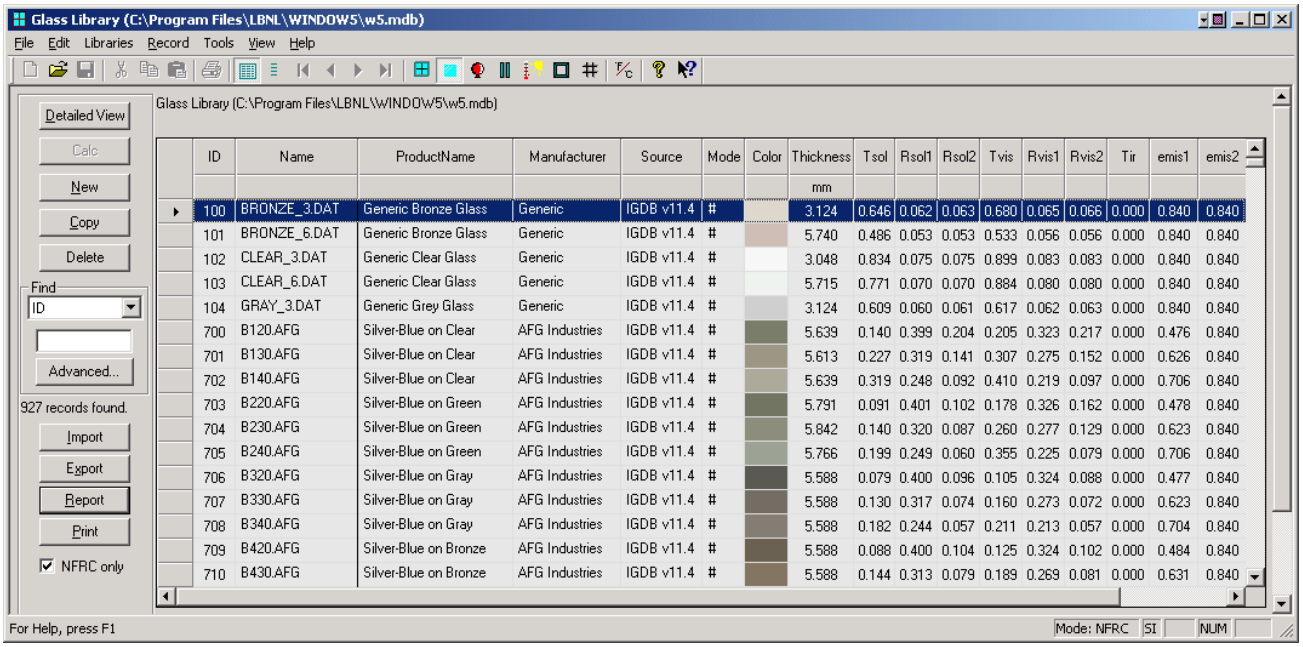
Figure 5-1. WINDOW Glazing System Library Detailed View.

5.2 Glass Library

The **Glass Library** contains individual glass layers that can be used to construct glazing systems. For NFRC simulations, the NFRC approved glass layers from the International Glazing Database found in the Optics program shall be used. WINDOW is shipped with the currently approved International Glazing Database, but the library is updated frequently so check the website mentioned in Section 5.1 for updates. The data in the International Glazing Database

is determined according to the *NFRC 300* procedure. When the NFRC approved glass data is used, a **#** symbol appears in the **Mode** fields of both the **Glass Library** (shown in Figure 5-2) and the **Glazing System Library** (shown in Figure 5-1). All certification simulations must use the most current NFRC-approved International Glazing Database (IGDB).

The Glass Library imported from the International Glazing Database contains glass products of specific manufacturers, as well as several entries for generic uncoated products, indicated by the Manufacturer field being set to "Generic". The values for these generic entries are not measured properties from any specific glass products, but are averaged spectral data from at least two samples.



ID	Name	ProductName	Manufacturer	Source	Mode	Color	Thickness	Tsol	Rsol1	Rsol2	Tvis	Rvis1	Rvis2	Tir	emis1	emis2
							mm									
100	BRONZE_3.DAT	Generic Bronze Glass	Generic	IGDB v11.4	#		3.124	0.646	0.062	0.063	0.680	0.065	0.066	0.000	0.840	0.840
101	BRONZE_6.DAT	Generic Bronze Glass	Generic	IGDB v11.4	#		5.740	0.486	0.053	0.053	0.533	0.056	0.056	0.000	0.840	0.840
102	CLEAR_3.DAT	Generic Clear Glass	Generic	IGDB v11.4	#		3.048	0.834	0.075	0.075	0.899	0.083	0.083	0.000	0.840	0.840
103	CLEAR_6.DAT	Generic Clear Glass	Generic	IGDB v11.4	#		5.715	0.771	0.070	0.070	0.884	0.080	0.080	0.000	0.840	0.840
104	GRAY_3.DAT	Generic Grey Glass	Generic	IGDB v11.4	#		3.124	0.609	0.060	0.061	0.617	0.062	0.063	0.000	0.840	0.840
700	B120.AFG	Silver-Blue on Clear	AFG Industries	IGDB v11.4	#		5.639	0.140	0.399	0.204	0.205	0.323	0.217	0.000	0.476	0.840
701	B130.AFG	Silver-Blue on Clear	AFG Industries	IGDB v11.4	#		5.613	0.227	0.319	0.141	0.307	0.275	0.152	0.000	0.626	0.840
702	B140.AFG	Silver-Blue on Clear	AFG Industries	IGDB v11.4	#		5.639	0.319	0.248	0.092	0.410	0.219	0.097	0.000	0.706	0.840
703	B220.AFG	Silver-Blue on Green	AFG Industries	IGDB v11.4	#		5.791	0.091	0.401	0.102	0.178	0.326	0.162	0.000	0.478	0.840
704	B230.AFG	Silver-Blue on Green	AFG Industries	IGDB v11.4	#		5.842	0.140	0.320	0.087	0.260	0.277	0.129	0.000	0.623	0.840
705	B240.AFG	Silver-Blue on Green	AFG Industries	IGDB v11.4	#		5.766	0.199	0.249	0.060	0.355	0.225	0.079	0.000	0.706	0.840
706	B320.AFG	Silver-Blue on Gray	AFG Industries	IGDB v11.4	#		5.588	0.079	0.400	0.096	0.105	0.324	0.088	0.000	0.477	0.840
707	B330.AFG	Silver-Blue on Gray	AFG Industries	IGDB v11.4	#		5.588	0.130	0.317	0.074	0.160	0.273	0.072	0.000	0.623	0.840
708	B340.AFG	Silver-Blue on Gray	AFG Industries	IGDB v11.4	#		5.588	0.182	0.244	0.057	0.211	0.213	0.057	0.000	0.704	0.840
709	B420.AFG	Silver-Blue on Bronze	AFG Industries	IGDB v11.4	#		5.588	0.088	0.400	0.104	0.125	0.324	0.102	0.000	0.484	0.840
710	B430.AFG	Silver-Blue on Bronze	AFG Industries	IGDB v11.4	#		5.588	0.144	0.313	0.079	0.189	0.269	0.081	0.000	0.631	0.840

Figure 5-2. WINDOW Glass Library.

On the left hand side of the screen, of particular interest is the **NFRC only** checkbox; if checked, only the records with a "#" in the **Mode** column will be displayed, which are the records certified for NFRC simulations.

Detailed View — Click on this button to see all the information about the currently highlighted record.

The optical properties defined for each glass entry are listed below:

ID — The unique ID associated with this record. For records whose **Source** is "Optics", this ID is the "NFRC ID" from the International Glazing Database. For records whose **Source** is "User", this ID is assigned automatically by WINDOW but can be overwritten by the user as long as it is unique.

Name — The name of the glass layer. If the record was imported from the International Glazing Database, this name will automatically come from that database.

Product Name — The Product Name field from the International Glazing Database.

Manufacturer	The name of the glass manufacturer. If the record was imported from the International Glazing Database, this name will automatically come from that database.
Source	Source of the glass record. Current options are: ▪ **Optics5 v 11.4:** Indicates that the data was imported from the International Glazing Database, with the database version number, in this example, 11.4. These records will have the spectral data information from the International Glazing Database. ▪ **User:** Indicates that the data was created when the user copyied an existing record into a new record. User defined records will not have associated spectral data values.
Mode	An identifier to determine if the glass layer is approved by NFRC. Only records with "#" in this field can be used for NFRC simulations.
Color	A graphic representation of the color of the glass.
Thickness	Glass thickness. Units: mm (SI); inches (IP).
Tsol	Solar transmittance of the glazing layer.
Rsol1	Solar reflectance of the glazing layer, exterior-facing side.
Rsol2	Solar reflectance of the glazing layer, interior-facing side.
Tvis	Visible transmittance of the glazing layer.
Rvis1	Visible reflectance of the glazing layer, exterior-facing side.
Rvis2	Visible reflectance of the glazing layer, interior-facing side.
Tir	Thermal infrared (longwave) transmittance of the glazing layer.
emis1	Infrared (longwave) emittance of the glazing layer, exterior-facing side
emis2	Infrared (longwave) emittance of the glazing layer, interior-facing side

5.3 Glazing System Library -- Center-of-Glazing U-factor

The center-of-glazing U-factor is determined in the WINDOW **Glazing System Library**. A glazing system is created by specifying layers of glass from the **Glass Library**, as well as the gas fill material between the layers, such as air or argon. Detailed instructions about creating a glazing system can be found in the *WINDOW 5 User's Manual*. A sample glazing system library entry is shown in Figure 5-3.

When defining a glazing system, the number of glass layers (**# Lay**), the **Tilt**, and the **Environmental Conditions** (**Env Cond**) must be specified. For NFRC certification calculations the **Environmental Conditions** have restricted values, as discussed in the next section. Also, the glass layers must be from the Glass Library using approved records from the International Glazing Database, indicated by a **#** value in the **Mode** field of the glass layer record, as shown in Figure 5-3.

*Note: to see the U-factor value to four decimal places, click on **File/Preferences** menu choice and in the **Calculation Options** tab, set the **Display Precision** field to"4"*

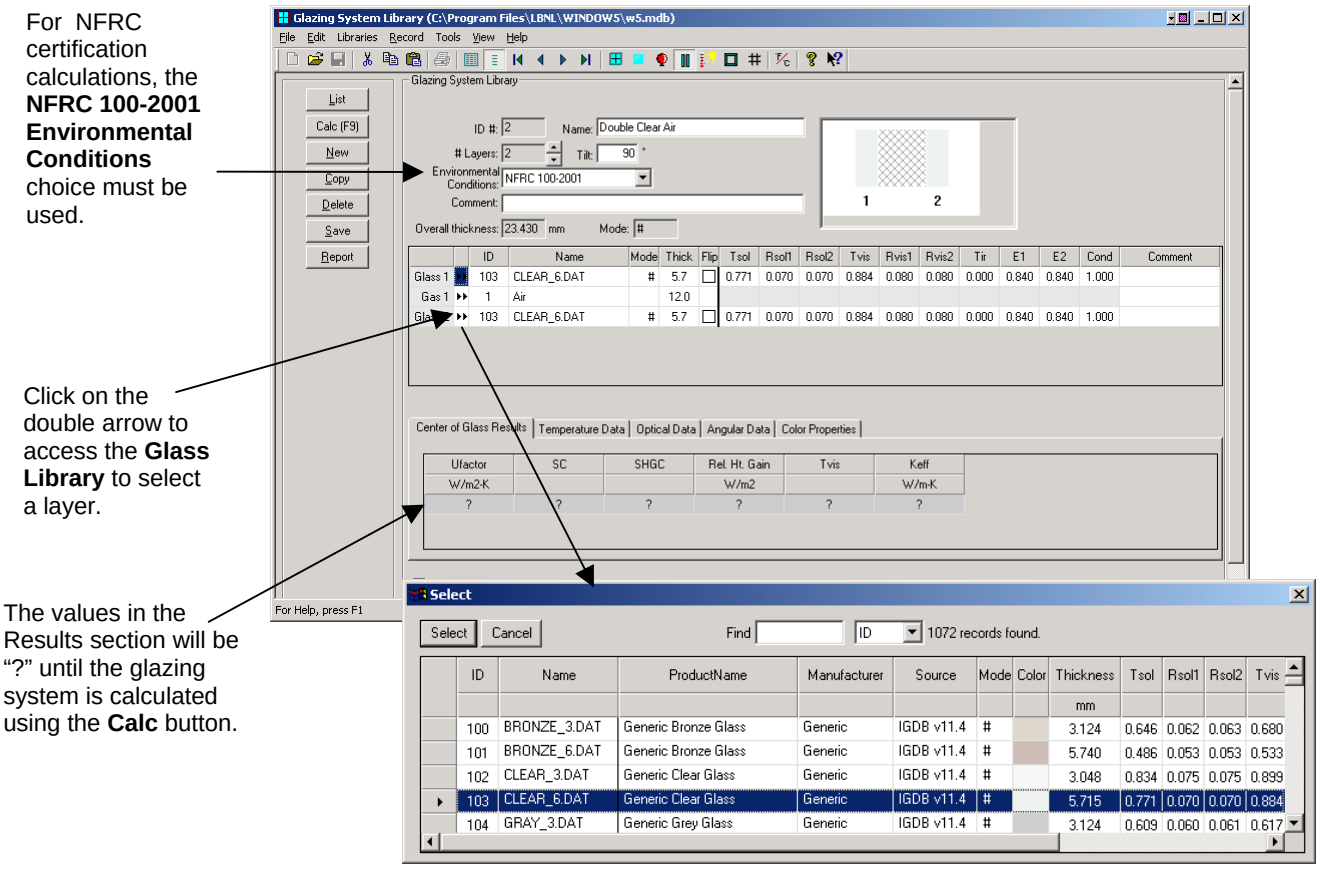
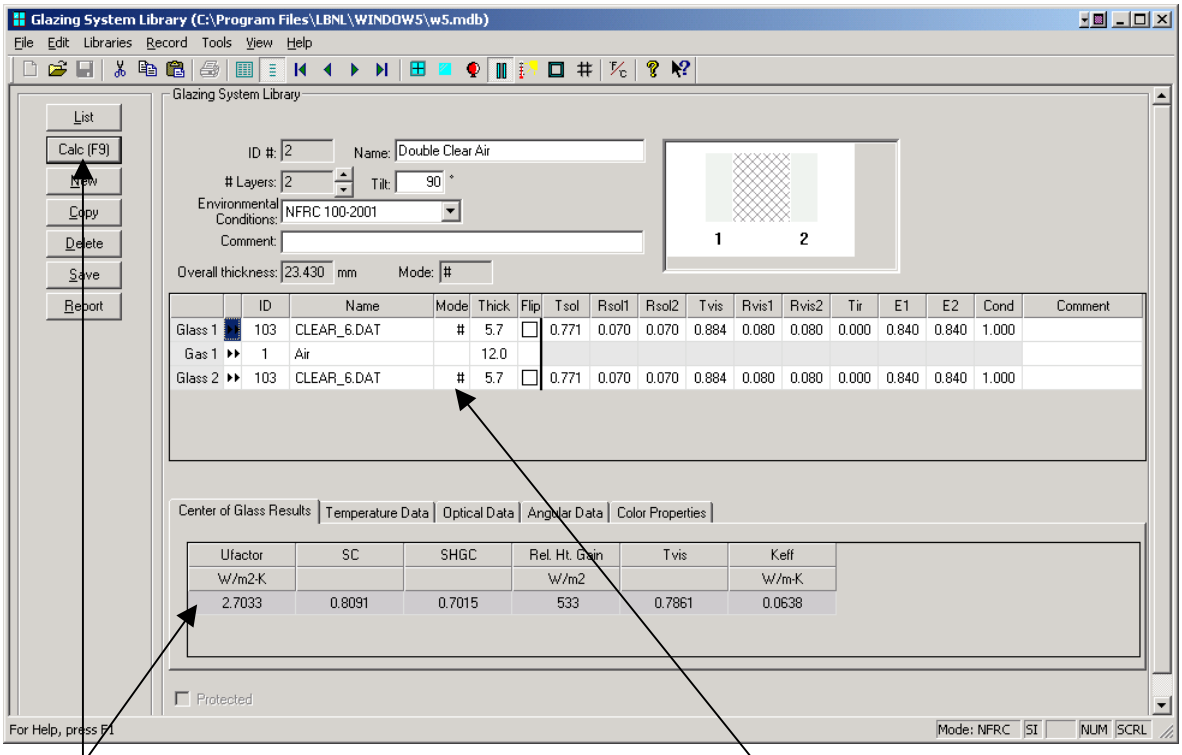


Figure 5-3. Selecting glass layers in the Glazing Systems Library.



When the glass and gap layers have been defined, click on the **Calc** button and the center-of-glazing U-factor as well as other results will be displayed in the **Results** section at the bottom of the screen. This value is used when the glazing system is imported into THERM.

For NFRC certification calculations of SHGC and VT, glass layers from the **Glass Library** with a # in the Mode field shall be used. The # indicates that the record is approved for NFRC simulations.

Figure 5-4. Calculating results in the Glazing Systems Library.

The Center of Glass Results tab at the bottom of the screen shows the results for the glazing system. The U-factor results are based on a default glazing system height of one meter. This center-of-glazing U-factor value will be recalculated in the Window Library to reflect the true height of the product being modeled. (See *Section 7*, "Total Product Calculations", for more information).

All the **Glazing System Library** records can be seen in the **List View**, access by clicking the **List** button from the **Glazing System Library Detailed View**.

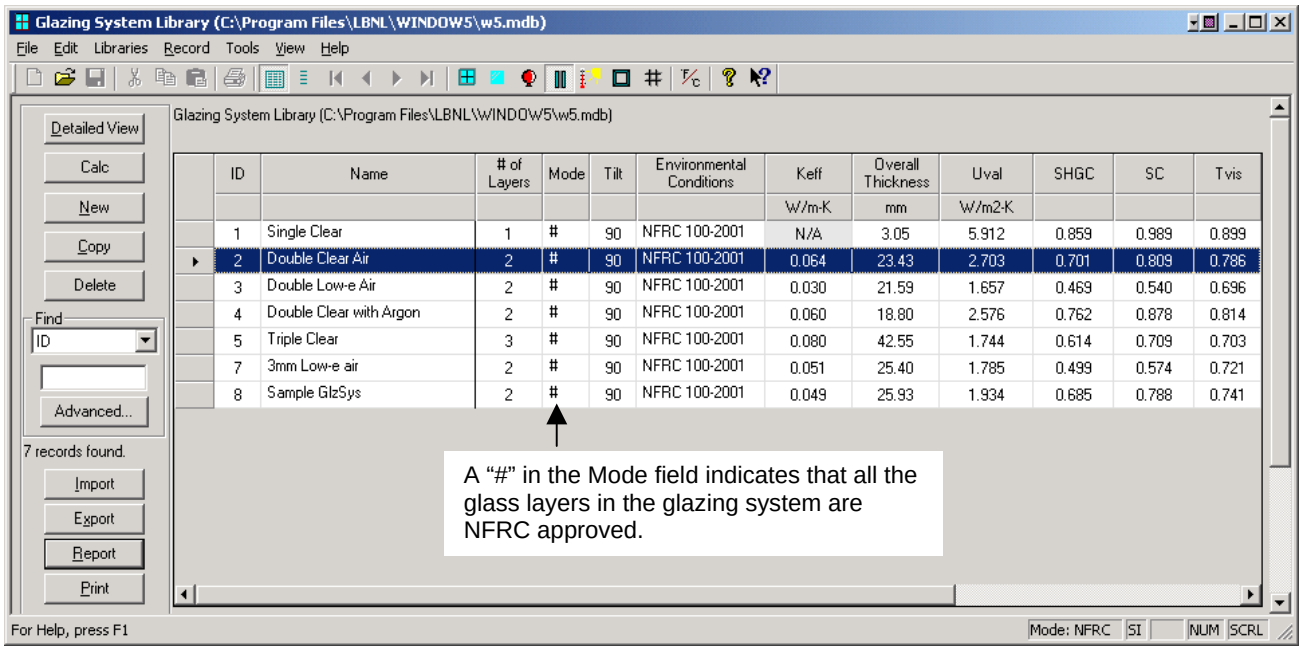


Figure 5-5. The List View of the Glazing System Library shows all the glazing systems.

5.3.1. Environmental Conditions

When defining the glazing system for use in an NFRC certified simulation, the **NFRC 100-2001** choice must be used for the **Environmental Conditions** (Env Cnd) parameter, which contains the parameters defined by *NFRC 100*. Figure 5-4 shows the NFRC 100-2001 choice in the WINDOW **Environmental Conditions Library**. Table 5-1 lists the values for the U-factor calculation and Table 5-2 lists the values for the Solar Heat Gain Coefficient calculation.

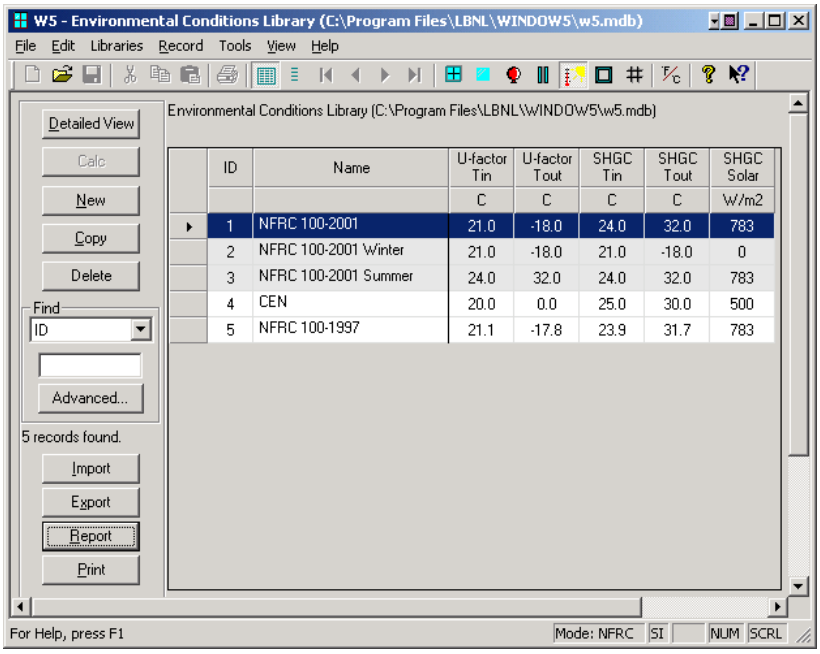


Figure 5-6. WINDOW Environmental Conditions Library List View.

Use the NFRC 100-2001 Environmental Conditions Library in WINDOW for NFRC center-of-glazing simulations

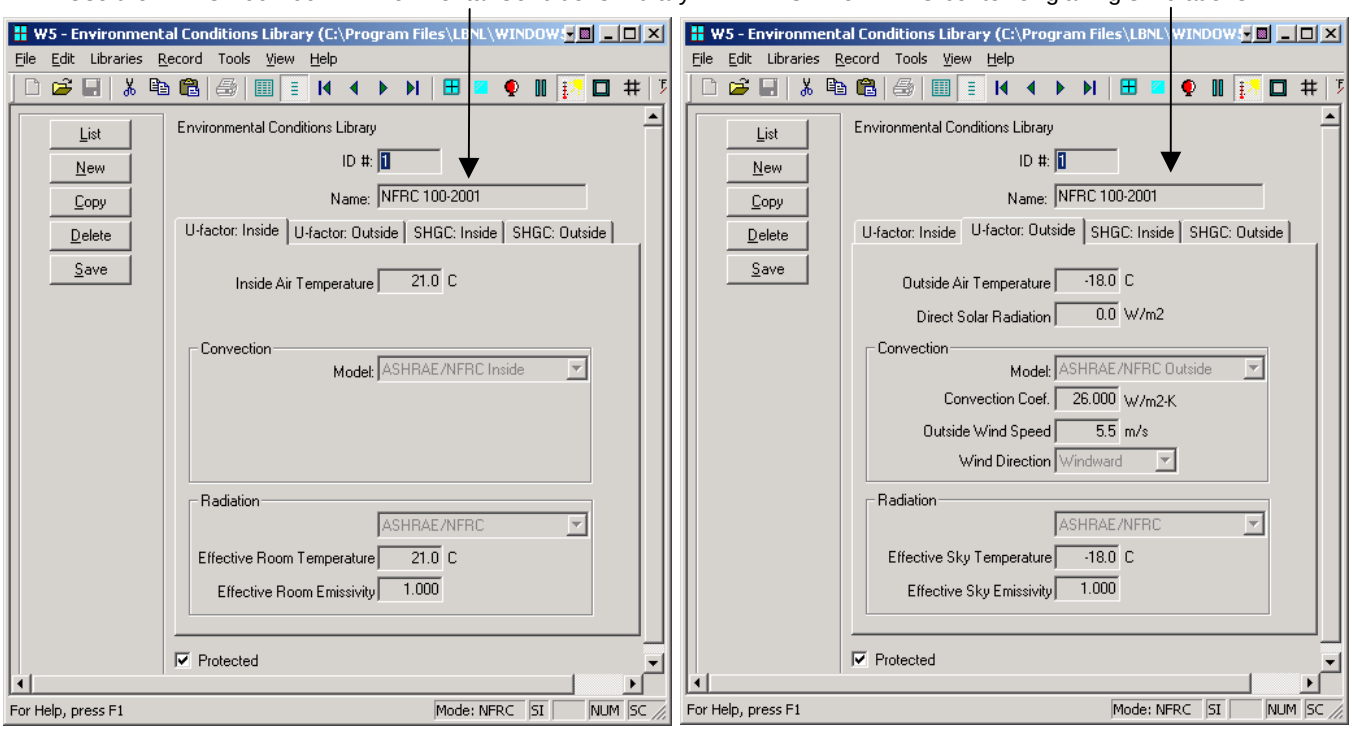


Figure 5-7. WINDOW Environmental Conditions Library Detailed View of U-factor settings.

Table 5-1. Environmental Conditions for NFRC Simulations for U-factor calculations.

Variable	SI Units	IP Units (reference only)
Outside Temperature	-18°C	0°F
Inside Temperature	21°C	70°F
Wind Speed	5.5 m/s	12.3 mph
Wind Direction	Windward	Windward
Direct Solar	0 W/m²	0 Btu/hr-ft²
Sky Temperature (Tsky)	-18°C	0°F
Sky Emissivity (Esky)	1.00	1.00

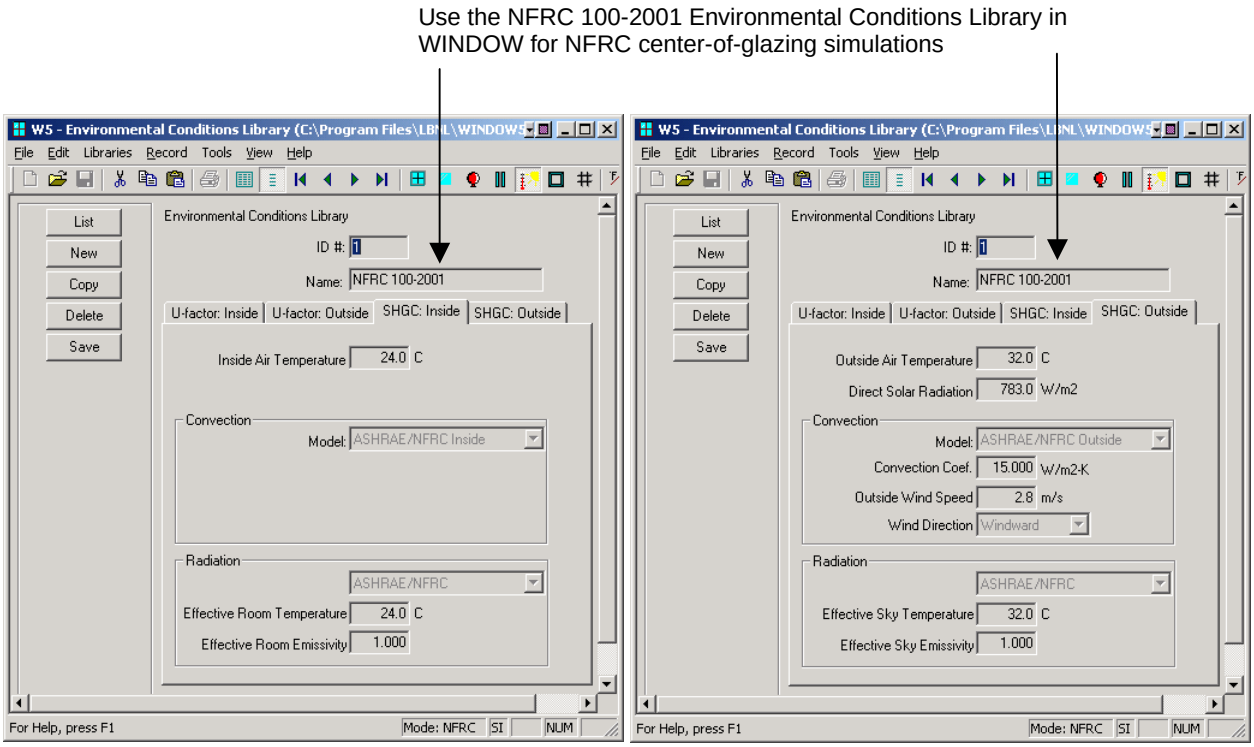


Figure 5-8. WINDOW Environmental Conditions Library – Settings for SHGC.

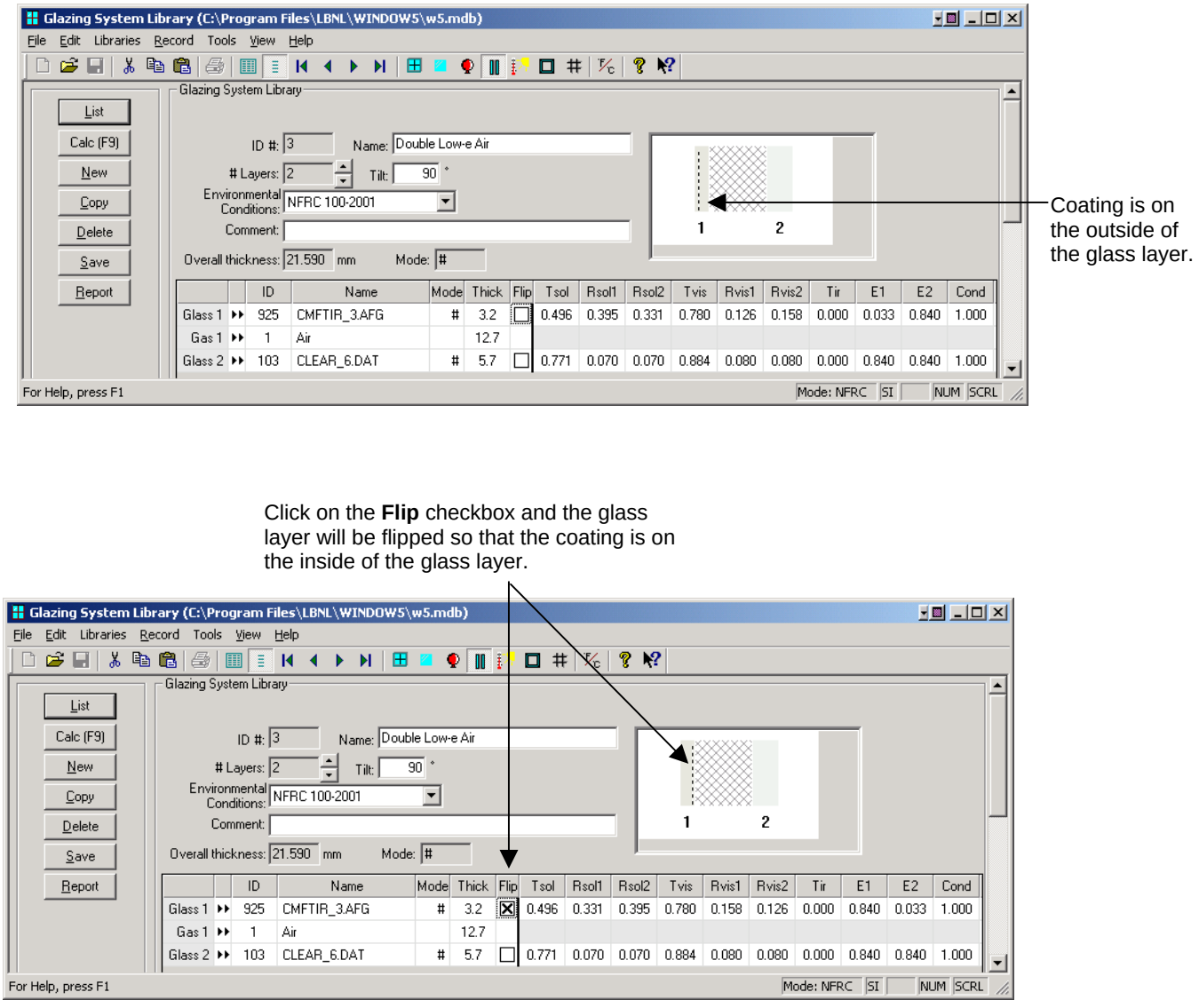
Table 5-2. Environmental Conditions for NFRC Simulations for SHGC and VT calculations.

Variable	SI Units	IP Units
Outside Temperature	32°C	89°F
Inside Temperature	24°C	75°F
Wind Speed	2.75 m/s	6.15 mph
Wind Direction	Windward	Windward
Direct Solar	783 W/m²	248.2Btu/hr-ft²
Sky Temperature (Tsky)	32°C	89°F
Sky Emissivity (Esky)	1.00	1.00

It is possible to make new environmental conditions with specific conditions specified, in order to evaluate the design of a product. However, only the pre-defined **NFRC 100-2001** shall be used for NFRC rating purposes.

5.3.2. Coatings

The location of coatings on a glass layer can affect the **center-of-glazing** U-factor and therefore the whole product calculation, so it is important to specify the location correctly. When using a glass entry from the WINDOW **Glass Library**, if the coating is not on the correct surface, the glass layer shall be flipped. To flip a glass layer, while on a glass layer in **Edit** mode, click on the **Flip** checkbox, and the glass surfaces will be flipped, as indicated by the dashed line in the graphic display of the glazing system.



		ID	Name	Mode	Thick	Flip	Tsol	Rsol1	Rsol2	Tvis	Rvis1	Rvis2	Tir	E1	E2	Cond
Glass 1	▸▸	925	CMFTIR_3.AFG	#	3.2	☐	0.496	0.395	0.331	0.780	0.126	0.158	0.000	0.033	0.840	1.000
Gas 1	▸▸	1	Air		12.7											
Glass 2	▸▸	103	CLEAR_6.DAT	#	5.7	☐	0.771	0.070	0.070	0.884	0.080	0.080	0.000	0.840	0.840	1.000

Figure 5-9. Use the Flip checkbox to flip the coatings on a glass layer.

5.3.3. Gas Fill

The gas used to fill the gap between the glass layers makes a significant contribution to the **center-of-glazing** U-factor, although it does not have much affect on the Solar Heat Gain Coefficient. For NFRC certified simulations, the gas to be shipped in the fenestration product shall be modeled. When creating a glazing system in WINDOW, choose the appropriate gas fill from the **Gas Library**, which contains the maximum gas fills that can be used, as shown in the figure below. Custom gas mixtures can be defined in the **Gas Library**. See the *WINDOW User's Manual* for more details about making a new gas mixture in the **Gas Library**.

When a gas is used to fill the gap between glass layers, there is always a mixture of the gas and air. The amount of air mixed in is dependent on many factors including the method used to fill the gap, either evacuated chamber filling, two-probe filling with a concentration sensor, or single-probe timed filling. Table 5-3 shows the maximum gas concentrations that can be achieved with each method. For NFRC certification simulations, the simulator shall request the gas-filling technique and the gas concentration for their product from the manufacturer.

Table 5-3. Gas Concentrations based on Filling Technique.

Filling Technique	Maximum Gas Concentrations Achieved
Evacuated Chamber Filling	97%
Two-Probe Filling with a Concentration Sensor	95% for Argon filled 90% for Krypton filled
Single-Probe Timed Filling	60-90%

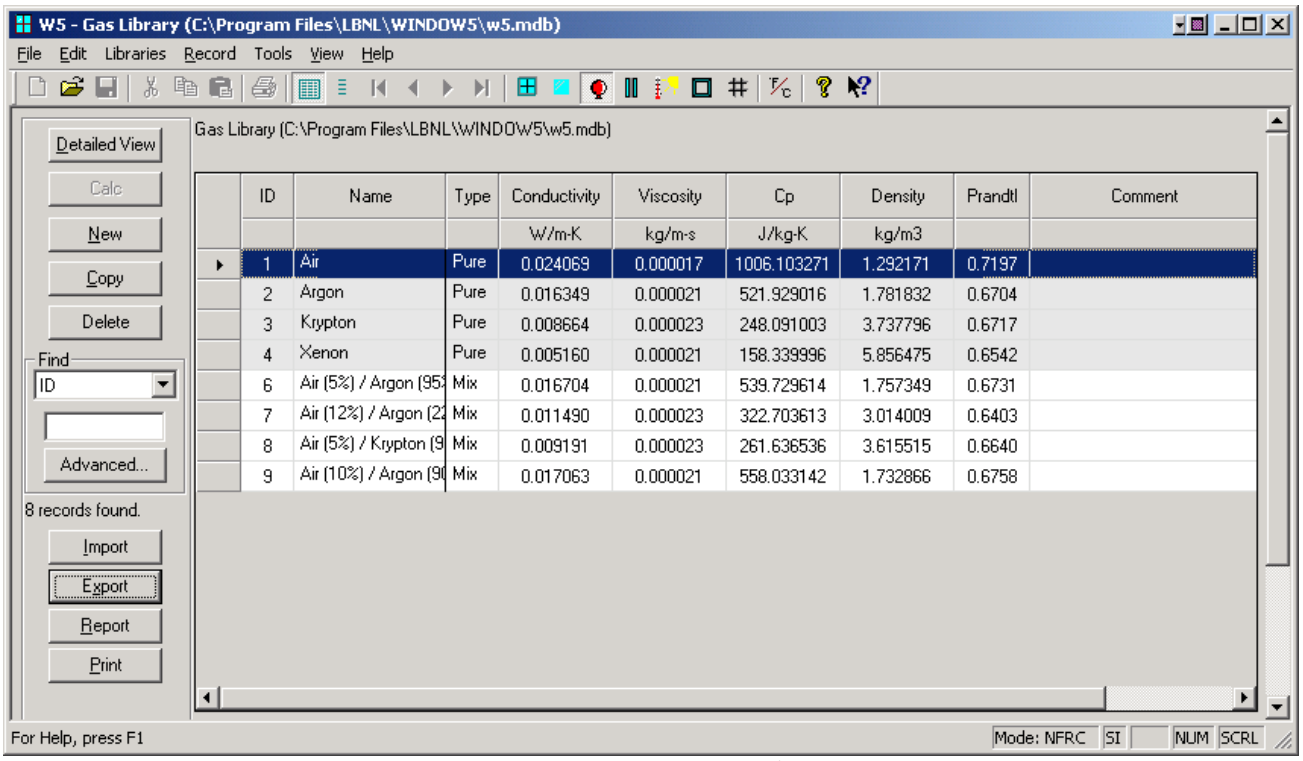


Figure 5-10. WINDOW Gas Library.

5.3.4. Laminated Glass / Applied Films

To model laminated glass or glass with applied films in WINDOW, use NFRC approved spectral data to create a record in the WINDOW Glass Library which can then be used as a glazing layer in the Glazing System Library.

5.4 Solar Heat Gain Coefficient and Visible Transmittance

The document *NFRC 200: Procedure for Determining Fenestration Product Solar heat Gain Coefficients at Normal Incidence* contains the rules and definitions for calculating the Solar Heat Gain Coefficient and Visible Transmittance for products. Consult NFRC 200 to determine how to group products for these calculations, as well as algorithm documentation.

In WINDOW, the center-of-glazing Solar Heat Gain Coefficient (SHGC) and Visible Transmittance (VT) are automatically calculated in the **Glazing System Library** in the **Center of Glass Results** tab, as shown in the figure below.

In addition, these values are calculated for the whole product and for the NFRC SHGC 0 and 1 and VT 0 and 1 cases in the Window Library, as explained in Chapter 7 of this manual.

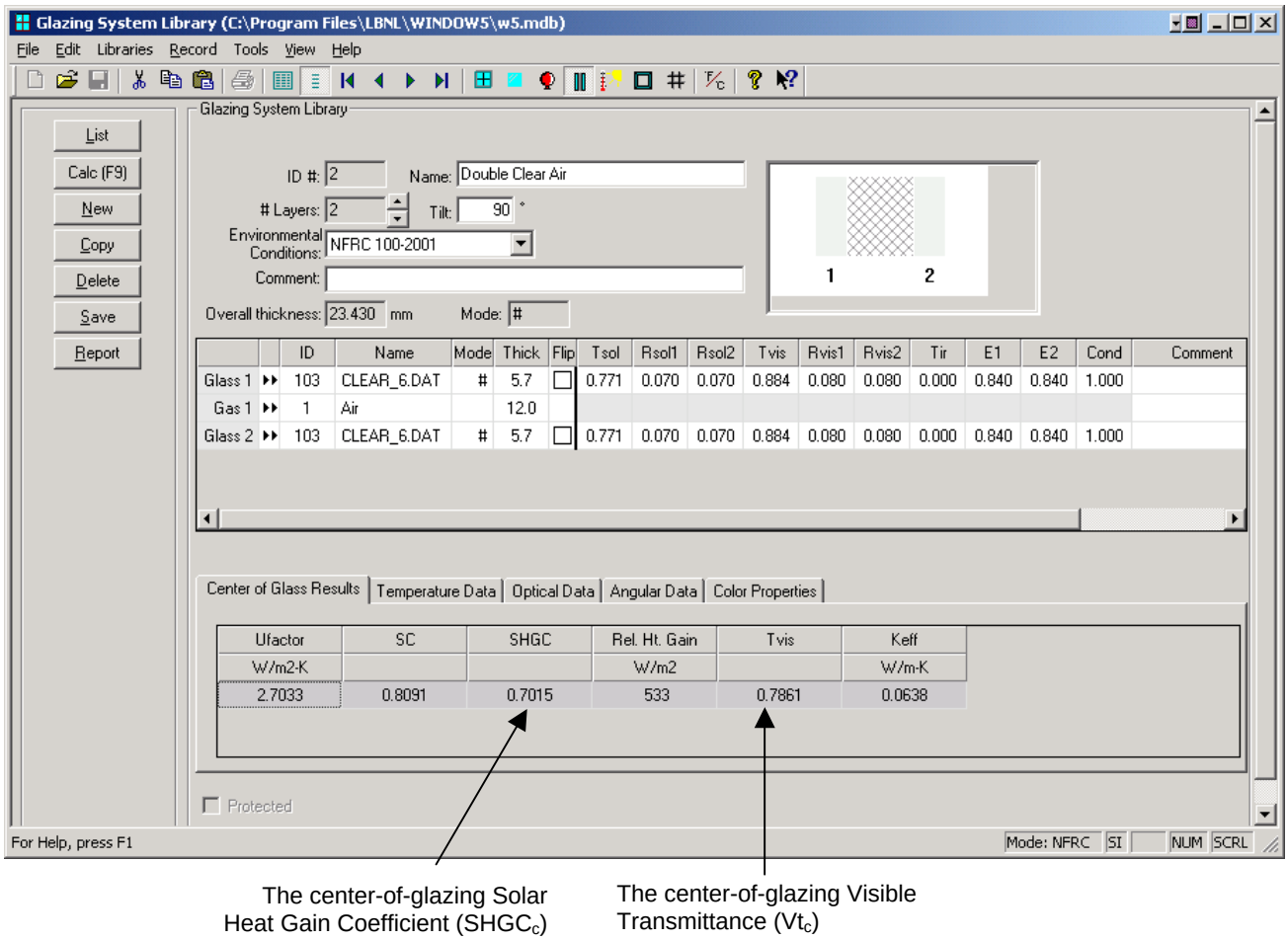


*Figure 5-11. The center-of-glazing SHGC, VT and Fading Resistance are calculated in the WINDOW **Glazing System Library**.*