9.6. Adding New Glazing Systems to the Type56 Window Library

9.6.1. Introduction

This tutorial will lead the TRNSYS user through the process of adding a new glazing system, generated by the Berkeley Lab WINDOW 7.x software to TRNBuild for use with the multizone building model Type 56. Users working with this tutorial should have a basic understanding of using TRNBuild and of how TRNBuild and Type 56 model windows. This tutorial deals with the standard window model only – a complex fenestration including “Bidirectional Scattering Distribution Function” (BSDF) is described by another tutorial.

A nearly endless variety of windows are available commercially. Window standards and the data available to describe their performance differ from region to region and certainly from county to country. Furthermore, the modeling of window performance is complex; numerous pieces of specialized software exist for simply modeling windows. For these reasons, a conscious decision was made on the part of the TRNSYS develop-ment team not to attempt to redo work already completed in modeling windows but instead to depend upon specialized software to create new windows, and then provide a method for importing those results into TRNSYS for use with Type56. Specifically, you will be using a freely available piece of software called WINDOW, developed by Lawrence Berkeley National Labs in Berkeley, California. The current version of the soft-ware at the writing of this tutorial is 7.4 (November 2018). It can be downloaded under: https://windows.lbl.gov/tools/window/software-download

The method described in this tutorial has successfully been applied to WINDOW 7.4 to WINDOW 7.6.

To add a new glazing system in a building project, the following steps have to be performed:

- Step 1: Composing glazing systems in WINDOW 7
- Step 2: Exporting the glazing system from WINDOW 7
- Step 3: Importing the glazing system into TRNbuild

9.6.2. Creating a Glazing System in WINDOW 7

Berkeley Lab WINDOW is a publicly available computer program for calculating total window thermal performance indices (i.e. U-values, solar heat gain coefficients, shading coefficients, and visible transmittances).

The resulting thermal and optical properties depend on the selected analysis method given by different standards. TRNSYS 18 has its own standard file (Trnsys18.std) defining the spectrum sources. Apart from that the user has the choice to select different standards in some dialog windows related to the thermal calculation method and the environmental conditions. Type 56 performs the thermal calculation itself every iteration step and applies the environmental conditions given by the simulation project. Therefore, these setting don’t influence the data used by the TRNSYS simulation but they effect the resulting thermal performance indices calculated and displayed by WINDOW.

In general, this manual follows the default settings using US standards (ISO 15099, NFRC 100-2010). Information for the use of European standards is given in Appendix A.

9.6.2.1. Setting Preferences

To generate the data used by Type 56, the default settings of WINDOW have to be adapted. The default settings can be changed under *File → Preferences*.

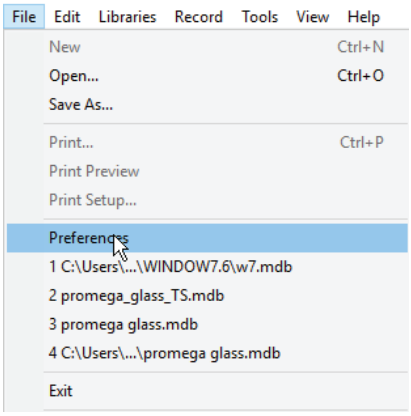

Figure 9-248: WINDOW Preferences

- Tab Options: Set Unit system to SI

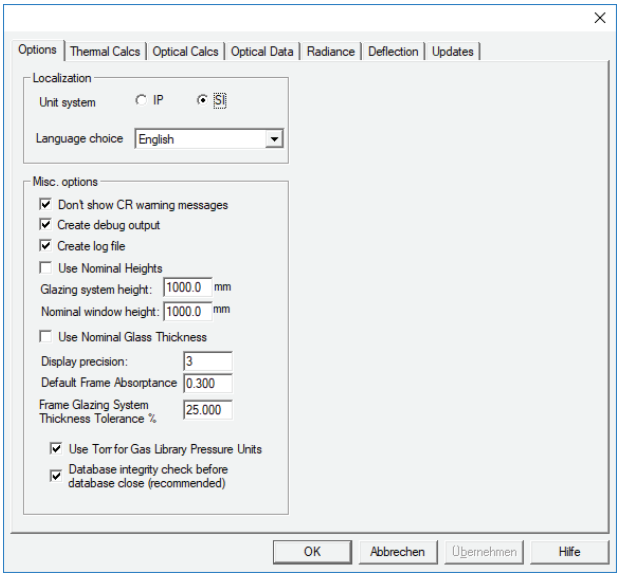

Figure 9-249: WINDOW Preferences: Options

- Tab Thermal Calcs: Default Setting (ISO 15099) can be used. (Note: Type 56 performs the thermal calculation itself every iteration step. The optical properties and the assembly of the glazing system is used from the WINDOW report.)

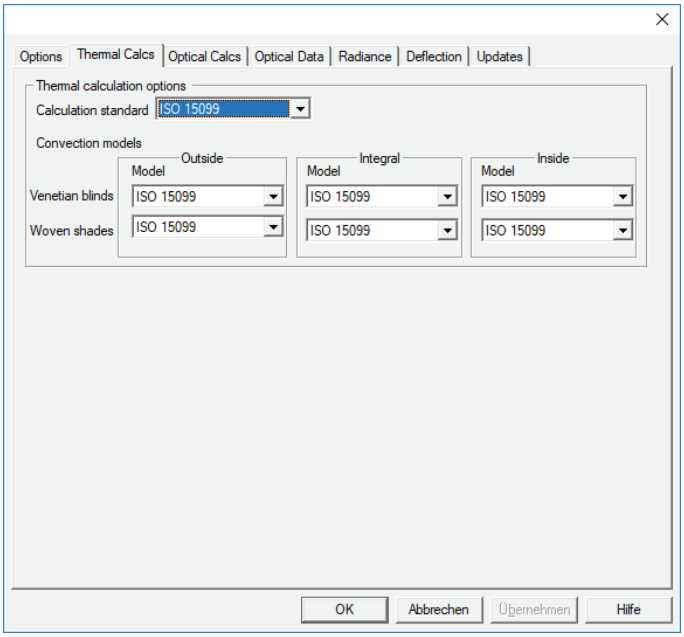

Figure 9-250: WINDOW Preferences: Thermal Calcs

- Tab *Optical Calcs*: nothing to do
- Tab *Optical Data*: Select Trnsys18.std as the Standards File.

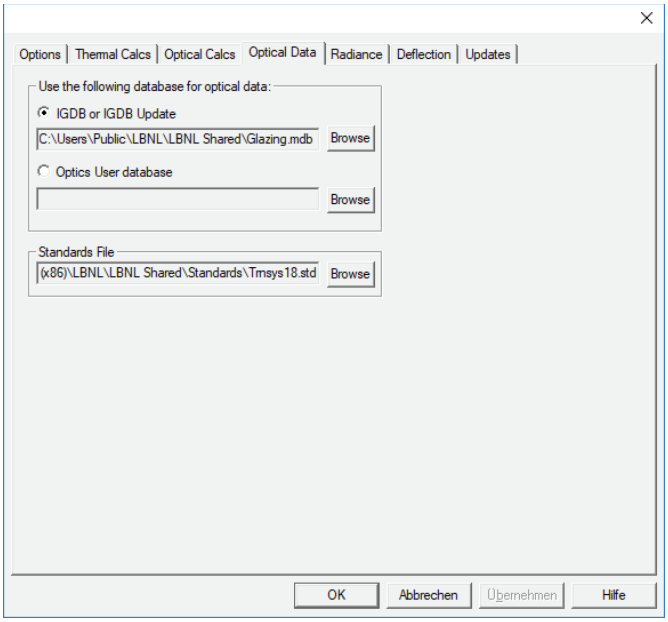

Figure 9-251: WINDOW Preferences: Optical Data

This is not available by default as it is created by *Transsolar*. It can be found in your TRNSYS installation under

<TRNSYS18>\Building\Lib\Trnsys18.std

The file references another file Trnsys18_evis.ssp (available in the same folder) containing the visual energy solar spectrum. This file must be placed in the same folder:

c:\Program Files (x86)\LBNL\LBNL Shared\Standards\

(Note: In order to consider selective glazing systems, the thermal window model of Type 56 divides the solar spectrum into 2 bands, a visual and non-visual band. Therefore, the integral characteristic of transmittance and reflectance for the visible range have to be based on the energy spectrum. For most other standard files available for the program WINDOW, these integral characteristics for the visible wave lengths do not represent the entire visible range, owing to spectral sensitivity of the human eye which means that they differ from the energy related characteristics required by Type56.

Integral characteristics for the visible wave lengths which consider the spectral sensitivity of the human eye are used for daylight calculations.)

- Tab *Radiance*: Nothing to be done here
- Tab *Deflection*: Nothing to be done here
- Tab *Updates*: Nothing to be done here

9.6.2.2. Creating a Glazing System

- In the main menu, go to Libraries > Glazing System or press F5
- Click the New button to create a new Glazing System (see Figure 9-252)
- Choose Detailed View to edit the new Glazing System (see Figure 9-253)

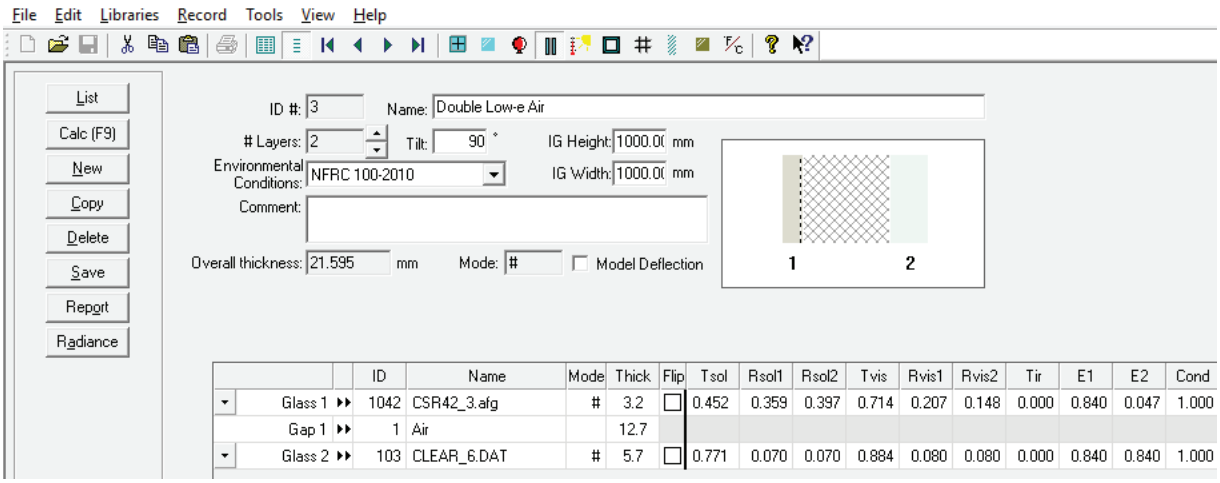

Figure 9-252: Create New Glazing System

- Customize your glazing system by defining glass layers and gaps. (Note: Shade or frit layers can't be used because they aren't included in the report procedure used by TRNBuild!):
    - Use a descriptive Name, avoid special characters and spaces. In the program glazing library of TRNBuild the names (e.g. GU_ClimaGuard_N_#3_Ar90) are made up of the following composition:

YY_name_NN_filling

YY - Manufacturer code (GU…Guardian, IP…Interpane, SG…SaintGobain, GT Glas Trösch) name - Glazing system name

NN - Coating position e.g #3 (numeration starts on the outer face)

Filling - Filling between glass panels

- Select the number of layers via # Layers.
- Set Environmental Conditions to NFRC 100-2010. (for European standards see Appendix A) (Note: selection not relevant for TRNBuild import)
- Define height/width. (Note: The entered values aren't relevant because they are redefined by the window type of TRNBuild)
- Glass layers are either chosen from the existing data base (Glass Library) or created by the user (see section 9.6.6). Click on the "double arrow" for opening the Glass Library. The option "flip" turns the glazing layer. This feature is useful the coating is on the wrong side.
- Select gap properties from the existing data base Gap Library. Click on the "double arrow" for opening the Gap Library
- Adapt the gap thickness

- Click on Save and Calc to finish the definition of the glazing system

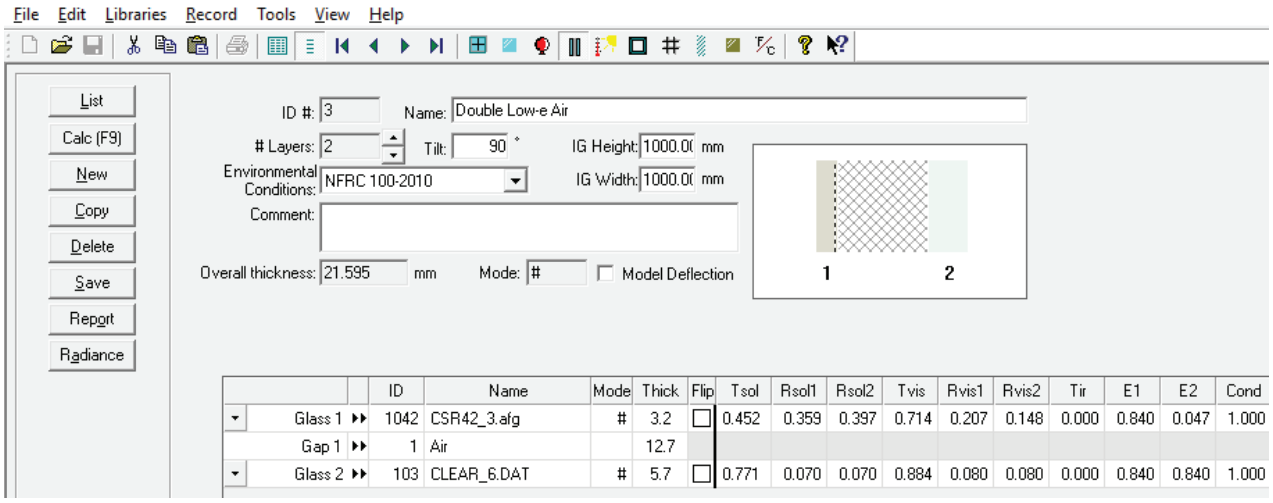

Figure 9-253: Customize New Glazing System

9.6.3. Exporting the Glazing System from WINDOW 7 to TRNSYS 18

TRNBuild still uses the DOE-2 report of WINDOW for importing which differs from the reports available in the glazing system dialog. Therefore, before writing the report, the glazing system has to be used in a window assembly.

9.6.3.1. Embedding a Glazing System in a Window Assembly

- In the main menu, go to Libraries > Window or press F2
- Click the New button to create a new window assembly. A dialog pops up showing a new ID #. Enter “OK”. (Note: This ID # used for identifying the window)
- Use a descriptive Name (avoid special characters and spaces). It is recommended to use the same name as for the glazing system
- Select Mode: NFRC
- Choose Type: Fixed (picture): (Note: It is important to select a FIXED window because the DOE-2 report format does not support other types of windows such as operable windows, vertical sliders, double doors etc.
- Choose Environmental conditions: NFRC 100-2010 (for European products see section 9.6.5)
- Defining Glazing System:
    - The glazing system is selected by clicking in the middle of the representative picture. When the glazing system is selected, it is shown with hatched, diagonal lines instead of as a solid color. (see Figure 9-254, Step 1 and 2)
    - The pull down menu beneath the representative picture appears and gives choices of predefined glazing systems. Choose the Glazing System as defined in section 9.6.2.2
- Selecting frame (optional - frame properties are not used by the TRNBuild import)
    - Click on one of the four frame components and the information about that component is displayed as well as a pull down menu showing all possible options included in the frame library. (Note: The DOE-2 file format does not support windows that have different types of frames; the window must have the same kind of frame on all four sides.)
- Click Save and Calc to calculate the properties

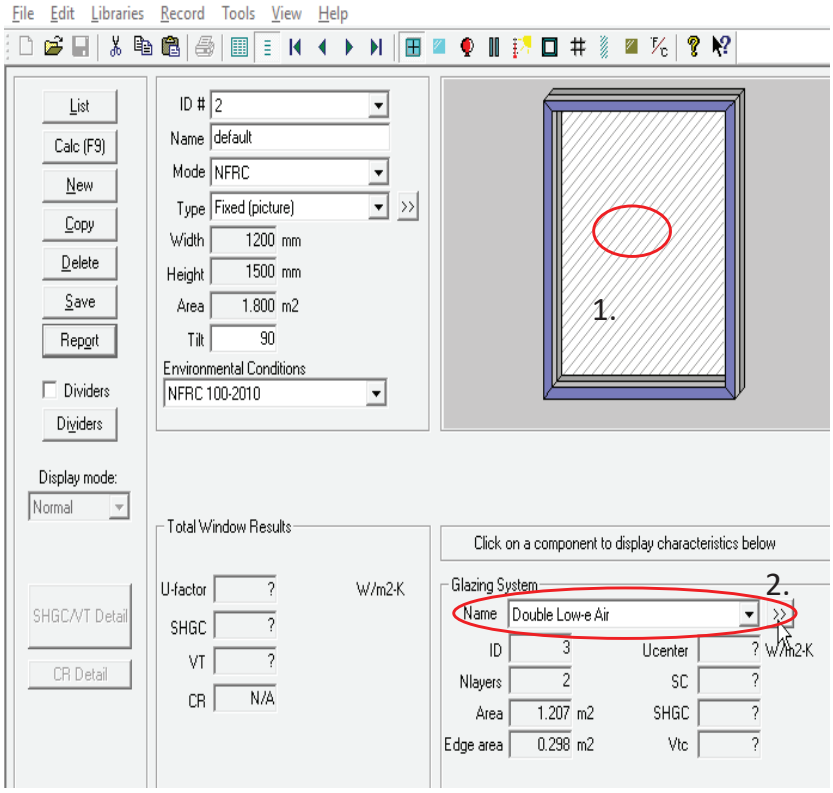

Figure 9-254: Create New Window

9.6.3.2. Writing the DOE-2 Report in WINDOW 7

- In the Window dialog, click the Report button (see Figure 9-255, Step 1) to output all necessary information. (Note: If you created more than one window, you can output several windows into one report by using the List view, marking multiple windows (Ctrl + click) and then clicking the Report button)

- Click Report and select Report type “DOE-2” and click OK for saving the report

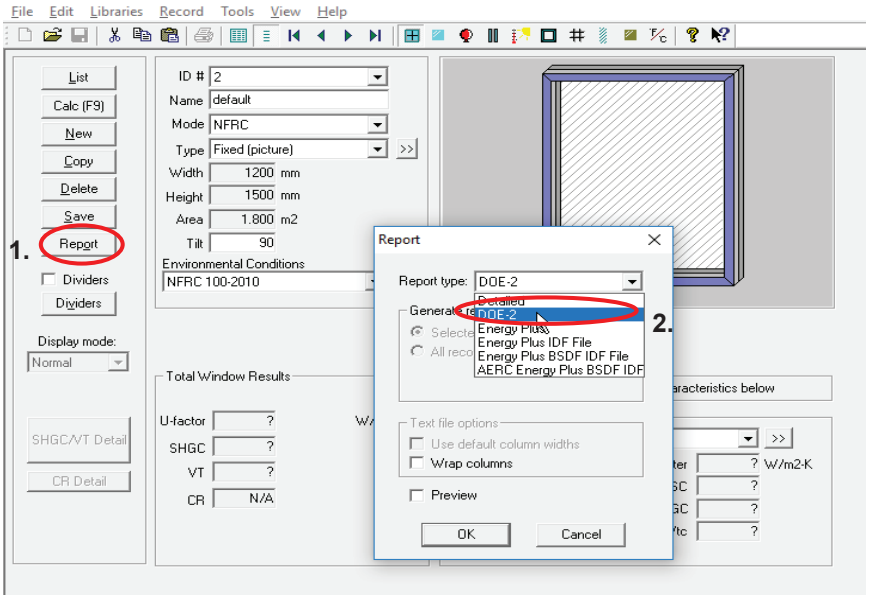

Figure 9-255: Output Window Information as DOE-2 Report

9.6.3.3. *Editing the DOE-2 Report with a Text Editor*

Open the previously written report file with a text editor or copy the report from. Figure 8 presents a DOE-2 report with a highlighting scheme showing the relevant values for TRNBuild/Type 56:

`grey text` is ignored by TRNBuild and not used during simulation by Type 56

`red text` is displayed in TRNbuild but not used during simulation by Type 56

`black text` is imported by TRNBuild and used during the simulation by Type 56

`blue text` is imported by TRNBuild and used during the simulation by Type 56 if the option “Spacer ID = 0” is selected in the window type dialog of TRNBuild

For each reported glazing systems make the following adaption:

- Add in line 1 “: generated with Trnsys18.std” (highlighted in yellow in Figure 9-256)

(Unfortunately, DOE-2 report doesn’t contain information about the standard file (see section 9.6.2.1) used for the multiband calculation. Type56 needs this information for a correct energetic weighting of the visible and non-visible band)

- Optional: Modify the Name of the new window entry to read “TRNSYS 18 Glazing Lib”
- Optional data: Adding visible transmittance for daylight simulation (highlighted in green in Figure 9-256) which is helpful for selecting the radiance material for daylight simulation.

Line 36:Replace SC: 0.XX with Tvis_daylight: 0.XXX

(Note: Dynamic daylight simulation based on DaySIM has been integrated into the TRNSYS multi-zone building model Type56. In contrast to the thermal model of Type56, the visible transmittance considering the spectral sensitivity of the human eye is needed for the daylight simulation. This value can be obtained from a product data sheet or from an additional calculation of the glazing system with a different standard file for example W5_NFRC_2003.std and prEN_410.std , respectively).

```
BERKELEY LAB WINDOW v7.4.6.0  DOE-2 Data File : Multi Band Calculation : generated with Trnsys18.std

Unit System : SI
Name        : TRNSYS 18 Glazing Lib
Desc        : GU_ClimaGuard_N_#3_Ar90
Window ID   : 3201
Tilt        : 90.0
Glazings    : 2
Frame       :  3 Wood                  2.270
Spacer      :  2 Class2                0.068   1.550  -0.143
Total Height: 1500.0 mm
Total Width : 1200.0 mm
Glass Height: 1360.3 mm
Glass Width : 1060.3 mm
Mullion     : None
Gap         Thick    Cond  dCond    Vis   dVis   Dens   dDens      Pr      dPr
1 Ar90/Air1 16.0 0.01712  5.410  2.062  6.300  1.711 -0.0060  0.687 -0.0001
2               0       0      0      0      0      0       0      0       0
3               0       0      0      0      0      0       0      0       0
4               0       0      0      0      0      0       0      0       0
5               0       0      0      0      0      0       0      0       0
Angle      0     10     20     30     40     50     60     70     80     90 Hemis
Tsol   0.562 0.562 0.558 0.552 0.544 0.522 0.467 0.353 0.175 0.000 0.483
Abs1   0.104 0.105 0.107 0.110 0.114 0.119 0.125 0.130 0.127 0.000 0.116
Abs2   0.095 0.095 0.097 0.098 0.097 0.095 0.092 0.082 0.051 0.000 0.091
Abs3       0     0     0     0     0     0     0     0     0     0     0
Abs4       0     0     0     0     0     0     0     0     0     0     0
Abs5       0     0     0     0     0     0     0     0     0     0     0
Abs6       0     0     0     0     0     0     0     0     0     0     0
Rfsol  0.239 0.238 0.238 0.240 0.246 0.265 0.317 0.435 0.647 1.000 0.300
Rbsol  0.249 0.249 0.250 0.252 0.260 0.280 0.332 0.449 0.666 1.000 0.314
Tvis   0.741 0.740 0.735 0.729 0.718 0.689 0.616 0.465 0.230 0.000 0.638
Rfvis  0.129 0.128 0.129 0.133 0.143 0.170 0.240 0.394 0.653 1.000 0.215
Rbvis  0.126 0.125 0.126 0.129 0.139 0.165 0.230 0.373 0.627 1.000 0.207
SHGC   0.660   N/A   N/A   N/A   N/A   N/A   N/A   N/A   N/A   N/A   N/A
Tvis_daylight:  0.800


Layer ID#          33000     33009         0         0         0         0
Tir                0.000     0.000         0         0         0         0
Emis F             0.860     0.040         0         0         0         0
Emis B             0.860     0.860         0         0         0         0
Thickness(mm)        4.0       4.0         0         0         0         0
Cond(W/m2-K     )250.0     250.0         0         0         0         0
Spectral File 33000_GU_Flo 33009_GU_Cli          None          None          None          None

Overall and Center of Glass Ig U-values (W/m2-K)
Outdoor Temperature                  -17.8 C       15.6 C       26.7 C       37.8 C
Solar      WdSpd  hcout hrout  hin
(W/m2)     (m/s)      (W/m2-K)
   0        0.00   0.00  0.00  0.00  1.37 1.37  1.09 1.09  1.12 1.12  1.14 1.14
   0        6.71   0.00  0.00  0.00  1.37 1.37  1.09 1.09  1.12 1.12  1.14 1.14
 783        0.00   0.00  0.00  0.00  1.37 1.37  1.09 1.09  1.12 1.12  1.14 1.14
 783        6.71   0.00  0.00  0.00  1.37 1.37  1.09 1.09  1.12 1.12  1.14 1.14
```

Figure 9-256: DOE-2 Report with Highlighted Values Relevant for TRNBuild/Type56

- Save the file with a meaning full name (for example W7_xxxx.dat). It is recommended to save the file in the standard library path of TRNBuild (see TRNBuild *Option* → *Settings*).

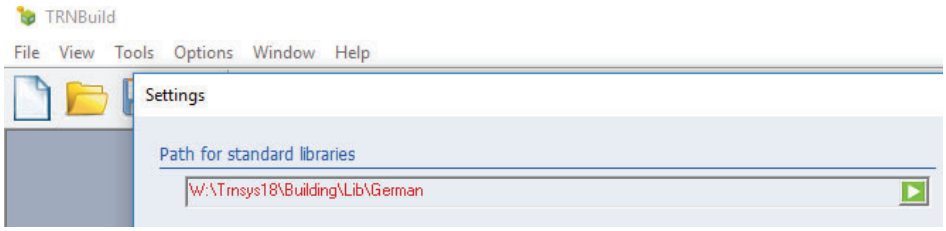

Figure 9-257: TRNBuild's Standard Library Path

For easy access it is useful to save all user generated glazing systems in a single file (for example W7-lib_user.dat)

- Copy the text of the new window data file and paste it into an existing the file below the rest of the windows. If a line that reads "*** END OF LIBRARY ***" it has to be placed before.

Note: You need to paste the new text directly following the previous entry. DO NOT leave any spaces between entries!!

- Modify the Window ID in order to be unique within the file.

9.6.4. Importing the New Glazing System into TRNBuild

In TRNBuild, the window properties are defined by the window type manager. For importing a new glazing system open an existing or a new window in the window type manager (see Figure 9-258)

- Click on Lib for opening a so-called WinID-Lib which contains reports for glazing systems
- Select the file which contains your previously generated and edited report file.
- Select the desired glazing system
- Close the dialog window
- If the ID number of the selected glazing systems already exists in the current building project, a dialog pops ups asking you whether to overwrite the existing data in the project or to add the glazing with a new unique ID number.

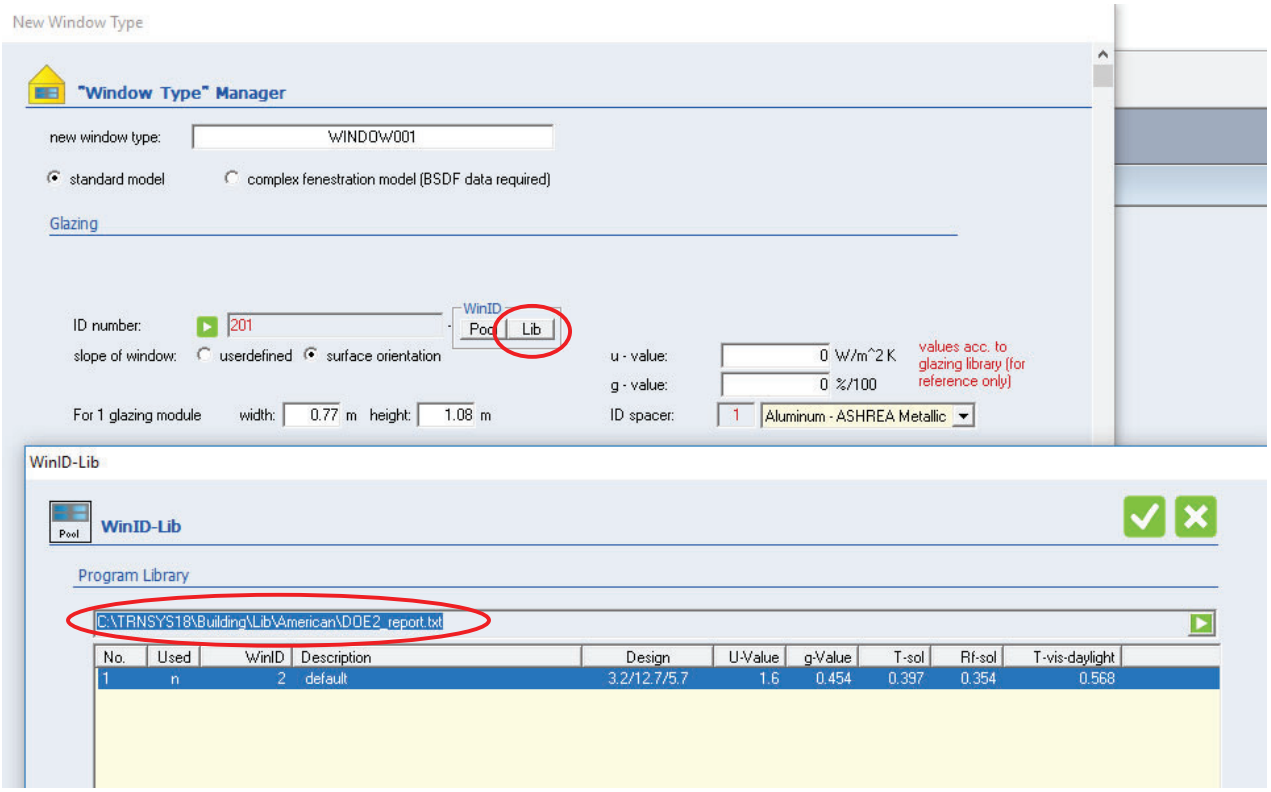

Figure 9-258: Open WINDOW Report File in TRNBuild

9.6.5. Appendix A: European Standards

The following section describes the modifications for adaption the WINDOW calculation to European standards only. Other settings, especially the standard file Trrnsys18.std, have to remain.

9.6.5.1. Thermal Calculation Standard

In *Preferences* → *Thermal Calcs:* EN673 can be selected as “Calculation Standard”.

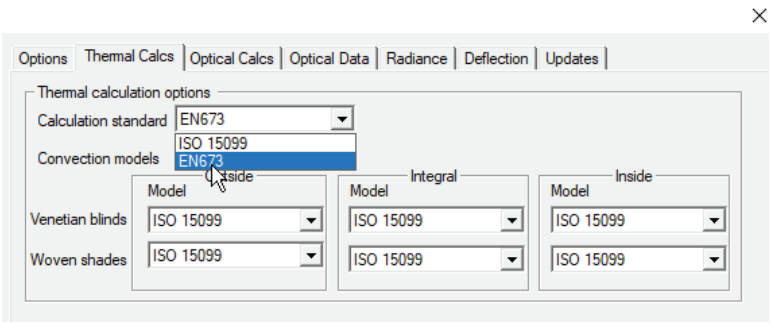

Figure 9-259: WINDOW 7 Preferences: ThermCalcs

9.6.5.2. *Environmental Conditions*

Environmental conditions can be selected in the glazing system dialog as well as in the window dialog.

The environmental conditions library (main menu, go to Libraries > Environmental Conditions or press F6) includes predefined CEN conditions. For DIN EN 673 and DIN EN 410 no predefinition exists.

According to DIN EN 673:2011 and DIN EN 410 the combined heat transfer coefficient is set to

- Outside heat transfer coefficient he = 25 W/(m2K)
- Inside combined heat transfer coefficient hi = 7.7 W/(m2K)

(valid for glass with a corrected emissivity of 0.837 on the inner surface)

The DIN EN673 also defines the temperature difference between the outermost and innermost glazing surface with ΔT=15 K, while the mean gap temperature is fixed to 10 °C. However, in WINDOW only the outside and inside temperature (see Figure 9-260) can be defined.

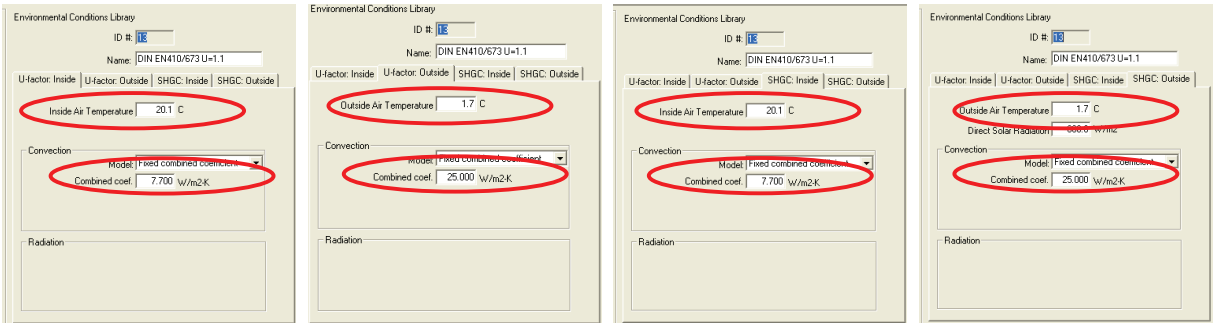

Figure 9-260: WINDOW 7 Environmental Conditions Input Dialog

Note: For calculating SHGC a reference irradiation value can be entered, but it doesn't influence the results of calculations according to DIN EN 410.

To keep the surface temperatures at a certain level the outside and inside temperatures need to be adapted depending on the heat transfer through the glazing. Calculating exactly according to EN 673 with WINDOW would require the determination of the outside and inside temperature for every single glazing. In order to keep it simple and avoid pre-processing in other software, three environmental conditions with

different heat transfer assumptions (U=0.65 W/m²K; U=1.1 W/m²K; U=2.5 W/m²K) turned out to be useful (see **Error! Reference source not found.**).

ID	Name	U-factor Tin	U-factor Tout	SHGC Tin	SHGC Tout	SHGC Solar
		C	C	C	C	W/m2
1	NFRC 100-2010	21.0	-18.0	24.0	32.0	783
2	NFRC 100-2010 Winter	21.0	-18.0	21.0	-18.0	0
3	NFRC 100-2010 Summer	24.0	32.0	24.0	32.0	783
4	CEN	20.0	0.0	25.0	30.0	500
12	DIN EN410/673 U=0.65	18.9	2.1	18.9	2.1	800
13	DIN EN410/673 U=1.1	20.1	1.7	20.1	1.7	800
14	DIN EN410/673 U=2.5	26.0	-0.2	26.0	-0.2	800
17	NFRC 100-2001	21.0	-18.0	24.0	32.0	783

Figure 9-261: WINDOW 7 Environmental Conditions

Depending on the U-Value given by the manufacturer the environmental conditions with the best matching U-Value are allocated to every glazing (see Figure 9-262).

Note: The U-value of single glazed windows (about 5.5 W/m²K) seems to mismatch the categories. Because of the neglect of the temperature dependency of the glass thermal conductivity in WINDOW, the environmental conditions don't influence the results of single glazing at all.

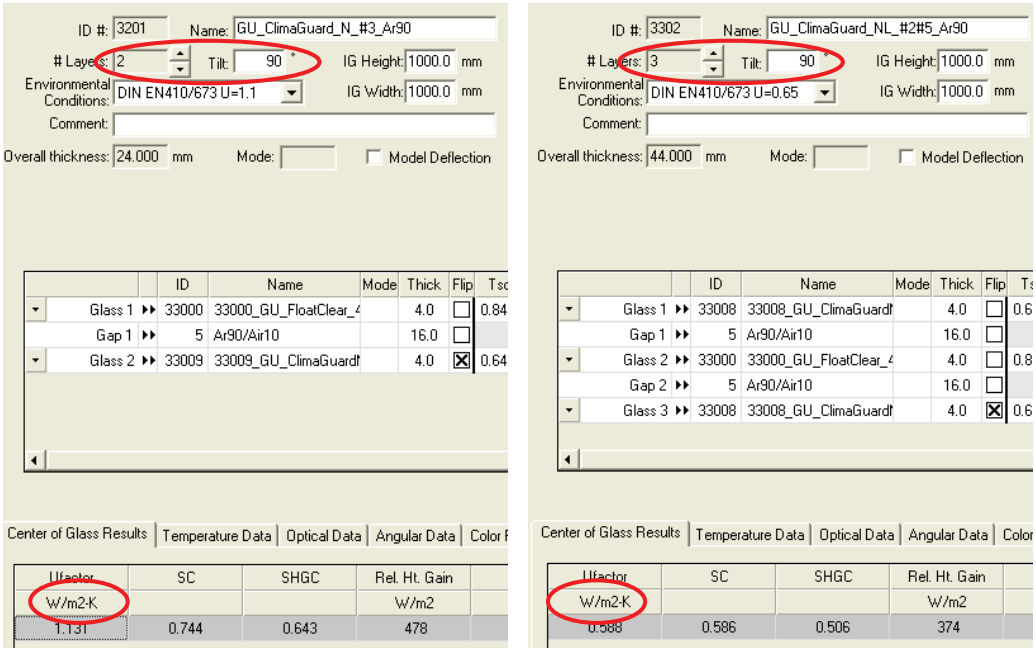

Figure 9-262: Examples – Allocating Environmental Conditions

9.6.5.3. Calculation Mode for Whole Window Assembly

For the whole window assembly (go to Libraries > window or press F2) the calculation mode can be set to CEN (see Figure 16). In addition, the Environmental conditions can be set to the previously defined conditions according to DIN EN 410/673.

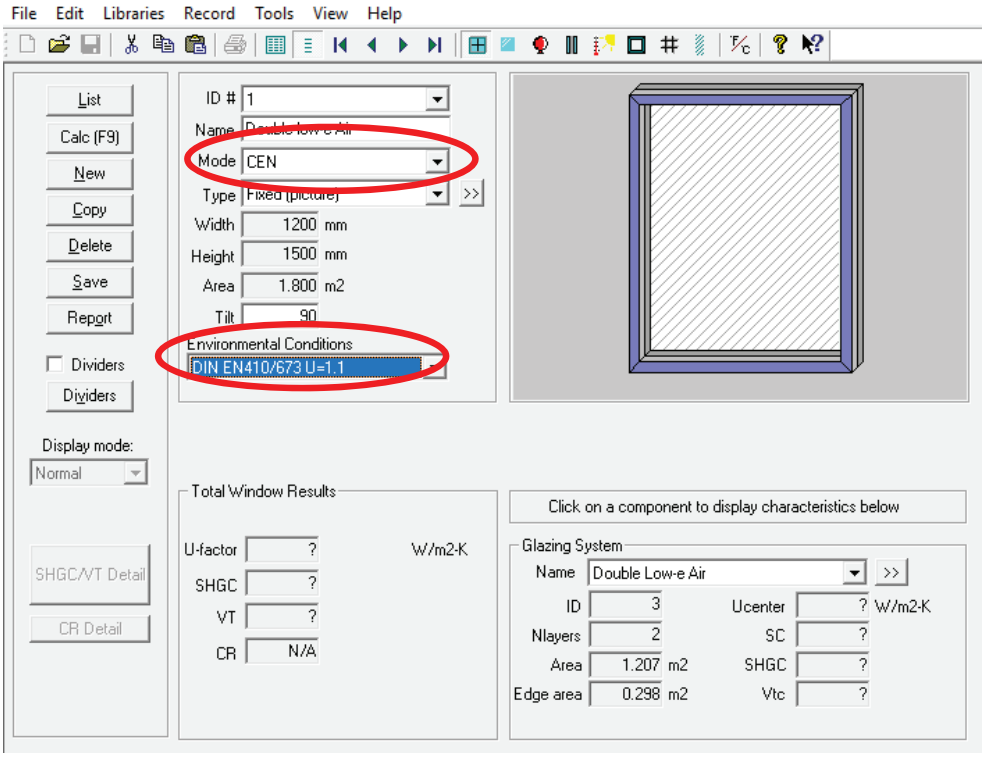

Figure 9-263: Using CEN Mode Instead of NFRC

9.6.6. Appendix B: Import Spectral Data into WINDOW 7 via OPTICS 6

OPTICS is a program for processing and analyzing glazing systems with spectral resolved data. It is possible to vary some parameters like thickness and the substrate. However, for our task we use OPTICS mainly to import given spectral data into an *.mdb data base readable by WINDOW 7.4. Therefore, this manual just describes the import function of OPTICS 6.

9.6.6.1. Database in Optics

OPTICS 6 gives access to the IGDB and a user database. Select the database by using the dropdown menu in the toolbar. (See Figure 9-264)

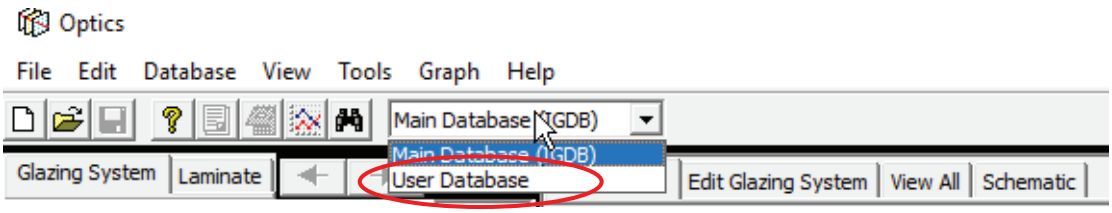

Figure 9-264: OPTICS Database Selection

If an already existing database should be accessed through the user database, the corresponding file can be chosen under Tools →„data base locations“(see Figure 9-265).

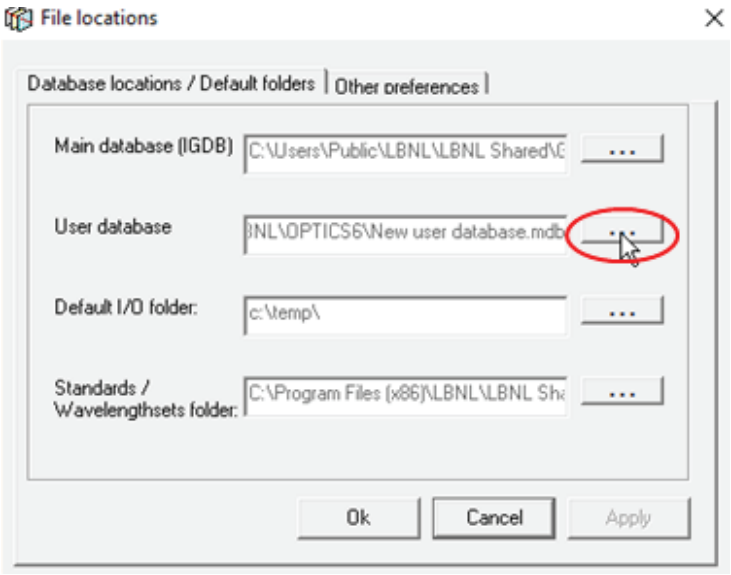

Figure 9-265: OPTICS Database Preferences

A new database can be created under Database → „create new user database“. The path described in Figure 9-265 can then automatically be created (see Figure 9-266)

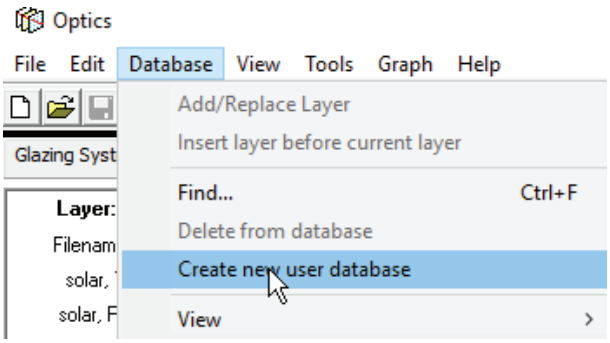

Figure 9-266: OPTICS Create New Database

9.6.6.2. Import spectral data files

Data from spectral data text files needs to be converted to the format described in the International Glazing Database: Data Submission Procedure and Reference Manual. Figure 9-267 shows an example of such a file.

```
{ Units, Wavelength Units } SI Microns
{ Thickness } 6
{ Conductivity } 1
{ IR Transmittance } TIR=0
{ Emissivity, front back } Emis= 0.037 0.837
{ }
{ Ef_Source: Text File }
{ Eb_Source: Text File }
```

```
{ IGDB_Checksum: 0 }
{ Product Name: iplus E - 6 mm }
{ Manufacturer: INTERPANE GLAS INDUSTRIE AG }
{ NFRC ID: 37003 }
{ Type: Coated }
{ Material: N/A }
{ Coating Name: 44107tw }
{ Coated Side: Front }
{ Substrate Filename: 44107ip6.SPC }
{ Appearance: clear }
{ Acceptance: }
{ Uses: }
{ Availability: }
{ Structure: }
0.300     0.0004     0.0610     0.0663
0.305     0.0002     0.0610     0.0655
...
...
...
2.495     0.2128     0.0659     0.0621
2.500     0.2216     0.0689     0.0732
```

Figure 9-267: IGDB Text File Format for Spectral Data

A suitable template can also be generated by choosing a similar product from the Main Database (IGDB) and exporting it as a text file (see Figure 9-268).

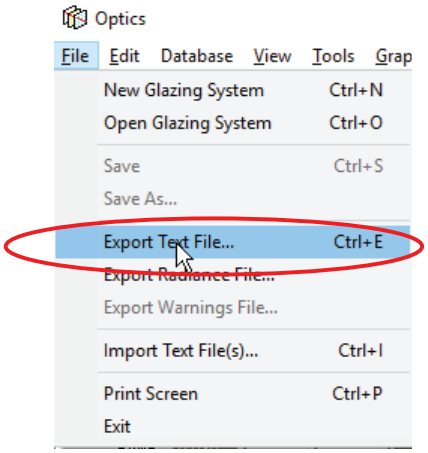

Figure 9-268: Export Suitable Template

The wavelength unit, thickness, conductivity and emissivity of the front and back surface are necessary in-formation in the header for a proper calculation in WINDOW.

Depending on the format of your original data file, you need to modify your file to match this format. The best way to do this is to copy the header of a working file and adapt the values and names. When you use the import function and some information is missing a window will pop up and ask if you would like to enter the missing information. However, we recommend entering as much information as possible already into the text-file, to avoid inconsistency when reading-in the file repeatedly.

The first column shows the wavelengths, usually given in microns. If it is given in nanometer you may adapt the data or substitute Microns for Nanometer in the first line, note almost everything in this program is case sensitive. The following columns are transmissivity, front reflectivity and back reflectivity.

9.6.6.3. Import function in Optics

Importing spectral data text files is the most used function for OPTICS in this context. The imported data is converted into an mdb format, which is readable by WINDOW.

This function can be chosen under File → Import Text Files. In the following pop-up window up to one hun-dred files can be chosen to be imported in sequences. If some information is missing you will be asked if you would like to fill in the missing information. (See Figure 9-269)

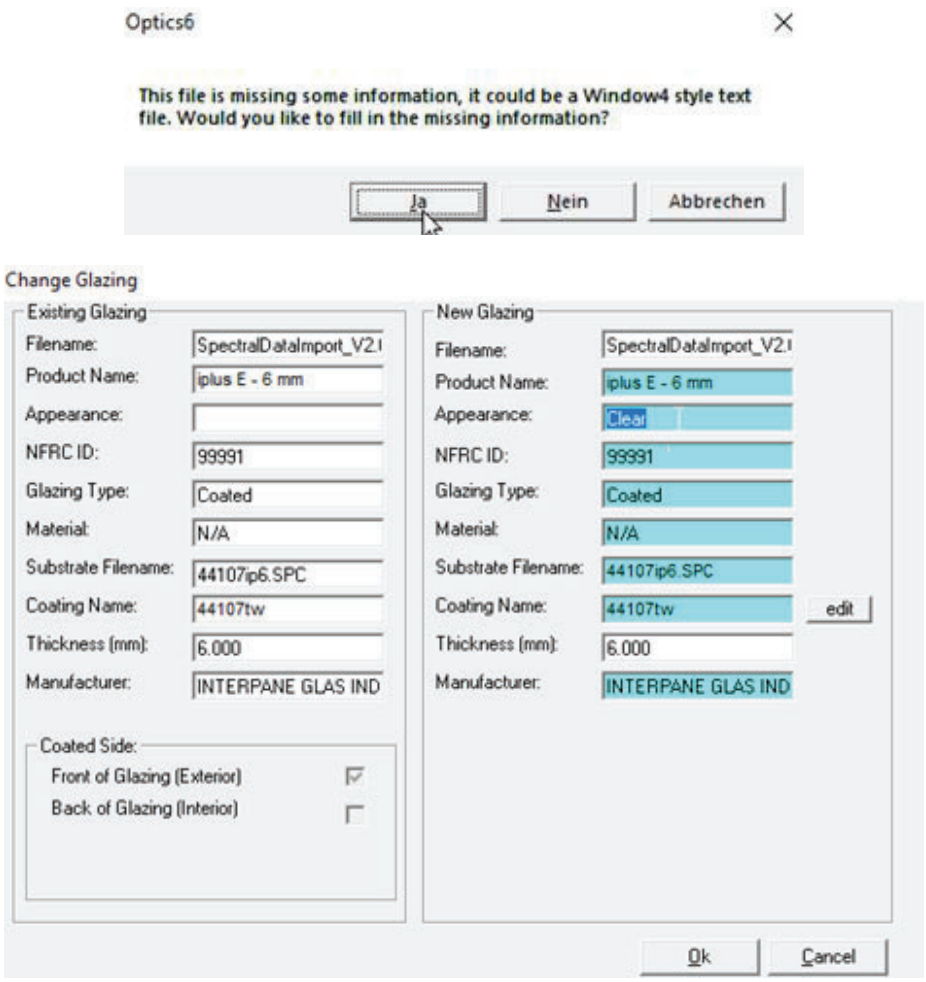

Figure 9-269: OPTICS Import

9.6.6.4. Import Glass from Optics *.mdb file into WINDOW 7 Glass Library

Open the WINDOW program and follow these steps:

- Go to File > Preferences > Optical Data and choose the OPTICS user database, generated in the step before
- Choose your user defined OPTICS 6 *.mdb database as shown in Figure 9-270.

- In the main menu, go to Libraries > Glass or press F3 and choose the List view (not Detailed View)
- Click on the Import button and choose Format IGDB or Optics User Database (see Figure 9-270)
- Choose self-created glass from menu.

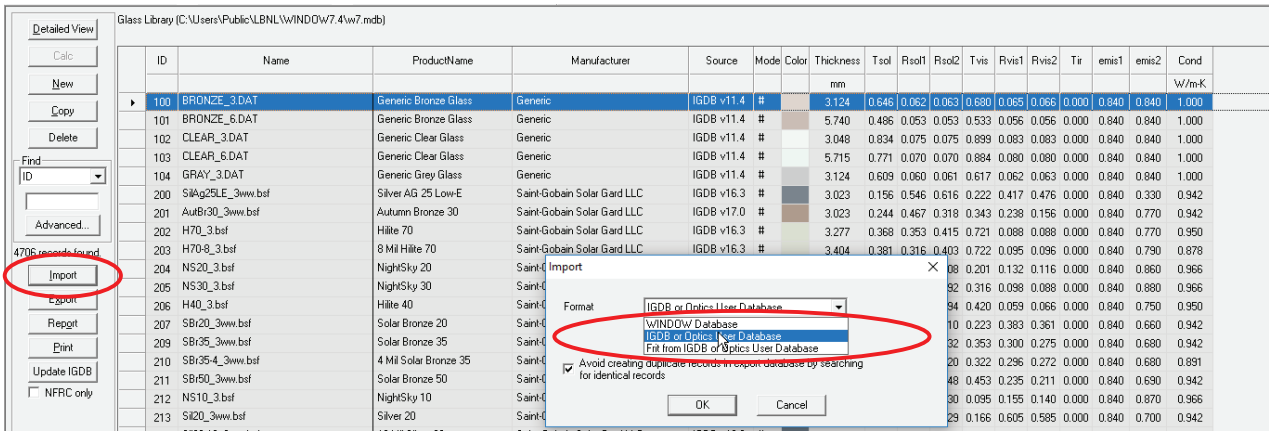

Figure 9-270: Import Glass from OPTICS User Database

9.6.6.5. *Summary: How to Import Data Text Files in OPTICS*

- Select the database to be extended or create a new database
- Convert spectral data from unknown format information into IGDB format
- Import file into OPTICS 6