TRNSYS 16

a TRaNsient SYstem Simulation program

Volume 6

Multizone Building modeling with Type56 and TRNBuild

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About This Manual

The information presented in this manual is intended to provide a complete reference on multizone building simulation with TRNSYS. It includes a description of the building model (known as Type 56) and a user guide for the associated visual interface (TRNBuild). This manual is not intended to provide detailed information about the TRNSYS simulation software nor any of its other utility programs. Detailed information concerning these programs can be found in other parts of the TRNSYS documentation set. The latest version of this manual is always available for registered users on the TRNSYS website (see here below).

Revision history

- 2004-09 For TRNSYS 16.00.0000
- 2005-04 For TRNSYS 16.00.0038
- 2005-11 For TRNSYS 16.01.0000
- 2007-02 For TRNSYS 16.01.0003

Where to find more information

Further information about the program and its availability can be obtained from the TRNSYS website or from the TRNSYS coordinator at the Solar Energy Lab:

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Notice

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Type 56 Contributors

The TRNBuild program described in this manual was developed by TRANSSOLAR Energietechnik GmbH, the German distributor of TRNSYS. Further information about the programs and their availability can be obtained from the TRNSYS distributor from which you purchased the programs or:

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Sections which are new compared to TRNSYS Version 15 are marked in blue.

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6. MULTIZONE BUILDING MODELING WITH TYPE56 AND TRNBUILD

6.1. Introduction

This component models the thermal behavior of a building divided into different thermal zones. In order to use this component, a separate pre-processing program must first be executed. The TRNBUILD program reads in and processes a file containing the building description and generates two files that will be used by the TYPE 56 component during a TRNSYS simulation. The file containing the building description processed by TRNBUILD can be generated by the user with any text editor or with the interactive program TRNBUILD. The required notation is described fully in the TRNBUILD documentation in the following section. 3 parameters are required by the TYPE 56 component. The first parameter is the FORTRAN logical unit for the data file with the building data (*.BUI). Since Version 16 this file contains also the thermal and optical data for all windows used in a project. The Data is taken from the Program Window library This ASCII file is distributed with TYPE 56 and may be extended using the DOE2 Output of WINDOW 4.1 or 5 program developed by Lawrence Berkeley Laboratory, USA. The second parameter is set to 1 if time-dependent convective heat transfer coefficients are used (for example in combination with floor panel heating systems). The third parameter gives the weighting factor between air and mean surface temperature for the calculation of an operative room temperature. The optional parameters 4 – 6 give FORTRAN logical unit numbers for the standard output files generated by TYPE 56. The inputs and outputs of TYPE 56 depend upon the building description and options within the TRNBUILD program. TRNBUILD generates an information file describing the outputs and required inputs of TYPE 56.

There are two ways to model the equipment for heating, cooling, humidification, and dehumidification. The two methods are similar to the "energy rate" and "temperature level" control modes available in the TYPE 12 and 19 load models. With the "energy rate" method, a simplified model of the air conditioning equipment is implemented within the TYPE 56 component. The user specifies the set temperatures for heating and cooling, set points for humidity control, and maximum cooling and heating rates. These specifications can be different for each zone of the building. If the user desires a more detailed model of the heating and cooling equipment, a "temperature level" approach is required. In this case, separate components are required to model the heating and/or cooling equipment. The outputs from the TYPE 56 zones can be used as inputs to the equipment models, which in turn produce heating and cooling inputs to the TYPE 56 zones.

Note: Only one unit of TYPE 56 is allowed per simulation.

There are 4 main sections in this guide:

- Section 6.2 explains how to use the TRNBuild program to define the multizone building data for TYPE 56 of TRNSYS.
- Section 6.3 shows the configuration of TYPE 56 (Parameters, Inputs, Outputs)
- Section 6.4 describes the mathematical models and assumptions behind the Type56 multizone building model.
- Section 6.5 presents building examples

6.2. TRNBuild

6.2.1. Introduction

Due to the complexity of a multizone building the parameters of TYPE 56 are not defined directly in the TRNSYS input file. Instead, a file so-called building file (*.BUI) is assigned containing the required information.

TRNBUILD (formerly known as PREBID) has been developed to provide an easy-to-use tool for creating the BUI file. Starting with some basic project data, the user describes each thermal zone in turn. Finally, the desired outputs are selected. All data entered are saved in the so-called building file (*.BUI), a readable ASCII text file. The BUI file is very handy for checking data entered in TRNBuild.

Note: The BUI-file has a rigorous syntax. Editing this file may cause a lot of trouble!

Compared to the previous version PREBID, several improvements have been made to TRNBuild and to the multizone building model itself (TYPE 56):

User interface:

- Automatic segmentation of active layers
- Automatic creation of T56 input files (*.bld,, *.trn, *.inf)
- Chilled ceilings
- Improved library management (walls, layers, gains, schedules and windows),
- Long variable names (all characters allowed except “blank” “:” “;”).
- Rename/copy/paste/delete/new option in all TYPE-Managers (e.g. wall, window, gains)
- Transparent insulation is treated like a normal window with a special data curve

Physical and mathematical modeling:

- Automatic calculation of convective heat transfer coefficients depending on surface temperatures
- New 2-band radiation window model
- Solar and thermal energy as well as moisture is automatically balanced

Note: Despite these improvements, the BUI-file created by PREBID 3 or 4 can be imported into TRNBuild 1.0. However, files can only be saved into a TRNBuild version 1.0 format. Errors and unexpected behavior may occur by loading files which have been created or changed outside of PREBID or TRNBuild!

6.2.2. Getting Started

Assuming that you have installed the TRNSYS package correctly, TRNBuild can be started from TRNEDIT under the UTILITIES menu or directly by double-clicking on the TRNBuild icon in the TRNSYS group. TRNBuild is also housed within the TrnsysStudio environment program. (Note, that TRNBuild 1.0 requires a screen resolution of at least 800x600 and WINDOW NT or 95,98,2000 or newer).

The initial TRNBuild window is shown in Figure 6.2.2-1. The information window will close automatically. The main menu of the initial TRNBuild window houses the following items:

- FILE (open, new, close, or save a *.BUI file)
- VIEW (toolbar, status bar)
- OPTIONS (settings such as library versions, external editor)
- WINDOW (cascade, tile, arrange icons, etc.)
- HELP

After you opened a new or existing project three additional items will be available in the main menu:

- ZONES (add and delete zones)
- GENERATE (create BUI file for max. heat load calculation, run TRNSYS input file)
- TYPEMANAGER (edit previously defined TYPES of walls, windows, gains, ventilation, infiltration, cooling, heating, layers, and schedules)

Many of the features of the main menu are also present in the tool bar. For users with small screens, it might be more convenient to hide the toolbar and status bar.

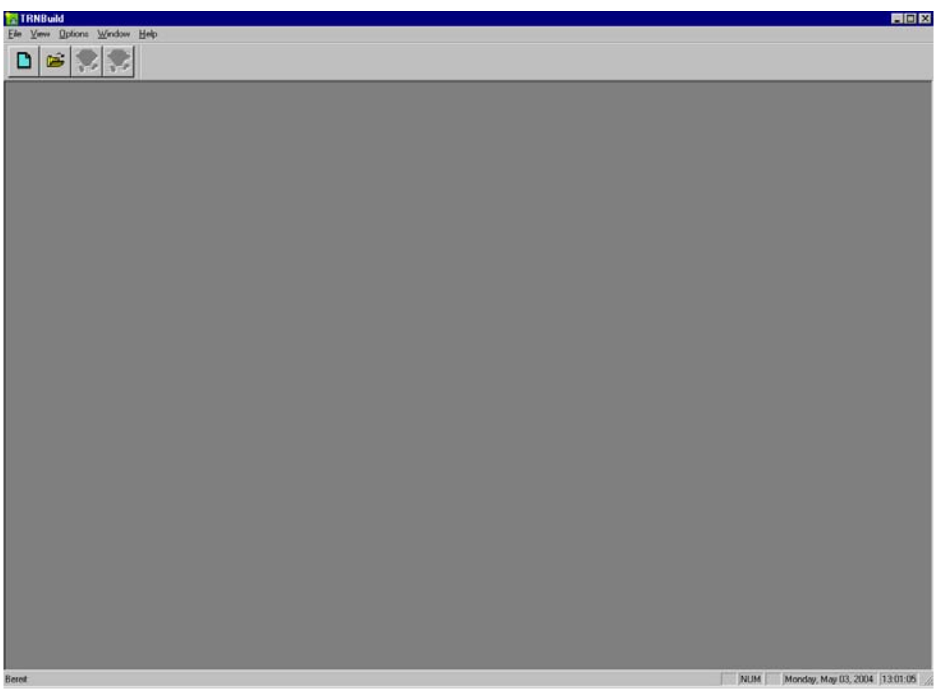


Figure 6.2.2-1: Initial TRNBuild Window

6.2.2.1. Settings

Under the OPTIONS menu, some settings used in TRNBuild can be specified as shown in Figure 6.2.2-2. The Path for standard Libraries accessible in the settings window is only used for:

- TRNSYS: spacer.lib
- TRNFLOW: headers.txt, pollutant.lib

The path and name for all other libraries, for instance windows, walls, layers or schedules, will be preset by the path given here, but can be changed interactively whenever needed, for example when you are describing a new wall or window.

Libraries for common windows, walls, and layers are provided in different languages:

- The United States version contains Standard ASHRAE walls and materials.
- The German version contains materials and walls according to DIN 4108 and VDI 2078, respectively. Glazing materials used on the German market have been added to the German window library.

The location of the TRNSYS application is needed for running a “max. heat load calculation” (see Section 6.2.7).

The TRNSYS application name changed from formerly TRNSYS.exe to TRNExe.exe in version 16.

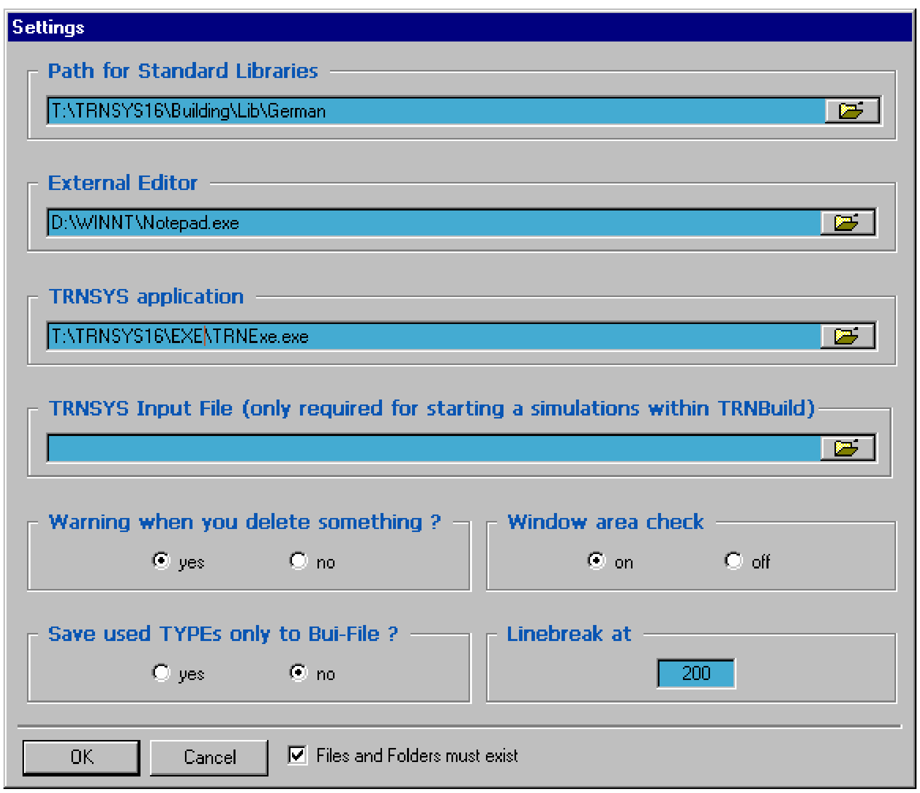


Figure 6.2.2-2: The SETTINGS Window

The new CHECK BOX "Files and Folders must exist" toggles on or off a test for the existence of file paths given in the input windows.

6.2.2.2. Opening and Creating a New File

To open an existing *.BUI file, click on FILE and then click on OPEN. To create a new file, click on FILE and then click on NEW. Once you have opened an existing file or started a new file, the PROJECT INITIALIZATION window opens, as shown in Figure 6.2.2-3. If ZONEs have already been defined in this file, the ZONE windows are opened as well.

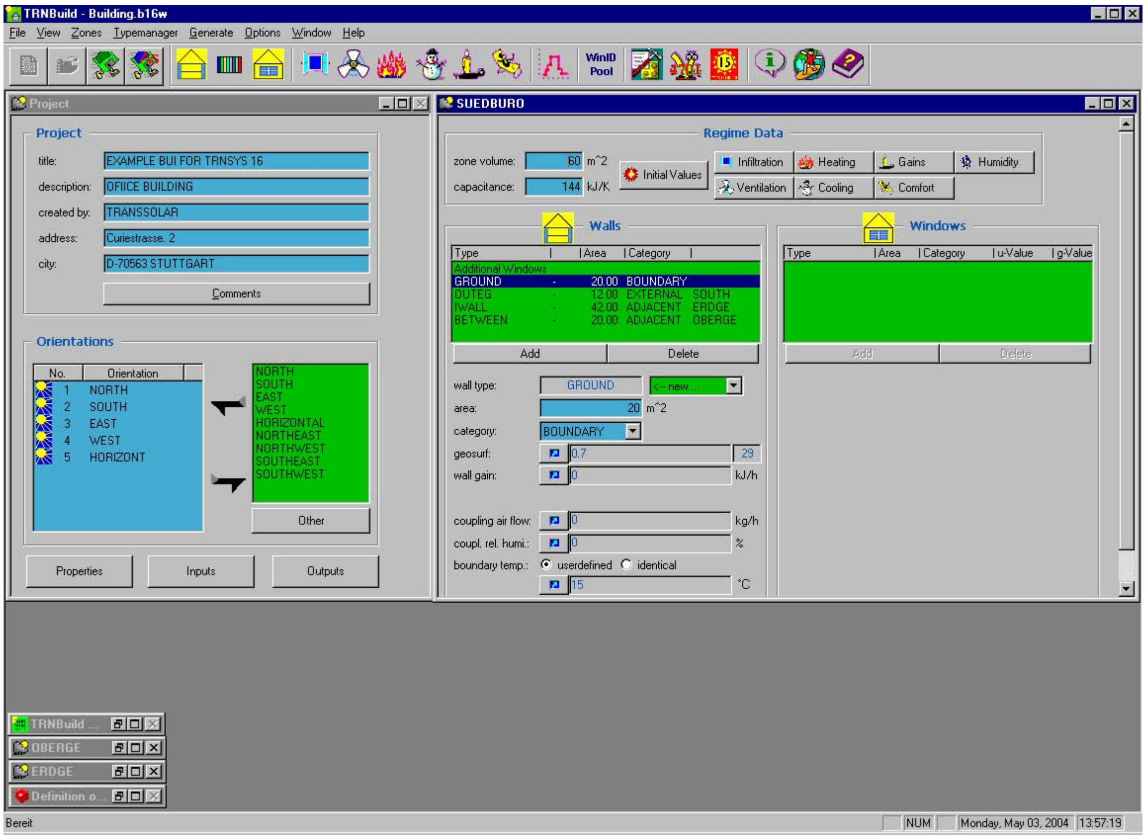


Figure 6.2.2-3: The PROJECT INITIALIZATION and ZONE Windows

6.2.2.3. Specifying the Required Input

In TRNBuild windows, required information is entered in one of several formats: input box, radio button, list box, pull-down menu, or DEF button. The use of each of these formats is explained below:

Input boxes

Input boxes are designed for the user to enter values or text, such as the name of a zone. They are easy to recognize by their light blue background color. (Note: gray colored boxes are used for display only). Some input boxes require a number and will not accept other characters. To enter information in an input box, double-click anywhere in the input box and enter the required information using the keyboard.

Radio buttons

Radio buttons group a set of mutually exclusive options. The selected option is shown with a black dot enclosed within a circle. To select a different radio button option with the mouse, just click on the cycle in front of the option name.

List boxes

A list box provides a list of “source” items from which one or more can be selected as shown in Figure 6.2.2-4. Select an item with the mouse, scroll it into view if necessary using the scroll bar. Click on the upper arrow (pointing left) to add an item. The selected item appears in another box on the left (see Figure 6.2.2-4). To delete an item, select the item in the left list and lick on the lower arrow (pointing right).Alternatively, the insert and delete key can used.

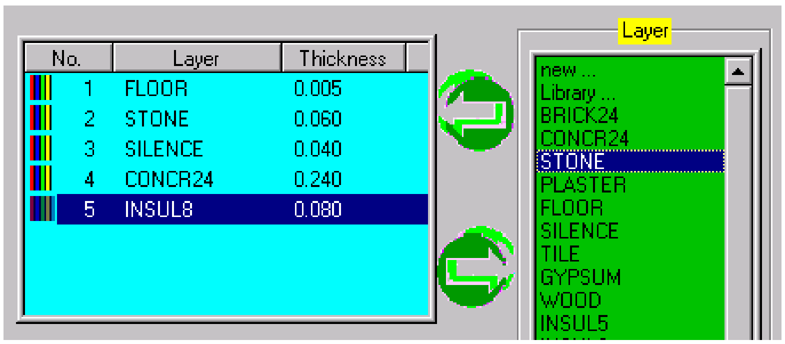


Figure 6.2.2-4: List Box Input

Pull-down menu

A pull-down menu provides a list of items from which only one can be selected. To select an item, click with the mouse on the arrow on the right side and keep the mouse button pressed while looking for the desired item. Release the mouse button when the desired item is highlighted. The pull-down menu reduces again to a single bar and the selected item appears in a display box.

DEF button

A DEF button is used to define items which can be a constant, an input or a schedule (i.e. the shading factor of an internal shading device as shown in Figure 6.2.2-5). In the display box, the defined constant, input or schedule is displayed, respectively. ‘I’ is the abbreviation for input and ‘S’ the abbreviation for schedule.

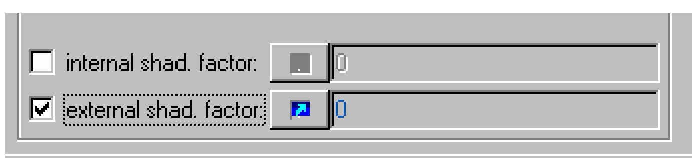


Figure 6.2.2-5: The DEF Button

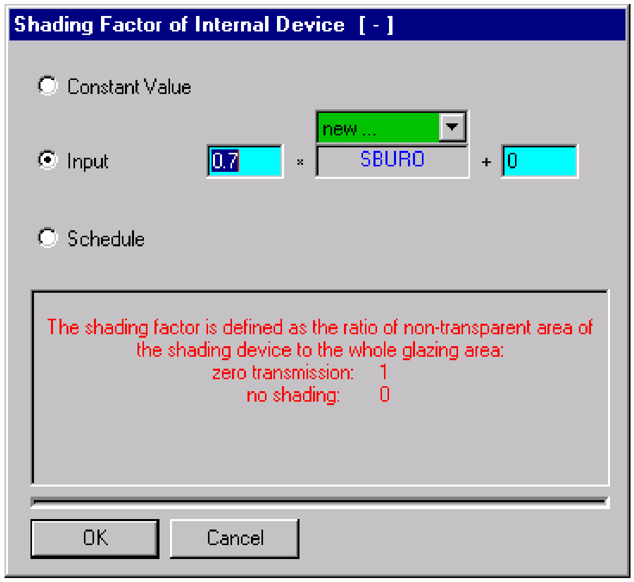


Figure 6.2.2-6: The DEFINITION Window for a Constant, an Input, or a Schedule

After clicking on the DEF button, a definition window opens as shown in Figure 6.2.2-6. A brief online help is provided in an information box. Using a radio button, the user selects whether a constant, an input or a schedule is to be defined:

- For a constant, the user enters a single value.
- For an input, the user selects an input from the pull-down menu as well as a multiplication and addition factor. If the option NEW from the pull-down menu is selected, the user is asked to enter a new unique input name.
- For defining a schedule, the user selects a schedule from the pull-down menu as well as multiplication and addition factors. If the option NEW from the pull-down menu is selected, a window for specifying the schedule appears as shown in Figure 6.2.2-7. This window offers the option to define a daily or a weekly schedule. For a daily schedule, the user specifies the type name first. Then the daily schedule is defined by entering values for the desired time intervals. For a weekly schedule, the user selects a daily schedule for every day of the week by a pull-down menu as shown in Figure 6.2.2-8. If the desired daily schedule has not yet been defined, the option NEW allows the user to define a new daily schedule.

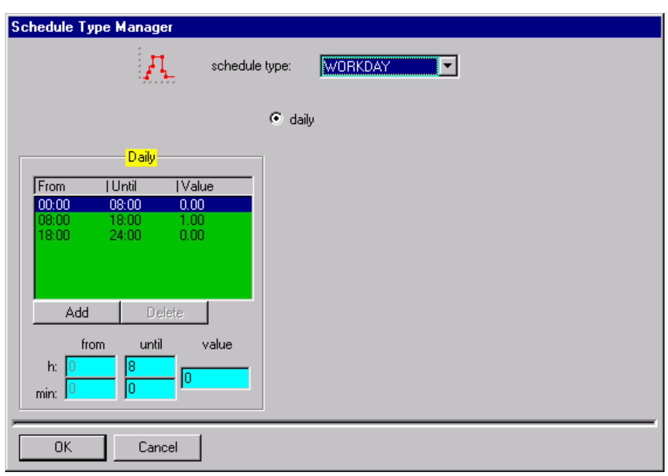


Figure 6.2.2-7: The SCHEDULE Window for a Daily Schedule

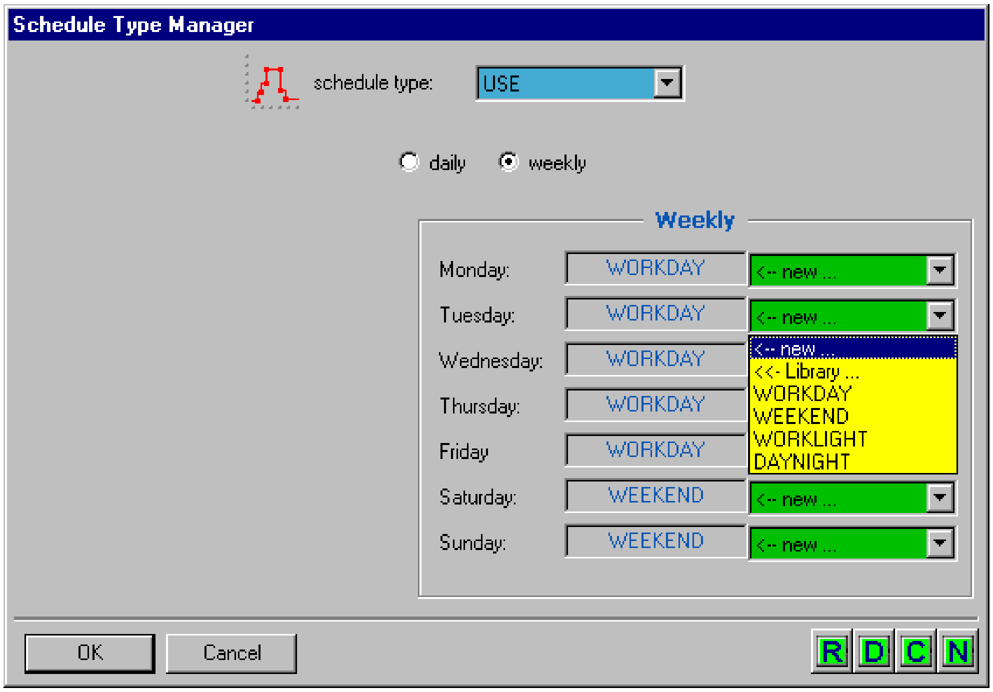


Figure 6.2.2-8: The SCHEDULE Window for a Weekly Schedule

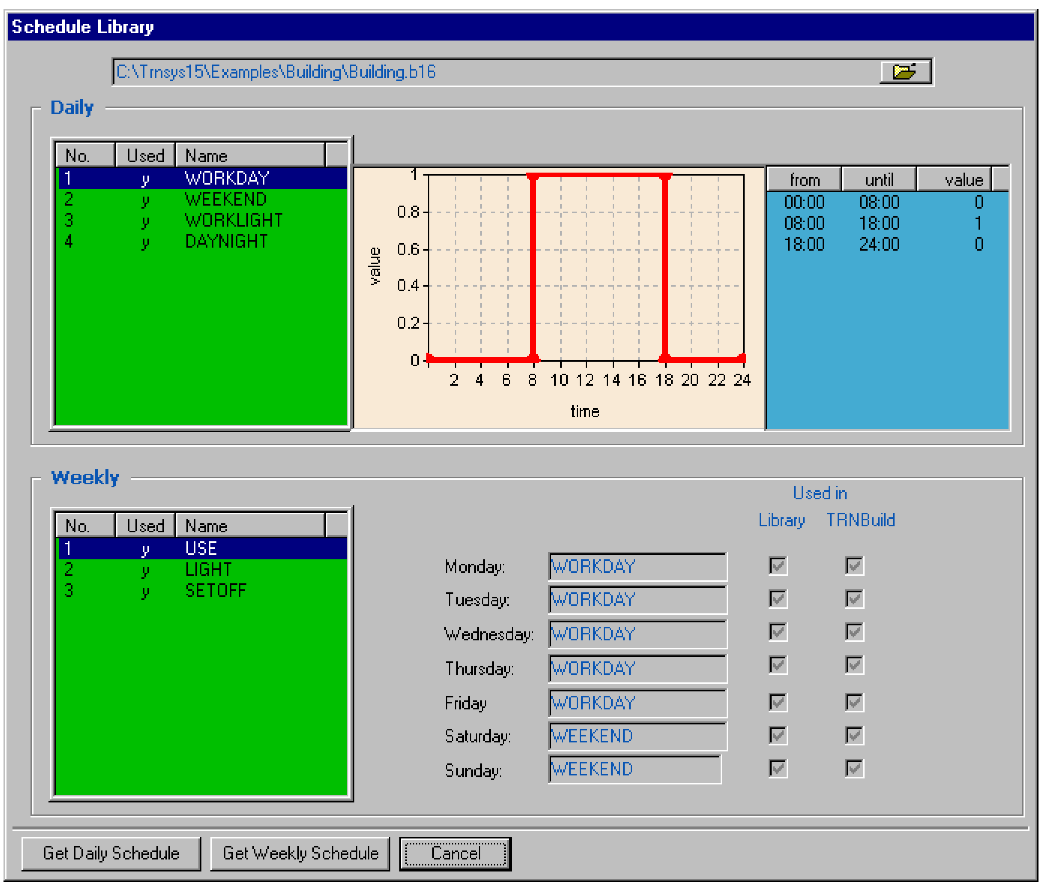


Figure 6.2.2-9: Getting a SCHEDULE for a Library

To take advantage of earlier defined schedules in libraries or any existing bui-file, schedule information can be accessed through the path and file name dialog box at the window top.

6.2.3. The Project Initialization Window

In the project initialization window, the user enters some general information about the project, defines the ORIENTATIONs of walls required by the described building, defines some basic material properties, views the list of required INPUTS to TYPE 56, and selects the desired OUTPUTS of TYPE 56.

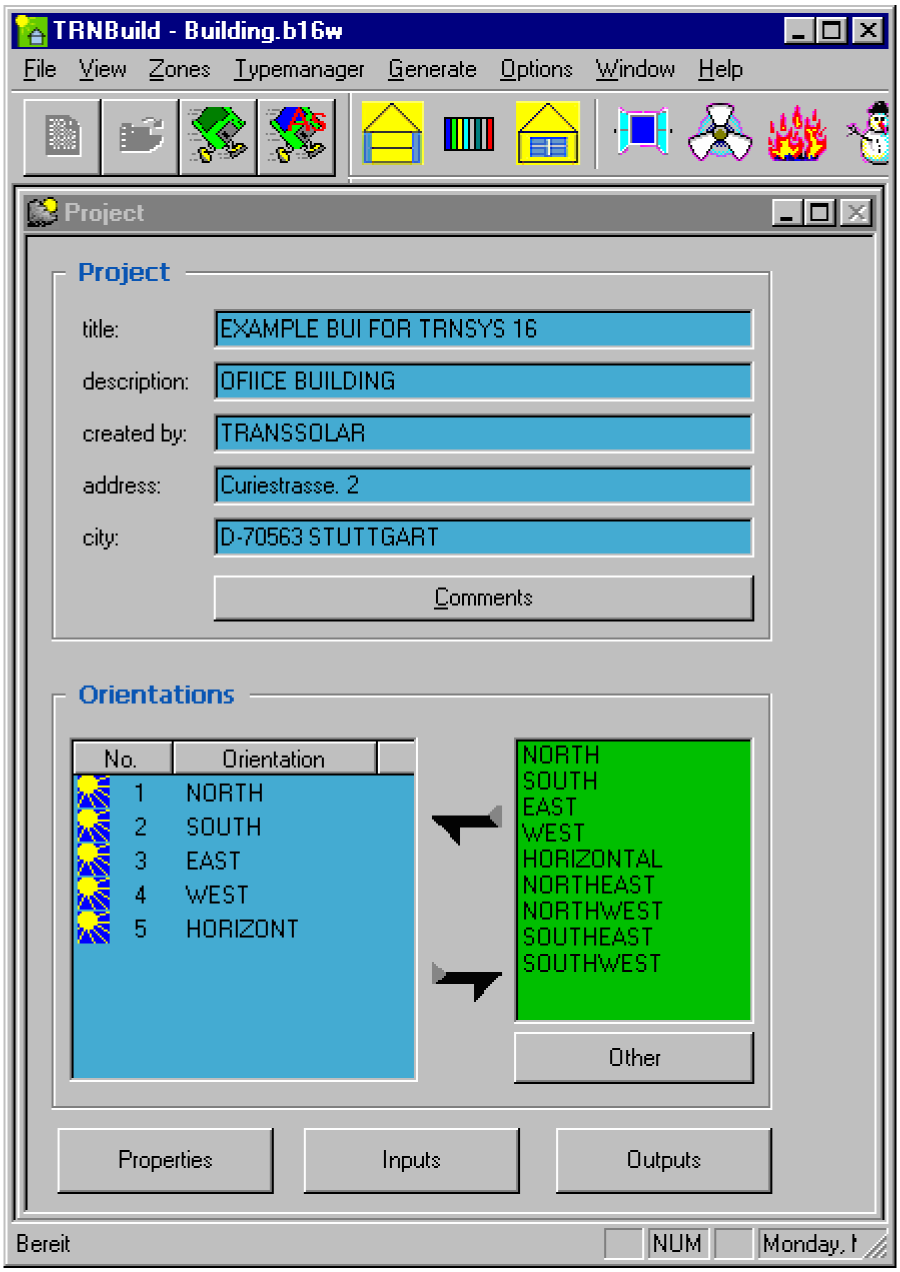


Figure 6.2.3-1: The PROJECT INITIALIZATION window

6.2.3.1. Orientation

All possible orientations of external building walls must be defined here by unique names. The table on the left side contains all orientations defined for this project. The table on the right side provides a list of standard orientations. For adding select the desired standard orientation and click on the upper arrow. The selected orientation will then appear in the left window. If other orientations are needed, click on the button OTHER and a new orientation name can be entered. A defined orientation can be deleted after selection by clicking on the lower arrow.

For each orientation name specified, an input of incident radiation to the Type 56 TRNSYS component will be required. This is generally provided by the Type 16 Radiation Processor.

> Note: The incident angle for an orientation must range from 0 to 180 degrees. Due to the fact that the zenith angle of Type 16 (Radiation processor) ranges only between 0 to 90 degrees, the orientation "horizontal" must be defined as a separate surface in Type 16 (Radiation processor.)

6.2.3.2. Properties

Figure 6.2.3-2 shows certain material properties If the user does not define them, the following default values are used.

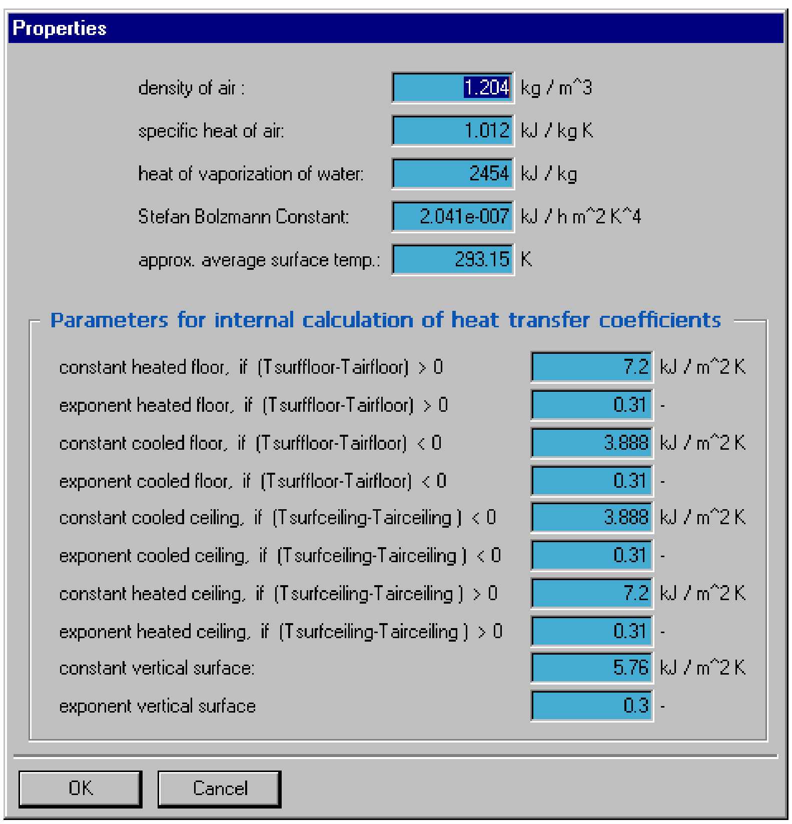


Figure 6.2.3-2: The PROPERTIES window

Heat transfer coefficients depend heavily on the temperature difference between surface and fluid and the direction of heat flow. For example, the flow pattern evolved by a chilled ceiling is similar to that of a heated floor, but completely different to that of a vertical surface. The mathematical formula used for appropriate heat transfer coefficients is of the form
$\alpha_{conv} = const\ (Tsurf–Tair)^{exp}$.

The coefficients const and exp can be changed here to fit different approaches from heat transfer research. Standard values are taken from literature; see TRNSYS Manual, description of TYPE 80 for further details.

Important note: the automatic calculation of heat transfer coefficients has to be activated during the description of a new wall (see Section 6.2.4.2) or in the WALL TYPE MANAGER and is applied only to these explicitly defined walls. In case of heated or chilled building surface, the heat transfer will depend on surface temperature, so automatic heat transfer coefficient calculation is strongly recommended.

For all other walls the standard approach will still be a constant heat transfer coefficient resulting in reduced calculation time.

6.2.3.3. Inputs

By clicking on the INPUTS button, an overview of INPUTs defined within the project is shown (see Figure 6.2.3-3).

New INPUTs can be added here, thus creating a list you want to use in the definition of gains, controller strategies etc. Unused INPUTs can be deleted, but it is not possible to delete INPUTS used in definitions somewhere in the building description. In certain cases it might be comfortable to change the sequence of INPUTs, which is done by drag and drop (left mouse button).

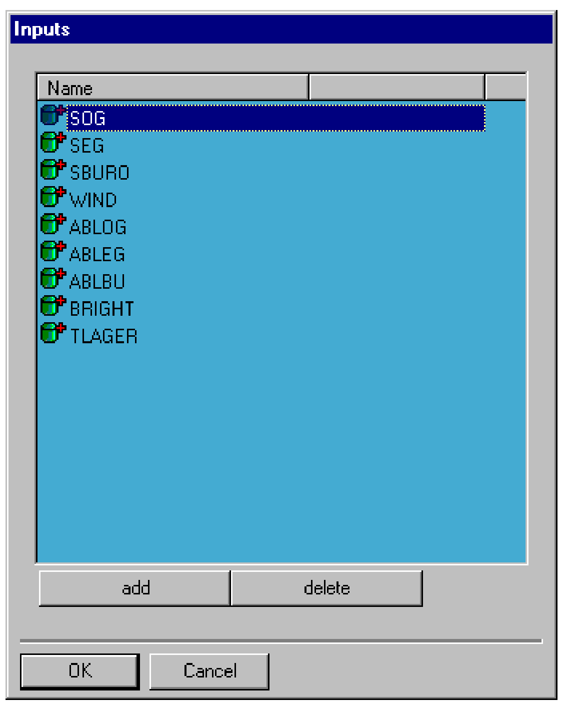


Figure 6.2.3-3: The INPUTS window

6.2.3.4. *Outputs*

By clicking on the OUTPUTS button, the OUTPUTS window opens as shown in Figure 6.2.3-4. In General, the definition of OUTPUTS is last step of the building description. The user may adjust the time base of the transfer function if necessary. The default value of 1 is adequate for most cases. For heavy constructions 2 up to 4 can be used, 0.5 for light walls. Caution: the start time in the TRNSYS input file (*.DCK) must match to the time base.

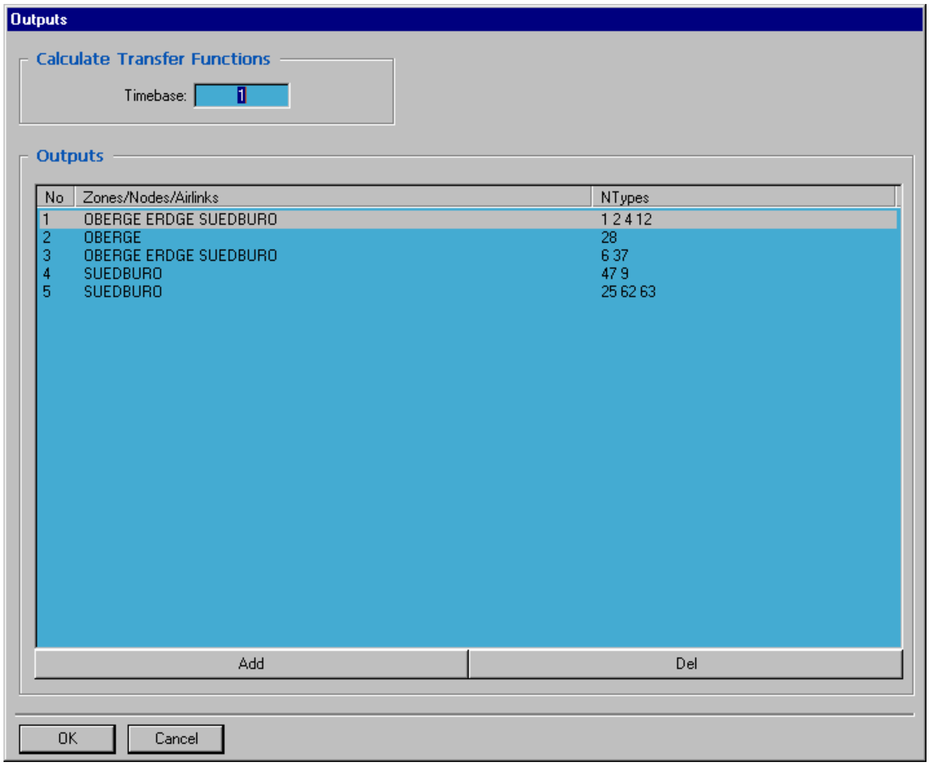


Figure 6.2.3-4: The OUTPUT window

In addition, the user can edit, add or delete outputs of TYPE 56, so-called NTYPES. Default outputs are provided (zone air temperatures (NTYPE 1) and sensible energy demands (NTYPE2) for all specified zones). To add a new output, the user clicks on the ADD button and the NEW OUTPUT window opens (see Figure 6.2.3-5). The user now has the following options:

- to use a DEFAULT setting (zone air temperatures (NTYPE 1) and sensible energy demands (NTYPE 2) for all specified zones)
- to select a single or a group of zones use the arrows between the upper boxes or the insert and delete key, respectively. Selected items appear in the left boxes. For specifying the desired outputs use the lower list boxes. Selected outputs appear in the lower left box, simultaneously selected items appear in a different color in the lower right box to prevent from multiple selection.
- in addition to outputs for single or multi-zones, balances are available for thermal energy, solar radiation and humidity, extremely helpful for consistency check of thermal modeling.
- If a so-called surface output is selected, the desired surfaces must be defined by a double click on the NTYPE of the left box. Afterwards, the selected surface numbers are displayed too. Also, for NTYPE 28 (values of schedules) the schedules must specified by a double click on the NTYPE of the left box.

For editing a previously defined OUTPUT, double-click on the output in the lower left Ntypes overview window.

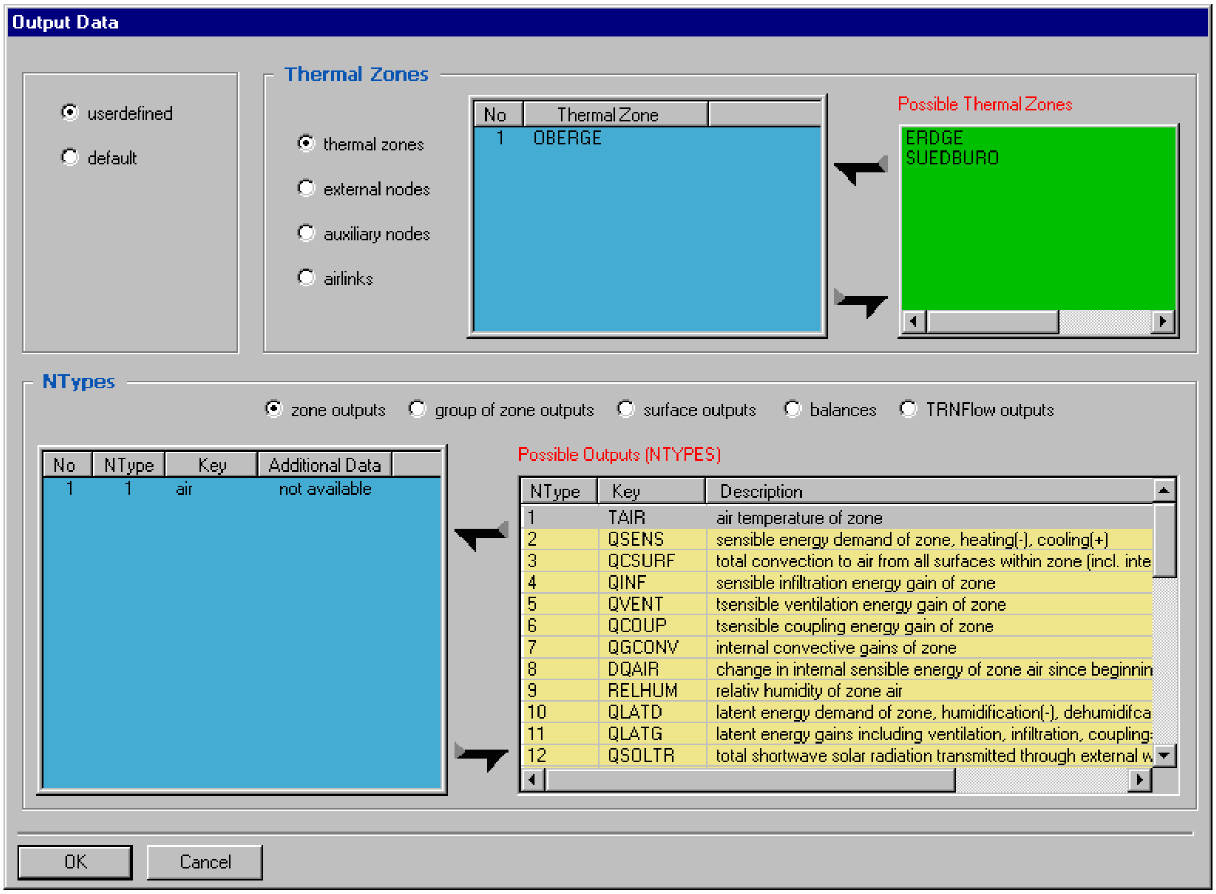


Figure 6.2.3-5: Adding a new user-defined OUTPUT

In Table 6.2.3-1 below, a list of optional outputs is shown. Table 6.2.3-1 is divided into so called “zone outputs” where a single output is produced for each zone specified and so called “surface outputs” where a single output is produced for specified surfaces of a zone. In addition, outputs for groups of zones can be defined. Zones are combined in groups by stating the zones in a row and then specifying the desired NTYPE numbers of possible group outputs. For each of these NTYPE numbers, a group output for the stated zones is produced.

Table 6.2.3-1: Optional Outputs

Zone Outputs:

NTYPE#	Label	Description	Unit
NTYPE 1	TAIR	air temperature of zone	[°C]
NTYPE 2	QSENS	sensible energy demand, heating(-), cooling(+)	[kJ/hr]
NTYPE 3	QCSURF	total convection to air from all surfaces within zone incl. internal shading	[kJ/hr]
NTYPE 4	QINF	sensible infiltration energy gain of zone	[kJ/hr]
NTYPE 5	QVENT	sensible ventilation energy gain of zone	[kJ/hr]
NTYPE 6	QCOUP	sensible coupling gains of zone	[kJ/hr]
NTYPE 7	QGCONV	internal convective gains of zone	[kJ/hr]
NTYPE 8	DQAIR	sensible change in internal energy of air in zone since the beginning of the simulation	[kJ/hr]
NTYPE 9	RELHUM	relative humidity of zone air	[%]
NTYPE 10	QLATD	latent energy demand of zone, humidification(-), dehumidification (+)	[kJ/hr]
NTYPE 11	QLATG	latent energy gains of zone including ventilation, infiltration, coupling, internal latent gains and vapor adsorption in walls	[kJ/hr]
NTYPE 12	QSOLTR	total shortwave solar radiation transmitted through external windows of zone (but not kept 100 % in zone)	[kJ/hr]
NTYPE 13	QGRAD	internal radiative gains of zone	[kJ/hr]
NTYPE 14	QTABSI	total radiation absorbed (or transmitted) at all inside surf. of zone (includes solar gains, radiative heat, internal radiative gains and wallgains)	[kJ/hr]
NTYPE 15	QTABSO	total radiation absorbed at all outside surf. of zone (includes solar gains, radiative heat, internal radiative gains and wallgains, but not longwave radiation exchange with T_{sky})	[kJ/hr]
NTYPE 16	QTCOMO	total convective and longwave rad. gains (T_{sky}) to outside surf.	[kJ/hr]

Surface Outputs:

NTYPE#	Label	Description	Unit
NTYPE 17	TSI	inside surface temperature [°C]	[°C]
NTYPE 18	TSO	outside surface temperature [°C]	[°C]
NTYPE 19	QCOMI	energy from inside surf. incl. conv. to air and longwave radiation to other surfaces	[kJ/hr]
NTYPE 20	QCOMO	energy to outside surf. incl. conv. to air and longwave radiation to other surfaces or T_{sky}	[kJ/hr]
NTYPE 21	QABSI	absorbed (or transmitted) at inside surf (includes solar gains, radiative heat, internal radiative gains and wallgains, except longwave radiation exchange with other walls)	[kJ/hr]
NTYPE 22	QABSO	radiation absorbed at outside surf. [kJ/hr] (includes solar gains, radiative heat, internal radiative gains and wallgains, except longwave radiation exchange with other walls or T_{sky})	[kJ/hr]

Zone Outputs:

NTYPE#	Label	Description	Unit
NTYPE 23	TSTAR	star node temperature of zone	[°C]
NTYPE 24	TMSURF	weighted mean surface temperature of zone	[°C]
NTYPE 25	TOP	operative zone temperature	[°C]
NTYPE 26	QVAPW	heat of vapor adsorption in walls of zone	[kJ/hr]
NTYPE 27	QUA	static UA-transmission losses (UA*dT) of zone	[kJ/hr]
NTYPE 28		value of schedule	
NTYPE 29	ABSHUM	absolute humidity of zone air	[kg_{water} / kg_{dry_air}]
NTYPE 30	QHEAT	sensible heating demand of zone (positive values)	[kJ/hr]
NTYPE 31	QCOOL	sensible cooling demand of zone (positive values)	[kJ/hr]

Note: NTYPE 27 (static UA-transmission losses of walls + windows of zone) and NTYPE 46 do not use the transfer functions calculated by BID but instead uses the stationary U-values to calculate steady state transmission losses of walls and windows without considering any capacitance effects. The following values of the surface resistance (combined for convection and radiation) are used for the U-value calculation:

HBACK > 30 kJ / (h m² K)	=>	1/α = 0.04 m² K / W
30 ≥ HBACK >0.005	=>	1/α = 0.13 m² K / W
0.005 ≥ HBACK	=>	1/α = 0 m² K / W
HFRONT	=>	1/α = 0.13 m² K / W

If the NTYPE 27 and 46 are used in short term calculations, large errors in the energy balances of the building may occur due to the neglect of internal energy changes within massive walls.

Outputs for Groups of Zones:

NTYPE#	Label	Description	Unit
NTYPE 32	SQHEAT	sum of sensible heating demand for specified zones (positive)	[kJ/hr]
NTYPE 33	SQCOOL	sum of sensible cooling demand for specified zones (positive)	[kJ/hr]
NTYPE 34	SQCSURF	sum of surf. conv. gains of specified zones	[kJ/hr]
NTYPE 35	SQINF	sum of sensible infiltration gains of specified zones	[kJ/hr]
NTYPE 36	SQVENT	sum of sensible ventilation gains of specified zones	[kJ/hr]
NTYPE 37	SQCOUP	sum of sensible coupling gains of specified zones	[kJ/hr]
NTYPE 38	SQGCONV	sum of int. conv. gains of specified zones	[kJ/hr]
NTYPE 39	SDQAIR	sum of changes in internal energy of air in specified zones (since the beginning of the simulation)	[kJ/hr]
NTYPE 40	SQLATD	sum of latent energy demand of specified zones humidification(-), dehumidification (+)	[kJ/hr]
NTYPE 41	SQLATG	sum of latent energy gains of specified zones including ventilation, infiltration, coupling and vapor adsorption in walls	[kJ/hr]
NTYPE 42	SQSOLT	sum of shortwave solar radiation transmitted through windows of specified zones (but not kept 100 % in zone)	[kJ/hr]
NTYPE 43	SGQRAD	sum of internal radiative gains of specified zones	[kJ/hr]
NTYPE 44	SQABSI	total rad. absorbed (or transmitted) at inside surf. of specified zones (includes solar gains, rad. heat, int. rad. and wallgains)	[kJ/hr]
NTYPE 45	SQABSO	total rad. absorbed at outside surf. of specified zones (incl. solar gains, rad. heat, int. rad. and wallgains, but not l-wave with T_{sky})	[kJ/hr]
NTYPE 46	SQUA	sum of static transmission losses (UA*dT) of specified zones	[kJ/hr]
NTYPE 47	SQVAPW	sum of heat of vapor adsorption in walls of specified zones	[kJ/hr]

Surface Outputs:

NTYPE#	Label	Description	Unit
NTYPE 48	ICOND	condensation flag (0 or 1) for inside surfaces	
NTYPE 49	OCOND	condensation flag (0 or 1) for outside surfaces	
NTYPE 50	UWIN	U-value of glazing and frame for external windows	[kJ/ hr m^2 K]
NTYPE 51	GWIN	g-value (solar heat gain coeff.) of glazing only	
NTYPE 52	TIGLS	inside surface temperature of the glazing	[°C]
NTYPE 53	TOGLS	outside surface temperature of the glazing	[°C]
NTYPE 54	TIFRM	inside surface temperature of the frame	[°C]
NTYPE 55	TOFRM	outside surface temperature of the frame	[°C]

Zone Outputs:

NTYPE#	Label	Description	Unit
NTYPE 56	QSEC	secondary heat flux of all windows of zone	[kJ/hr]

Surface Outputs:

NTYPE#	Label	Description	Unit
NTYPE 57	TALM	node temperature of active layer	[°C]
NTYPE 58	TOFL	fluid outlet temperature of active layer	[kJ/hr]
NTYPE 59	QALFL	energy input by fluid of active layer to active layer (> 0: cooling, < 0: heating)	[kJ/hr]
NTYPE 60	QALE	energy input by gains of active layer to active layer	[kJ/hr]
NTYPE 61	QALTL	total energy input by fluid&gains of active layer to active layer	[kJ/hr]

Zone Outputs:

NTYPE#	Label	Description	Unit
NTYPE 62	PMV	predicted mean vote (PMV) value of zone	
NTYPE 63	PPD	predicted percentage of dissatisfied persons (PPD) value of zone	[%]

Surface Outputs:

NTYPE#	Label	Description	Unit
NTYPE 64	QSGL	solar rad. absorbed on all panes of window	[kJ/hr]
NTYPE 65	QSISH	solar rad. absorbed on internal shading device of window	[kJ/hr]
NTYPE 66	QSOFR	solar rad. absorbed on outside of ext. window frame	[kJ/hr]
NTYPE 67	QSIFR	solar rad. absorbed on inside frame and both sides of adjacent windows	[kJ/hr]
NTYPE 68	QSOUT	solar transmission to outside through external window	[kJ/hr]

Balance Outputs:

NTYPE#	Label	Description	Unit
NTYPE 901	Bal_1	Solar Balance for Zones	[kJ/hr]
NTYPE 902	Bal_2	Solar Balance for Sum of all Zones	[kJ/hr]
NTYPE 903	BAL_3	Solar Balance for External Window	[kJ/hr]
NTYPE 904	BAL_4	Energy Balance for Zones	[kJ/hr]
NTYPE 905	BAL_5	Energy Balance for Sum of all Zones	[kJ/hr]
NTYPE 906	BAL_6	Energy Balance for surfaces	[kJ/hr]
NTYPE 907	BAL_7	Moisture balance for zones	[kJ/hr]
NTYPE 908	BAL_8	Miosture Balance for Sum of all Zones	[kJ/hr]

6.2.3.5. Balance Outputs

Since Version 16 automatic balances are available. The balance output can be chosen like a normal output in TYPE56. In order to avoid to large files the balance is then printed hourly. (Note: The values actual values at the time and they **aren't integrated** except for balance 9). The balance output files are printed in the directory of the TRNSYS input file DCK

6.2.3.5.1. BALANCE 1 - SOLAR BALANCE FOR ZONES (NTYPE 901)

This Balance shows how much solar radiation is blocked how much is entering the zone and how much is exchanged with other zones. This balance is printed always for all zones in one file (called SOLAR_ZONES.BAL) if NTYPE 901 was selected in the output manager for one zone.

BAL_QSOL1= QSOLTOT+QSOLADJ-QBLK_REF-QBLK_ABSO-

QBLK_FRAU-QBLK_ESH-QSOL_LOS-QSOLABSI- Eq. 6.2.3-1

QBLK_RISH-QISH_CCI-QSOLWGAIN [kJ/hr]

Balance:

BAL_QSOL1 solar balance for one zone should be always 0.

Maximum possible Gains:

QSOLTOT total external solar radiation on all windows of one zone including frame

QSOLADJ solar gains due to exchange with adjacent zones (gains +; Losses -). Including multiple refection.

Blocked Gains:

QBLK_REF solar blocked due to reflection of glazing of all windows of a zone

QBLK_FRA solar blocked due to frames of all windows of a zone. Secondary heat flux into zone from absorbed solar on external surface of frame is not included.

QBLK_ESH solar blocked due to external shading devices of all windows of a zone

QBLK_ABSO solar blocked due to absorption on glazing of all external windows (only absorbed gains not entering the zone)

QBLK_RISH solar blocked due to reflection on internal shading devices of all windows of a zone

QSOL_LOS solar radiation leaving zone through external windows of zone (excluding solar reflected by internal shading device)

Gains of zone:

QSOLABSI Absorbed solar gains on all windows of zones going inside (secondary heatflux for total window including frame and internal shading device without CCISHADE Part)

QISH_CCI Absorbed on all internal shading devices of zone and directly transferred to the airnode by ventilation (CCISHADE).

QSOLWGAIN absorbed solar radiation on all walls of zone.

6.2.3.5.2. BALANCE 2 - SOLAR BALANCE FOR SUM OF ALL ZONES (NTYPE 902)

This balance is the same as Balance 1 but all values for all zones are summed up together. If NTYPE 902 was selected in the output manager for one zone, this balance is printed in one file called SOLAR_TOT.BAL.

6.2.3.5.3. BALANCE 3 - SOLAR BALANCE FOR EXTERNAL WINDOW (NTYPE 903)

This Balance shows how much solar radiation is blocked and how much is entering the zone through a EXTERNAL window. If NTYPE 903 was selected in the output manager, this balance will be printed for all selected external windows in one file each (called SOLAR_WIN_XXX.BAL). Due to the aim of this balance is to show the performance of a window and its shading devices only the solar radiation entering a external window is taken into account. Reflected radiation from the room or solar radiation entering through other windows is excluded from this balance.

BAL_QSOL3= QW_EXT_SOL-QW_BLK_ES

. -QW_BLK_FR-QW_BLK_REFG-QW_SOLABSO1

. -QW_BLK_REF_IS-QW_SOLABSO2 Eq. 6.2.3-2

. -QSHF_W_P-QW_TRANS_S [kJ/hr]

Balance:

BAL_QSOL3 solar balance for one external window should be always 0.

Maximum possible Gains:

QW_EXT_SOL total external solar radiation on the external windows including frame

Blocked Gains:

QW_BLK_REFG	solar blocked due to reflection of glazing of external window
QW_BLK_FR	solar blocked due to frame of external window of a zone.
QW_BLK_ES	solar blocked due to external shading devices of external window
QW_SOLABSO1	solar blocked due to absorption on glazing of external window (only absorbed from primary solar radiation on this window)
QW_BLK_REF_IS	solar blocked due to reflection on internal shading device (only shortwave radiation included)
QW_SOLABSO2	solar blocked due to reflection on internal shading device (part which is absorbed and then going out only longwave)

Gains of zone:

QSHF_W_P	secondary heatflux of external window only primary solar no reflected radiation or radiation through other windows included.
QW_TRANS_S	short wave transmission through external window to zone

Out of these parts the performance of the window and its shading devices can be calculated:

gtot = (QW_TRANS_S + QSHF_W_P) / QW_EXT_SOL

gtot = fc_Eshade * gframe * gglas * fc_ishade Eq. 6.2.3-3

6.2.3.5.4. BALANCE 4 - ENERGY BALANCE FOR ZONES (NTYPE 904)

The system boundary for this energy balance includes the inside surface node of all surfaces of a zone. Due to this also all radiative heat fluxes appear in this balance. This is different from the balance shown in Section 6.4.1.1 which could only treat the Convective Heat Flux to the Air Node. How ever the system boundary doesn't include the inside of a wall so the energy of an active layer as well as the stored energy of walls is not part of this balance but of the detailed balance for surfaces (see 6.2.3.5.6). If NTYPE 904 was selected in the output manager, this balance will be printed for all zones in one file (called ENERGY_ZONES.BAL).

BAL_ENERGY=- DQAIRdt+ QHEAT -QCOOL +QINF+QVENT+

QCOUP+QTRANS+ QGINT+ QWGAIN+ QSOLGAIN Eq. 6.2.3-4

[kJ/hr]

BAL_ ENERGY energy balance for one zone should be always closed to 0. In order to save time the matrix of TYPE 56 is not inverted all the time, but only if the error is less than a certain tolerance. Due to this fact the energy balance of the zone isn't always 0.

DQAIRdt change of internal energy of zone (calculated with capacitance of air +additional capacitance which might be added in trnbuild)

QHEAT power of ideal heating (convective+radiative)

QCOOL power of ideal cooling

QINF infiltration gains

QVENT ventilation gains

QCOUP coupling gains

QTRANS transmission into the wall from inner surface node (might be stored in the wall, going to a slab cooling or directly transmitted)

QGINT internal gains (convective+radiative)

QWGAIN wall gains

QSOLGAIN absorbed solar gains on all inside surfaces of zones (NOTE: This gain isn't equal to Balance 1, because the absorbed solar gains of the inside surface of all windows are taken into account. These absorbed gains may go inside or outside. For Balance 1, the absorbed gains on the inside and outside node going inside are used.)

6.2.3.5.5. BALANCE 5 - ENERGY BALANCE FOR SUM OF ALL ZONES (NTYPE 905)

This balance is the same as Balance 4 but all values for all zones are summed up together. If NTYPE 905 was selected in the output manager for one zone, this balance is printed in one file called ENERGY_TOT.BAL.

6.2.3.5.6. *BALANCE 6 - ENERGY BALANCE FOR SURFACES (NTYPE 906)*

This Balance shows the detailed energy balance of a surface. If NTYPE 906 was selected in the output manager, this balance will be printed for all selected walls in one file each (called ENERGY_SURF_XXX.BAL).

BAL_ENERGY_Surf= - DQwalldt - QCOMI + QCOMO + QT_RGain_i +QT_Rgain_o-QT_AL [kJ/hr] Eq. 6.2.3-5

BAL_ENERGY_Surf	energy balance for a surface should be always 0.
DQwalldt	change of internal energy of surface
QCOMI	combined heat flux to inside (going into zone+; going into wall -)
QCOMO	combined heat flux to outside (going to outside-; going into wall +)
QT_RGain_i	Total radiative gains for inner surface node (including solar gains, rad. internal gains wallgains and rad. heating see 6.4.1.3)
QT_RGain_o	Total radiative gains for outside surface node (including solar gains, rad. internal gains wallgains and rad. heating see 6.4.1.3)
QT_AL	Total energy gains by an active layer or a chilled ceiling (heating -; cooling +).

6.2.3.5.7. *BALANCE 7 - MOISTURE BALANCE FOR ZONES (NTYPE 907)*

This Balance shows the moisture balance for all zones separately. Note: if the humidity ratio reaches 100 % with an on going positive water gain to the zone. This will still lead to a increasing amount of water stored in the air while actually there would be water drops somewhere on surfaces.

BAL_MOISTURE_Z= dmw_air_dt+dmw_buffer_dt-mw_inf-mw_vent-mw_coupl- mw_gain -mw_heat_hum+mw_cool_dehum [kJ/h] Eq. 6.2.3-6

BAL_MOISTURE_Z	moisture balance for each zone should be always 0.
dmw_air_dt	change of water stored in the air of zone
dmw_buffer_dt	change of water stored in the surfaces of zone for the detailed humidity model (sum of deep and surface storage)
mw_inf	water gain of zone due to infiltration
mw_vent	water gain of zone due to ventilation
mw_coupl	water gain of zone due to coupling
mw_gain	water gain from internal loads

mw_heat_hum water gain due to ideal humidification of heating type

mw_cool_dehum water loss due to ideal dehumidification of cooling type

6.2.3.5.8. BALANCE 8 - MIOSTURE BALANCE FOR SUM OF ALL ZONES (NTYPE 908)

This balance is the same as Balance 7 but all values for all zones are summed up together.

6.2.3.5.9. BALANCE 9 – SUMMARY

This balance is automatically printed for all building simulations (SUMMARY.BAL). The first part of this summary balance is based on balance 4 - energy balance per zone (see 6.2.3.5.4) where all values per time step (not only each hour) are summed over the total simulation time.

BAL_ENERGY= -DQAIRdt+ QHEAT -QCOOL +QINF + QVENT

+ QCOUP + QTRANS + QGINT + QWGAIN + Eq. 6.2.3-7

QSOLGAIN [kJ]

The second part of this summary is based on balance 6 – energy balance for surfaces (see 6.2.3.5.6) where all values per time step (not only each hour) are summed over the total simulation time.

SUM_Dqwalldt = SUM_QCOMI + SUM_QCOMO +

SUM_QT_RGain_i + SUM_QT_Rgain_o – Eq. 6.2.3-8

SUM_QT_AL [kJ]

For a yearly simulation the integrated internal energy change of the wall this values should be small because the initial conditions are close to the final conditions of the simulation.

6.2.4. The Zone Window

The ZONE window contains all information describing a thermal zone of the building as shown in Figure 6.2.4-1. To add a new zone, click on ADD ZONE under the ZONES menu. An active zone can be deleted by clicking on DELETE ACTIVE ZONE under the ZONES menu.

In addition, you may use the zone manager by a right mouse click. For opening an existing zone click on the zone name within the zone manager. Since Windows 95 and 98 have a bug concerning the resource handling you may have up to 6 zone windows open at once only.

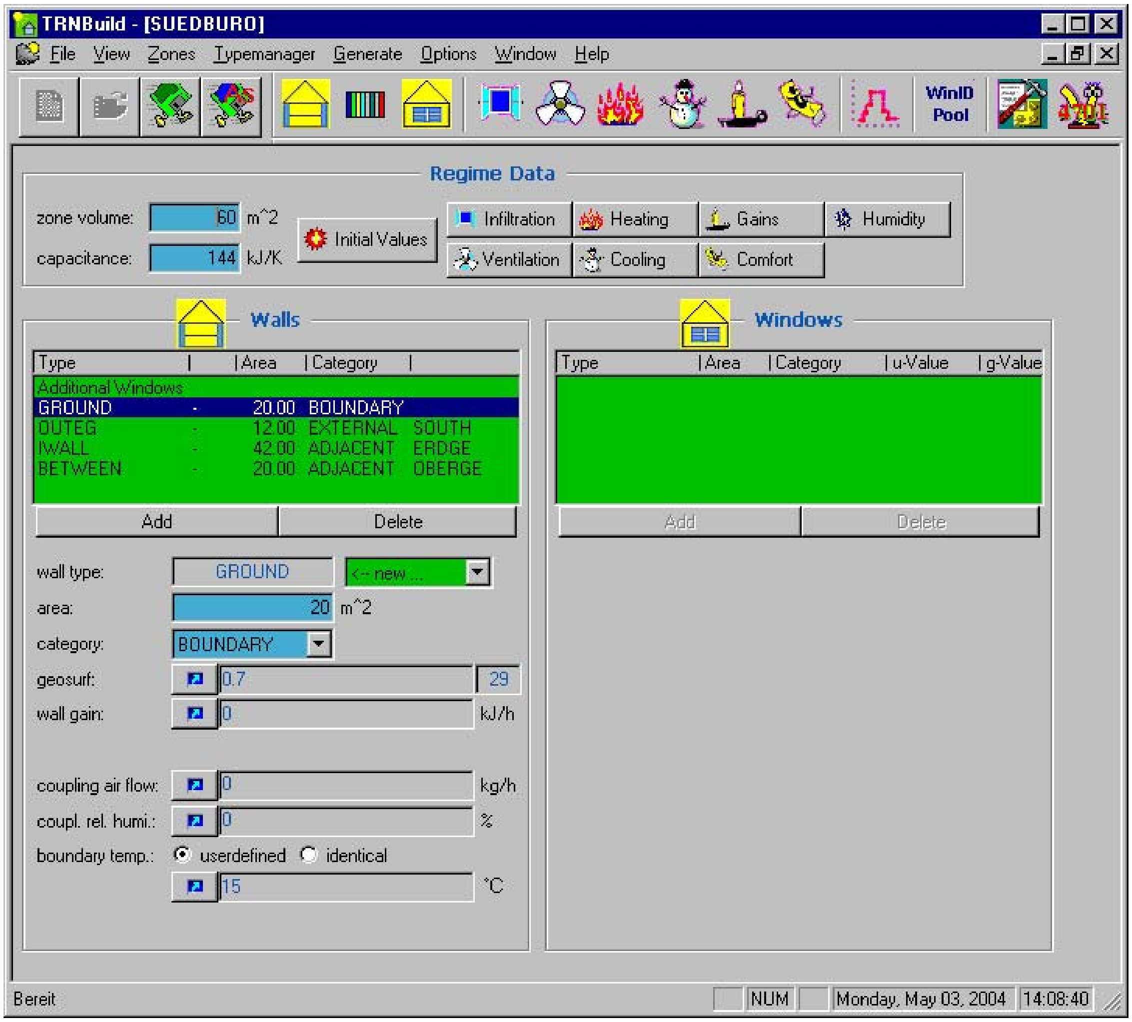


Figure 6.2.4-1: The ZONE window

The data describing a zone can be divided into four main parts:

a) the required REGIME DATA,

b) the WALLs of the zone

c) the WINDOWs of the zone and

d) optional equipment data and operating specifications including INFILTRATION, VENTILATION, COOLING, HEATING, GAINS and COMFORT.

When entering data for a new zone, it is recommended that the user proceeds in the order shown above.

6.2.4.1. Input of the Required Regime Data

The following data is entered in the REGIME DATA portion of the ZONE window:

- zone volume — volume of the air within the zone
- capacitance — total thermal capacitance of zone air plus that of any mass not considered as walls (e.g. furniture,...)
- initial temp. — initial temperature of the zone air
- initial rel. humidity — initial relative humidity of the zone air
- humidity model — a simple (capacitance) or detailed (buffer storage) model

In order to simplify the input, default values for all parameters except the ZONE VOLUME are provided. The CAPACITANCE will be automatically set to a default value of 1.2*VOLUME. However, it is recommended that the user check the default values carefully and to adjust them if necessary.

In order to model the buffer effect of humidity within a zone, two humidity models are available. The simple humidity model represents an effective capacitance model in which only the humidity capacitance ratio must be specified. The humidity capacitance ratio entered accounts for humidity capacitance of the air plus any other mass within the zone.

In addition to the simple model, a more detailed moisture capacitance model has been added since TRNSYS 14.2. This model describes a separate humidity buffer divided into a surface and a deep storage portion. Each buffer is defined by three parameters as shown in Figure 6.2.4-2. The exchange coefficient of the surface buffer storage describes the humidity exchange between the zone air and the surface buffer. The exchange coefficient of the deep buffer surface describes the humidity exchange of the surface and the deep buffer storage. See the main TRNSYS Reference Manual for a detailed description of this model.

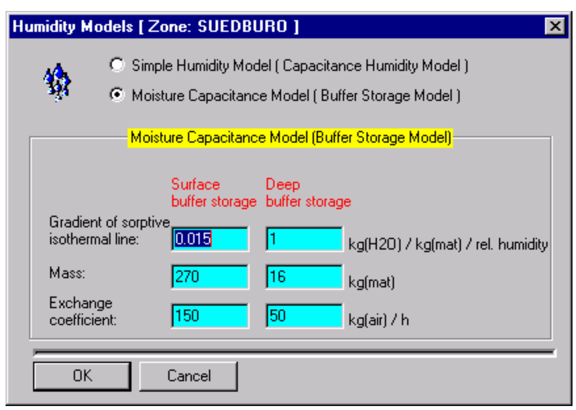


Figure 6.2.4-2: The DETAILED HUMIDITY MODEL window

6.2.4.2. Input of Walls

The information about WALLs within a zone is displayed in the left lower part of the ZONE window. Here, the user can add, delete or edit the walls of a zone. A box in the upper part provides an overview of all defined walls. By clicking on a wall within this overview box, the definition of the selected wall is displayed below and can be edited. To delete a defined wall, select the desired wall in the overview box and click on the DELETE button.

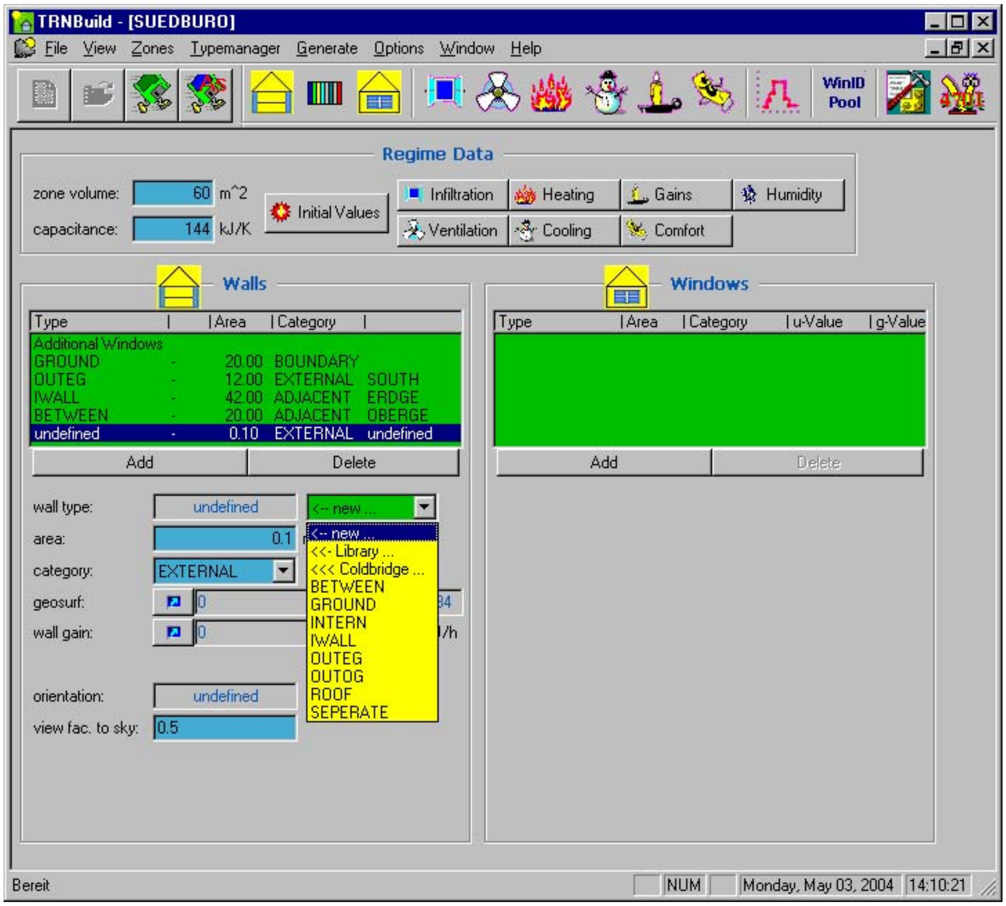


Figure 6.2.4-3: Adding a new wall

To add a new wall, click on the ADD button below the overview box and a new undefined wall is added as shown in Figure 6.2.4-3. Now it is necessary to define this new wall:

- WALL TYPE

The wall type can be specified by using the pull-down menu on the right side. This menu offers the option of defining a new wall type, selecting a wall type out of a library, defining a wall with coldbridge effect, or selecting a previously defined wall type. The first three options are explained later in detail. The name of the selected wall type appears in the display box.

- AREA

The entered area of the wall should include the area of all windows within the wall. For internal walls, the area should be doubled, because the front as well as the back surface of the wall is exposed to the zone.

- CATEGORY

The wall category is set to EXTERNAL by default. To change the wall category, use the pull-down menu on the right side. The following wall categories are available:

EXTERNAL	an exterior wall
INTERNAL	a wall within a zone
ADJACENT	a wall that borders another zone
BOUNDARY	a wall with boundary conditions

> Note: In contrast to the previous version, the wall categories do not change if a wall gain is defined.

- GEOSURF

Explicit distribution factors can be defined by the user for the distribution of direct solar radiation entering a zone. The value of GEOSURF represents the fraction of the total entering direct solar radiation that strikes the surface. The sum of all values of GEOSURF is not allowed to exceed 1 within a zone. The movement of the sun patches within a zone can be modeled by defining a SCHEDULE or an INPUT. The default value of GEOSURF is 0. If the sum of values within a zone is zero, the direct radiation is distributed the same way as the diffuse radiation (by absorptance weighted area ratios).Note: In the previous version both diffuse and direct radiation were always distributed according to absorptance weighted area ratios.

- SURFACE NUMBER

The surface number is a unique number used for surface identification. The number is generated by TRNBUILD automatically and displayed behind the edit box of GEOSURF in blue.

- WALL GAIN

With wall gain an energy flux to the inside wall surface can be defined

The display of the other required input data adjusts automatically based on the window category. For the “view factor to the sky” (fraction of the sky to the total hemisphere seen by the wall) a value ≤ 1 must be entered (i.e. 1 for a horizontal surface, 0.5 for a vertical surface with unobstructed view). The value is used as a weighting factor between ambient and sky temperature.

6.2.4.2.1. *THE WALL LIBRARY*

Before creating a new wall type, it is recommended that the user first check the wall library by selecting LIBRARY from the WALL TYPE pull-down menu within the ZONE window. The wall library window opens as shown in Figure 6.2.4-4.

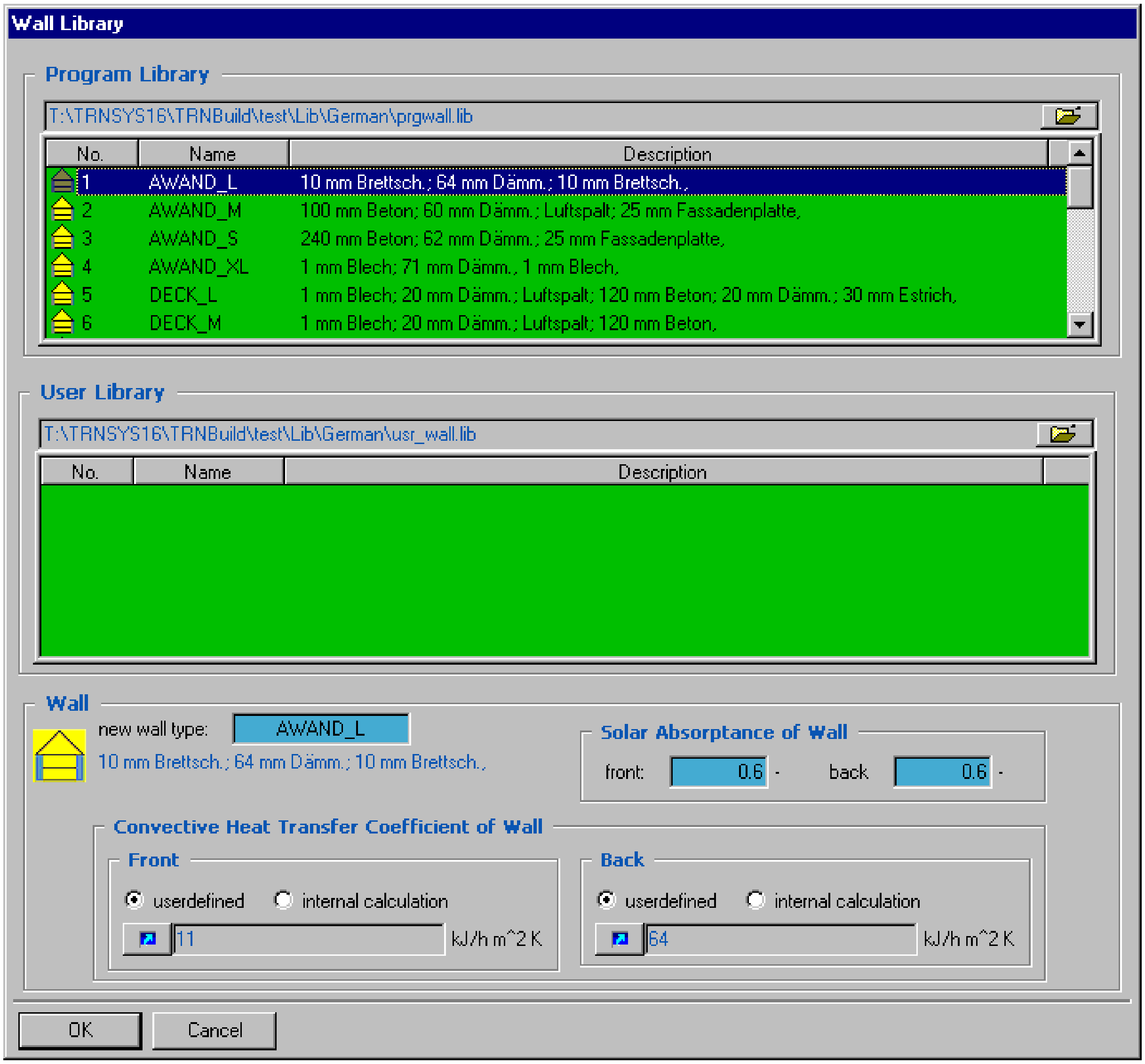


Figure 6.2.4-4: The WALL LIBRARY window

Here, the user can use the mouse to select the wall construction from two different libraries: a program library and a user library. If the German library version is selected under SETTINGS from the OPTIONS menu, typical wall constructions according to VDI 2078 are available. If the United States version is selected, 144 wall constructions according to the ASHRAE Standard are provided.

The definition of walls can be loaded from standard libraries as can be seen in the upper part or from user defined libraries. In both cases, path and file name can be changed from wall to wall by use of the interactive file dialog boxes.

A default wall type name is given by the program after the selection, but can be changed to a more meaningful one. The 'front' and 'back' default values for the solar absorptance and convective heat transfer coefficient correspond to the internal surface and external surface, respectively, for both vertical and horizontal external walls. Thus, they need to be adjusted based on the desired wall category.

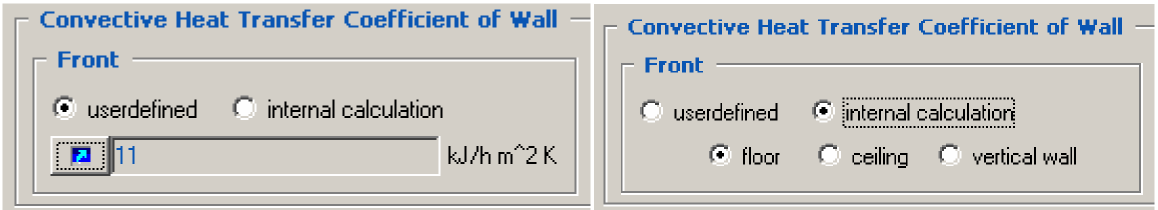


Figure 6.2.4-5: Heat transfer coefficient definition

While a constant heat transfer coefficient will be sufficient in most cases, it is possible to choose internal calculation if desired. You will have to select whether the wall is a floor a ceiling or vertical to fit the appropriate heat transfer mechanism. See Section 6.2.3.2 for further information.

6.2.4.2.2. DEFINITION OF A NEW WALL TYPE

To define a new wall type, select NEW from the pull-down menu of WALL TYPE within the ZONE window and a window as shown in Figure 6.2.4-6 will pop up. Besides entering a unique name for the wall type, the solar absorptance, and the convective heat transfer coefficient, the user must specify the construction of the wall type. The construction is specified by a series of layers starting from the "inside" surface (front) of the wall to the "outside" (back). The user can create a new layer, select a layer from a library or select a previously defined layer by using the right box and the arrow buttons. After entering the thickness the selected layer appears in the left box. The thickness of a layer in the left box can be edited by a double-click. (Note: In contrast to the previous version the layer thickness is no longer part of the layer type!!). TRNBUILD calculates the total wall thickness as well as a standard U-value. This standard U-value is determined with combined heat transfer coefficients of 7.7 W/ (m² K) inside and 25 W/ (m² K) outside.

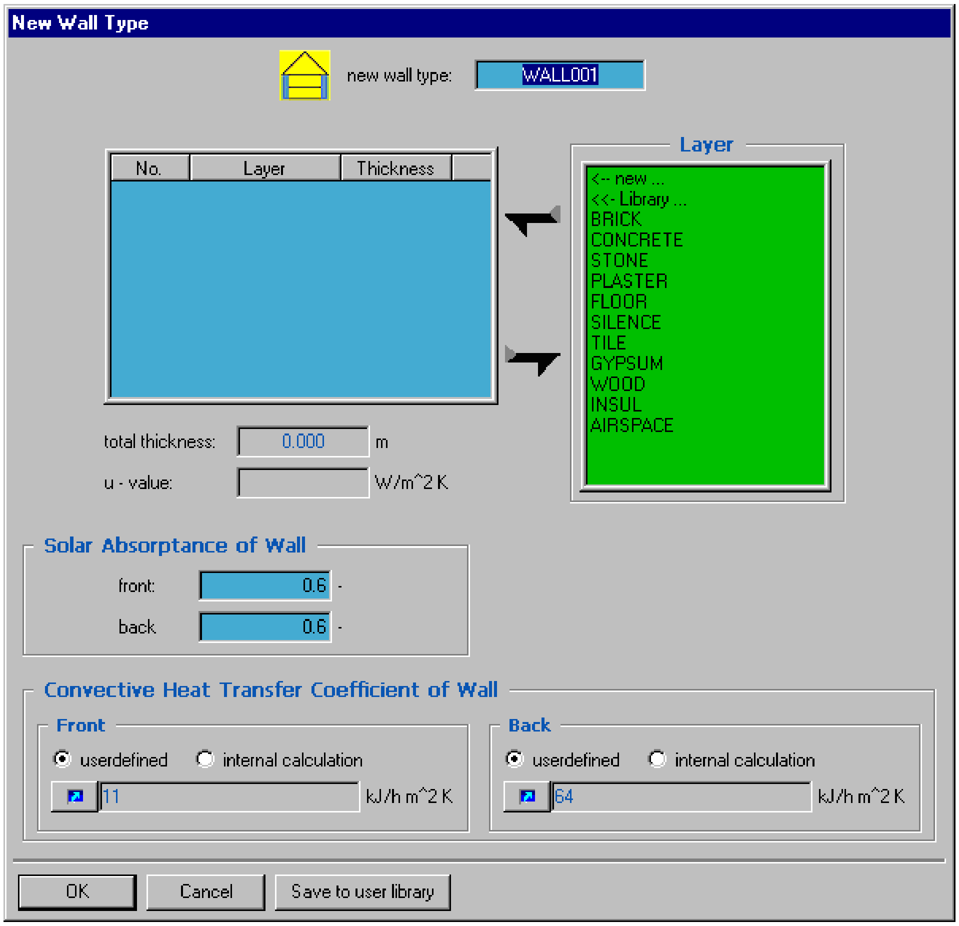


Figure 6.2.4-6: The NEW WALL TYPE window

Before defining a new layer, the user should first check the provided layer libraries by clicking on LIBRARY in the layer box. The layer library window opens as shown in Figure 6.2.4-7. Here, the user can use the mouse to select layers from two different libraries: a program library and a user library. If the German library version is selected under SETTINGS from the OPTIONS menu, over 500 different layers according to DIN4108 are available. If the United States version is selected, over 500 different layers are also available. A default layer name is given by the program, but it is recommended that the user change it into a more meaningful one. Finally, the user must specify the thickness of the layer.

If the user defines a new layer, the definition window for a new layer opens (see Figure 6.2.4-8). The user can now enter the corresponding material properties for the layer. To save the newly defined layer to the user library, press the SAVE TO LIBRARY button before clicking on the OK button. Henceforth, the saved layer will be available for other projects and will appear in the previously described layer library window.

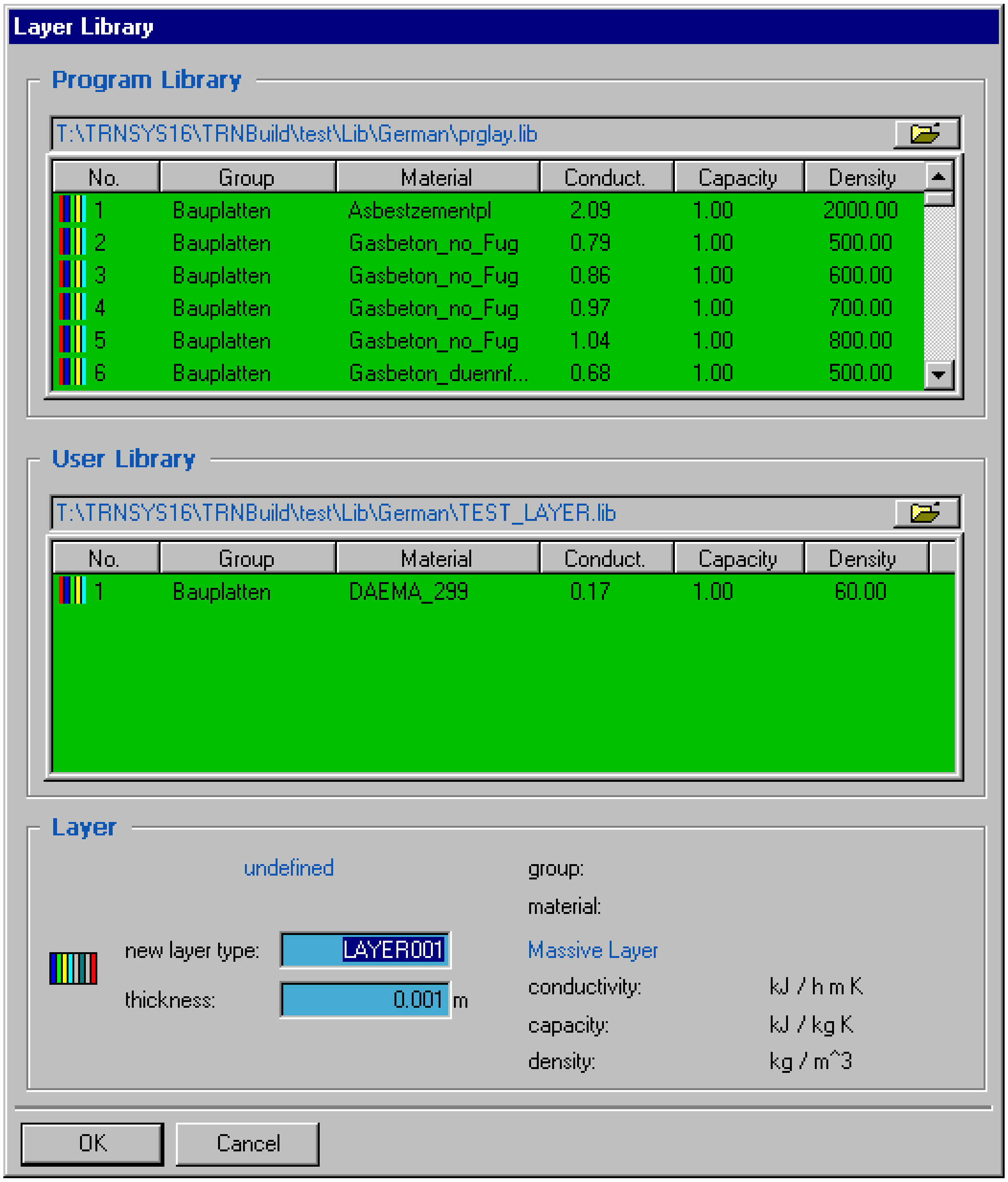


Figure 6.2.4-7: The LAYER LIBRARY window

Again, path and file name for program lib or user lib might be changed for each selected layer by use of file dialog boxes.

For the definition of a new layer there are 4 options:

- Massive: this is the most common one usually used in all constructions
- Massless: only used when trnbuild is not able to create the transfer functions of a wall with only massive layers. In that case this layer type is used for very thin layers where the thermal mass can be neglected
- Active: used for concrete core cooling and heating, capillary tube system and for floor heating and cooling systems (see Section 0)

- Chilled ceiling: chilled ceiling panel decoupled from the rest of the wall due to insulation or airspace (see Section 6.2.4.2.4)

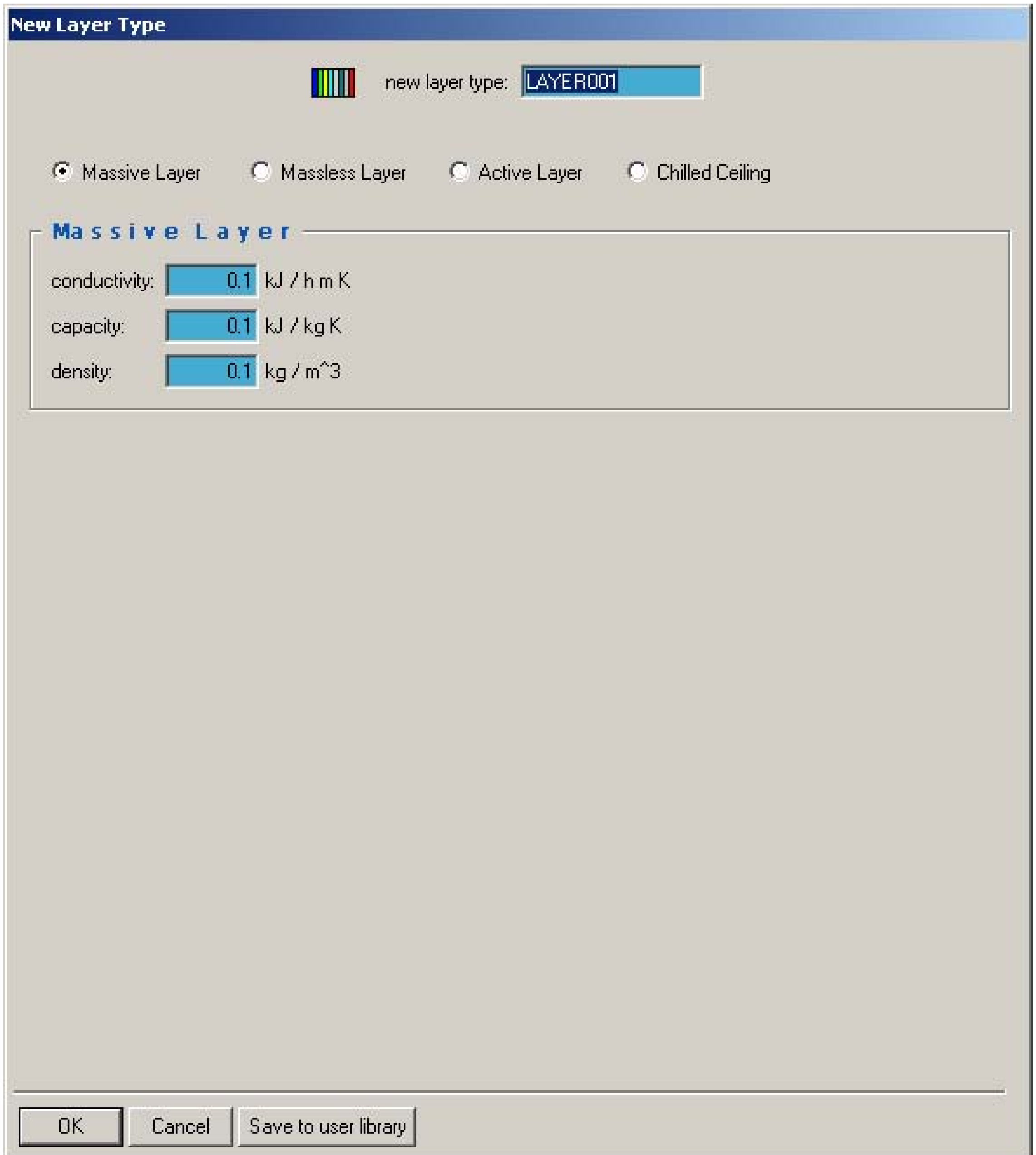


Figure 6.2.4-8: The NEW LAYER window

In addition to the wall construction coefficients of the solar absorptance is required. The solar absorptance coefficient depends on the properties of the wall finish.

Outside surface	solar absorptance coefficient
Roof tile, colored ceramic, slate, concrete	
• rough surface, dark red	0.75 ... 0.80
• smooth surface, dark color	0.70 ... 0.75
• asbestos concrete	0.60 ... 0.65
Roof coating	
• green	0.60 ... 0.65
• aluminum color	0.60 ... 0.65
• light grey, bright	0.30 ... 0.40
• white, smooth	0.20 ... 0.25
Exterior wall	
• smooth surface, dark color	0.70 ... 0.75
• rough surface, medium bright color yellow and yellow red clinker, brick)	0.65 ... 0.70
• smooth surface, medium bright color (chalky sandstone, asbestos concrete)	0.60 ... 0.65
• rough surface and white color	0.30 ... 0.35
• smooth surface and white color	0.25 ... 0.30
Metallic surface	
• zinc sheet, aged and dirty	0.75 ... 0.80
• aluminum, matted surface	0.50 ... 0.55
• aluminum color	0.35 ... 0.40
• bright and polished surface	0.20 ... 0.25

Note: In contrast to previous versions, the solar absorptance coefficient should **not be used** for solar radiation distribution. The distribution factor GEOSURF has been implemented for that behalf.

Finally, the convective heat transfer coefficient (without a radiative part!) must be defined. Common values are:

- inside: 11 kJ / h m² K
- outside: 64 kJ / h m² K

Figure 6.2.4-9: Heat transfer coefficient definition

While a constant heat transfer coefficient will be sufficient in most cases, it is possible to choose internal calculation for any wall within a zone if desired. You will have to select whether the wall is a floor a ceiling or vertical to fit the appropriate heat transfer mechanism. See Chapter 6.2.3.2 Properties for further information.

> Note: The automatic calculation of heat transfer coefficients is only appropriate for inside surfaces. There for it can not be used for outside surfaces of external or boundary walls. For this kind of surfaces a user defined correlation may be defined taking into account also wind influence.

6.2.4.2.3. *DEFINITION OF A WALL WITH AN ACTIVE LAYER*

For modeling a radiant heating and cooling, an "active layer" is added to the wall, floor or ceiling definition. The layer is called "active" because it contains fluid filled pipes that either add or remove heat from the surface. In general, the definition process begins similarly to that of a normal wall. The active layer is described by 5 parameters (see Figure 6.2.4-10).

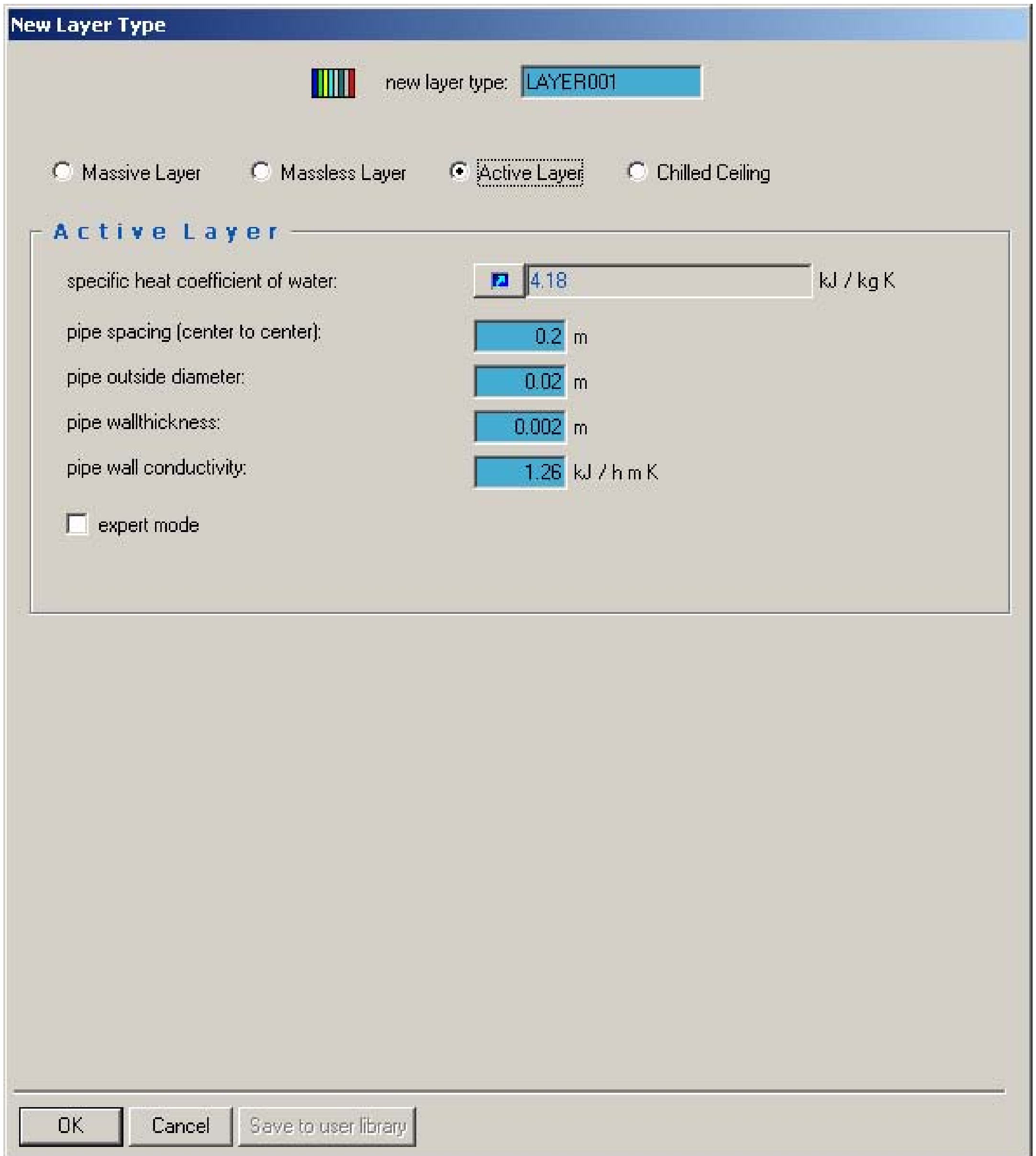


Figure 6.2.4-10: NEW ACTIVE LAYER

For surfaces containing an active layer, the convective heat transfer coefficient between surface and zone air is depends on the temperature of the active layer. Consequently, it is recommended to use the internal calculation of heat transfer coefficient, see Section 6.2.3.2 for further information.

After finishing the wall definition, the wall is marked with an “A” in the overview box of walls. In addition, a button for the active layer specification is displayed in the zone window. By clicking on this button entities like the inlet mass flow rate, inlet temperature, number of loops and additional energy gain at the fluid level (see Figure 6.2.4-11) can be modified. The number of loops is used for calculating the pipe length:

$$\text{pipe length} = \frac{\text{wall area}}{\text{pipe spacing} \cdot \text{number of loops}}$$

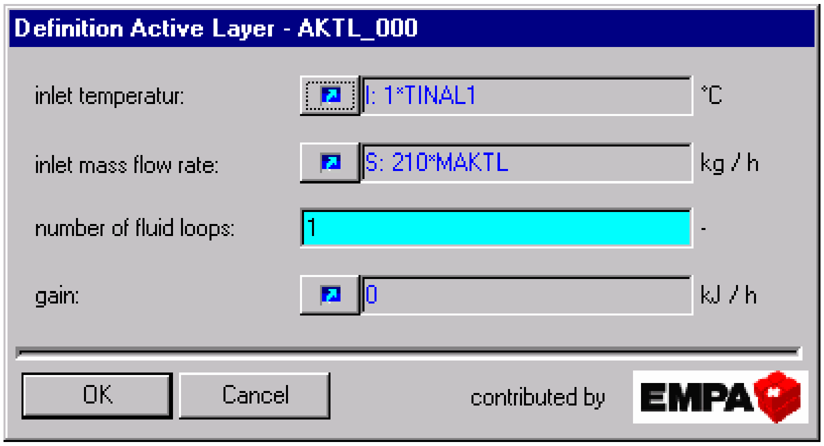


Figure 6.2.4-11: The ACTIVE LAYER SPECIFICATION window

The following thermoactive systems can be modeled:

- Concrete core cooling and heating
- Capillary tube system
- Floor heating and cooling systems

Concrete core cooling and heating

According to the equations given in the manual a specific minimum mass flow rate is necessary to assure that a linearization of the exponential curve between inlet and outlet temperature is possible. In most common cases the specific mass flow rate has to be greater then 13 kg/hm² (the exact value is calculated for each active Layer). Therefore an ordinary piping system can be modeled by 2 segments in series for most cases. The thickness of both layers adjacent to the active layer must be ≥ 0.3 * pipe spacing

Capillary tube system

In addition to previous versions, capillary tube systems can now be modeled too. Unfortunately, 2 segments in series like for the ordinary piping system are insufficient: Depending on the entered data up to 8 segments are required.

Floor heating and cooling system

For defining floor heating and cooling systems, please follow this guideline:

1. For entering the layers of the floor heating system start with a thickness of the layer adjacent to the active layer with a thickness ≥ 0.3 * pipe spacing.

2. Define an active layer. Automatically, a new layer with the same properties of the layer above the active layer is added below.

3. Enter an insulation layer with a resistance of at least 0.825 (m^2 K / W)

4. Now you can modify the thickness of the layer between the active layer and the insulation layer (thickness ≥ 1/ 2 * outside pipe diameter)

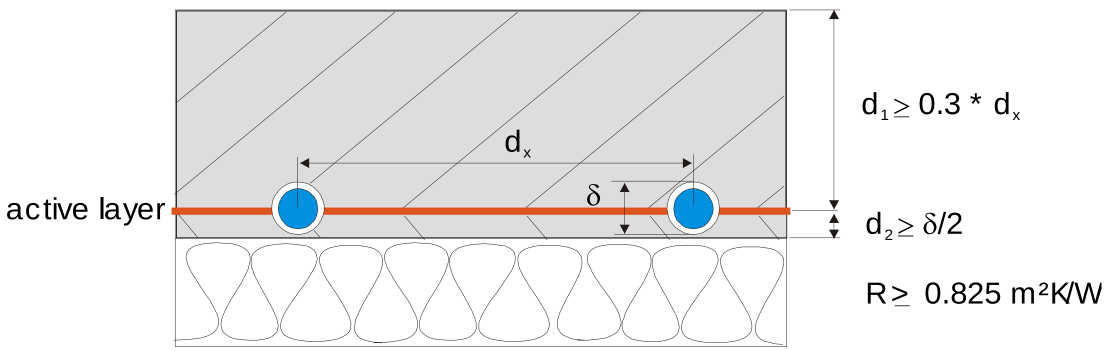


Figure 6.2.4-12: Wall with an ACTIVE LAYER for floor heating or cooling

5. After confirmation of the inputs you get back to the regime data window. When the active layer wall is selected, you see a specification button, leading you to the next menu, the active layer definition window (see Figure 6.2.4-14).

Figure 6.2.4-13: Active Layer Specification Bar

6. Depending on the definition of pipe diameter, spacing, mass flow per unit area etc. it might be necessary to define several segments. The first segment of a heating system will have the highest surface temperature, resulting in a higher heat flow to the room, the next segment somewhat smaller and so on. To ease the use of the active layer and to support a physically correct use, an automatic specification tool, called "Autosegmentation" is provided. Pushing the DO-Button (see Figure 6.2.4-14) will generate the appropriate number of surfaces related to the segments. If you want to see the details of that calculation, toggle the “show calculation” check box on before autosegmentation.

Note: the check disappears anyway after segmentation. The surface numbers associated with the segments appear in the “surface number of segments” window, except when no segments are needed; in this case the statement “no segmentation” appears.

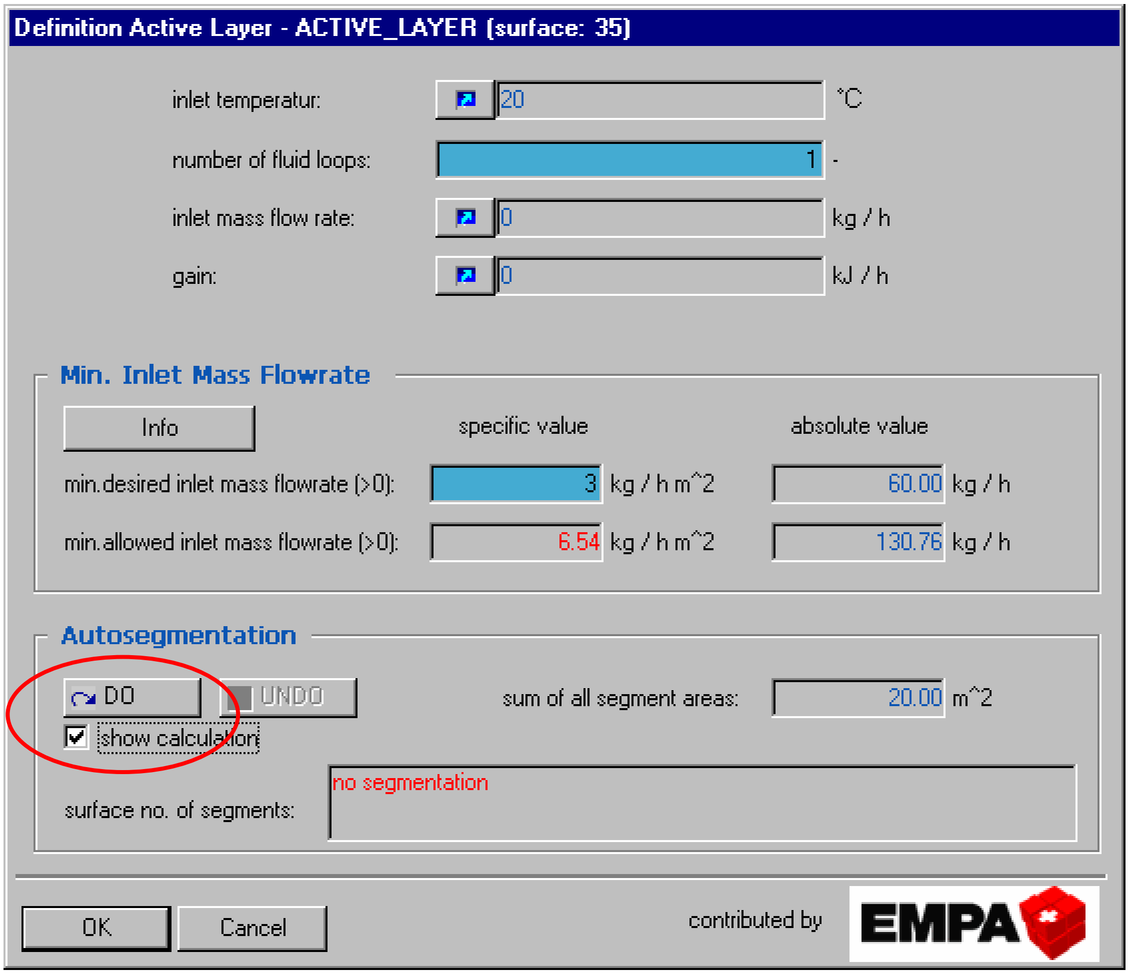


Figure 6.2.4-14: Do autosegmentation

7. Finally, press the OK-button, then the wall window shows the active layer wall you defined indicated by AS1, and a number of surfaces indicated by ASN. The original area value of the active layer wall is evenly shared between these surfaces (see Figure 6.2.4-15).

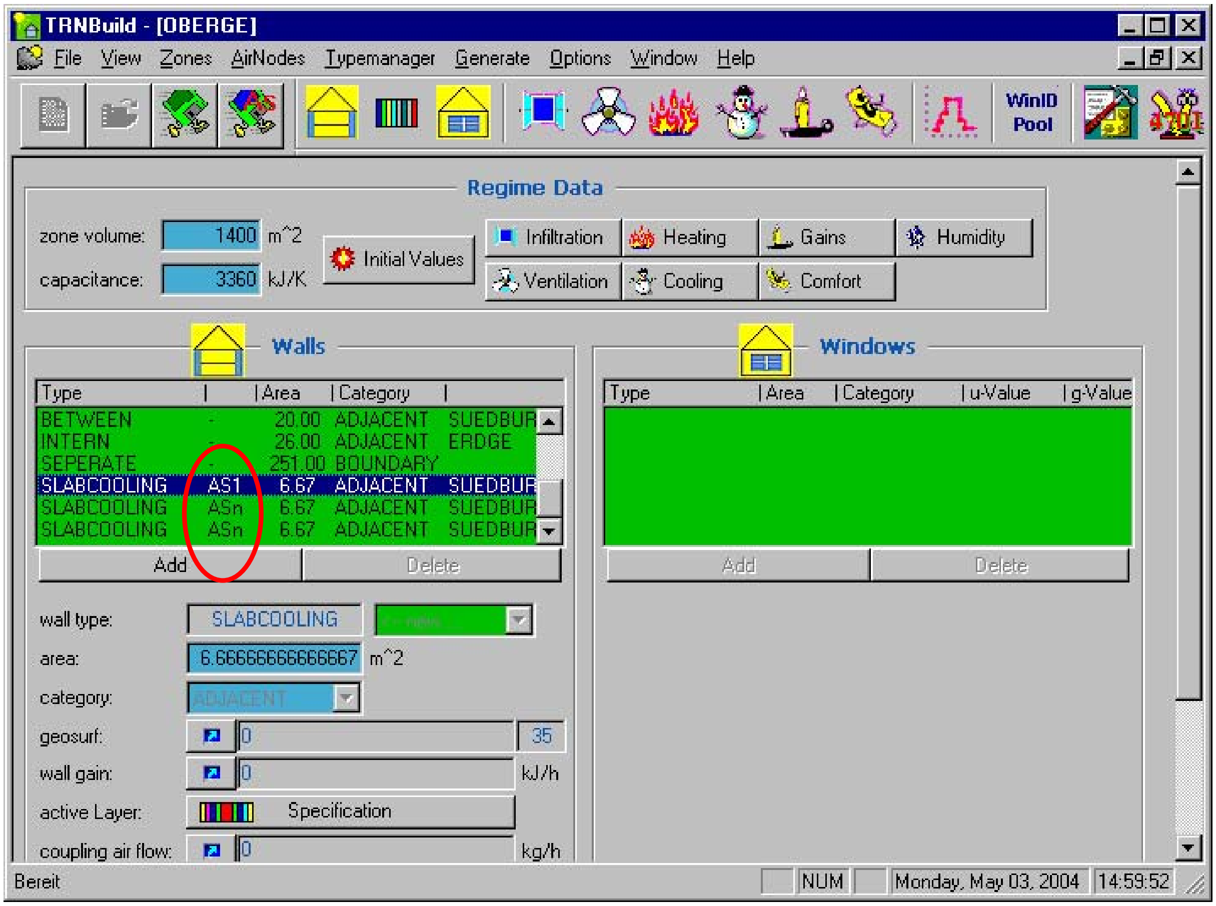


Figure 6.2.4-15: Auto segments AS1 Asn

The bui-file syntax uses the keywords MFLOWMIN for the minimum mass flow rate allowed and ASEGSURF for the list of associated wall segments:

```
WALL  =BDU_AL1133 : SURF= 91 : AREA=        7 : BOUNDARY=INPUT 1*TRAUM : INTEMP = INPUT 1*TINAL1 : MFLOW = INPUT 1*MFTAB : NLOOP = 1 ;
: MFLOWMIN = 2 : ASEGSURF = 91 ,5 ,6 ,
WALL  =BDU_AL1133 : SURF=  5 : AREA=        7 : BOUNDARY=INPUT 1*TRAUM : MFLOW = INPUT 1*MFTAB : NLOOP = 1 ;
: MFLOWMIN = 2 : ASEGSURF = 91 ,5 ,6 ,
WALL  =BDU_AL1133 : SURF=  6 : AREA=        7 : BOUNDARY=INPUT 1*TRAUM : MFLOW = INPUT 1*MFTAB : NLOOP = 1 ;
: MFLOWMIN = 2 : ASEGSURF = 91 ,5 ,6 ,
```

Figure 6.2.4-16: Keywords associated with segmentation

6.2.4.2.4. DEFINITION OF A WALL WITH A CHILLED CEILING LAYER

For modeling a cooling ceiling panel, a “chilled ceiling” layer (see Figure 6.2.4-17) is added to the ceiling definition. This layer can only be added on position 1 or for adjacent walls using the FRONT/BACK switch on the last position of a wall definition.

Beside the parameters pipe spacing, inside diameter and specific heat coefficient of fluid additional parameters to define the performance at test conditions after the German norm DIN

4715-1 for the chilled ceiling panel are needed. This parameters as specific norm power, specific norm mass flow rate, norm area and norm number of loops can be obtained from the producer of a chilled ceiling panel.

There are two options for the chilled ceiling panel to be coupled to the ceiling.

The first is an air gap between chilled ceiling and ceiling. In that case the air gap and the heat transfer within the gap is model internally and the air gap has not to be defined as a Layer. So the next layer after a chilled ceiling in a wall definition could be e.g. a concrete layer.

The second option is direct contact: in that case the model requires for the next layer in the wall definition a insulation with a Resistance > 10

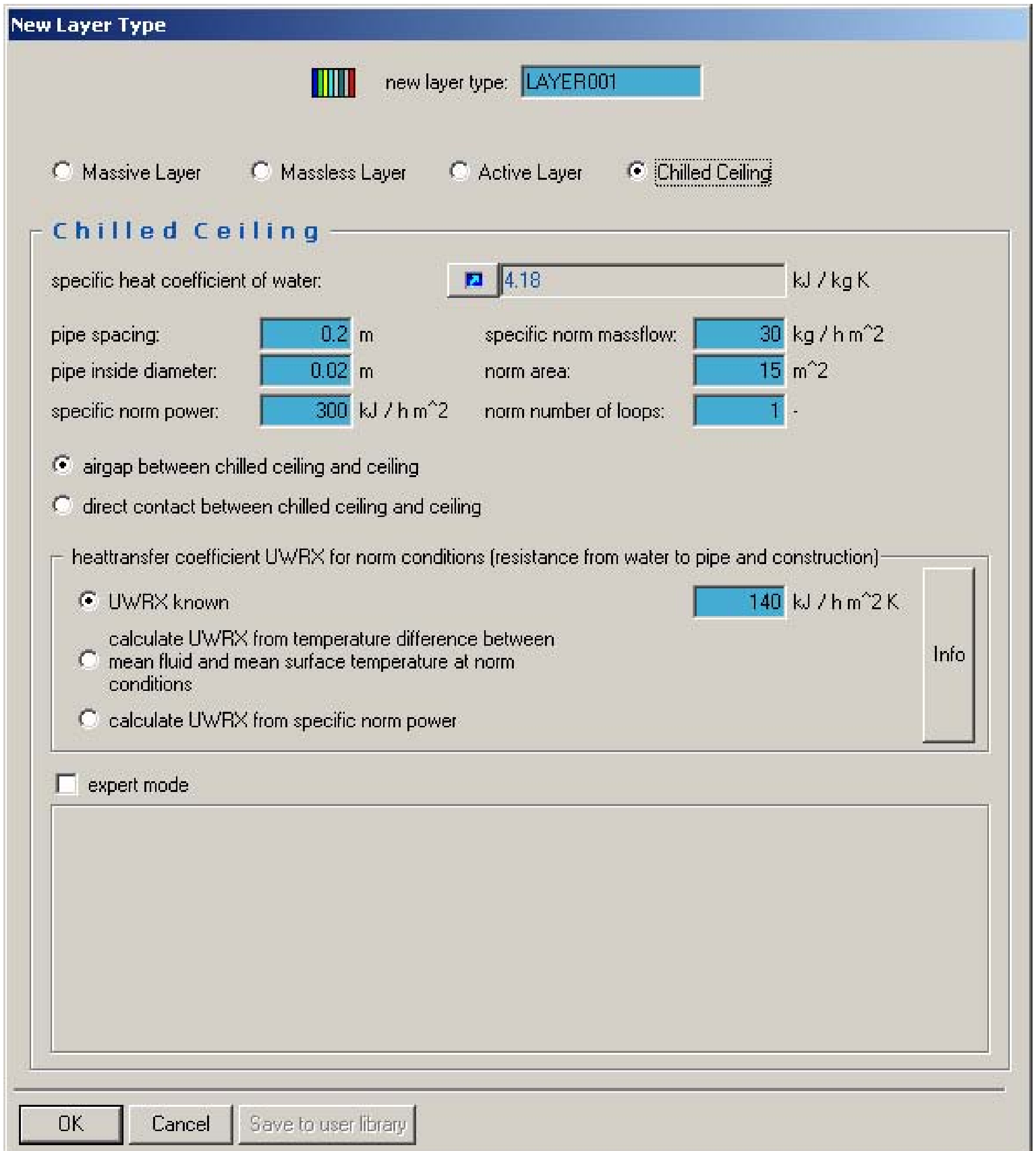


Figure 6.2.4-17: The chilled ceiling window

To divide the specific normpower into radiative and convective part the mean surface temperature $\vartheta_{o,kd}$ has to be known at test conditions unfortunately only the mean fluid temperature ϑ_W is a standard output of a chilled ceiling panel test after DIN4715-1 (see Figure 6.2.4-18).

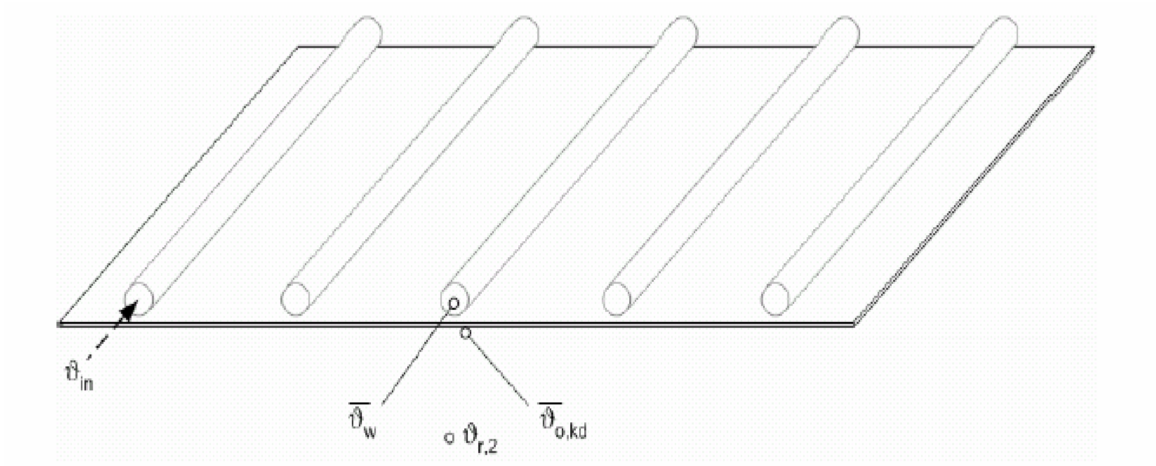


Figure 6.2.4-18: chilled ceiling panel

Figure 6.2.4-19 shows the resistance model for chilled ceiling test conditions after 4715-1. With the heat transfer coefficient Uwrx = 1/ (Rw+Rr+ Rx) the mean surface temperature can be calculated for any condition. The heat transfer coefficient Uwrx can be calculated internally from the specific norm power with an approximation for common used chilled ceiling panels or be an user defined input. Also the difference between mean fluid temperature and mean surface temperature if known for test conditions can be entered directly. The resulting heat transfer coefficient Uwrx is then displayed for information only.

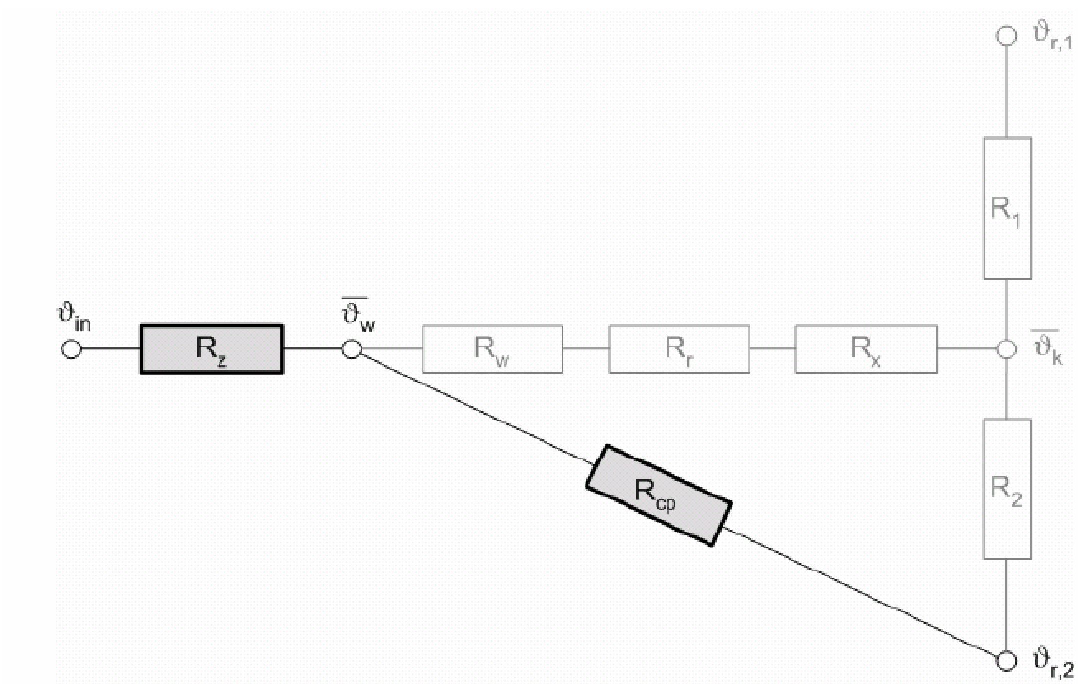


Figure 6.2.4-19: Resistance model for chilled ceiling test conditions after 4715-1.

In an expert mode additional heat transfer coefficients for the upper and the lower side of a chilled ceiling panel may be added. Also the coefficients for the calculation of the heat transfer in an air gap may be modified in the expert mode.

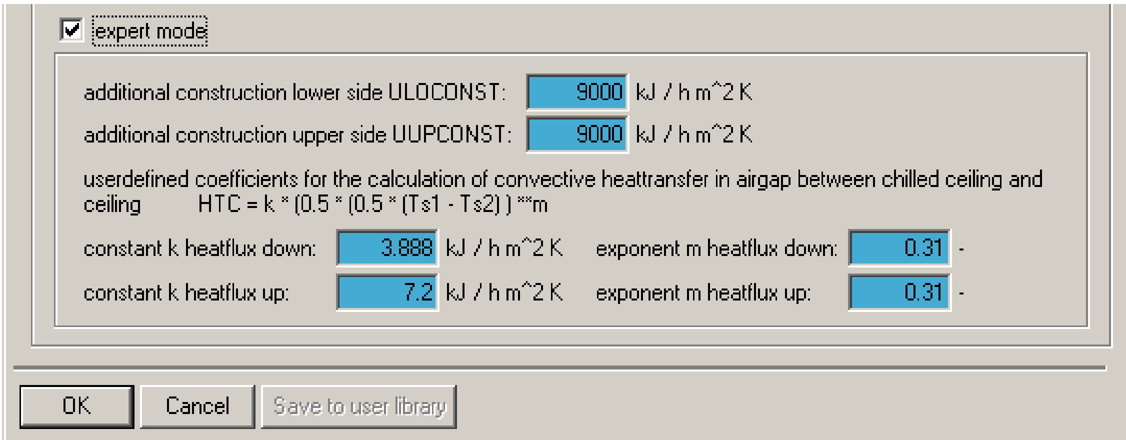


Figure 6.2.4-20: Expert mode for chilled ceiling

The model automatically calculates the convective heat transfer into the room depending on the panel surface temperature and the zone air temperature. The model adjusts the heat transfer calculated according to TYPE 80 with a fin-factor to fit the performance at norm conditions e. g. for a convective cooling panel. Therefore the convective heat transfer coefficient option for a wall with chilled ceiling is always predefined by TRNBUILD on the side with the chilled ceiling layer to internal calculation/ceiling (see Figure 6.2.4-21).

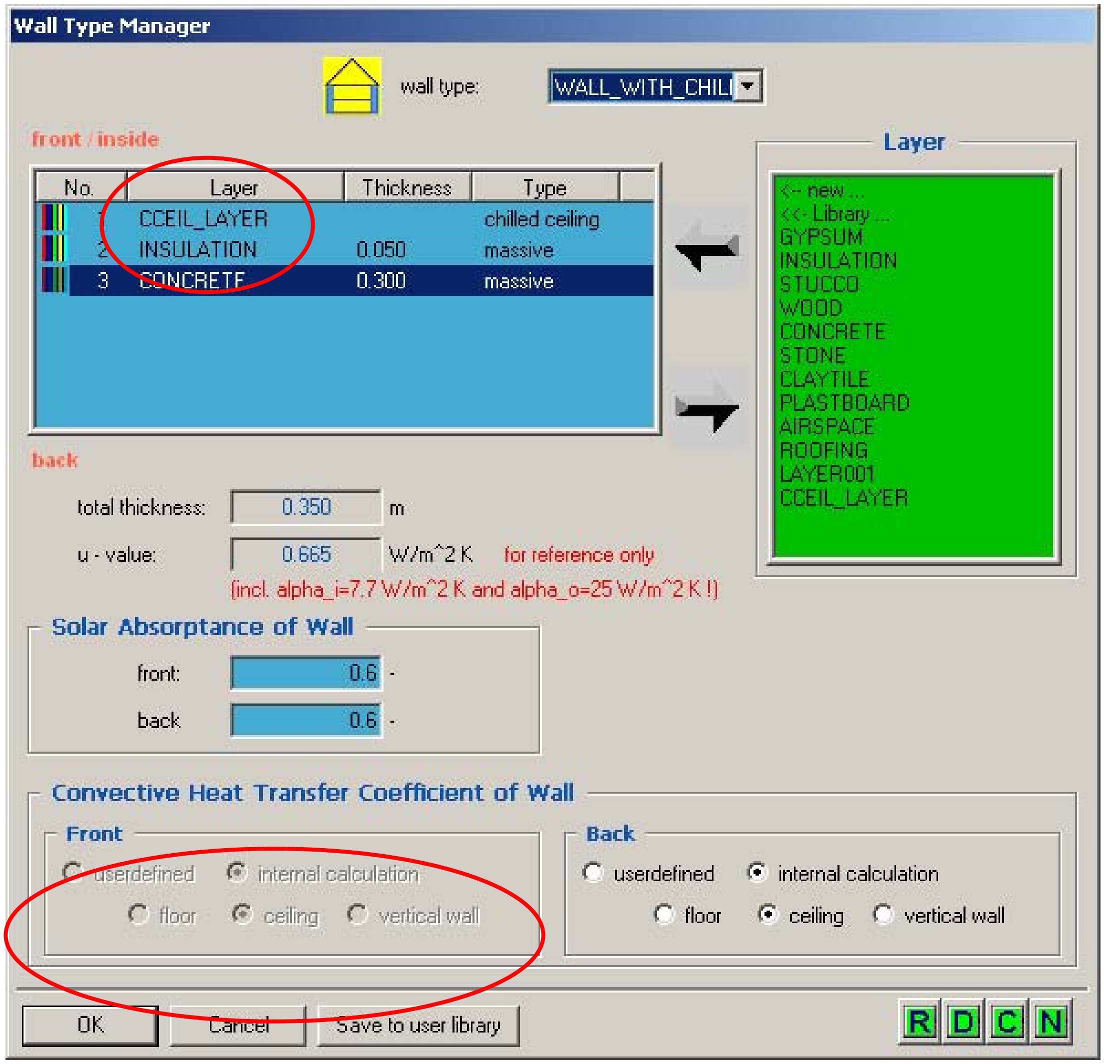


Figure 6.2.4-21: Wall with chilled ceiling window

With a double click on the specification bar of a wall with chilled ceiling this will open a window where for each wall with a chilled ceiling the inlet temperature the mass flow rate and the number of fluid loops can be entered.

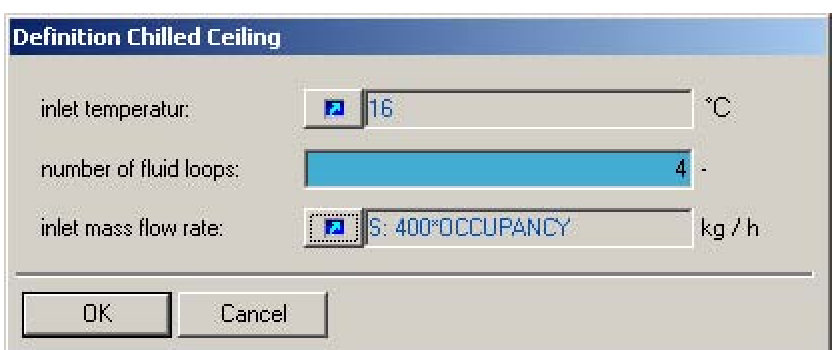


Figure 6.2.4-22: chilled ceiling specification window

6.2.4.2.5. DEFINITION OF A WALL WITH COLDBRIDGE EFFECT

The process of defining an external wall with coldbridge effects is similar to the previously described process. To define such a wall type, select COLDBRIDGES from the pull-down menu of WALL TYPE within the ZONE window and a window will pop up as shown in Figure 6.2.4-23. The user must enter a new unique name of the wall type. This name must start with the letters CBR in order to be recognized as a wall with coldbridge effect. Afterwards, the thermal resistance of the coldbridge must be entered. The layer type is automatically given the name of the wall type. Finally, the solar absorptance and the convective heat transfer coefficient must be specified.

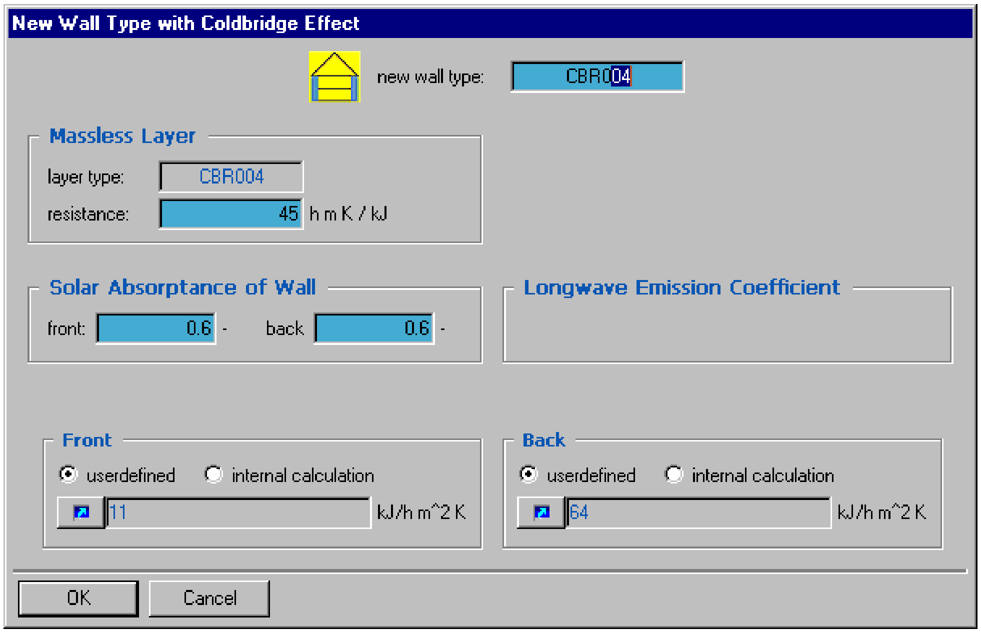


Figure 6.2.4-23: The NEW WALL TYPE with COLDBRIDGE EFFECT window

After clicking the OK button, the LENGTH of the cold bridge must be entered. If, for example, the cold bridge consists of an edge formed by two exterior walls, the length of that edge has to be input. TRNBUILD automatically selects the wall category EXTERNAL and the user must select an orientation and a view factor to the sky.

6.2.4.3. Input of Windows

Windows can be defined for external and adjacent walls or as additional window without a related wall. If an external or adjacent wall (without coldbridge effect) is highlighted in the overview box of walls, the right part of the ZONE window allows the user to edit, delete or add windows for that particular wall.

By clicking on a window within the overview box, the definition of the selected window is displayed below and can be edited. To delete a defined window, select the desired window in the overview box and click on the DELETE button.

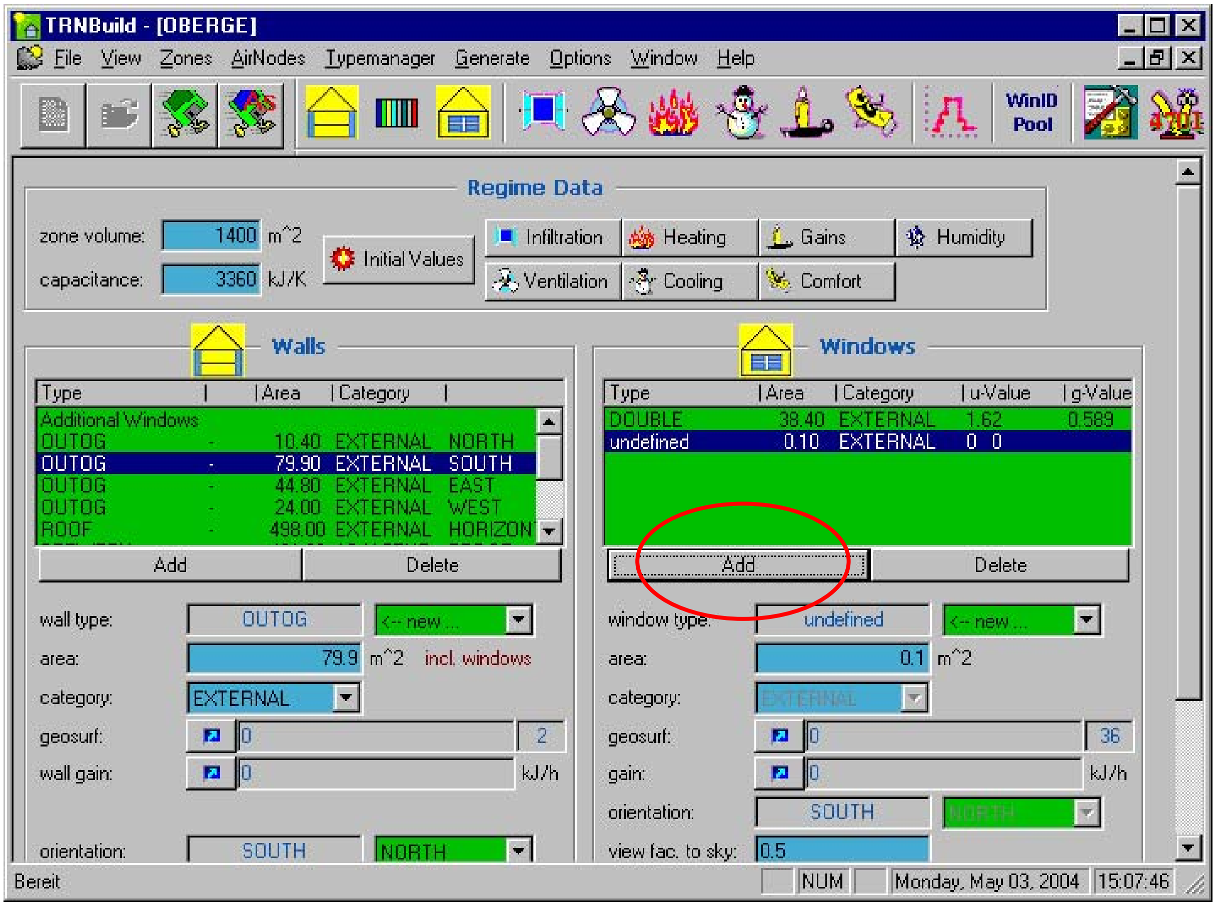


Figure 6.2.4-24: Adding a new window

To add a new window, click on the ADD button below the overview box and a new undefined window is added as shown in Figure 6.2.4-24. Now, it is necessary to define this new window:

- WINDOW TYPE

The window type can be specified by using the pull-down menu on the right side. This menu offers the options of defining a new window type, selecting a window type out of a library or selecting a previously defined window type. The first two options are explained later in detail. The name of the selected window type appears in the display box. Also, TRNBUILD displays the U-value (describing window losses) and the g-value (solar heat gain coefficient or SHGC) of the selected window for user information (if available).

- AREA

When the *.BUI file is written, the entered area of the window will be subtracted automatically from the wall area.

- CATEGORY

The category is created automatically by TRNBUILD depending on the wall category (external or adjacent)

- GEOSURF

Explicit distribution factors can be defined by the user for the distribution of direct solar radiation entering a zone. The value of GEOSURF represents the fraction of the total entering direct solar radiation that strikes the surface. The sum of all values of GEOSURF is not allowed to exceed 1 within a zone. The movement of the sun patches within a zone can be modeled by defining a SCHEDULE or an INPUT. The default value of GEOSURF is 0. If the sum of values within greater zero but not equal 1 used GEOSURF values will be normalized so that the sum in the zone is equal 1. If the sum of values within a zone is zero, the direct radiation is distributed the same way as the diffuse radiation (by “absorptance” weighted area ratios). Note: In the version 14.2 both diffuse and direct radiation were always distributed according to absorptance weighted area ratios.

- SURFACE NUMBER

The surface number is a unique number used for surface identification. The number is generated by TRNBUILD automatically and displayed behind the edit box of GEOSURF in blue.

- GAIN

With gain an energy flux to the inside window surface can be defined

- ORIENTATION

The orientation needs to be defined for adjacent windows and so called “additional windows” (windows that do not relate to a wall). For the adjacent windows either the orientation of the front side or the back side can be used.

- SHADING DEVICE

For an EXTERNAL window the user can select an internal and/or external shading device and must specify its shading factor. As the DEF button indicates, the shading factor can be a constant, an input or a schedule. For an adjacent window an internal shading device can be defined at the FRONT side only.

The display of further required input data adjusts automatically based on the window category. For the “view factor to the sky” (fraction of the sky to the total hemisphere seen by the window) a value ≤ 1 must be entered. For an unobstructed surface with the slope β, FSKY is calculated by the following equation: $FSKY = (1+\cos\beta)/2$ (i.e. 1 for a horizontal surface, 0.5 for a vertical surface with unobstructed view). The value is used as a weighting factor between ambient and sky temperature and thereby especially important for windows.

6.2.4.3.1. THE WINDOW LIBRARY

Before creating a new window type, it is recommended that the user first checks the window library by selecting LIBRARY from the pull-down menu of WINDOW TYPE within the ZONE window. The window library opens as shown in Figure 6.2.4-25.

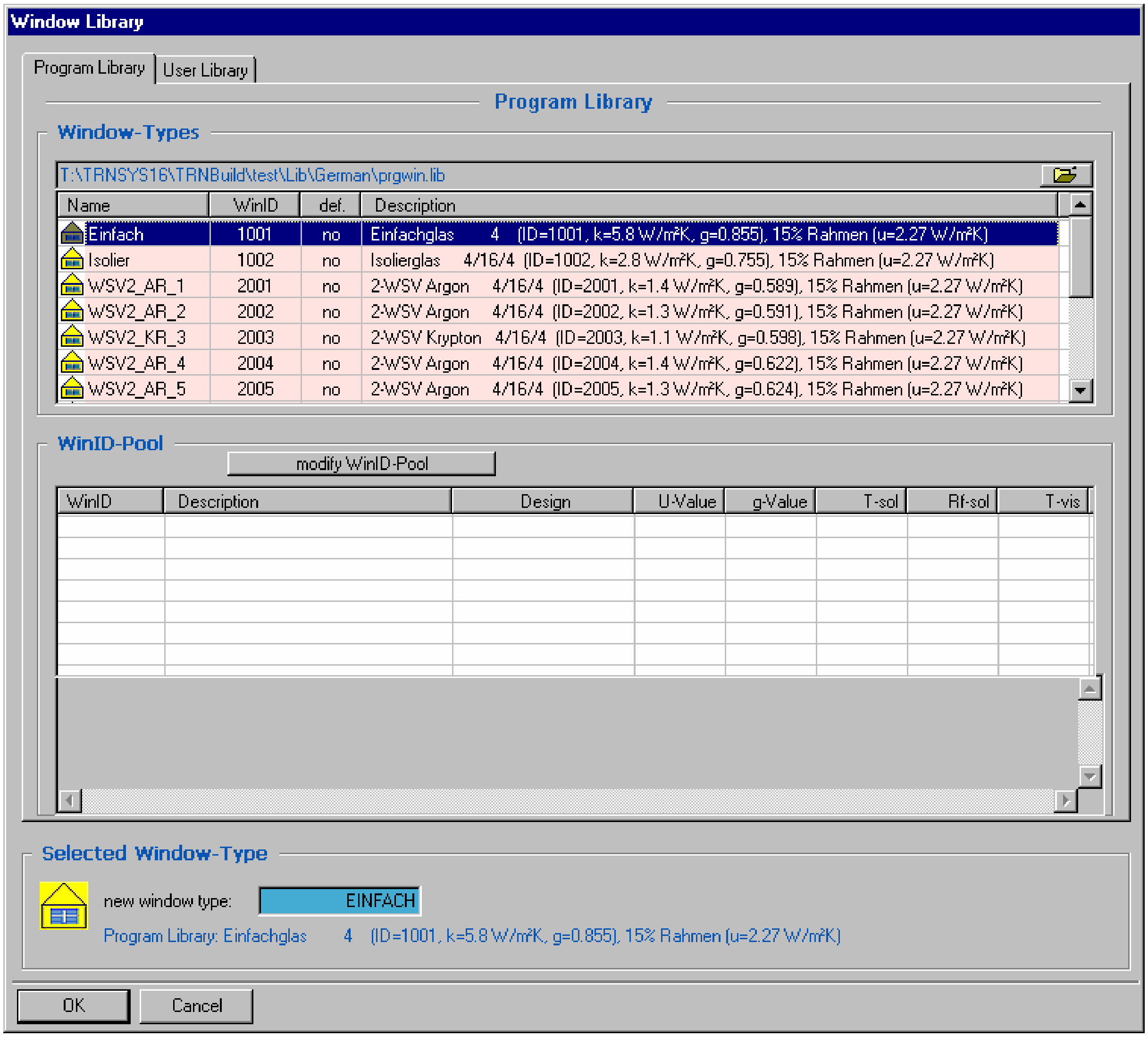


Figure 6.2.4-25: The WINDOW LIBRARY window

Former versions of TRNBUILD had a problem due to portability of TRNSYS simulation models, since window library data were just linked to a certain library by path and name. Exporting bui-files to another computer with same path structure, but different window library content thus resulted in obviously differing results.

Now consistency is ensured by a complete storage of all these information in a data pool exclusively related to the building under examination and stored in the bui-file itself.

Windows can be stored with all their information about frame, spacing and shadings in a User Library. Since Version 16 the detailed glazing data will be also stored in a data pool exclusively related to the library.

If you want to add a window from a User Library of a version before TRNSYS 16 all windows with missing glazing data will first appear red. Figure 6.2.4-25 shows this for a window definitions by use of WINID like “1001”.

You can modify the WINID-pool data by selecting the path where your glazing data for this User Library was located in the former Version e.g.: “c:\Trnsys15\prebid\Lib\German\W4-Lib.dat”. This results in a connection between IDs and related physical input (see Figure 6.2.4-26). All windows with available glazing data in the Library will appear yellow.

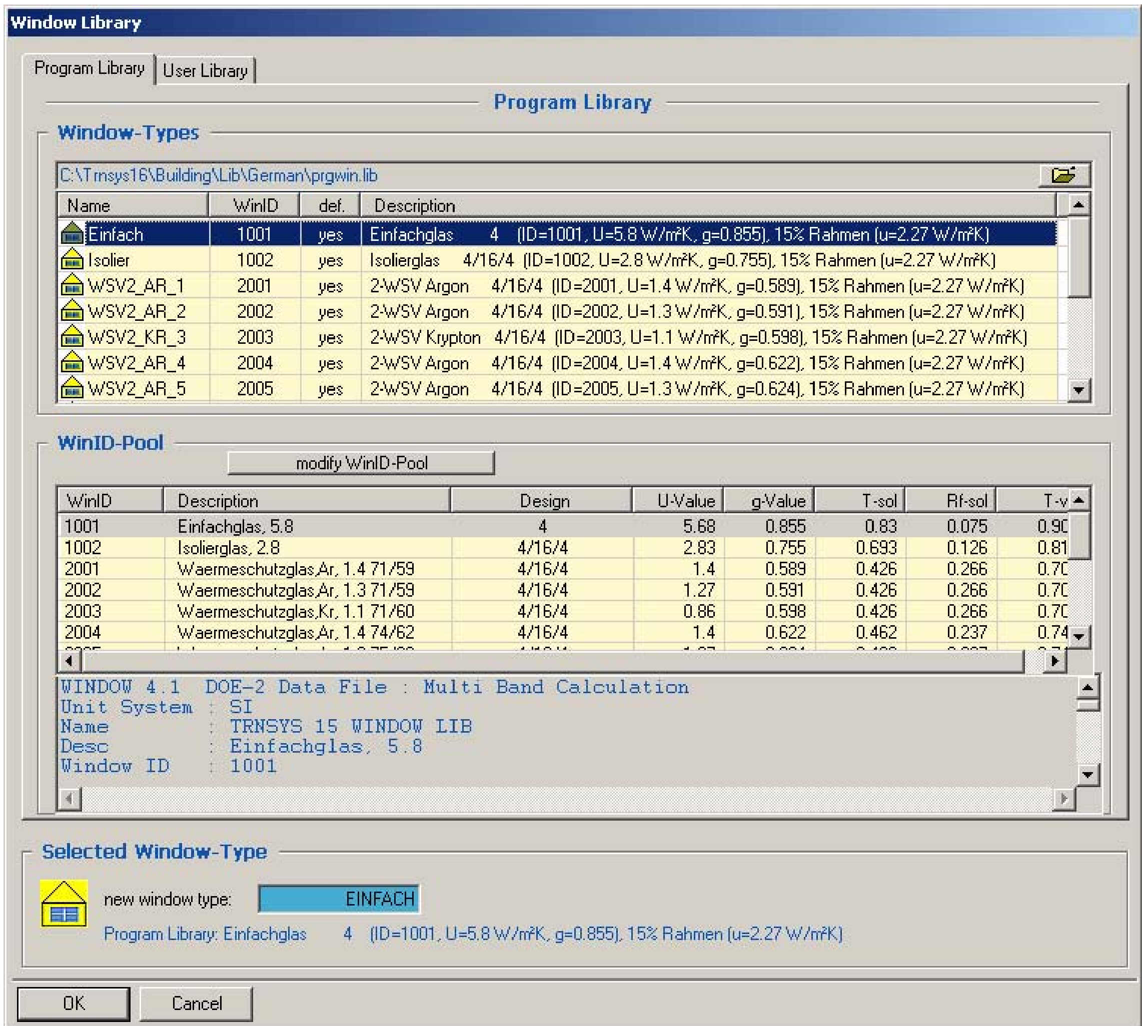


Figure 6.2.4-26: The WINID-Pool Library window

Here, the user can use the mouse to select windows from two different libraries: a program library and a user library. If the German library version is selected under SETTINGS from the OPTIONS menu, 14 common window constructions of German glazing systems are available

Additional this library contains product specific glazings which are based on data provided by Pilkington, Saint Gobain, Interpane and Luxguard. However, TRANSSOLAR Energietechnik GmbH makes any warranty, expressed or implied, or assumes any liability or responsibility for the accuracy, completeness or usefulness of any information, apparatus, product or process disclosed, or represents that its use would not infringe privately owned rights.

If the United States version is selected, several common United States window constructions according are provided. Both libraries were created with the program WINDOW 4.1 from the Lawrence Berkeley Laboratory, USA. For further information on the WINDOW program, please check the main TRNSYS Reference Manual. A default window type name is given by TRNBUILD after the selection, but it is recommended that the user change it to a more meaningful one.

6.2.4.3.2. DEFINITION OF A NEW WINDOW TYPE

The option to define a new window type should be used with caution. In contrast with the definition of wall types, the window properties used during the simulation cannot be fully defined within TRNBUILD. An additional ASCII file called W4-LIB.DAT containing certain window properties must be assigned for the simulation. The window ID represents the connection between the window type defined in TRNBUILD and window properties of the ASCII file W4-LIB.DAT. To create this additional ASCII file, the program WINDOW 4.1 from the Lawrence Berkeley Laboratory can be used. For further information on the ASCII file and the WINDOW program, please check the main TRNSYS Reference Manual.

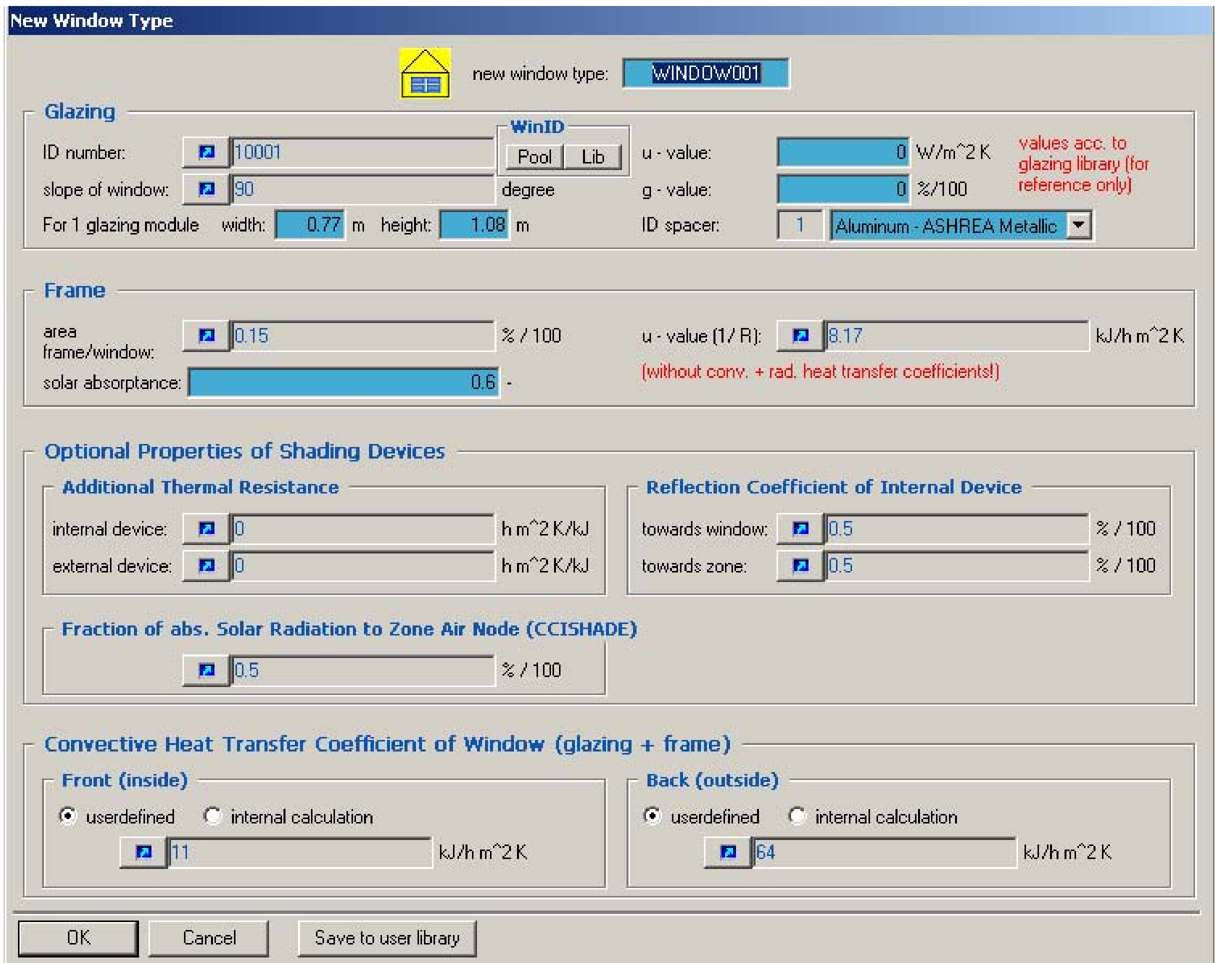


Figure 6.2.4-27: The NEW WINDOW TYPE window

To define a new window type in TRNBUILD, select NEW from the pull-down menu of WINDOW TYPE within the ZONE window and a window as shown in Figure 6.2.4-27 will pop up. Besides entering a new unique name for the window type, the user must specify the glazing and frame properties as well as the optional properties of the shading devices. In the following, some of the properties are explained more in detail:

- ID Number

The ID number is used to identify the window in the ASCII library file W4-LIB.DAT used during the simulation. In order to ensure consistency between the window type definition in TRNBUILD and that in W4-LIB.DAT, it is recommend that the user use the button W4-LIB for selecting the window ID. By clicking on the button W4-LIB, a window showing all available glazings of the W4-LIB.DAT pops up. The desired window can be selected by a mouse click. After clicking OK, the window ID, U-value and the g-value are set according to the selection. Alternatively, WIN-IDs can be loaded from the Pool of window data, i.e. data already used in the actual project.

- ID Spacer

For calculating the edge correction of the U-value of the glazing 5 spacer types are available.

Spacer ID	Spacer ID	1. Coefficient	2. Coefficient	3. Coefficient
0	data from w4-lib.dat	-	-	-
1	Aluminum - ASHREA Metallic	2.33	-0.01	0.138
2	Stainless steel (dual seal)	1.03	0.76	0.0085
3	Butyl/Metal (fiberglass etc)	0.82	0.80	0.0022
4	Insulated	0.35	0.83	0.018
5	No spacer	-	-	-

For Spacer ID = 0 all parameter including the glass height and width are read from the w4-lib.dat as in previous TRNBUILD-Versions. Thereby, the backwards compatibility is assured. For Spacer ID 1 to 4 the height and width of one glazing module has to be defined. The following shows the corresponding section of the BUI including the new KEYWORDS

```
WINDOW WSV

 WINID=2001 : HINSIDE=11 : HOUTSIDE=64 : SLOPE=90 : SPACID=1 : WWID=0.8 : ;

 WHEIG=2. : FFRAME=0.2 : UFRAME=8.1 : ABSFRAME=0.6 : RISHADE=0 : RESHADE=0 :;

 REFLISHADE=0.5 : REFLOSHADE=0.5 : CCISHADE=0.5
```

- U-VALUE and g-VALUE

The numbers entered for the U-value and the g-value of the glazing are displayed for user information only. (**Note:** Both values aren't used in the simulation but are calculated by TYPE 56.) Note that for adjacent windows it is important which side is defined as front or back. For example for an office with a double-facade the front side should be defined towards the office. For external windows the side towards the zone is automatically defined as front.

- CONVECTIVE HEAT TRANSFER COEFFICIENT

The convective heat transfer coefficient defined (without a radiative part!) is used for the whole window (glazing + frame). Common values are inside: 11 kJ / h m² K and outside: 64 kJ / h m² K. Like mentioned above for the input of walls, the internal calculation of heat transfer coefficients can be selected. See Chapter 6.2.3.2 Properties for further information on internal heat transfer calculation. The outside surface heat transfer coefficient is dominated by forced convection due to wind, but for the inside surface the internal calculation makes sense, since the glass surface temperature varies largely with room conditions.

- FRAME properties

The properties of the frame are not read from the W4-LIB.Dat file. They must be entered in TRNBUILD. The U_{frame}-value has to be entered without the heat transfer coefficients α_o and α_i . The solar absorptance is used for both sides of the frame (Note: In Prebid 3.0 the solar absorptance wasn't user defined). If U_{frame} is negative (only possible by using an input) U-value from W4-lib is taken for calculations. For positive U-values this value is taken for calculations.

- Optional Properties of Shading Devices

The properties entered for the shading devices are effective only if a shading device is actually defined for the window in the zone description (see Section 6.2.4.3). (Note: In the previous version, the reflection towards the zone of an internal shading device was neglected.). The coefficient CCISHADE defines the part of the absorbed radiation which goes directly to the air node by convection. It depends on the actual temperatures, the type of shading device (louvers, blinds, etc.) and the geometry of the air volume between the shading device and the window, especially the height of the shading device and the distance to the inner window pane. If the internal shading device is located very close to the inner window pane without any flow of air in between, CCISHADE should be set to zero. A value of one for this coefficient represents an internal shading device located in the room very far from the window. Typical values for CCISHADE range from 0.3 to 0.6. ISHADE defines the opaque fraction of a shading device 1-τ. REFLISHADE defines the reflection of the opaque part of a shading device.

example: measured data for a closed internal shading device

transmission	τ	30.0 %	
absorption	α	43.4 %	
reflection	ρ	26.6 %	
=> ISHADE	$= 1- \tau$		= 0.7
=> REFLISHADE	$= \rho/(1- \tau)$		= 0.38

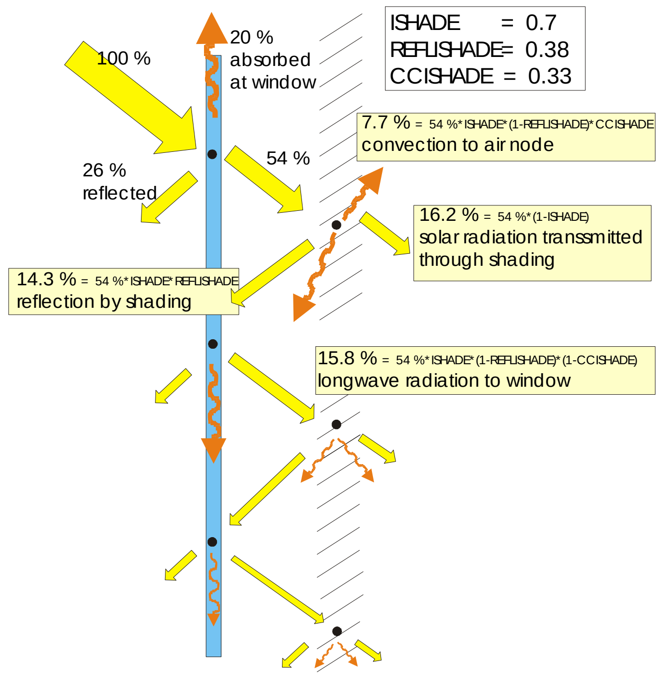


Figure 6.2.4-28: coefficients of an internal shading

6.2.4.4. *Infiltration*

An air flow into the zone from outside the zone can be specified by INFILTRATION. The specification of infiltration is optional and the default setting of the infiltration is off. After clicking on the INFILTRATION button in the ZONE window, a dialog box opens as shown in Figure 6.2.4-29. The user can switch the infiltration on and define an infiltration type for the zone by selecting a previously defined type or a new type from the pull-down menu.

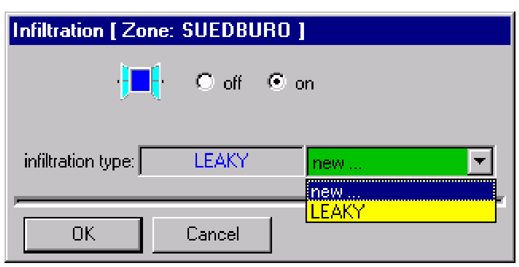


Figure 6.2.4-29: The INFILTRATION window

If the user selects the NEW option, an input window for the new infiltration type pops up (see Figure 6.2.4-30). The user must now enter a new unique name for the infiltration type and define the air change rate of the infiltration by clicking on the DEF button. The user can enter a constant, an input or a schedule.

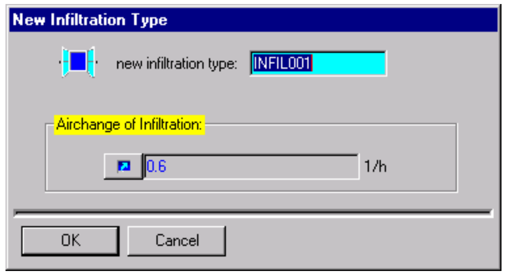


Figure 6.2.4-30: The NEW INFILTRATION TYPE window

6.2.4.5. Ventilation

An air flow e.g. from heating or cooling equipment into the zone can be specified by VENTILATION. The specification of ventilation is optional and the default setting of the ventilation is off. After clicking on the VENTILATION button in the ZONE window, a dialog box opens as shown in Figure 6.2.4-31. The user can add/delete ventilation types by selecting a previously defined type or a new type from the pull-down menu. (Note: In contrast to Prebid 3.0 multiple ventilations can now be defined for a zone.)

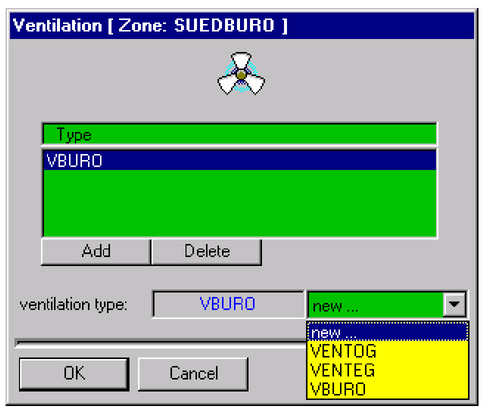


Figure 6.2.4-31: The VENTILATION window

If the user selects the NEW option, an input window for the new ventilation type pops up (see Figure 6.2.4-32). Besides entering a new unique name, the user must define the air change rate, temperature, and relative humidity of the air flow. As indicated by the DEF button, all variables can be defined as a constant, an input, or a schedule. By selecting the option OUTSIDE for the temperature and the relative humidity, the temperature and the relative humidity of the outside air are used.

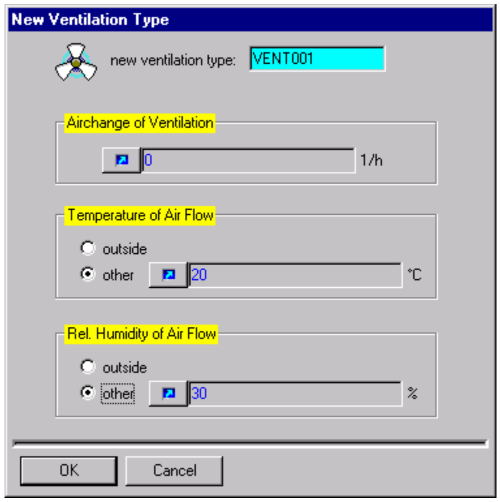


Figure 6.2.4-32: The NEW VENTILATION TYPE window

6.2.4.6. Heating

The heating requirement of any zone subject to idealized heating control can be determined by specifying a heating type. If the heating equipment is modeled external to the TYPE 56 component, the heating type should not be used. Instead, VENTILATION AIRCHANGE, TEMPERATURE and HUMIDITY should be defined as INPUTS, fed by outputs from the conditioning equipment component(s) or the supplied heating power should be defined as CONVECTIVE and RADIATIVE GAINS. The specification of a heating control is optional and the default setting of the heating control is off.

The procedure for defining a heating control is similar to the previously described cooling control. After clicking on the HEATING button in the ZONE window, a dialog box opens as shown in Figure 6.2.4-33. The user can switch the heating control on and define a heating type for the zone by selecting a previously defined type or a new type from the pull-down menu.

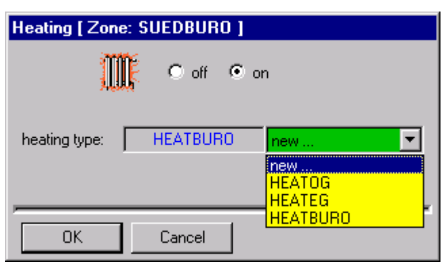


Figure 6.2.4-33: The HEATING window

If the user selects the NEW option, then an input window for the new heating type pops up (see Figure 6.2.4-34). Besides entering a new unique name, the user must define the room setpoint temperature, the heating power with its radiative part, and the humidification of the air within the zone. As indicated by the DEF button, all variables can be defined as a constant, an input, or a schedule. By selecting the option UNLIMITED for the heating power, the heating power is set to a very high number. The humidification can be turned on or off. If it is turn on, the user must specify the desired relative humidity by clicking on the DEF button.

For the simulation of heating equipment with both convective and radiative effects, a radiative fraction of the heating power RRAD may be defined. This fraction of the heater power is supplied as internal radiative gains and distributed to the walls of the zone. As the set temperature for the heating equipment is related to the air temperature of the zone, the radiative fraction of the heating power RRAD cannot be higher than 0.99 in order to have a convective part remaining to ensure stable control of the heating equipment. For using RRAD greater than 0 it is recommended to limit the maximum power.

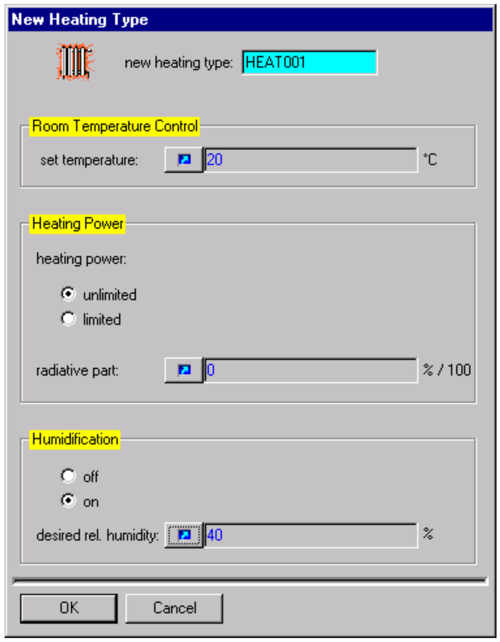


Figure 6.2.4-34: The NEW HEATING TYPE window

6.2.4.7. Cooling

The cooling requirement of any zone subject to idealized cooling control can be determined by specifying a cooling type. If the cooling equipment is modeled external to the TYPE 56 component, the cooling type should not be used. Instead, the VENTILATION AIRCHANGE, TEMPERATURE and HUMIDITY should be defined as INPUTS, fed by outputs from the conditioning equipment component(s) or negative CONVECTIVE and RADIATIVE GAINS should be defined. The specification of a cooling control is optional and the default setting of the cooling control is off.

To define an idealized cooling control, click on the COOLING button. The user can switch the cooling control on and define a cooling type for the zone by selecting a previously defined type or a new type from the pull-down menu.

If the user selects the NEW option, then an input window for the new cooling type pops up (see Figure 6.2.4-35). Besides entering a new unique name, the user must define the room setpoint temperature, the cooling power, and the dehumidification of the air within the zone. As indicated by the DEF button, all variables can be defined as a constant, an input, or a schedule. By selecting the option UNLIMITED for the cooling power, the cooling power is set to a very high number. The dehumidification can be turned on or off. If it is turned on, the user must specify the desired relative humidity of the zone air above which there is dehumidification by clicking on the DEF button.

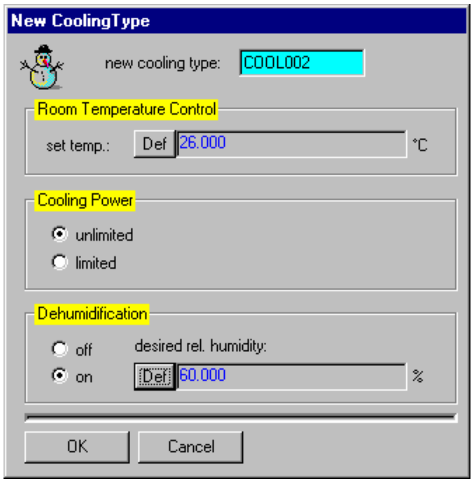


Figure 6.2.4-35: The NEW COOLING TYPE window

6.2.4.8. Gains

Internal gains (including persons, electrical devices, etc.) can be defined by GAINS. The specification of gains is optional. By default there are no gains defined. To change the default setting, click on the GAINS button in the ZONE window and an input window opens.

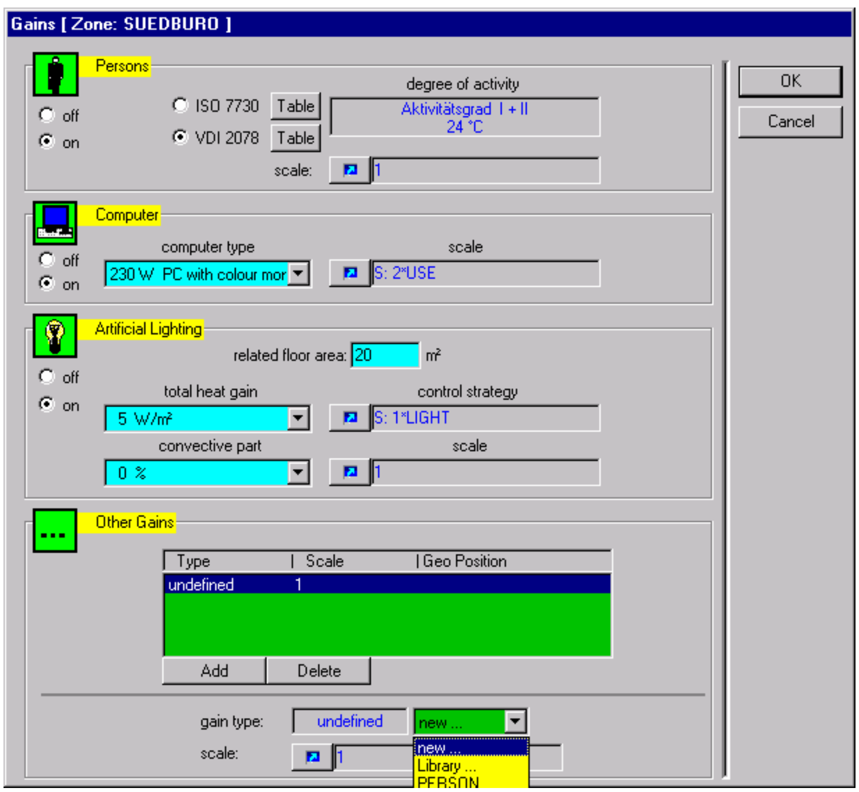


Figure 6.2.4-36: The standard GAINS window

In order to simplify the definition of common internal gains like persons, computers and artificial lighting, there are predefined options. The user can select the desired item from a pull-down menu (computer, artificial lighting) or tables (person) and then specify the scale by clicking the DEF button. The scale indicates the number of people or computers, because the predefined values correspond to a single person or computer only. For artificial lighting, the related floor area as well as the convective part must be defined in addition to the type of lamp. Also, the user can define a control strategy as an input or schedule (brightness control for optimal use of daylight, for example). To specify the heat gain from occupants, two options exits: according to ISO 7730 and depending the room temperature according to VDI 2078. Instead of defining new gains, previously used gains can be imported from a user defined gain lib accessible by "Library" instead of "new".

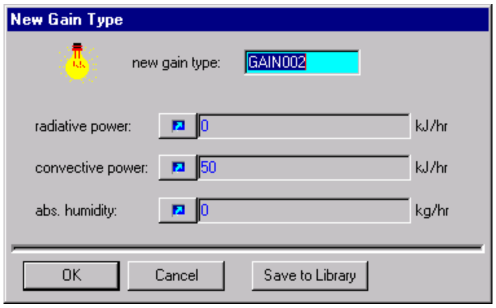


Figure 6.2.4-37: The NEW GAIN window

Besides these predefined gains, the user can add other gains. An overview box shows user-defined gains for this zone. The displayed parameters below the overview box correspond to the highlighted item in the overview box. To add a gain, click on the ADD button, and an undefined gain will be added to the overview window. Next, the user must specify the gain type by selecting a previously defined type, one from the user library, or the new option of the pull-down menu. If a previously defined type is selected, the user need only specify the scale to be used with that gain. If the user selects the option NEW, then an input window appears as shown in Figure 6.2.4-37. Besides entering a new unique name, the user must define the total power, the convective part and the absolute humidity of the gain by clicking the DEF buttons. Afterwards, click on OK to return to the GAINS window. Finally, the user must specify the scale to be used with this gain. Please note the "Save to Library" button in Figure 6.2.4-37. Any new definition of gains can be stored in your personal gain library, thus saving a lot of time for future modeling projects.

6.2.4.9. Comfort

Thermal comfort calculation is a new feature in TRNBUILD 1.0 based on EN ISO 7730. The specification of comfort is optional and the default setting is “off”. After clicking on the COMFORT button in the ZONE window, a dialog box opens. The user can switch the comfort module on and define a comfort type for the zone by selecting a previously defined type or a new type from the pull-down menu.

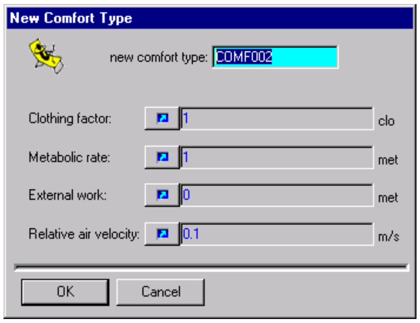


Figure 6.2.4-38: The NEW COMFORT window

If the user selects the NEW option, an input window for the new comfort type pops up (see Figure 6.2.4-38). The user must now enter a new unique name for the comfort type and define four entities:

- CLOTHING factor

In EN ISO 7730 a lot of clothing factors are given for a large variety of clothing. The following table gives a brief data for common clothing ensembles:

Clothing ensemble	**Clothing factor [clo]**
Nude	0
Shorts	0.1
Light summer clothing (long light-weight-trousers, open neck shirt with short sleeves)	0.5
Light working ensemble (Athletic shorts, woolen socks, cotton work shirt, work trousers)	0.6
Typical business suit	1.0
Typical business suit + Cotton coat	1.5
Light outdoor sportswear (Cotton shirt, trousers, T-shirt, shorts, socks, shoes, single ply poplin jacket)	0.9
Heavy traditional European business suit	1.5

- METABOLIC rate

The metabolic rate represents a heat production depending on the activity level:

Degree of Activity	Metabolic rate [met] (acc. to EN ISO 7730)
Seated, relaxed	1.0
Seated, light work (office, home, school, laboratory)	1.2
Standing, light work (Shopping, laboratory, light factory work)	1.6
Standing, moderate work (Sale activity, housework, operating of a machine	2.0
Walking, 2 km/h	1.9
Walking, 3 km/h	2.4
Walking, 4 km/h	2.8
Walking, 5 km/h	3.4

- EXTERNAL WORK

In general the external work is around 0.

- REALTIVE AIR VELOCITY

The air velocity relative to the person must be entered.

As indicated by the DEF button, the user can enter a constant, an input or a schedule for all values. For more information check the EN ISO 7730. Despite the theory part the appendices provide detail information on clothing factors etc.

6.2.5. The Type Managers

For every sort of TYPE such as WALL, LAYER, WINDOW, INFILTRATION, VENTILATION, SCHEDULE etc. a TYPE MANGER exists. These TYPE MANAGERs are needed for editing the properties of previously defined TYPEs. These windows look similar to the definition window of a NEW TYPE, but instead of allowing the definition of a new type name, only previously defined type names can be selected (compare the WALL TYPE MANAGER window shown in Figure 6.2.5-1 with the NEW WINDOW TYPE WINDOW shown in Figure 6.2.4-27). The TYPE MANAGERs can be accessed by the menu item TYPEMANAGERs or by the corresponding buttons in the tool bar.

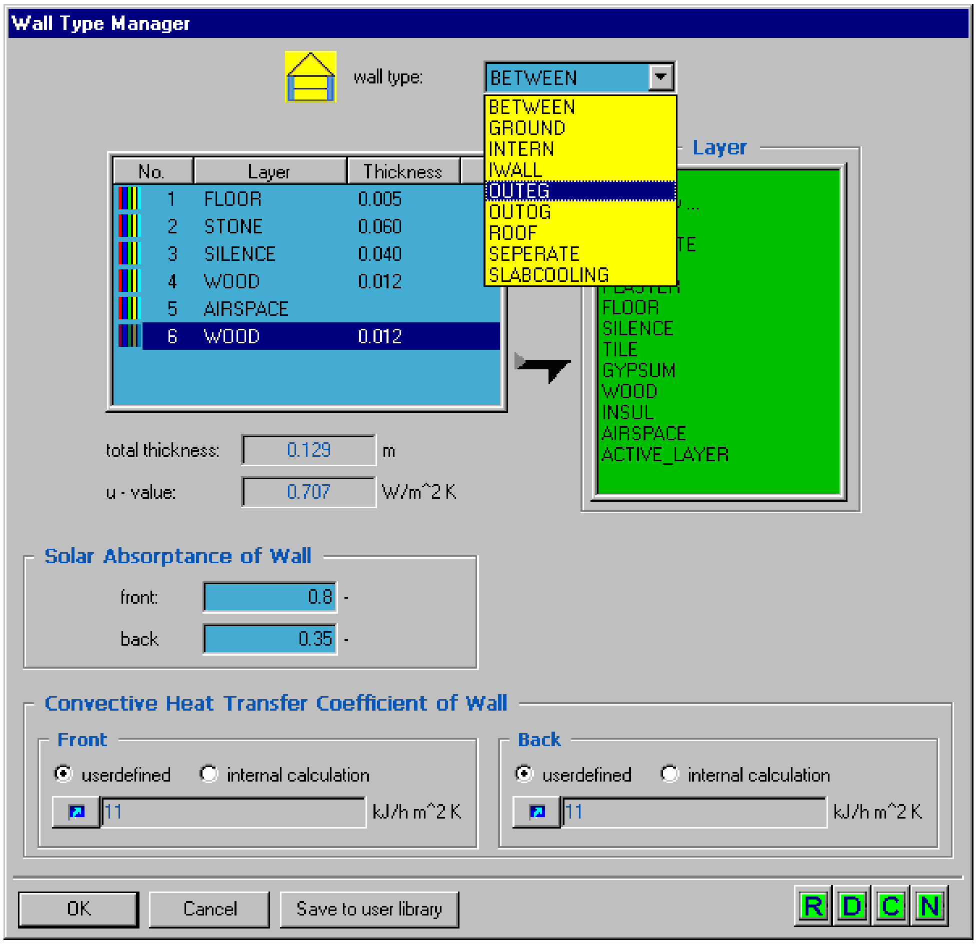


Figure 6.2.5-1: The WALL TYPE MANAGER window

For walls with surface heat transfer coefficients differing largely due to surface temperature changes, the internal calculation of heat transfer coefficients can be selected. See Chapter 6.2.3.2 Properties for further information on internal heat transfer calculation.

EDIT buttons

The four edit buttons shown explicitly in Figure 6.2.5-2 can be found in any type manager window like wall type manager, ventilation type manager etc. to ease type handling. Just click the appropriate button for the desired operation:

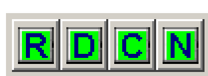


Figure 6.2.5-2: Rename-Delete-Copy-New

6.2.6. Generating TYPE56 Files

The information entered in TRNBUILD and saved to the *.BUI file is used to generate three new files:

- a file containing all information about the building excluding the wall construction (*.BLD) and
- another file that contains the ASHRAE transfer functions for the walls (*.TRN).
- In addition, an information file (*.INF) is generated. The information file contains the processed BUI file followed by the values of wall transfer function coefficients, the overall heat transfer conductance U and the related U-value. This information may be useful for the user in verifying the wall description data. Next, the list of inputs required for the Type 56 is printed. These will most commonly be outputs of other components in the TRNSYS simulation. Also, the information file (*.INF) provides a list of outputs of Type 56 as selected by the user. These outputs may be inputs to other components. Finally, a brief table with all of the wall types and their U-values is printed to the information file. (Note: In previous versions of TRNBUILD, another program called BIDWIN was used to generate the TYPE 56 files. For user convenience, BIDWIN has now been merged into TRNBUILD.)

The *.BLD and *.TRN files are used by TYPE 56 during the simulation process.

In TRNBUILD generation process will be started automatically each time you save your BUI file. The generated files get the name as the opened *.BUI file and are located in the same directory. If an error occurs, no files are generated. A window displays for detailed information on the error.

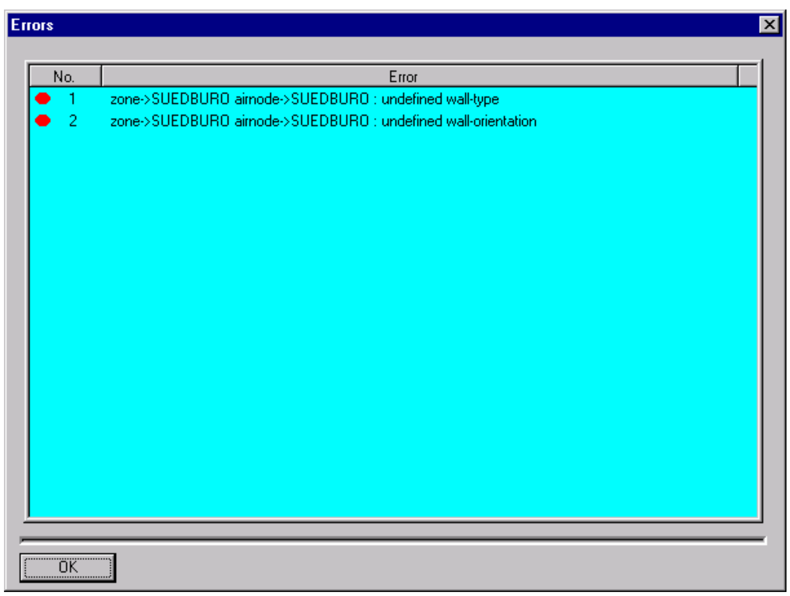


Figure 6.2.6-1: The Error window

6.2.7. *Maximum heat load calculation*

The option „Max. heat load calculation" in the Generate - pull-down Menue offers a fast and convenient way to calculate the maximum heating load of each zone with certain standard conditions at the respectve location. Due to its static nature, the results can be checked easily by a hand calculation. Therefore, TRNBUILD generates a special BUI file, a corresponding TRNSYS input file including the ambient conditions and starts the simulation by a mouse click.

The calculated heating load is a static one using NTYPE 27 and 4 of TYPE 56 such that the user can check the numbers entered in TRNBUILD by a hand calculation. The following values of the outer surface resistance are used for the U-value calculation of walls:

HBACK > 30 kJ / (h m² K) => $1/\alpha$ = 0.04 m² K / W

30 ≥ HBACK >0.005 => $1/\alpha$ = 0.13 m² K / W

0.005 ≥ HBACK => $1/\alpha$ = 0 m² K / W

The inner surface resistance is set to 0.13 m² K / W. The U-value of the windows is calculated by the window model of TYPE 56.

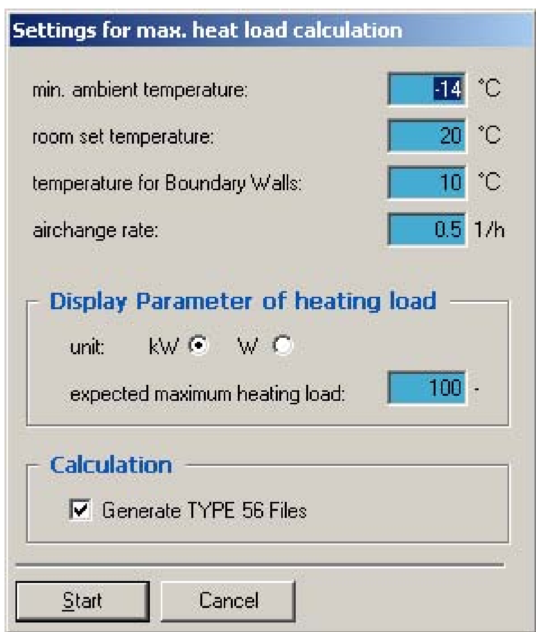


Figure 6.2.7-1: Settings for max. heat load calculation

For determining the maximum heating load the user is asked to define some design conditions like the ambient temperature, the room set temperature, temperature for BOUNDARY WALLS and an AIRCHANGE rate (see Figure 6.2.7-1). In addition, some display parameters like the unit of the heating load and an expected maximum value needs to be specified. The option "Generate TYPE 56 files" should be turned on in order to assure that the correct BLD and TRN files are used during the following simulation.

After clicking on the START button, a special BUI file called *maxheatload.BUI is generated by TRNBUILD. This file is similar to the current opened BUI-file, but all internal gains are ignored. Additionally, VENTILATION and COOLING is turned off for all zones. All SCHEDULES and INPUTS for HEATING and INFILTRATION are transformed into the fixed values entering in the settings window. However, the user has to be aware that if no INFILTRATION or HEATING is defined within the zone, TRNBUILD does not add this automatically! The boundary temperature of all BOUNDARY WALLs is set to the entered value, except for walls with a boundary temperature equals IDENTICAL.

For ambient conditions, TRNBUILD assumes no solar radiation and a constant value for the ambient temperature as specified in the settings window. After the creation of the *maxheatload.BUI file and a corresponding TRNSYS input file, TRNBUILD generates the TYPE 56 files (if the option is selected). If the TRNSYS 56 files are generated successfully the user has the option to run the TRNSYS simulation by clicking on the button “RUN TRNSYS” as shown in Figure 6.2.7-2. However, make sure that the correct path is defined for TRNSYS.EXE under the menu OPTIONS \ SETTINGS. In the TRNSYS simulation, the resulting maximum heating power of each zone as well as the total heating power of all zones are determined. The simulation results are not only printed into a printer file (*maxheatload.PRN), but also shown on the ONLINE. For the ONLINE display, the maximum number of zone is restricted to 19.

Figure 6.2.7-2: Starting the TRNSYS simulation

6.2.8. Input Data Limits of TRNbuild

Since version 15, TYPE 56 uses a dynamic array sizing in order to reduce fixed data limits. However, the following limits apply:

- maximum number of INPUTS 999
- maximum number of OUTPUTS 999
- maximum number of SURFACES 999

6.2.9. A Simple TRNBuild Example

Perhaps the best way to learn to use TRNBUILD is through building up a simple model. This tutorial will step you through creating the Type56 model of a one story house with a ventilated attic. In the main reference manual a more complicated building example is given in 4.8.8.2.4.

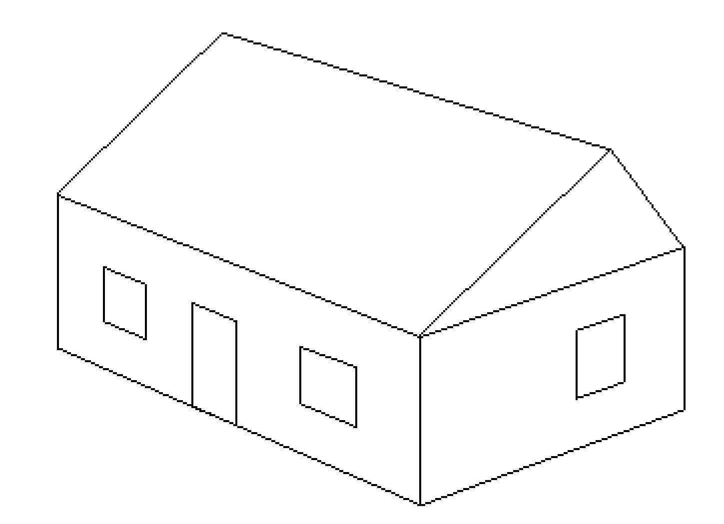


Figure 6.2.9-1: One Story House with a Thermally Isolated Attic

6.2.9.1. Starting a Project

Start TRNBUILD and start a new project under the file menu. You will see a “Project Initialization” window which contains information affecting the entire project (not just a single zone). Fill in the information and then save the project in the directory ..\TRNSYS16\myhouse\house.bui. You will have to create this directory as it does not yet exist. We will leave the orientation information alone for now. At this point we will make sure that all the TRNBUILD settings are correct as well. Choose “settings” under the menu item “Options.” Set the library version to your choice. This tutorial uses the American library option. Also make sure that the path of TRNSYS application TRNEXE.exe is correct

6.2.9.2. Defining a Zone and Adding Walls

The next step is to create the first thermal zone. Select “Add Zone” from the Zone menu and name it “LIVING.” This brings up a window where all the information concerning the living space will be entered.

Zone Volume	500	m^3
Capacitance	600	kJ/K
Initial Zone Temperature	20	°C
Initial Zone Relative Humidity	50	%

Next, we need to define the walls. Click the “Add” button beneath the list of walls. From the pulldown menu that appears, select “new…;” we are going to define our own wall. A “New Wall” window will pop up. However, before we define the wall, we need to first give the wall a name (“outside” for example) and second define the materials that will make up the layers of the wall. These we will choose from a library of predefined materials; so click “Library” in the rightmost field. Select the following materials. The listed names will appear automatically but you must enter the thicknesses. If these materials are not available in the list that opens, check to make sure that you have the American library selected under “settings” in the “option” menu item.

Material #	Material Group	Material	Layer Name	Thickness (m)
63	Construction board	wall_board	WALL_BOARD	0.006
173	Insulation material	mineral _wool035	MINERAL_WO	0.102
181	Wooden material	spruce_pine	SPRUCE_PIN	0.051
183	Wooden material	Plywood	PLYWOOD	0.006
190	Covering/seal material	poly-vinyl_chloride	POLYVINYL	0.013

Once all the layers of the wall are defined, we are ready to define the walls themselves. Double clicking on a given material in one field will send it to the other field. In this way you can move and rearrange the wall materials to obtain the desired wall. It should be noted that the first material in the wall definition should be the innermost material (WALL_BOARD in our case). Once you have rearranged the wall to match the above list, click "OK."

Now that we have added a wall to the project, we can use it in a thermal zone. Select OUTSIDE" as the new wall's type. This is the wall that we just defined above. Next enter the wall's area; in our case, 50 m^2. The wall is an external wall, and faces NORTH. The sky view factor should remain 0.5. Continue defining walls until you have four external walls, one in each direction (North, South, East, West). The east and west facing walls should have areas of 25 m^2 while the north and south walls have areas of 50 m^2.

At this stage, it is a good idea to test our zone and make sure that it is properly defined. Save the project and click on the Run button (icon of a motorcycle). This action calls the program that creates all the files that TRNSYS requires to simulate a multizone building. If everything is defined properly, you should see four files in the ..\TRNSYS16\myhouse directory. House.bui (the TRNBUILD project file), house.bld (geometric information about the building), house.inf (an informational file) and house.trn (the file containing the wall transfer function coefficients).

6.2.9.3. Adding Windows to the Zone

Houses without windows and doors are not very popular. The next step is to add them to our thermal model. Select the south facing wall; the first window will be automatically added. We re going to pick our windows from a predefined list so choose "Library" next to Window Type and select a double pane window from the list. Next, give the window an area of 2 m^2. Add a second window of the same type and same dimensions. Select the other walls and make one window in each of them. For simplicity, each window should be 2 m^2.

6.2.9.4. Heating and Cooling Set Points

Although it is not required, we are going to add heating and cooling to the house. To do this, click the button labeled "Cooling" in the upper right hand corner of the zone window. Click the "on" radio button, then define a new cooling type. We will use the default settings: a setpoint of 26 °C, an oversized cooling system, and no dehumidification. The only change we are going to make is to call the cooling type "COOL" instead of "COOL001," since we will only have this one cooling system in the house.

Heating is defined in exactly the same manner as cooling. The setpoint should be 20 °C, unlimited power, no humidification and call the type “HEAT.” Save the project and run it again to make sure there are no errors. Congratulations, you have just set up your first thermal zone!

6.2.9.5. Adding a Second Zone

Another problem with the house that we have built so far is that it has no roof; the occupants will not be too happy. We could define a new wall type which represents the roof and put it onto our first zone. However, we are interested in the effects of an unconditioned attic space, so we are going to add a second zone. The basics of adding a second zone are no different than adding the first zone. However, there are a few things that we need to do first.

If you remember the project initialization window, there were a number of orientations listed. In order to have a sloped roof on our attic as shown in Figure 6.2.9-1: One Story House with a Thermally Isolated Attic, we need to add two new orientations. Go to the Project Initialization Window and click “other” at the bottom of the list on the right. Create an orientation called NSLOPE and an orientation called SSLOPE. You don’t need to give TRNBUILD any more information than the names of these orientations. Their slopes, azimuths and the radiation falling on them will be inputs to Type56 inside the TRNSYS input file.

Select “Add Zone” from the “Zones” menu and call it “ATTIC.” The zone specifics will be:

Zone Volume	433	m^3
Capacitance	519.6	kJ/K
Initial Zone Temperature	20	°C
Initial Zone Relative Humidity	50	%

This time when we add a wall, we are going to use a predefined ASHRAE wall from the library. As far as TRNBUILD is concerned, there is no difference between walls and roofs; they simply have different layers. We’ll choose wall type 98, which is a frame wall with 125 mm of insulation. Instead of a “new…” wall, select “Library…” Scroll down in the program library window until you find wall type 98. Select it. You cannot rename this wall type; it will automatically be called WTYPE98. Once you have added the wall type to the project, you can use it in the attic zone. From the ATTIC zone window, create two external walls as shown below.

Type	Area	Category	Orientation
WTYPE98	100.0	EXTERNAL	NSLOPE
WTYPE98	173.2	EXTERNAL	SSLOPE

The last thing we have to do is to create the ceiling that separates the two zones. From the attic zone window, add a wall and select “new…” we are going to make our own wall. When the wall type manager comes up, you may notice that the materials that we have used in our other walls, are all ready for us to use: we don’t have to create any new layers. Call the wall type “CEILING” and add wall_board followed by three consecutive layers of insul125 (125 mm of insulation). This will give us a total of 375 mm (14.6 in.) of insulation.

Once the wall is created, we specify its area as 200 m^2. This wall is adjacent to the LIVING zone. When you choose adjacent, TRNBUILD will ask you to specify which zone is on the other side of the wall. It will also ask you to specify which zone contains the front of the wall. Remember when we were defining external walls, we defined them from the inside out. When we defined this wall, the list went wallboard, insulation, insulation, insulation. So the “front” of the wall is in the LIVING zone. You’ll need to switch the radio button accordingly. Since there are no openings to the attic in this house, there is no air flow to specify between the two zones.

6.2.9.6. Adding Ventilation

The attic zone in this house is going to have some ventilation in it. From the ATTIC zone window, click on the “Ventilation” button and change the radio button to “on.” Define a new ventilation type called VENTIL and click the “Def.” button to define its characteristics. There are three options here: constant, schedule or input. We will choose a constant 0.2 airchanges per hour. Alternatively, we could specify a schedule in TRNBUILD or we could tell TRNBUILD that we want the ventilation air flow rate to be an input that we will give to Type56 in the TRNSYS input file.

6.2.10. *Building Input Description File(BUI) - Created By TRNBuild*

TRNBUILD provides data files necessary for using the TRNSYS TYPE 56 Multi-Zone Building component. TRNBuild stores all entered data in a socalled BUI - file (*.BUI). The BUI – file is an ASCII file wirtten in the socalled “BID language”. Besides using TRNBUILD, the user may also use any text editor for creating the BUI file. However, due to the rigorous syntax the usage of a text editor is very susceptible to errors. Therefore, it **is strongly recommended that you use TRNBUILD.**

The user defines simple building blocks, called TYPES, which are used to describe the building. TYPES represent unique descriptions that can be used many times to either define other TYPES or to construct the building. For instance, a LAYER TYPE represents a material description of an individual wall layer. Several LAYER TYPES may be used to define a unique WALL TYPE, which in turn may be used in the description of the building. Other necessary TYPES include WINDOWS, ORIENTATIONS, GAINS, COMFORT, INFILTRATION, VENTILATION, HEATING, COOLING, and ZONES. Each of these TYPES is characterized by a name that is assigned to it and its associated data. Many of the variables that define these TYPES may vary with time. There are two ways to accomplish this. One is to reference pre-defined periodic functions defined with SCHEDULE TYPES. Secondly, INPUTS (to the Type 56 component) may be defined which will ultimately be outputs of other TRNSYS components in the simulation. An example application of SCHEDULES would be to define GAINS for people which depend upon time of the day and week. INPUTS might be used to consider GAINS from heating or cooling equipment whose performance depends upon the conditions of the zones.

The completed building description file is converted by TRNBUILD into files required by Type 56. The next section gives general information concerning BUI file and its syntax. The user is advised to read the next section carefully such that he is able to read and understand the BUI file. Information on the interface TRNBUILD is provided by in the previous sections and the online help.

6.2.10.1. *Rules Governing the “BID Language”*

The user constructs a file containing the building description, which is read and processed by the TRNBUILD program. Four groups of data are required in the following order: PROPERTIES, TYPES, BUILDING, and OUTPUT. PROPERTIES represent general property data concerning the entire building. OUTPUT defines the level of output from both TRNBUILD and the Type 56 component. The complete set of data terminates with an END statement.

Within each data group, there are a limited number of keywords that are recognized by the program. In some cases, this data must be in a particular sequence, in other cases not. The group keywords must appear prior to their data. For each data item within a group, a keyword precedes the actual data. The keyword must be separated from the data by an equal sign (=). The data may be a constant numerical value, a name defining a new TYPE, a name referring to a previously defined TYPE, or of a special form to reference previously defined SCHEDULES or INPUTS. In some instances, more than one data item follows a keyword. In this case, the data should be separated by a space. Numerical data can be in any format (integer, fixed point, or floating point). Table 6.2.10-1 is used in the next section to identify the appropriate data types associated with each keyword.

Table 6.2.10-1: Data Types

Data Type	Description
1	constant numerical values(s)
2	TYPE names
3	constant numerical values, SCHEDULE, or INPUT

To use previously defined SCHEDULES or INPUTS, the general form is

Keyword = SCHEDULE A*name + B

or

Keyword = INPUT A*name + B

where A and B are optional scaling parameters and name refers to a previously defined SCHEDULE or INPUT TYPE. This scaling feature is very useful for defining gains for different zones that follow the same schedules. See the example in Section 6.5.2.2.

In general, it is necessary to supply all characters of the keywords. Abbreviation may be used for the keyword ORIENTATION (ORI) and for the keyword COUPLING (COUPL). Since Version 16 names that are given to TYPES must no more be between 1 and 10 characters long. Special characters like é, è ö, ü, ä are also allowed now. Each item of program data may be contained on separate lines in the file or on the same line when separated by a colon (:). It is also possible to continue a data description from one line to another by the use of a semi-colon (;) at the end of the first line. Another special character combination is *#C . It allows the introduction of a comment by the user in the data file, when it appears in the first column of a record. A single asterisk (*) also introduces a comment. However, these comments are deleted by TRNBUILD.

The Type 56 Multi-Zone Component is designed to be used with a modified set of SI units as given below. Since TRNSYS uses hours for its time base, power and energy units are based on the unit hour instead of seconds. Required units are given in Table 6.2.10-2.

Table 6.2.10-2: Required Units

Quantity	SI Unit	Unit
time	Hour	[hr]
length	Meter	[m]
mass	Kilogram	[kg]
temperature	degree Celsius	[°C]
energy	kilojoule	[kJ]
power or energy rate	kilojoules/hour	[kJ/hr]

In the following sections, the program input is described for each data group. This information is presented in tables for easy reference. For each keyword, the data type along with a description is given. Data types refer to Table 6.2.10-1.

6.2.10.2. Properties

Following the PROPERTIES keyword, five data items must appear as follows.

Table 6.2.10-3: PROPERTIES Data

Keyword	Data Type	Data Description
DENSITY	1	density of air
CAPACITY	1	specific heat of air
HVAPOR	1	heat of vaporization of water
SIGMA	1	Stefan-Boltzmann constant
RTEMP	1	approx. average surface temperature (K)

Parameters for internal calculation of heat transfer coefficients

KFLOORUP	1	constant for heated floor	(default 7.2 [kJ/m²K])
EFLOORUP	1	exponent for heated floor	(default 0.31 [-])
KFLOORDOWN	1	constant for chilled floor	(default 3.888 [kJ/m²K])
EFLOORDOWN	1	exponent chilled floor	(default 0.31 [-])
KCEILUP	1	constant for chilled ceiling	(default 7.2 [kJ/m²K])
ECEILUP	1	exponent for chilled ceiling	(default 0.31 [-])
KCEILDOWN	1	constant for heated ceiling	(default 3.888 [kJ/m²K])
ECEILDOWN	1	exponent for heated ceiling	(default 0.31 [-])
KVERTICAL	1	constant for vertical wall	(default 5.76 [kJ/m²K])
EVERTICAL	1	exponent for vertical wall	(default 0.30 [-])

RTEMP is used to linearize the long-wave radiation exchange between surfaces within a zone. This value can be approximated by the year-long average zone temperature. In most HVAC applications, 20°C is reasonable. The effects of RTEMP will normally be small and therefore only a rough approximation is needed.

Each of the above properties requires a value that is independent of time. The units of this data must be consistent with that of the rest of the data to be entered. Values of these properties at 20°C are given below (Table 6.2.10-4) in the units of Table 6.2.10-2, except for RTEMP and SIGMA which must be based on an absolute temperature scale.

Table 6.2.10-4: Values of PROPERTIES at 20°C (Units from Table 6.3.5-2)

Property	SI Units	Unit
density of air	1.204	[kg/m³]
specific heat of air	1.012	[kJ/kg]
heat of vaporization of water	2454	[kJ/kg]
Steffan-Boltzmann Constant	2.0411 E-07	[kJ/hr-m²-K4]
average surface temperature	293.15	[K]

6.2.10.3. Types

There are 13 different TYPES that can be defined. Some TYPES are only useful in the BUILDING description, others may be used in other TYPE definitions. TYPES must be defined in a fixed order as shown in Table 6.2.10-5. The TYPE keyword must precede the definition of TYPES. TYPE definitions are terminated when the keywords BUILDING or OUTPUT are encountered.

Table 6.2.10-5: Required TYPE order

PROPERTIES

LAYER

INPUTS

SCHEDULE

WALL

WINDOW

GAIN

COMFORT

INFILTRATION

VENTILATION

COOLING

HEATING

ZONES

ORIENTATIONS

6.2.10.3.1. LAYER TYPES

There are three types of layers that may be defined:

- layers having non-negligible mass,
- layers to be treated as pure resistances and
- active layers for modeling thermally activated building components. (e.g. concrete slab cooling)

For layers with mass, the following data applies. Material data can be found within the description of Type 19 or in the layers library of TRNBUILD.

Table 6.2.10-6: Massive LAYER TYPE Data

Keyword	Data Type	Data Description	Unit
LAYER	2	layer name	
THICKNESS	1	layer thickness	[m]
CONDUCTIVITY	1	material thermal conductivity	[kJ/h m K]
CAPACITY	1	material specific heat	[kJ/kg K]
DENSITY	1	material density	[kg/m3]

For a massless layer, the required data is:

Table 6.2.10-7: Massless LAYER TYPE Data

Keyword	Data Type	Data Description	Unit
LAYER	2	layer name	
RESISTANCE	1	material thermal resistance (reciprocal of overall heat transfer coefficient, without surface film coefficients)	[h m²K/kJ]

For an active layer, the required data is:

Table 6.2.10-8: Active LAYER TYPE Data

Keyword	Data Type	Data Description	Unit
LAYER	2	layer name	
PSPACING	1	pipe spacing center to center	[m]
PDIAMETER	1	pipe outside diameter	[m]
PWALLTHICKNESS	1	pipe wall thickness	[m]
PCONDUCTIVITY	1	pipe wall conductivity	[kJ/h m K]
CPFLUID	3	specific heat coefficient of fluid	[kJ/kg K]

Note: The pipe diameter has to be smaller than 0.2* pipe spacing!

For a chilled ceiling layer, the following data is required:

Table 6.2.10-9: Chilled Ceiling LAYER TYPE Data

Keyword	Data Type	Data Description	Unit
LAYER	2	layer name	
CC_PSPACING	1	pipe spacing center to center	[m]
CC_PIDIAMETER	1	pipe **inside** diameter	[m]
CC_CPFLUID	3	specific heat coefficient of fluid	[kJ/kg K]
SP_NORMPOWER	1	specific norm power	[kJ/h m²]
SP_NORMMFLOW	1	specific norm massflow	[kg/h m²]
NORMAREA	1	norm area at test conditions	[m²]
NORMNLOOP	1	number of loops at test conditions	
UCOMB	2	define kind of contact-chilled ceiling and ceiling	
GAP	2	keywords to define an air-gap or direct-contact between chilled ceiling and ceiling	
DIRECT_CONTACT	2		
UWRX	1+2	heat transfer coefficient	[kJ/hm²K]
F(SP_NORMPOWER)	2	keyword to define internal calculation of UWRX	[-]
DTSURFNORM	1	only if UWRX calculated from temperature difference between mean fluid and mean surface temperature at test conditions	[K]

The following data is only used in the expert mode of a chilled ceiling layer:

Table 6.2.10-10: Chilled Ceiling LAYER TYPE expert mode Data

Keyword	Data Type	Data Description	Unit
UUPCONST	1	additional heat transfer coefficient for construction on upper side of chilled ceiling	[kJ/hm²K]
ULOCONST	1	additional heat transfer coefficient for construction on lower side of chilled ceiling	[kJ/hm²K]
K_DOWN	1	constant for heat transfer calculation in the gap - heatflux going down	[kJ/hm²K]
M_DOWN	1	exponent for heat transfer calculation in the gap - heatflux going down	[-]
K_UP	1	constant for heat transfer calculation in the gap - heatflux going up	[kJ/hm²K]
M_UP	1	exponent for heat transfer calculation in the gap - heatflux going up	[-]

6.2.10.3.2. INPUT TYPE

This data is used to define all inputs to the Type 56 Multi-Zone Building Component that are in addition to the ambient conditions and incident radiation.

Table 6.2.10-11: INPUTS TYPE Data

Keyword	Data Type	Data Description
INPUTS	2	names associated with inputs to Type 56 Multi-Zone Component

6.2.10.3.3. SCHEDULE TYPEs

Schedules are periodic functions whose output may vary according to the time of day and/or week. Two forms of SCHEDULE TYPEs may be defined. The first requires values of the schedule as a function of the time of day:

Table 6.2.10-12: Hourly SCHEDULE TYPE Data

Keyword	Data Type	Data Description
SCHEDULE	2	schedule name
HOURS	1	hours of the day at which the output of the schedule will change (starting from 0, ending at 24) [h]
VALUES	1	the values of the schedule corresponding to the hours given

The hourly SCHEDULE VALUES change with a step at each of the HOURS given, producing a square-wave. The second form for SCHEDULE TYPES is for specifying the use of different hourly SCHEDULEs as a function of the day of the week.

Table 6.2.10-13: Daily SCHEDULE TYPE Data

Keyword	Data Type	Data Description
SCHEDULE	2	schedule name
DAYS	1	days of the week on which the schedule changes (starting from 1, ending at 7)
HOURLY	2	names of previously defined hourly schedules corresponding to the days given

The DAYS of the week are relative to the first day of the simulation. For TRNSYS, the year starts with Monday.

6.2.10.3.4. WALL TYPEs

A WALL TYPE uses previously described layers. Layers should be given from front of the wall to back where the front corresponds to the inside surface of the wall for an exterior wall or wall with a specified boundary condition (see Section 6.2.4.2) and is arbitrary otherwise. Up to 20 layers are allowed for any wall. Both the front and back of every wall are assumed to be black for internal radiative gains and for long-wave radiation exchange between the internal surfaces.

Table 6.2.10-14: WALL TYPE Data

Keyword	Data Type	Data Description	Unit
WALL	2	wall name	
LAYER	2	names of previously defined layers that comprise the wall from front to back (or inside to outside for external walls)	
THICKNESS	1	thickness of each layer	[m]
ABS-FRONT	1	front surface absorptance for solar radiation (material data)	[ratio]
ABS-BACK	1	back surface absorptance for solar radiation (material data)	[ratio]
HFRONT	3	front surface convective heattransfer coefficient	[kJ/h m² K]
HBACK 3	3	back surface convective heat transfer coefficient	[kJ/h m² K]
FLOOR	-	keyword internal calculation of HFRONT or HBACK of a floor; no other data is required	
CEILING	-	keyword internal calculation of HFRONT or HBACK of a ceiling; no other data is required	
VERTICAL	-	keyword internal calculation of HFRONT or HBACK of vertical wall; no other data is required	

Note:

HFRONT and HBACK are always *convective* heat transfer coefficients only (no radiative part). If one HFRONT or HBACK of an internal surface is defined as a variable INPUT TYPE, since Version 16 the star network will be automatically recalculated each TRNSYS iteration. If one HFRONT or HBACK of an internal surface is set to internal calculation the star network will be recalculated each internal iteration of TYPE56. For wall types with active layer type the convective heat transfer coefficient is important for the heat transfer to the zone. Therefore, it is recommended to use temperature depending correlation's to calculate convective heat transfer coefficient. Since Version 16 the common way to do so is to use the internal calculation option by this all walls set to this options will be calculated with the correlation of TYPE80 using the parameters set at properties.

$$\alpha_{conv,floor\_heated} = K_{fl\_heated}\,(Tsurf_{floor} - Tair_{floor})^{efl\_heated}$$

$$\alpha_{conv,floor\_cooled} = K_{fl\_cooled}\,(Tsurf_{floor} - Tair_{floor})^{efl\_cooled}$$

$$\alpha_{conv,ceiling\_coooled} = K_{ce\_cooled}\,(Tsurf_{ceiling} - Tair_{ceiling})^{ece\_cooled}$$

$$\alpha_{conv,ceiling\_heated} = K_{ce\_heated}\,(Tsurf_{ceiling} - Tair_{ceiling})^{ece\_heated}$$

$$\alpha_{conv,vertical} = K_{vertical}\,(Tsurf_{vertical} - Tair_{vertical})^{evertical}$$

Of course it is still possible to define a variable INPUT TYPE and to calculate the heat transfer coefficient external with TYPE 80 e.g. if you want to calculate the heat transfer coefficients only for one wall with different user defined parameters.

For wall types with a **known boundary** temperature, the convective heat transfer coefficient can be set to a very small value (less than 0.001 kJ/h/m²) to force the surface temperature of the wall to be equal to the boundary temperature. The use of a very small value can be confusing but was kept for backwards compatibility reasons.

ABS-FRONT and ABS-BACK should **not be used** for shifting solar radiation to certain surfaces! Therefore, the keyword GEOSURF has been introduced to the wall description within a zone.

For walls with active layers, the thickness of the layers adjacent to the active layer has to be **larger than 0.3 * pipe spacing**! In addition, the adjacent layers have to be the same layer type.

6.2.10.3.5. WINDOW-TYPES

In the program WINDOW 4.1 (Lawrence Berkeley Laboratory, USA), a detailed calculation of reflections between the individual panes and the absorption and transmission of each pane is performed. Thermal properties and optical data for the window are written to an ASCII file by the WINDOW 4.1 program. These output files, combined in a window library, are accessible through a FORTRAN logical unit given as the third parameter of Type 56. An example of the window data is shown in Table 6.2.10-16. Windows are considered black for internal radiative gains and long-wave radiation exchange between internal surfaces.

Table 6.2.10-15: WINDOW TYPE Data

Keyword	Data Type	Data Description	Unit
WINDOW	2	window name	
WINID	3	window identification number	
HINSIDE	3	convective heat transfer coefficient at the inside surface of the window	[kJ/h m² K]
HOUTSIDE	3	convective heat transfer coefficient at the outside surface of the window	[kJ/h m² K]
SLOPE	3	slope of the window (vertical = 90)	[degree]
FFRAME	3	ratio of the frame area to the total window area	[%/100]
UFRAME	3	heat transfer coefficient of the window frame	[kJ/h m² K]
ABSFRAME	1	front and back absorptance for solar radiation of the window frame	[%/100]
RISHADE	3	additional thermal resistance of the internal shading element	[h m² K/kJ]
RESHADE	3	additional thermal resistance of the external shading element	[h m² K/kJ]
REFLISHADE	3	reflection coefficient of the internal shading element towards the window	[%/100]
REFLOSHADE	3	reflection coefficient of the internal shading element towards the zone	[%/100]
CCISHADE	3	fraction of the solar radiation absorbed by the internal shading element that is transferred to the air node by additional convection between the inner window pane and the internal shading element	[%/100]

Note: HINSIDE and HOUTSIDE are always *convective* heat transfer coefficients only (no radiative part). If HINSIDE or HOUTSIDE is defined as a variable INPUT TYPE, the fourth parameter of Type 56 must be set to 1, in order to recalculate the star network every timestep.

Table 6.2.10-16: Window data used by the Type 56

```
WINDOW 4.1  DOE-2 Data File : Multi Band Calculation

Unit System : SI
Name            : TRNSYS 14.2  WINDOW LIB
Desc            : Double Low-E Glazing, Argon
Window ID      : 2001
Tilt            : 90.0
Glazings        : 2
Frame           : 11 TRNSYS              2.270
Spacer          :  1 Class1              2.330  -0.010   0.138
Total Height     : 1219.2 mm
Total Width      :  914.4 mm
Glass Height     : 1079.5 mm
Glass Width      :  774.7 mm
Mullion          : None
Gap      Thick  Cond  dCond    Vis   dVis   Dens   dDens     Pr    dPr
1 Argon    16.0 0.01620  5.000  2.110  6.300  1.780 -0.0060  0.680 0.00066
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  0.462 0.465 0.458 0.448 0.436 0.412 0.360 0.263 0.121 0.000 0.384
Abs1  0.114 0.114 0.116 0.120 0.125 0.132 0.139 0.146 0.147 0.000 0.128
Abs2  0.186 0.188 0.195 0.199 0.198 0.197 0.199 0.186 0.118 0.000 0.189
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 0.237 0.232 0.231 0.233 0.241 0.260 0.303 0.406 0.614 1.000 0.289
Rbsol 0.179 0.172 0.170 0.173 0.183 0.202 0.239 0.328 0.542 0.999 0.227
Tvis  0.749 0.754 0.743 0.730 0.711 0.674 0.589 0.428 0.200 0.000 0.626
Rfvis 0.121 0.115 0.114 0.118 0.132 0.163 0.228 0.376 0.649 1.000 0.203
Rbvis 0.109 0.102 0.099 0.102 0.115 0.140 0.188 0.296 0.529 0.999 0.170
SHGC  0.624 0.629 0.627 0.622 0.608 0.584 0.534 0.427 0.227 0.000 0.549
SC: 0.58

Layer ID#           9052     9055       0       0       0       0
Tir                0.000    0.000       0       0       0       0
Emis F             0.840    0.100       0       0       0       0
Emis B             0.840    0.840       0       0       0       0
Thickness(mm)        4.0      4.0       0       0       0       0
Cond(W/m2-C     )225.0    225.0       0       0       0       0
Spectral File       None     None    None    None    None    None

Overall and Center of Glass Ig U-values (W/m2-C)
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-C)
   0       0.00  12.25  3.24  7.60  1.46 1.46  1.20 1.20  1.23 1.23  1.35 1.35
   0       6.71  25.47  3.21  7.63  1.53 1.53  1.23 1.23  1.27 1.27  1.40 1.40
 783       0.00  12.25  3.38  8.02  1.61 1.61  1.42 1.42  1.37 1.37  1.39 1.39
 783       6.71  25.47  3.29  7.86  1.70 1.70  1.50 1.50  1.44 1.44  1.43 1.43
```

The values for Window ID, Spacer, Height and Width of glazing, Gap 1-5, Tsol, Abs1 - Abs6, Rfsol, Rbsol, EmisF, EmisB, Thickness and Cond as well as the Ug-value at 26.7°C, no solar radiation and 6.71 m/s windspeed are read and used by Type 56 for the calculation of the thermal and optical window behavior (see bold and highlighted lines in Table 6.2.10-16). The Height and Width of the glazing are used for edge correction only. The actual area of the window is defined in the zone description.

Internal shading devices are defined by specifying the shading factor (fraction of non-transmitted solar radiation) in the zone description of the window, the reflection of the shading device of both sides (material data), and the coefficient for additional convection to the zone air node. This coefficient CCISHADE is dependent on the actual temperatures, the type of shading device (louvers, blinds, etc.) and the geometry of the air volume between the shading device and the window, especially the height of the shading device and the distance to the inner window pane. If the internal shading device is located very close to the inner window pane without any flow of air in between, CCISHADE should be set to zero. A value of one for this coefficient represents an internal shading device located in the room very far from the window. Typical values for CCISHADE range from 0.3 to 0.6.

6.2.10.3.6. GAIN TYPES

Gains are used within the description of each zone. They are considered to include energy convection, radiation, and humidity.

Table 6.2.10-17: GAIN TYPE DATA

Keyword	Data Type	Data Description
GAIN	2	gain name
CONVECTIVE	3	convective energy gain rate
RADIATIVE	3	radiative energy gain rate
HUMIDITY	3	humidity gain (mass per time)

It is possible to scale gains for any zone within the BUILDING description. This scaling may also vary according to a SCHEDULE. In this way, generalized gains such as from a single person or single computer terminal may be defined with GAIN TYPES and subjected to different scales and/or schedules (see below and the example of Sections 6.5.1 and 6.5.2). Gain data for different GAIN TYPES are listed in Table 6.2.10-18. In addition, predefined gains according to VDI 2078 are integrated in the TRNBUILD interface (check the TRNBUILD manual for more details).

Table 6.2.10-18: Rates of Heat Gain from Occupants of Conditioned Spaces[a]

			Total Heat Adjusted[b]		Sensible Heat		Latent Heat	
No.	Degree of Activity	Typical Application	Watts	Btu/h	Watts	Btu/h	Watts	Btu/h
1	Seated at rest	Theatre, movie	100	350	60	210	40	140
2	Seated, very light writing	Office, hotels, apartments	120	420	65	230	55	190
3	Seated, eating	Restaurant[c]	170	580	75	255	95	325
4	Seated, light work, typing	Offices, hotels, apartments	150	510	75	255	75	255
5	Standing, light work, or walking slowly	Retail Store, bank	185	640	90	315	95	325
6	light bench work	Factory	230	780	100	345	130	435
7	walking, 1.3 m7s (3mph) light machine work	Factory	305	1040	100	345	205	695
8	Bowling[d]	Bowling alley	280	960	100	345	180	615
9	moderate dancing	Dance hall	375	1280	120	405	255	875
10	Heavy work, lifting Heavy machine work	Factory	470	1600	165	565	300	1035
11	Heavy work, athletics	Gymnasium	525	1800	185	635	340	1165

[a] Tabulated values are based on 25.5°C (78°F) room dry-bulb temperature. For 26.6°C (80°F) room dry bulb temperature, the total heat remains the same, but the sensible heat value should be decreased by approximately 8% and the latent heat values increased accordingly.

[b]Adjusted total head gain is based on normal percentage of men, women, and children for the application listed, with the postulate that the gain from an adult is 85% of that for an adult male, and that the gain from a child is 75% of that for an adult male.

[c]Adjusted total heat value for eating in a restaurant, includes 17.6 W (60 Btu/h) for food per individual (8.8 W (30 Btu/h) sensible and 8.8 (30 Btu/h) latent).

[d]For bowling figure one person per alley actually bowling, and all other sitting 117 W (400 Btu/h) of standing and walking slowly 231 W (790 Btu/h).

All values rounded to nearest 5 Watts or to nearest 10 Btu/h.

6.2.10.3.7. COMFORT TYPE

A COMFORT type may be used within the description of each zone. The thermal comfort calculation is based on EN ISO 7730. A COMFORT type is considered to include clothing factor, metabolic rate, external work and relative air velocity. No influence of direct or diffuse solar radiation onto the occupants are considered for PMV and PPD calculation!

Table 6.2.10-19: COMFORT TYPE DATA

Keyword	Data Type	Data Description	Unit
COMFORT	2	gain name	
CLOTHING	3	clothing factor acc. to ISO 7730	[clo]
MET	3	metabolic rate acc. to ISO 7730	[met]
WORK	3	external work acc. to ISO 7730	[met]
VELOCITY	3	rel. air velocity acc. to ISO 7730	[m/s]

EN ISO 7730 provides large variety of clothing factors. The following table gives a brief summary for common clothing ensembles.

Table 6.2.10-20: CLOTHING factor of different clothing ensemble

Clothing ensemble	**Clothing factor [clo]**
Nude	0
Shorts	0.1
Light summer clothing (long light-weight-trousers, open neck shirt with short sleeves)	0.5
Light working ensemble (Athletic shorts, woolen socks, cotton work shirt, work trousers)	0.6
Typical business suit	1.0
Typical business suit + Cotton coat	1.5
Light outdoor sportswear (Cotton shirt, trousers, T-shirt, shorts, socks, shoes, single ply poplin jacket)	0.9
Heavy traditional European business suit	1.5

In most cases, the external work is 0.

The metabolic rate represents a heat production depending on the activity level. The following table gives a brief summary of common values.

Table 6.2.10-21: METabolic rate

Degree of Activity	**Metabolic rate [met]** (acc. to EN ISO 7730)
Seated, relaxed	1.0
Seated, light work (office, home, school, laboratory)	1.2
Standing, light work (Shopping, laboratory, light factory work)	1.6
Standing, moderate work (Sale activity, housework, operating of a machine	2.0
Walking, 2 km/h	1.9
Walking, 3 km/h	2.4
Walking, 4 km/h	2.8
Walking, 5 km/h	3.4

6.2.10.3.8. INFILTRATION TYPE

Infiltration is given in terms of the number of zone air changes per hour. Thus, the infiltration mass flow rate for any zone is the product of the air changes, the zone volume, and the air density. Infiltration air is assumed to be at outside ambient conditions.

Table 6.2.10-22: INFILTRATION TYPE Data

Keyword	Data Type	Data Description
INFILTRATION	2	infiltration name
AIRCHANGE	3	air changes per hour from ambient source [1/h]

6.2.10.3.9. VENTILATION TYPE

As with infiltration, the ventilation rates are expressed in zone air changes per hour. If heating or cooling equipment is modeled externally, the AIRCHANGE, TEMPERATURE and HUMIDITY should be defined in terms of INPUTS to Type 56 from the external equipment.

Table 6.2.10-23: VENTILATION TYPE Data

Keyword	Data Type	Data Description
VENTILATION	2	ventilation name
AIRCHANGE	3	number of air changes per hour for ventilation flow stream [1/h]
TEMPERATURE	3	temperature of ventilation air flow (ambient temperature if the keyword OUTSIDE is entered) [°C]
HUMIDITY	3	relative humidity of ventilation air flow (ambient relative humidity if the keyword OUTSIDE is entered) [%]

6.2.10.3.10. COOLING TYPE

The cooling requirement of any zone subject to idealized cooling control can be determined by specifying a COOLING TYPE for that regime. If cooling equipment is modeled external to the Type 56 component, the COOLING TYPE should not be used. Instead, the VENTILATION AIRCHANGE, TEMPERATURE and HUMIDITY should be defined as INPUTS, fed by outputs from the conditioning equipment component(s) or negative CONVECTIVE and RADIATIVE GAINS should be defined. A temperature setpoint and maximum cooling rate are required to describe the COOLING TYPE. If used in conjunction with a HEATING TYPE, the zone is only free floating (with no energy requirement) when the temperature is greater than the heating setpoint and less than the cooling setpoint. To consider the effect of energy required for dehumidification of air, it is necessary to specify a relative humidity of the zone air above which there is dehumidification. Setting this ratio to 100% results in a free floating humidity. It is assumed that there is no limit to the amount of energy available for dehumidification.

Table 6.2.10-24: COOLING TYPE Data

Keyword	Data Type	Data Description
COOLING	2	cooling name
ON	3	temperature above which cooling begins [°C]
POWER	3	the maximum cooling power [kJ/hr]
HUMIDITY	3	the relative humidity of zone air above which there is dehumidification of the air (100 for free floating) [%]

6.2.10.3.11. HEATING TYPE

The heating power required by a building zone subject to idealized heating control can be determined by specifying a HEATING TYPE for that regime. If heating equipment is modeled external to Type 56, the HEATING TYPE should not be used. Instead, VENTILATION AIRCHANGE, TEMPERATURE and HUMIDITY should be defined as INPUTS, fed by outputs from the conditioning equipment component(s) or the supplied heating power should be defined as CONVECTIVE and RADIATIVE GAINS. A temperature setpoint and maximum heating power are required to describe the HEATING TYPE. To consider the effect of energy required for humidification of air, it is necessary to specify a relative humidity of the zone air below which there is humidification. Setting this ratio to 0.0 results in a free floating humidity. It is assumed that there is no limit to the amount of energy available for humidification.

For the simulation of heating equipment with both convective and radiative effects, a radiative fraction of the heating power RRAD may be defined. This fraction of the heater power is supplied as internal radiative gains and distributed to the walls of the zone. As the set temperature for the heating equipment is related to the air temperature of the zone, the radiative fraction of the heating power RRAD cannot be higher than 0.99 in order to have a convective part remaining to ensure stable control of the heating equipment. For using RRAD greater than 0 it is recommended to limit the maximum power.

Table 6.2.10-25: HEATING TYPE Data

Keyword	Data Type	Data Description
HEATING	2	heating name
ON	3	temperature below which heating begins [°C]
POWER	3	the maximum heating power [kJ/hr]
HUMIDITY	3	the relative humidity of zone air below which there is humidification of the air (0 for free floating) [%]
RRAD	3	radiative fraction of the heating power [%/100]

6.2.10.3.12. ZONE TYPE

The purpose of the ZONES TYPE is to define names associated with the zones that will be described in the BUILDING data group.

Table 6.2.10-26: ZONES TYPE Data

Keyword	Data Type	Data Description
ZONES	2	names associated with zones to be described in BUILDING

6.2.10.4. Orientations

This data is necessary for the definition of all possible orientations for external walls and windows. For each orientation name specified, an input of incident radiation to the Type 56 TRNSYS component will be required. This is generally provided by the Type 16 Radiation Processor.

> **Note:** The incident angle for a orientation must range from 0 to 180 degrees. Due to the fact that the zenith angle of Type 16 (Radiation processor) ranges only between 0 to 90 degrees, the orientation “horizontal” must be defined as a separate surface in Type 16 (Radiation processor.)

Table 6.2.10-27: ORIENTATIONS TYPE Data

Keyword	Data Type	Data Description
ORIENTATIONS	2	names associated with orientations for which incident radiation inputs will be provided

6.2.10.5. Building

The building description begins following the BUILDING keyword. Each zone description is initiated with the keyword ZONE followed by the name associated with the zone to be described. The names of all zones to be described must have been defined with a ZONES TYPE. After zone name the AIRNODE has to be specified. Up to know every zone has only one AIRNODE. Thus the AIRNODE name is the same name as the zone name. Within each ZONE description, there are three primary descriptions: WALLS, WINDOWS, and REGIME.

6.2.10.6. Walls

WALL descriptions refer to previously defined WALL TYPEs. There are four applications of walls that may be specified: external walls (EXTERNAL), walls separating zones (ADJACENT), internal walls (INTERNAL), and walls having a known external boundary condition (BOUNDARY). Type 56 also offers the possibility to define a certain energy flux to a certain wall surface. Also, thermally activated walls for cooling/heating are integrated in Type 56. If the wall type includes an active layer, optional Keywords are used for specification. A special external wall type to model thermal bridges is added to the wall description. In the following descriptions, the FRONT of a WALL is associated with the first layer given in the WALL TYPE definition. External walls are subjected to ambient conditions. The wall front is assumed to be at the inside of the zone.

For the distribution of direct solar radiation entering a zone explicit distribution factors can be defined by the user. The keyword GEOSURF represents the fraction of the total entering direct solar radiation that strikes the surface. The sum of all values of GEOSURF should not exceed 1 within a zone. If it does, the values will be automatically normalized to ensure a sum of 1 is used for the simulation. The movement of the sun patches within a zone can be modeled by defining a SCHEDULE or an INPUT. The default value of GEOSURF is 0. If the sum of values within a zone is zero, the direct radiation is distributed the same way as the diffuse radiation (by absorptance weighted area ratios). Note: In the previous version (14.2) both diffuse and direct radiation were always distributed according to absorptance weighted area ratios.

6.2.10.6.1. *EXTERNAL WALLS*

Table 6.2.10-28: External Wall Data

Keyword	Data Type	Data Description
WALL	2	name of previously defined WALL TYPE
SURF	1	unique surface number for identification (number must be greater than 0)
AREA	1	area of inside surface of wall [m²]
EXTERNAL	-	keyword specifying an external wall; no other data is required
ORIENTATION	2	name associated with orientation for this wall
FSKY	1	fraction of the sky in the total hemisphere seen by the wall, used as a weighting factor between T_{amb} and T_{sky} [%/100]
WAGAIN	3	energy flux to the inside wall surface [kJ/hr]
GEOSURF	3	fraction of the total direct solar radiation entering the zone that strikes this surface [%/100]

The keyword FSKY gives the fraction of the sky in the total hemisphere in view of the specified wall. This is parameter is used as a weighting factor between the ambient temperature (assuming the ground and other obstructions are at the ambient temperature) and the sky temperature, which is the third input to Type 56.

6.2.10.6.2. EXTERNAL WALLS WITH ACTIVE LAYERS

Table 6.2.10-29: External Wall with active layer Data

Keyword	Data Type	Data Description	Unit
WALL	2	name of previously defined WALL TYPE	
SURF	1	unique surface number for identification (number must be greater than 0)	
AREA	1	area of inside surface of wall	[m²]
EXTERNAL	-	keyword specifying an external wall; no other data is required	
ORIENTATION	2	name associated with orientation for this wall	
FSKY	1	fraction of the sky in the total hemisphere seen by the wall, used as a weighting factor between T_{amb} and T_{sky}	[%/100]
WAGAIN	3	energy flux to the inside wall surface	[kJ/hr]
GEOSURF	3	fraction of the total direct solar radiation entering the zone that strikes this surface	[%/100]
INTEMP	3	inlet temperature of fluid	[°C]
MFLOW	3	inlet flow rate of fluid	[kg/h]
NLOOP	1	number of fluid loops	
EGAIN	3	userdefined energy gain	[kJ/h]
ALFAEQV_SELECTED	-	keyword defining whether the ALFAEQV is used instead of the built in correlation	
ALFAEQV	3	userdefined spec. heat transfer coefficient between inlet fluid temp. and the mean temp. of the plane surface cutting the wall construction at the center of the fluid pipes	[kJ/m² h K]
MFLOWMIN	1	specific desired minimum massflow rate during simulation for auto segmentation	[kg/hm²]
ASEGSURF	1	surfaces order of an auto segmentation first= inlet, ... ,last= outlet	

The user definition of ALFAEQV is for experts only. The value of ALFAEQV may be time dependent.

6.2.10.6.3. External Walls with Chilled Ceiling

Table 6.2.10-30: External Wall with Chilled Ceiling Data

Keyword	Data Type	Data Description	Unit
WALL	2	name of previously defined WALL TYPE	
SURF	1	unique surface number for identification (number must be greater than 0)	
AREA	1	area of inside surface of wall	[m²]
EXTERNAL	-	keyword specifying an external wall; no other data is required	
ORIENTATION	2	name associated with orientation for this wall	
FSKY	1	fraction of the sky in the total hemisphere seen by the wall, used as a weighting factor between T_{amb} and T_{sky}	[%/100]
WAGAIN	3	energy flux to the inside wall surface	[kJ/hr]
GEOSURF	3	fraction of the total direct solar radiation entering the zone that strikes this surface	[%/100]
INTEMP	3	inlet temperature of fluid	[°C]
MFLOW	3	inlet flow rate of fluid	[kg/h]
NLOOP	1	number of fluid loops	

Chilled ceiling only allowed on position 1 of wall definition. External wall has to be a ceiling.

6.2.10.6.4. External Walls with a Thermal Bridge Effect

To consider the effects of thermal bridging on the thermal behavior (heat losses) and other physics (condensation and mold) of walls, the description of this effect was included in the building description. Thermal loss rates are found in thermal bridge (coldbridge) catalogues, and are normally defined in W/m length of the coldbridge or, in TRNSYS units, in kJ/h m. Walltypes for coldbridges are special coldbridge types defined with a resistance and therefore are considered to be without thermal capacitance.

Table 6.2.10-31: Coldbridge Data

Keyword	Data Type	Data Description
WALL	2	name of previously defined COLDBRIDGE TYPE, the first three characters must be 'CBR'
SURF	1	unique surface number for identification (number must be greater than 0)
LENGTH	1	length of the coldbridge [m]
EXTERNAL	-	keyword specifying an external wall; no other data is required
ORIENTATION	2	name associated with orientation for this wall
FSKY	1	fraction of the sky in the total hemisphere seen by the coldbridge wall, used as a weighting factor between T_{amb} and T_{sky} [%/100]
WAGAIN	3	energy flux to the inside wall surface [kJ/hr]
GEOSURF	3	fraction of the total direct solar radiation entering the zone that strikes this surface [%/100]

6.2.10.6.5. WALLS BETWEEN ZONES

For a wall separating zones, it is necessary to specify the name associated with the adjacent zone and the side of the wall that is within the zone. If the wall is symmetrical about its center, then the specification of FRONT or BACK for the wall is arbitrary. It is also possible to specify a mass flow rate of air (COUPLING) from the adjacent zone to the current zone across this wall.

Table 6.2.10-32: Wall Between Zones

Keyword	Data Type	Data Description
WALL	2	name of previously defined WALL TYPE
SURF	1	unique surface number for identification (number must be greater than 0)
AREA	1	area of inside surface of wall
ADJACENT	2	name of the zone which is adjacent to current zone having this wall in common
FRONT or BACK	-	keyword defining whether the front or back of the wall is in the zone; no other data is required
COUPLING	3	convective flow from adjacent zone to the current zone across this wall [kg/hr]
WAGAIN	3	energy flux to the inside wall surface [kJ/hr]
GEOSURF	3	fraction of the total direct solar radiation entering the zone that strikes this surface [%/100]

The COUPLING is only a mass flowrate into the zone being specified. The magnitude of this coupling will directly affect the zone temperature and zone humidity, but will have no affect on the adjacent zone from which the air flowrate originates. It is up to the user to insure proper mass balances for each zone.

6.2.10.6.6. *WALLS BETWEEN ZONES WITH ACTIVE LAYER*

Table 6.2.10-33: Wall Between Zones with Active Layer

Keyword	Data Type	Data Description	Unit
WALL	2	name of previously defined WALL TYPE	
SURF	1	unique surface number for identification (number must be greater than 0)	
AREA	1	area of inside surface of wall	
ADJACENT	2	name of the zone which is adjacent to current zone having this wall in common	
FRONT or BACK	-	keyword defining whether the front or back of the wall is in the zone; no other data is required	
COUPLING	3	a convective flow from the adjacent zone to the current zone across this wall	[kg/hr]
WAGAIN	3	energy flow to the wall surface in the current zone	[kJ/hr]
GEOSURF	3	fraction of the total direct solar radiation the zone that strikes this surface	[%/100]
INTEMP	3	inlet temperature of fluid	[°C]
MFLOW	3	inlet flow rate of fluid	[kg/h]
NLOOP	1	number of fluid loops	
EGAIN	3	energy gain	[kJ/h]
ALFAEQV_SELECTED	-	keyword defining whether the ALFAEQV used instead of the built in correlation	
ALFAEQV	3	Userdefined spec. heat transfer between inlet fluid temp. and the mean temp. of the plane surface cutting the wall construction at the center of the fluid pipes	[kJ/m² h K]
MFLOWMIN	1	specific desired minimum massflow rate during simulation for auto segmentation	[kg/hm²]
ASEGSURF	1	surfaces order of an auto segmentation first= inlet, ... ,last= outlet	

The user definition of ALFAEQV is for experts only. The value of ALFAEQV may be time dependent.

6.2.10.6.7. WALLS BETWEEN ZONES WITH CHILLED CEILING

Table 6.2.10-34: Wall Between Zones with Chilled Ceiling

Keyword	Data Type	Data Description	Unit
WALL	2	name of previously defined WALL TYPE	
SURF	1	unique surface number for identification (number must be greater than 0)	
AREA	1	area of inside surface of wall	
ADJACENT	2	name of the zone which is adjacent to current zone having this wall in common	
FRONT or BACK	-	keyword defining whether the front or back of the wall is in the zone; no other data is required	
COUPLING	3	a convective flow from the adjacent zone to the current zone across this wall	[kg/hr]
WAGAIN	3	energy flow to the wall surface in the current zone	[kJ/hr]
GEOSURF	3	fraction of the total direct solar radiation entering the zone that strikes this surface	[%/100]
INTEMP	3	inlet temperature of fluid	[°C]
MFLOW	3	inlet flow rate of fluid	[kg/h]
NLOOP	1	number of fluid loops	

6.2.10.6.8. INTERNAL WALLS

An internal wall is a wall with both surfaces within the same zone. Internal walls are assumed to affect building response only as the result of their mass.

Table 6.2.10-35: Internal Wall Data

Keyword	Data Type	Data Description
WALL	2	name of previously defined WALL TYPE
SURF	1	unique surface number for identification (number must be greater than 0)
AREA	1	total surface area of wall within zone (includes both sides of the wall)
INTERNAL	-	keyword specifying an internal wall; no other data is required
WAGAIN	3	energy flow to the wall surface in the current zone [kJ/hr]
GEOSURF	3	fraction of the total direct solar radiation entering the zone that strikes this surface [%/100]

6.2.10.6.9. Walls with Known Boundary Condition

A wall having a known boundary condition might be a concrete floor resting on ground of a known temperature or a wall adjacent to a zone whose temperature is known. The front of the wall is considered to be at the inside of the zone. Normally, the boundary condition is the temperature of a node connected to the back surface of the wall through a pure resistance. It is possible to specify the surface temperature of the outside by setting the back side heat transfer coefficient of the WALL TYPE (HBACK) to a very small value (less than 0.001 kJ/h/m²). This WALL TYPE is then only appropriate for use as a wall with a known boundary. The use of a very small value may be confusing but was kept for backwards compatibility reasons.

Table 6.2.10-36: Data for Wall with Known Boundary Condition

Keyword	Data Type	Data Description	Unit
WALL	2	name of previously defined WALL TYPE	
SURF	1	unique surface number for identification (number must be greater than 0)	
AREA	1	area of inside surface of wall	
BOUNDARY	3	temperature associated with boundary at side of wall; use the keyword IDENTICAL for a boundary temperature equal to the zone temperature	[°C]
COUPLING	3	a convective flow from the boundary to the zone across this wall	[kg/hr]
COUPL_HUMI	3	the relative humidity associated to the convective flow from the boundary to the zone across this wall	[%]
WAGAIN	3	energy flow to the wall surface in the current zone	[kJ/hr]
GEOSURF	3	fraction of the total direct solar radiation entering the zone that strikes this surface	[%/100]

6.2.10.6.10. *WALLS WITH KNOWN BOUNDARY CONDITION AND ACTIVE LAYER*

Table 6.2.10-37: Data for Wall with Known Boundary Condition and an active layer

Keyword	Data Type	Data Description	Unit
WALL	2	name of previously defined WALL TYPE	
SURF	1	unique surface number for identification (number must be greater than 0)	
AREA	1	area of inside surface of wall	
BOUNDARY	3	temperature associated with boundary at side of wall; use the keyword IDENTICAL for a boundary temperature equal to the zone temperature	[°C]
COUPLING	3	a convective flow from the boundary to the zone across this wall	[kg/hr]
COUPL_HUM	3	the relative humidity associated to the convective flow from the boundary to the zone across this wall	[%]
WAGAIN	3	energy flow to the wall surface in the current zone	[kJ/hr]
GEOSURF	3	fraction of the total direct solar radiation entering the zone that strikes this surface	[%/100]
INTEMP	3	inlet temperature of fluid	[°C]
MFLOW	3	inlet flow rate of fluid	[kg/h]
NLOOP	1	number of fluid loops	
ALFAEQV_SELECTED	-	keyword defining whether the ALFAEQV is used instead of the built in correlation	
ALFAEQV	3	Userdefined spec. heat transfer coefficient between inlet fluid temp. and the mean temp. of the plane surface cutting the wall construction at the center of the fluid pipes	[kJ/m² h K]
MFLOWMIN	1	specific desired minimum massflow rate during simulation for auto segmentation	[kg/hm²]
ASEGSURF	1	surfaces order of an auto segmentation first= inlet, ... ,last= outlet	

The user definition of ALFAEQV is for experts only. The value of ALFAEQV may be time dependent.

6.2.10.6.11. Walls with Known Boundary Condition and Chilled Ceiling

Table 6.2.10-38: Data for Wall with Known Boundary Condition and Chilled Ceiling

Keyword	Data Type	Data Description	Unit
WALL	2	name of previously defined WALL TYPE	
SURF	1	unique surface number for identification (number must be greater than 0)	
AREA	1	area of inside surface of wall	
BOUNDARY	3	temperature associated with boundary at side of wall; use the keyword IDENTICAL for a boundary temperature equal to the zone temperature	[°C]
COUPLING	3	a convective flow from the boundary to the zone across this wall	[kg/hr]
COUPL_HUM	3	the relative humidity associated to the convective flow from the boundary to the zone across this wall	[%]
WAGAIN	3	energy flow to the wall surface in the current zone	[kJ/hr]
GEOSURF	3	fraction of the total direct solar radiation entering the zone that strikes this surface	[%/100]
INTEMP	3	inlet temperature of fluid	[°C]
MFLOW	3	inlet flow rate of fluid	[kg/h]
NLOOP	1	number of fluid loops	

The chilled ceiling layer is only allowed on position 1 of wall definition. Boundary wall has to be a ceiling.

6.2.10.7. Windows

Windows are assumed to be EXTERNAL or ADJACENT. By defining an INPUT for the keywords ESHADE or ISHADE, connected to an external controller, individually controlled shading devices may be modeled. As in the case of external walls, the FSKY parameter must be specified for use as a weighting factor between Tamb and Tsky for the calculation of long-wave radiative exchange.

For the distribution of direct solar radiation entering a zone explicit distribution factors can be defined by the user. The keyword GEOSURF represents the fraction of the total entering direct solar radiation that strikes the surface. The sum of all values of GEOSURF should not exceed 1 within a zone. If it does, the values will be automatically normalized to ensure a sum of 1 is used for the simulation. The movement of the sun patches within a zone can be modeled by defining a

SCHEDULE or an INPUT. The default value of GEOSURF is 0. If the sum of values within a zone is zero, the direct radiation is distributed the same way as the diffuse radiation (by absorptance weighted area ratios). Note: In the previous version (14.2) both diffuse and direct radiation were always distributed according to absorptance weighted area ratios.

Table 6.2.10-39: External Window Data

Keyword	Data Type	Data Description
WINDOW	2	name of window type
SURF	1	unique surface number for identification (number must be greater than 0)
AREA	1	area of inside surface of window opening [m²]
EXTERNAL	-	keyword specifying an external wall; no other data is required
ORIENTATION	2	name associated with orientation for this window
FSKY	1	fraction of the sky in the total hemisphere seen by the window, used as a weighting factor between T_{amb} and T_{sky} [%/100]
WAGAIN	3	energy flow to the surface in the current zone [kJ/hr]
GEOSURF	3	fraction of the total direct solar radiation entering the zone that strikes this surface [%/100]
ISHADE	3	shading factor of the internal shading device (opaque fraction of the device) [%/100]
ESHADE	3	shading factor of the external shading device (opaque fraction of the device) [%/100]

Table 6.2.10-40: Adjacent Window Data

Keyword	Data Type	Data Description
WINDOW	2	name of window type
SURF	1	unique surface number for identification (number must be greater than 0)
AREA	1	area of inside surface of window opening [m²]
ADJACENT	2	name of the zone which is adjacent to current zone having this window in common
FRONT or BACK	-	keyword defining whether the front or back of the window is in the zone;
COUPLING	3	a convective flow from the adjacent zone to the current zone across this wall [kg/hr]
ORIENTATION	2	name associated with orientation for this window
WAGAIN	3	energy flow to the surface in the current zone [kJ/hr]
GEOSURF	3	fraction of the total direct solar radiation entering the zone that strikes this surface [%/100]
ISHADE (only at FRONT)	3	shading factor of the internal shading device (opak fraction of the device) [%/100]

6.2.10.8. Regime

The REGIME represents the air within the thermal zone. The input data establish initial conditions, gains, and conditioning. There are optional and required data types. The regime description begins following the keyword REGIME. The optional data must appear prior to the required data. Four of the optional inputs refer to previously defined TYPES only.

Table 6.2.10-41: Optional REGIME Data Referring Only to TYPES

Keyword	Data Type	Data Description
COMFORT	2	name of previously defined COMFORT TYPE
INFILTRATION	2	name of previously defined INFILTRATION TYPE
VENTILATION	2	name of previously defined VENTILATION TYPE
HEATING	2	name of previously defined HEATING TYPE
COOLING	2	name of previously defined COOLING TYPE

This data may appear in any order. Only one statement of COMFORT, INFILTRATION, HEATING and COOLING is allowed per zone. It is possible to define thermal gains for a REGIME with the following data.

Table 6.2.10-42: Optional GAINS Data

Keyword	Data Type	Data Description
GAINS	2	name of previously defined GAIN TYPE
SCALE	3	a factor which scales the GAIN TYPE for this REGIME

Following the optional data statements, five or ten data statements are required depending on the humidity model used.

If the capacitance humidity model is used, a fifth parameter WCAPR must be specified. WCAPR is used as a multiplier to increase the humidity capacitance due to the air in the zone and normally ranges from 1 to 10. WCAPR accounts for the humidity capacitance of the air plus any other mass within the zone. If WCAPR = 1, only the humidity capacitance of the air is used.

Table 6.2.10-43: Required REGIME Data using the Capacitance Humidity Model

Keyword	Data Type	Data Description
CAPACITANCE	1	thermal capacitance of total zone air plus any mass not considered as walls (the value 0 is allowed) [kJ/K]
VOLUME	1	volume of air within zone [m³]
TINITIAL	1	initial temperature of zone air [°C]
PHIINITIAL	1	initial relative humidity of zone air [%]
WCAPR	1	humidity capacitance ratio (set on 1 if only zone air is considered)

If the more advanced buffer storage humidity model is used, six parameters following PHIINITIAL must be specified. KSURF and KDEEP describe the gradients of the linearized sorptive isothermal lines of the materials used in the surface and deep buffer storage, respectively. MSURF and MDEEP give the total mass of the surface and deep buffer storage materials, respectively. BSURF represents the moisture exchange coefficient between the zone air and the surface storage. BDEEP represents the moisture exchange coefficient between the surface and the deep buffer storage. This data is shown in Table 6.4.3-1.

Table 6.2.10-44: Required REGIME Data using the Buffer Storage Humidity Model

Keyword	Data Type	Data Description	Unit
CAPACITANCE	1	thermal capacitance of total zone air plus any mass not considered as walls (the value 0 is allowed)	[kJ/K]
VOLUME	1	volume of air within zone	[m^3]
TINITIAL	1	initial temperature of zone air	[°C]
PHIINITIAL	1	initial relative humidity of zone air	[%]
KSURF	1	gradient of the sorptive isothermal line for the surface buffer storage	[kg_{water}/kg_{mat}/rel. hum.]
KDEEP	1	gradient of the sorptive isothermal line for the deep buffer storage	[kg_{water}/kg_{mat}/rel. hum.]
MSURF	1	mass of the surface buffer storage	[$kg_{material}$]
MDEEP	1	mass of the deep buffer storage	[$kg_{material}$]
BSURF	1	exchange coefficient between zone air and surface buffer storage	[kg_{air}./hr]
BDEEP	1	exchange coefficient between surface buffer and deep buffer storage	[kg_{air}/hr]

6.2.10.9. Output

The user identifies the outputs desired from the TRNSYS Type 56 component. TRNBuild creates three data files from the user input. The first file is an information file for the user describing the inputs and outputs necessary for the Type 56 (*.INF). The other two files will be used by Type 56: one contains the building description (*.BLD) and the other contains the transfer function coefficients for each wall (*.TRN).

Following the OUTPUT keyword is the data necessary for specifying the calculation of the wall transfer function coefficients. If these calculations are required (and the corresponding file), the following data applies:

Table 6.2.10-45: Data for Wall Transfer Function Calculations

Keyword	Data Type	Data Description
TRANSFER	-	keyword specifying that transfer function calculations will be performed; no other data is required
TIMEBASE	1	the time series that characterizes the walls is based upon a time interval equal to the TIMEBASE; ASHRAE recommends 1 hour (for heavy constructions, 2 - 4 can be used; 0.5 for light walls)

Note: The start time and the time step used in the TRNSYS input file DCK needs to adjusted acc. to the timebase of the walls.

The output data of the Type 56 component is defined by the declaration of the zone airnodes to which the output refers and by the definition of so-called NTYPES, specification numbers which refer to the desired quantity (see Table 6.2.3-1).

The default outputs of Type 56 are zone air temperatures and sensible energy demands (NTYPES 1 and 2) for all zones. To specify the defaults, enter the keywords rather than the explicit specification.

There are many optional outputs from Type 56 that may be specified by the user. The input data for this specification are:

Table 6.2.10-46: Data for Optional Zone Outputs

Keyword	Data Type	Data Description
AIRNODES	2	names of airnodes for which outputs are desired
NTYPES	1	numbers associated with the optional outputs of Table 6.2.3-1; these outputs are provided for each zone specified

Table 6.2.10-47: Data for Optional Surface Outputs

Keyword	Data Type	Data Description
AIRNODE	2	name of airnode for which outputs are desired (only one airnode allowed for surface outputs)
NTYPES	1	number associated with the optional outputs of Table 6.2.3-1;
SURF	1	number of surfaces separated by a comma

Multiple output specifications are possible. Thus it is possible to specify different outputs for different zones. There are optional outputs for zone quantities, for the surfaces within zones or for quantities summed up for a group of zones.

6.3. TRNSYS Component Configuration

6.3.1. Parameters

PARAMETER NO.		DESCRIPTION
1	LUb	FORTRAN logical unit for reading the *.bui file written by TRNBUILD
2	T*-MODE	Switch for calculation of star network, <1: only at start of simulation, >1: every iteration. If automatic heat transfer coefficients are used or one heat transfer coefficient is an input/schedule Version 16 automatically performs the calculation of star network each iteration. Specific zones may be calculated with combined convective and radiative heat surface coefficients. The No. of zones with star network calculation is given by Abs(PAR(2))-100, counting from the first specified zone. The following zones are calculated with surface film coefficients (HFRONT/HBACK, HINSIDE/HOUTSIDE) as combined heat transfer coefficients. Values of PAR(2) below 1 indicate a calculation of star network only at the simulation start; Values of PAR(2) above and equal 1 -> recalculation of star network every iteration.
3	A_{op}	Weighting factor for operative room temperature $T_{op} = A_{op} \cdot T_{air} + (1-A_{op}) \cdot T_{surf}$
4 (optional)	LUs	FORTRAN logical unit for monthly summary standard report for all building zones.
5 (optional)	LUht	FORTRAN logical unit for standard report of hourly zone temperatures for all building zones.
6 (optional)	LUhp	FORTRAN logical unit for standard report of hourly heating and cooling demand for all building zones.

6.3.2. *Inputs*

As described previously since Version 16, TRNBUILD is called before each building simulation automatically and creates a file for the building description (*.BLD) and another for the transfer function coefficients (*.TRN) that characterize the wall constructions. These two files are assign internally to TYPE and include all information TYPE56 needs about the building.

In addition, TRNBUILD generates an information file (*.INF) with a list of required inputs and available outputs. The user must specify the proper input connections in the TRNSYS input file.

6.3.3. *Outputs*

As described previously since Version 16, TRNBUILD is called before each building simulation automatically and creates a file for the building description (*.BLD) and another for the transfer function coefficients (*.TRN) that characterize the wall constructions. These two files are assign internally to TYPE and include all information TYPE56 needs about the building.

In addition, TRNBUILD generates an information file (*.INF) with a list of required inputs and available outputs. The user must specify the proper input connections in the TRNSYS input file.

Besides the outputs defined in TRNBuild standard output reports for TYPE 56 for the most interesting variables is available by specifying optional logical unit numbers (LU) for PAR (4) to PAR(6).

PAR(4) > 0: **simulation summary** including HEATING (NTYPE 32), COOLING (NTYPE 33), INFILTR (NTYPE 4), VENTILAT (NTYPE 5), SOLAR_RAD (NTYPE12) and INT_GAINS (NTYPE 7+13)

```
****************************************************************
*             MONTHLY SUMMARY STANDARD REPORT       *
****************************************************************
```

SUMMARY VALUES FOR ALL ZONES COMBINED
****

MONTH	HEATING	COOLING	INFILTR.	VENTILAT.	SOLAR_RAD.	INT_GAINS
-	[KWH]	[KWH]	[KWH]	[KWH]	[KWH]	[KWH]
JAN	7.415E+03	0.000E+00	-6.463E+03	-8.022E+00	7.767E+02	5.034E+03
FEB	6.391E+03	0.000E+00	-5.400E+03	-2.561E+01	1.133E+03	3.971E+03
MAR	4.860E+03	0.000E+00	-4.678E+03	-4.975E+01	1.751E+03	3.412E+03
APR	2.100E+03	0.000E+00	-3.114E+03	-5.360E+01	1.908E+03	2.978E+03
MAY	1.089E+03	0.000E+00	-2.373E+03	-1.527E+02	1.958E+03	2.800E+03
JUN	1.114E+01	0.000E+00	-1.679E+03	-6.473E+02	1.937E+03	2.349E+03
JUL	0.000E+00	0.000E+00	-9.287E+02	-2.435E+03	1.996E+03	2.730E+03
AUG	0.000E+00	0.000E+00	-1.036E+03	-2.252E+03	1.960E+03	2.867E+03
SEP	6.870E+00	0.000E+00	-1.834E+03	-4.518E+02	1.843E+03	2.868E+03
OCT	1.477E+03	0.000E+00	-3.271E+03	-5.129E+01	1.412E+03	4.245E+03
NOV	5.517E+03	0.000E+00	-5.206E+03	-1.546E+01	9.428E+02	4.653E+03
DEC	6.794E+03	0.000E+00	-5.710E+03	0.000E+00	6.764E+02	4.747E+03
SUM	3.566E+04	0.000E+00	-4.169E+04	-6.142E+03	1.829E+04	4.265E+04

ZONE NUMBER IS 1
****

MONTH	HEATING	COOLING	INFILTR.	VENTILAT.	SOLAR_RAD.	INT_GAINS
-	[KWH]	[KWH]	[KWH]	[KWH]	[KWH]	[KWH]
JAN	3.409E+03	0.000E+00	-2.798E+03	0.000E+00	2.491E+02	2.265E+03
FEB	2.931E+03	0.000E+00	-2.337E+03	0.000E+00	3.623E+02	1.797E+03

(.......)

PAR(5) > 0: printer file incl. air temperatures (NTYPE 1) and operative temperatures (NTYPE 25)

TIME	TAMB	T_AIR	T_OP	1_T_AIR	1_T_OP	2_T_AIR	2_T_OP	3_T_AIR	3_T_OP
[HR]	[C]	[C]	[C]	[C]	[C]	[C]	[C]	[C]	[C]
0.00	0.00	20.00	20.00	20.00	20.00	20.00	20.00	20.00	20.00
1.00	-2.80	19.27	19.39	19.36	19.48	19.22	19.32	19.04	19.09

....

The first column is the ambient temperature (except for the first hour). The 2nd and 3rd column shows the mean air temperature of the whole building. Then follows for each zone the air temperature and the operative temperature. The zone can be identified by the figure in front of the label. So, the air temp. of zone one is 1_T_AIR the operative temp. is 1_T_OP . The values are given in °C. Up to 50 zones can be printed. Note: The actual value is printed and NOT the integrated value over the last hour.

PAR(6) > 0: printer file incl. heating power (NTYPE 32) and cooling power (NTYPE 33)

TIME	TAMB	HEAT	COOL	1_HEAT	1_COOL	2_HEAT	2_COOL	3_HEAT	3_COOL
[HR]	[C]	[KW]	[KW]	[KW]	[KW]	[KW]	[KW]	[KW]	[KW]
0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
1.00	-2.80	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
2.00	-2.08	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00

....

The first column shows also the ambient temperature (except for the first hour). The 2nd and 3rd column shows the total heating and cooling power of the whole building. Then follows for each zone the heating and cooling power. The zone can be identified by the figure in front of the label. So, the heating power of zone one is 1_HEAT the cooling power is 1_COOL . The values are given in kW. Up to 50 zones can be printed.

6.4. Mathematical Description of Type 56

The general case, which does not include the simplified model of the heating and cooling equipment, is presented first. If separate equipment components are used, they can be coupled to the zones as either internal convective gains or ventilation gains. Following this, the simplified method of providing heating and cooling equipment within the TYPE 56 component is described. Another section will cover the use of a simulation timestep that is not equal to the timebase on which the wall transfer function relationships are based. Finally, descriptions of the optical and thermal window model, the way in which solar and internal radiation are distributed within each zone, the moisture balance calculations and the integrated model for thermo-active walls are given.

6.4.1. Thermal Zone

The building model in TYPE 56 is a non-geometrical balance model with one air node per zone, representing the thermal capacity of the zone air volume and capacities which are closely connected with the air node (furniture, for example). Thus the node capacity is a separate input in addition to the zone volume.

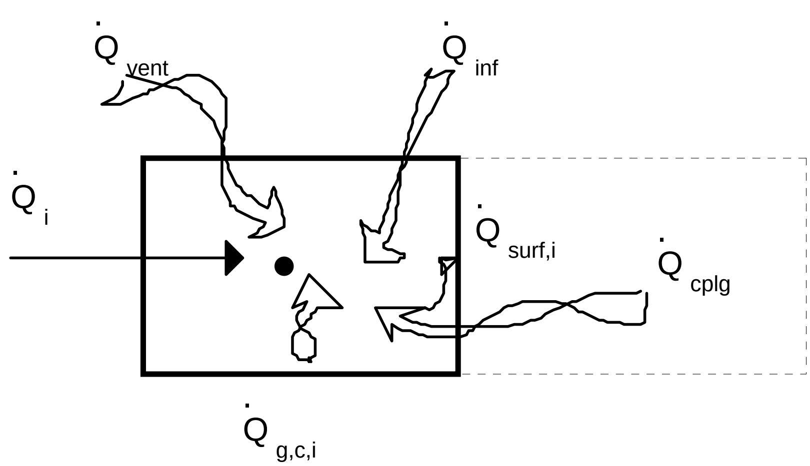


Figure 6.4.1-1: Heat balance on the zone air node

6.4.1.1. Convective Heat Flux to the Air Node

$$\dot{Q}_i = \dot{Q}_{surf,i} + \dot{Q}_{inf,i} + \dot{Q}_{vent} + \dot{Q}_{g,c,i} + \dot{Q}_{cplg,i} \qquad \text{Eq. 6.4.1-1}$$

where $\dot{Q}_{surf,i}$ is the infiltration gains (air flow from outside only), given by

$$\dot{Q}_{\inf,i} = \dot{V} \cdot \rho \cdot c_p \cdot \left(T_{outside} - T_{air}\right) \qquad \text{Eq. 6.4.1-2}$$

$\dot{Q}_{vent,i}$ is the ventilation gains (air flow from a user-defined source, like an HVAC system, given by

$$\dot{Q}_{vent,i} = \dot{V} \cdot \rho \cdot c_p \cdot \left(T_{ventilation,i} - T_{air}\right) \qquad \text{Eq. 6.4.1-3}$$

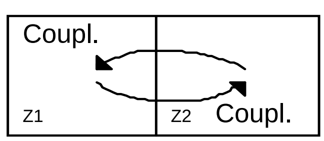
$\dot{Q}_{g,c,i}$ is the internal convective gains (by people, equipment, illumination, radiators, etc.), and

$\dot{Q}_{cplg,i}$ is the gains due to (connective) air flow from zone I or boundary condition, given by

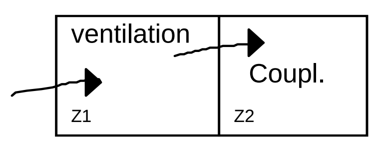
$$\dot{Q}_{cplg,i} = \dot{V} \cdot \rho \cdot c_p \cdot \left(T_{zone,i} - T_{air}\right) \qquad \text{Eq. 6.4.1-4}$$

6.4.1.2. Coupling

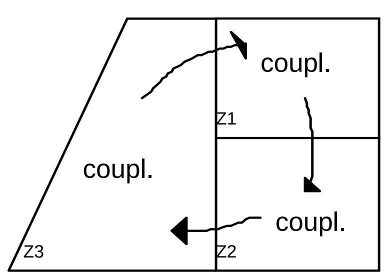
The coupling statement allows the definition an air mass flow a zone <u>receives</u> from another zone, considered as a heat flow from or to the air node. The statement does not automatically define the air flow back to the adjacent zone as would occur in an interzonal air exchange. To consider this return flow, the corresponding coupling must be defined in the adjacent zone to <u>receive</u> the same air flow in return. The reason for this convention is to allow the user to describe cross ventilation or a ventilation circle within 3 or more zones (e.g., thermosyphon through a 2 story winter-garden,).



interzonal airchange



cross ventilation



Ventilation circle

Note: There is no air balance check in TYPE 56. The user can empty or overload a zone by couplings. Be sure that the specified air flows into a zone by coupling, ventilation, and infiltration are physically meaningful.

6.4.1.3. Radiative Heat Flows (only) to the Walls and Windows

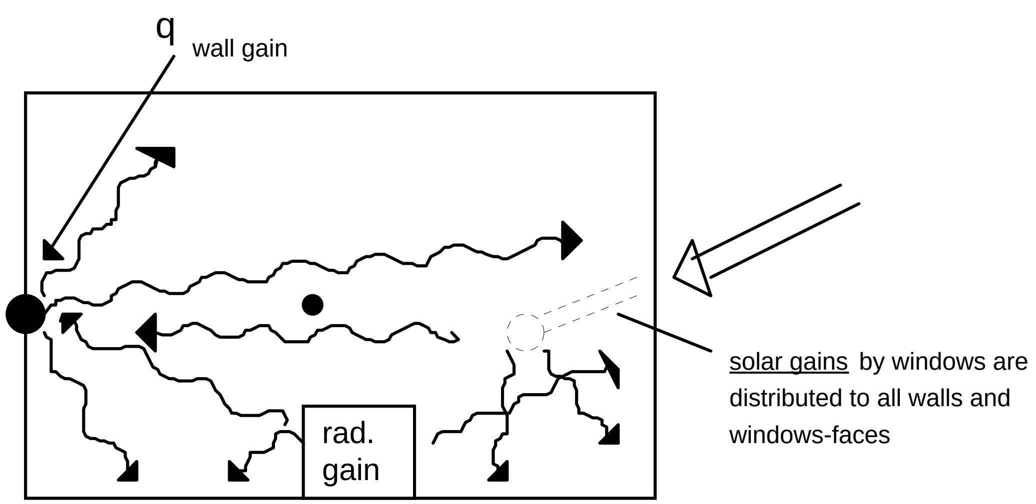


Figure 6.4.1-2: Radiative energy flows considering one wall with its surface temperature node.

$$\dot{Q}_{r,w_i} = \dot{Q}_{g,r,i,w_i} + \dot{Q}_{sol,w_i} + \dot{Q}_{long,w_i} + \dot{Q}_{wall-gain} \qquad \text{Eq. 6.4.1-5}$$

where $\dot{Q}_{r,w_i}$ is the radiative gains for the wall surface temperature node, $\dot{Q}_{g,r,i,w_i}$ is the radiative zone internal gains received by wall, $\dot{Q}_{sol,w_i}$ is the solar gains through zone windows received by walls, $\dot{Q}_{long,w_i}$ is the longwave radiation exchange between this wall and all other walls and windows (ε_i =1), and $\dot{Q}_{wall-gain}$ is the user-specified heat flow to the wall or window surface. All of these quantities are given in kJ/h.

6.4.1.4. Integration of Walls and Windows

Figure 6.4.1-3 shows the heat fluxes and temperatures that characterize the thermal behavior of any wall or window. The nomenclature used in this figure is defined as follows:

$S_{s,i}$	Radiation heat flux absorbed at the inside surface (solar and radiative gains)
$S_{s,o}$	Radiation heat fux absorbed at the outside surface (solar gains)
$\dot{q}_{r,s,i}$	Net radiative heat transfer with all other surfaces within the zone
$\dot{q}_{r,s,o}$	Net radiative heat transfer with all surfaces in view of the outside surface
$\dot{q}_{w,g,i}$	User defined heat flux to the wall or window surface
$\dot{q}_{s,i}$	Conduction heat flux from the wall at the inside surface
$\dot{q}_{s,o}$	Into the wall at the outside surface
$\dot{q}_{c,s,i}$	Convection heat flux from the inside surface to the zone air
$\dot{q}_{c,s,o}$	Convection heat flux to the outside surface from the boundary/ambient
$T_{s,i}$	Inside surface temperature
$T_{s,o}$	Outside surface temperature

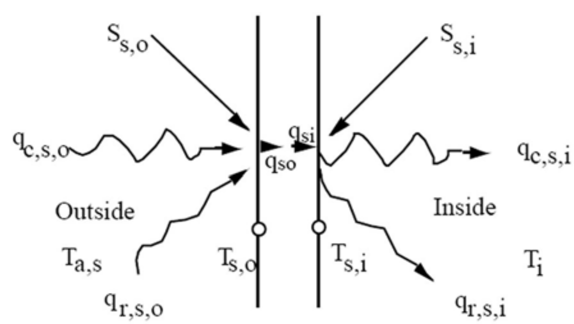


Figure 6.4.1-3: Surface Heat Fluxes and Temperatures

The walls are modeled according to the transfer function relationships of Mitalas and Arseneault [1,2,6] defined from surface to surface. For any wall, the heat conduction at the surfaces are:

$$\dot{q}_{s,i} = \sum_{k=0}^{n_{b_s}} b_s^k T_{s,o}^k - \sum_{k=0}^{n_{c_s}} c_s^k T_{s,i}^k - \sum_{k=1}^{n_{d_s}} d_s^k \dot{q}_{s,i}^k \qquad \text{Eq. 6.4.1-6}$$

$$\dot{q}_{s,0} = \sum_{k=0}^{n_{a_s}} a_s^k T_{s,o}^k - \sum_{k=0}^{n_{b_s}} b_s^k T_{s,i}^k - \sum_{k=1}^{n_{d_s}} d_s^k \dot{q}_{s,0}^k$$ Eq. 6.4.1-7

These time series equations in terms of surface temperatures and heat fluxes are evaluated at equal time intervals. The superscript k refers to the term in the time series. The current time is k=0, the previous time is for k=1, etc. The time-base on which these calculations are based is specified by the user within the TRNBUILD description. The coefficients of the time series (a's, b's, c's, and d's) are determined within the TRNBUILD program using the z-transfer function routines of reference [2].

A window is thermally considered as an external wall with no thermal mass, partially transparent to solar, but opaque to long-wave internal gains. Long-wave absorption is considered to occur only at the surfaces. In the energy balance calculation of the TYPE 56, the window is described as a 2-node model shown in Figure 6.4.1-4. The detailed optical and thermal window model is described in Section 6.4.2. Eq. 6.4.1-6 to Eq. 6.4.1-17 are valid for a window with:

$$a_s^o = b_s^o = c_s^o = d_s^o = U_{g,s}$$

$a_s^k = b_s^k = c_s^k = d_s^k = 0$ for $k>0$.

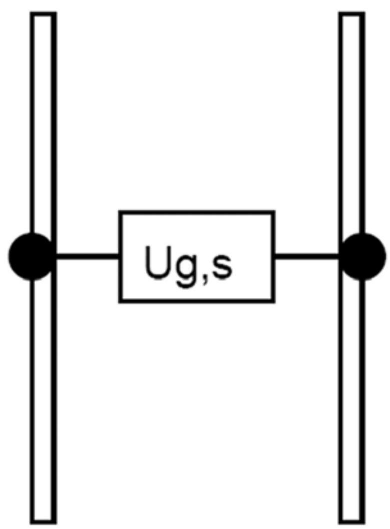


Figure 6.4.1-4: Two-node window model used in th TYPE56 energy balance equation.

6.4.1.5. Transfer Function Method by Mitalas

The method of the transfer function or response factors can be described as the method to tell the "thermal history" of the wall. The wall is considered as a black box. The number of time-steps (k) related to the time-base (defined by the user) shows whether the wall is a heavy wall with a high thermal mass (k $\leq$ 20) or if only a few time-steps have to be considered to describe the thermal behavior of this wall. If the time-base of the considered wall is higher than the time-constant, the calculation of the Transfer-function matrix coefficients is stopped. Therefore such a "thin" wall can be replaced by a resistance definition neglecting the thermal mass. As an example, the Figure 6.4.1-5 shows the different material layers of a wall. The wall example consists of three layers with concrete, mineral wool and gypsum from outside to inside.

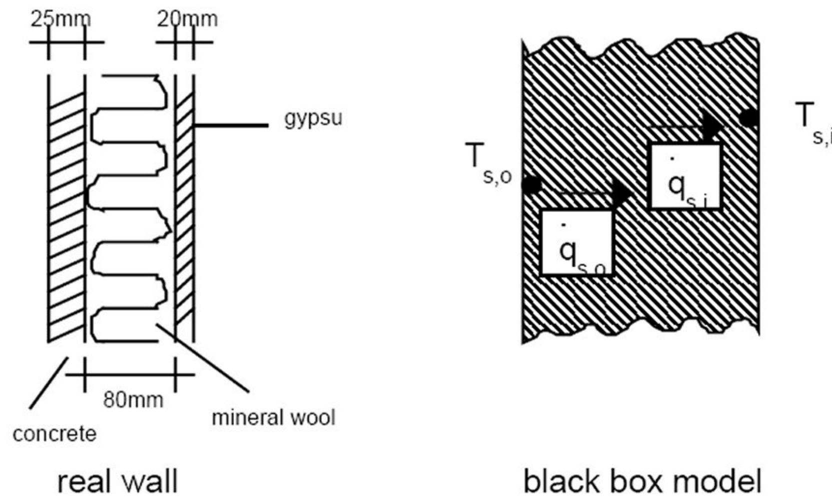


Figure 6.4.1-5: Real wall and black box model of the wall

Material data	**Thickness [m]**	**Conductivity [kJ/h·m·K]**	**Capacity [kJ/kg·K]**	**Density [kg/m3]**
Concrete	0.025	7.56	1.0	2400
Mineral Wool	0.08	0.144	1.0	40
Gypsum	0.02	2.52	1.0	1400

Using the transfer function method, the TRNBUILD-program calculates the transfer function coefficients, listed below for the example wall.

```
---------- WALL TYPE EXAMPLE          ----------

THERMAL CONDUCTANCE, U=    1.76429 kJ/h m2K; U-value=    0.45239 W/m2K

TRANSFERFUNCTION COEFFICIENTS

  K        A                  B                C                D

  0    3.0402072E+01    8.6597596E-01    6.2473097E+01    1.0000000E+00
  1   -2.8791436E+01    8.7958309E-01   -6.1044043E+01   -5.5725114E-03
```

2	1.4382785E-01	8.9032318E-03	3.2541274E-01	1.0083948E-07
3	-1.0589132E-06	4.0042651E-07	-4.7183532E-06	
SUM	1.7544627E+00	1.7544627E+00	1.7544627E+00	9.9442759E-01

Figure 6.4.1-6: Transfer function equation-system (Mitalas)

For the test wall, the coefficient table looks like that above. In addition to the transfer function coefficients, the listing contains a calculation of the heat conduction value U of the wall construction and the total heat transfer coefficient k considering a constant combined (convective+radiative) heat transfer (α_i, α_o) for the inside and outside surface.

Note: these combined heat transfer coefficients are not used during the simulation. For the calculation of the U-values stated in the information file (*.INF), the following combined heat transfer coefficients are used:

$$\frac{1}{\alpha_i} = 0.13 \left[W/m^2K\right]^{-1}$$

$$\frac{1}{\alpha_o} = 0.04 \left[W/m^2K\right]^{-1}$$

A dynamic simulation considering the thermal mass of a wall element does not use these values explicitly, but is describing the thermal resistance implicit in transient heat flows into and out of the wall surfaces. The latest validation report for the transfer function method and the whole TYPE 56 building model was prepared by Peter Voit [7] using detailed measurements from the CEC research program PASSYS.

6.4.1.6. The Long-Wave Radiation

The long-wave radiation exchange between the surfaces within the zone and the convective heat flux from the inside surfaces to the zone air are approximated using the star network given by Seem [3] and represented in Figure 6.4.1-7. This method uses an artificial temperature node (T_{star}) to consider the parallel energy flow from a wall surface by convection to the air node and by radiation to other wall and window elements. Comparisons to the detailed building model JOULOTTA from the University of Lund, Sweden done by S. Holst, ZAE Munich [4], show a good agreement for the surface temperatures. A single node model using a combined convective and radiative heat transfer coefficient shows much higher differences (IEA Task 13 report,[7]).

$$R_{STAR,i} = f(\alpha_i, A_{Surf,i}) = \frac{1}{Q_{surf,i}}(T_{Star} - T_i) \qquad \text{Eq. 6.4.1-8}$$

Methods to calculate the resistances $R_{equiv,i}$ and $R_{star,i}$ can be found in reference [3]. Area ratios are used in these calculations to find the absorption factors between all surfaces. The star temperature can be used to calculate a net radiative and convective heat flux from the inside wall surface:

$$\dot{q}_{comb,s,i} = \dot{q}_{c,s,i} + \dot{q}_{r,s,i} \quad \text{Eq. 6.4.1-9}$$

then,

$$\dot{q}_{comb,s,i} = \frac{1}{R_{equiv,i} A_{s,i}} \left(T_{s,i} - T_{star} \right) \quad \text{Eq. 6.4.1-10}$$

where $\dot{q}_{comb,s,i}$ is the combined convective and radiative heat flux, and $A_{s,i}$ is the inside surface area.

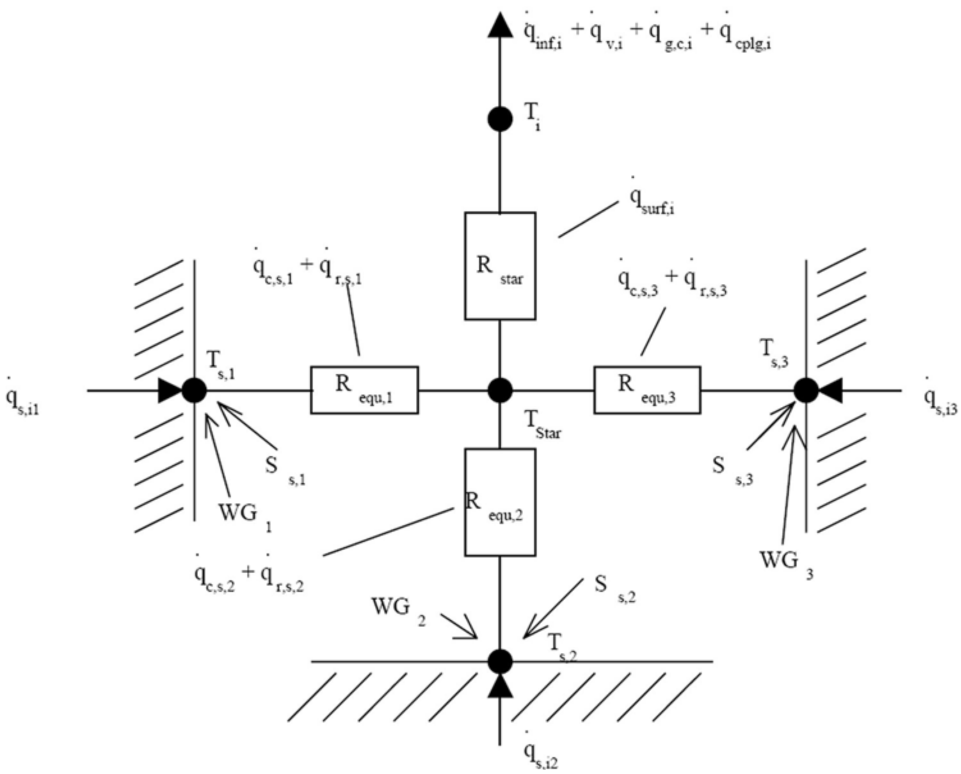


Figure 6.4.1-7: Star network for a zone with three surfaces.

For external surfaces the long-wave radiation exchange at the outside surface is considered explicitly using a fictive sky temperature, T_{Sky}, which is an input to the TYPE 56 model and a view factor to the sky, f_{sky}, for each external surface. The total heat transfer is given as the sum of convective and radiative heat transfer:

$$\dot{q}_{comb,s,o} = \dot{q}_{c,s,o} + \dot{q}_{r,s,o} \quad \text{Eq. 6.4.1-11}$$

with

$$\dot{q}_{c,s,o} = h_{conv,s,o}\left(T_{a,s} - T_{s,o}\right) \qquad \text{Eq. 6.4.1-12}$$

$$\dot{q}_{r,s,o} = \sigma\, \varepsilon_{s.o}\left(T_{s,o}^{4} - T_{fsky}^{4}\right) \qquad \text{Eq. 6.4.1-13}$$

$$T_{fsky} = \left(1 - f_{sky}\right)T_{a,s} + f_{sky}T_{sky} \qquad \text{Eq. 6.4.1-14}$$

where

$\dot{q}_{comb,s,o}$	Combined convective and radiative heat flux to the surface
$\dot{q}_{c,s,o}$	Convective heat flux to the surface
$\dot{q}_{r,s,o}$	Radiative heat flux to the surface
$h_{conv,s,o}$	Convective heat transfer coefficient at the outside surface
f_{sky}	Fraction of the sky seen by the outside surface[1]
T_{sky}	Fictive sky temperature used for long-wave radiation exchange
$\varepsilon_{s,o}$	Long-wave emissivity of outside surface (ε =0.9 for walls; value read from window library for windows)
σ	Stephan-Boltzmann constant

Energy balances at the surfaces give:

$$\dot{q}_{s,i} = \dot{q}_{comb,s,i} + S_{s,i} + Wallgain \qquad \text{Eq. 6.4.1-15}$$

$$\dot{q}_{s,o} = \dot{q}_{comb,s,o} + S_{s,o} \qquad \text{Eq. 6.4.1-16}$$

For internal surfaces $S_{s,i}$ can include both solar radiative and long-wave radiation generated form internal objects such as people or furniture.

Wallgain is a user-defined energy flow to the inside wall or window surfaces. It can describe solar gains changing during the day due to different sun positions or might be used as a simple way to

[1] For a vertical wall with no buildings nearby, a reasonable value for fsky is 0.5. If there are buildings in front of the wall obstructing the view of the sky, the value for fsky would be lower than 0.5. For a horizontal roof with only the sky in view, fsky would be 1.0.

model a floor heating or a chilled ceiling system. For external surfaces, $S_{s,o}$ consists of solar radiation only.

6.4.1.7. External Walls

It is possible to combine Eq. 6.4.1-7 to Eq. 6.4.1-16 to express the inside surface heat flux for an external wall as a function of the boundary air temperatures:

$$\dot{q}_{s,i} = B_s T_{a,s} - C_s T_{a,s} + D_s \qquad \text{Eq. 6.4.1-17}$$

where

$$B_s = \frac{e_s\ h_{s,o}}{(1 - f_s)} \qquad \text{Eq. 6.4.1-18}$$

$$C_s = \frac{f_s}{(f_s - 1)} \left(\frac{1}{R_{equiv,i} A_{s,i}} \right) \qquad \text{Eq. 6.4.1-19}$$

$$D_s = \frac{f_s S_{s,i} + e_s (S_{s,o} - k_{s,o}) + K_{s,i}}{(1 - f_s)} \qquad \text{Eq. 6.4.1-20}$$

$$e_s = \frac{b_s^o}{a_s^o + h_{s,o}} \qquad \text{Eq. 6.4.1-21}$$

$$f_s = (b_s^o e_s - c_s^o) R_{equiv,i} A_{s,i} \qquad \text{Eq. 6.4.1-22}$$

The values for $K_{s,i}$ and $K_{s,o}$ are defined by the transfer function equations:

$$K_{s,i} = \sum_{k=0}^{n_{b_s}} b_s^k T_{s,o}^k - \sum_{k=0}^{n_{c_s}} c_s^k T_{s,i}^k - \sum_{k=1}^{n_{d_s}} d_s^k \dot{q}_{s,i}^{\,k} \qquad \text{Eq. 6.4.1-23}$$

$$K_{s,o} = \sum_{k=0}^{n_{a_s}} a_s^k T_{s,o}^k - \sum_{k=0}^{n_{b_s}} b_s^k T_{s,i}^k - \sum_{k=1}^{n_{d_s}} d_s^k \dot{q}_{s,o}^{\,k} \qquad \text{Eq. 6.4.1-24}$$

6.4.1.8. Walls with Boundary Conditions

Eq. 6.4.1-17 also applies for a wall with a known boundary temperature, $T_{b,s}$, with $T_{b,s}$ substituted for $T_{a,s}$.

6.4.1.9. Adjacent, Internal Walls and Walls with Identical Boundary Conditions

For walls adjacent to another zone, internal walls, or walls adjacent zones with identical conditions, Eq. 6.4.1-17 applies, but with:

Adjacent zone:	$T_{a,s} = T_{star,j}$
Internal wall:	$T_{a,s} = T_{star,i}$
Adjacent identical	$T_{a,s} = T_{star,i}$

and

$$B_s = \frac{e_s}{(1-f_s)}\left(\frac{1}{R_{equiv,j}A_{s,j}}\right) \quad \text{Eq. 6.4.1-25}$$

$$e_s = \frac{b_s^o}{a_s^o + \dfrac{1}{R_{equiv,j}A_{s,j}}} \quad \text{Eq. 6.4.1-26}$$

Note: For an internal wall, both sides must be considered for the area A_s.

It is also possible to specify a boundary condition for the outside surface temperature rather than an air temperature by setting HBACK $\leq$ 0.001. In this case, $T_{a,s} = T_{s,o} = T_{b,s}$. Eq. 6.4.1-17 applies, but with:

$$B_s = \frac{b_s^o}{1 + c_s^o R_{equiv,i} A_{s,i}} \quad \text{Eq. 6.4.1-27}$$

$$C_s = \frac{c_s^o}{1 + c_s^o R_{equiv,i} A_{s,i}} \quad \text{Eq. 6.4.1-28}$$

$$D_s = \frac{K_{s,i} + c_s^o R_{equiv,i} A_{s,i} S_{s,i}}{1 + c_s^o R_{equiv,i} A_{s,i}} \quad \text{Eq. 6.4.1-29}$$

6.4.1.10. Total Gains from Surfaces in a Zone

The total gain to zone i from all surfaces is the sum of the combined heat transfers, or from Eq. 6.4.1-16 and Eq. 6.4.1-17, is:

$$\dot{Q}_{surf,i} = \sum A_s \dot{q}_{comb,i} = \sum_{j=1}^{Adj.Zones} \sum_{i=1}^{surface\ ito\ j} A_s B_s T_{star,j} + \sum^{ext.surfaces} A_s B_s T_a + \sum^{\text{int}.walls} A_s B_s T_{star} + \sum^{known\ bound} A_s B_s T_{b,s} - \sum^{\substack{surface\\ in\ zone\ i}} A_s (C_s T_{star,i} - D_s - S_{s,i})$$ Eq. 6.4.1-30

where A_s is the inside area of surface s.

Both sides of an internal wall are considered as inside surfaces and must be included twice in Eq. 6.4.1-30.

An energy balance on the star node in Figure 6.4.1-7 also shows that:

$$\dot{Q}_{surf,i} = \frac{1}{R_{star,i}} \left(T_{star,i} - T_i \right)$$ Eq. 6.4.1-31

6.4.1.11. Infiltration, Ventilation, and Convective Coupling

Infiltration and ventilation rates are given in terms of air changes per hour for each zone. The mass flow rate is the product of the zone air volume, air density, and air change rate. Infiltration occurs always from outdoor conditions, while ventilation occurs from a specified (possibly variable) temperature. Equal amounts of air are assumed to leave the zone at the zone temperature. The energy gains to any zone i due to infiltration and ventilation are:

$$\dot{Q}_{\text{inf},i} = \dot{m}_{\text{inf},i} C_p \left(T_a - T_i \right)$$ Eq. 6.4.1-32

$$\dot{Q}_{v,i} = \sum_{k}^{nvent} \dot{m}_{v,k,i} C_p \left(T_{v,k} - T_i \right)$$ Eq. 6.4.1-33

where

$\dot{m}_{\text{inf},i}$	mass flow rate of infiltration air
$\dot{m}_{v,k,i}$	mass flow rate of ventilation air of ventilation type k
C_p	specific heat of the air
$T_{v,k}$	temperature of ventilation air of ventilation type k
T_a	ambient air temperature

For each wall or window separating zones of floating temperature or each wall having a known boundary condition, it is possible to specify a convective coupling. This coupling is the mass flow rate that enters the zone across the surface. An equal quantity of air is assumed to leave the zone at the zone temperature. The energy gain due to the convective coupling is the sum of all such gains for all walls or windows in the zone.

$$\dot{Q}_{cp\lg,i} = \sum^{adj.zones} \sum^{surfaces\,si\,to\,j} \dot{m}_{cp\lg,s}\, C_p (T_j - T_i) + ... + \sum^{knownbound} \dot{m}_{cp\lg,s}\, C_p (T_{b,s} - T_i) \qquad \text{Eq. 6.4.1-34}$$

where $\dot{m}_{cp\lg,s}$ is the mass flow rate of air entering zone i across walls or windows.

6.4.1.12. Floating Zone Temperature (No Heating or Cooling)

The rate of change of internal energy for any free floating zone is equal to the net heat gain or

$$C_i \frac{d}{dt} T_i = \dot{Q}_i \qquad \text{Eq. 6.4.1-35}$$

where C_i is the thermal capacitance of zone i (minimal = $V_i\, \rho\, C_p$ with V_i = zone volume).

The net heat gain, $\dot{Q}_i$, is a function of T_i and the temperatures of all other zones adjacent to zone i.

> Note: To simplify the solution of the set of equations, $\dot{Q}_i$ is considered constant during any timestep, evaluated at average values of the zone temperatures. In this case, the solution to the differential equation for final temperature for a given time interval is

$$T_{i,\tau} = T_{i,\tau-\Delta t} + \frac{\overline{\dot{Q}_{i\Delta t}}}{C_i} \qquad \text{Eq. 6.4.1-36}$$

where

Δt = The simulation time-step

$T_{i,\tau-\Delta t}$ = The zone temperature at the beginning of the time-step.

The temperature variation is linear, such that the average is:

$$T_i = \frac{T_{i,\tau} + T_{i,\tau-\Delta t}}{2} \qquad \text{Eq. 6.4.1-37}$$

If Eq. 6.4.1-37 is solved for $T_{i,\tau}$ and the result substituted into Eq. 6.4.1-36, along with the individual expressions representing the net heat gain, the following is obtained:

$$\frac{2 \cdot C_i \cdot (\bar{T}_i - T_{i,\tau-\Delta t})}{\Delta t} = \sum_{j=1}^{\substack{adjac.\\zones}} \sum^{\substack{surfaces\\i\ to\ j}} \dot{m}_{cplg,s} \cdot C_p \cdot \bar{T}_j + \dot{m}_{inf,i} \cdot C_p \cdot T_a + \sum^{\substack{known\\boundaries}} \dot{m}_{cplg,i} \cdot C_p \cdot T_{b,s}$$

$$- \left(\frac{1}{R_{star,i}} + \left(\sum^{\substack{known\\boundaries}} \dot{m}_{cplg,i} + \sum_{j=1}^{\substack{adjac.\\zones}} \sum^{\substack{surfaces\\i\ to\ j}} \dot{m}_{cplg,s} + \dot{m}_{inf,i} + \sum_{k}^{nvent} \dot{m}_{v,k,i} \right) C_p \right) \bar{T}_i$$

$$+ \left(\frac{1}{R_{star,i}} \cdot \bar{T}_{star,i} + \sum_{k}^{nvent} \dot{m}_{v,k,i} \cdot C_p \cdot T_{v,k} + Q_{g,c,i} \right)$$

Eq. 6.4.1-38

Eq. 6.4.1-30 and Eq. 6.4.1-31 can be equated and regrouped to find:

$$\left(\frac{1}{R_{star,i}} - \sum^{int.walls} A_s B_s + \sum^{surf.ini} A_s C_c \right) \bar{T}_{star,i} - \left(\sum^{adj.zone} \sum^{walls\,i\,to\,j} A_s B_s \right) \bar{T}_{star,j} - \frac{1}{R_{star,i}} \bar{T}_i$$

$$= \left(\sum^{\substack{exterior\\surfaces}} A_s B_s \right) T_a + \sum^{\substack{known\\bounderies}} A_s B_s T_{b,s} + \sum^{\substack{surface\\in\,zone\,i}} A_s \left(D_s + S_{s,i} \right)$$

Eq. 6.4.1-39

The set of energy balances given by Eq. 6.3.2-38 and Eq. 6.4.1-39, written for all zones, results in a linear set of equations in average zone temperatures and average star temperatures. In matrix form,

$$[X][\bar{T}] = [Z]$$

Eq. 6.4.1-40

This matrix can be partitioned such that

$$[X] = \begin{bmatrix} X_{11} & X_{12} \\ X_{21} & X_{22} \end{bmatrix}$$

Eq. 6.4.1-41

$$[T] = \begin{bmatrix} \bar{T}_1 \\ \bar{T}_2 \end{bmatrix} = \begin{bmatrix} \bar{T} \\ \bar{T}_{star} \end{bmatrix}$$

Eq. 6.4.1-42

$$[Z] = \begin{bmatrix} Z_1 \\ Z_2 \end{bmatrix}$$

Eq. 6.4.1-43

where

$$X_{11,ii} = \left(\sum_{i\ to\ j}^{surfaces} \dot{m}_{cplg,s} + \dot{m}_{\inf,i} + \sum_{k}^{nvent} \dot{m}_{v,k,i} \right) \cdot C_p + \frac{2C_i}{\Delta t} + \frac{1}{R_{star,i}} + \sum^{\substack{known\\boundaries}} \dot{m}_{cplg,i} \cdot C_p \qquad \text{Eq. 6.4.1-44}$$

$$X_{11,ij} = -\sum_{j=1}^{\substack{adjac.\\zones}} \sum^{\substack{surfaces\\i\ to\ j}} \dot{m}_{cplg,s} \cdot C_p \qquad \text{for} \qquad i \neq j \qquad \text{Eq. 6.4.1-45}$$

$$X_{12,ii} = \frac{-1}{R_{star,i}} \qquad \text{Eq. 6.4.1-46}$$

$$X_{12,ij} = 0 \qquad \text{for} \qquad i \neq j \qquad \text{Eq. 6.4.1-47}$$

$$X_{21,ii} = -\frac{1}{R_{star,i}} \qquad \text{Eq. 6.4.1-48}$$

$$X_{21,ij} = 0 \qquad \text{Eq. 6.4.1-49}$$

$$X_{22,ii} = -\sum^{\text{int}.walls} A_S \cdot B_S + \sum^{\substack{surf\ in\\zone\ i}} A_S \cdot C_S + \frac{1}{R_{star,i}} \qquad \text{Eq. 6.4.1-50}$$

$$X_{22,ij} = -\sum^{\substack{adj.\\zones}} \sum^{\substack{walls\\i\ to\ j}} A_s B_s \qquad \text{Eq. 6.4.1-51}$$

$$Z_{1,i} = \dot{m}_{\inf,i} \cdot C_p \cdot T_a + \sum^{\substack{known\\boundaries}} \dot{m}_{cplg,s} \cdot C_p \cdot T_{b,s} + \sum_{k}^{nvent} \dot{m}_{v,k,i} \cdot C_p \cdot T_{v,k} + \frac{2C_i \cdot T_{i,\tau-\Delta t}}{\Delta t} + Q_{g,c,i}$$

Eq. 6.4.1-52

$$Z_{2,i} = \left(\sum^{ext.surf.} A_s B_s \right) T_a + \sum^{\substack{known\\boundaries}} A_s B_s T_{b,s} + \sum^{\substack{surf.\\in\ zone\ i}} A_s \left(D_s + S_{s,i} \right) \qquad \text{Eq. 6.4.1-53}$$

For the case of all zones in floating temperature,

$$\left[\overline{T} \right] = \left[X \right]^{-1} \left[Z \right] \qquad \text{Eq. 6.4.1-54}$$

The final temperature for each zone I is

$$T_{i,\tau} = 2\overline{T}_i - T_{i,\tau-\Delta t}$$ Eq. 6.4.1-55

Note: The mean temperatures during the time-step for each zone are output by TYPE 56. This follows the TRNSYS standard for providing results as mean values during the last time-step.

6.4.1.13. Simplified Heating and Cooling

It is possible to determine the energy requirement for zones controlled in an idealized way. Therefore the heating and cooling energy flow is directly connected to the zone air temperature node. The output of the heating and/or cooling equipment is a function of the zone temperature as shown in Figure 6.4.1-8, where

P_i	Power output for zone i (negative for heating, positive for cooling)
$P_{max,i}$	Absolute value of the maximum power for zone i
$T_{set,i}$	Set temperatures for heating or cooling in zone i

For the simulation of heating equipment that produces a partially radiative gain to the zone, the radiative fraction of the supplied heating power may be defined. This fraction of the power is supplied as internal radiative gains and distributed to the walls of the zone. As the set temperature for the heating equipment is related to the air temperature of the zone, *the radiative fraction of the heating power cannot be higher than 0.99* in order to have a convective part left to ensure stable control of the heating equipment.

The zone temperature is free floating in the comfort region where the power is zero. If the temperature of a free floating zone is within the heating or cooling regions at the end of a timestep, power is applied throughout the timestep so that the final zone temperature just reaches T_{set}. If the power required is greater than the maximum specified, then the maximum power is applied throughout the timestep and the zone temperature is again free floating.

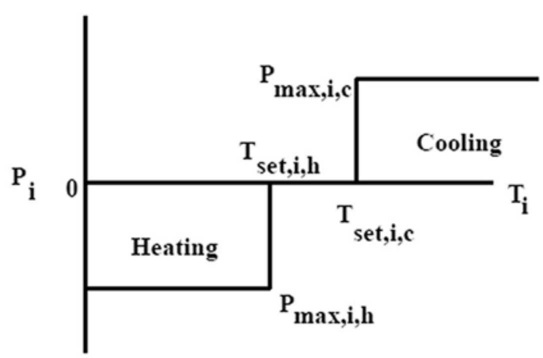


Figure 6.4.1-8: Power output versus temperature

The temperature change of the zone air, when power is supplied, is assumed to be linear. If power is required and enough is available to maintain the final zone temperature at $T_{set,i}$, then the final and average zone temperatures are known.

$$T_t = T_{set,i} \qquad \text{Eq. 6.4.1-56}$$

$$T_{req,i} = \frac{T_{\tau-\Delta t} + T_{set,i}}{2} \qquad \text{Eq. 6.4.1-57}$$

where, $T_{req,i}$ is the average zone temperature over the time-step if less than maximum power is required.

It is necessary to consider the general case of zones that are in different control regions. With the inclusion of the control laws, the equations remain linear. For the zones that have floating temperatures, the solution for average zone temperatures and star temperatures is again of the form

$$\left[\overline{T}\right] = \left[X'\right]^{-1}\left[Z'\right] \qquad \text{Eq. 6.4.1-58}$$

The coefficients of the X' matrix and Z' vector depend upon the control region. In the comfort zone, with no energy requirement:

$X'_{ij} = X_{ij}$ for all i and j   Eq. 6.4.1-59

$Z'_i = Z_i$ Eq. 6.4.1-60

For zones whose temperature falls below the point for maximum heating or above that for maximum cooling

$X'_{ij} = X_{ij}$ for all i and j   Eq. 6.4.1-61

$Z'_i = Z_i + P_{max,i,h}$ or $Z'_i = Z_i - P_{max,i,c,}$ Eq. 6.4.1-62

For zones that fall within the heating or cooling regions and require less than maximum power, the final temperature is assumed to be equal to the heating or cooling set temperature and the average room temperature is then $T_{req,i}$. Eq. 6.4.1-35 can be rewritten to include the power requirements.

$$C_i \frac{d}{dt} T_i = \dot{Q}_i - P_i \qquad \text{Eq. 6.4.1-63}$$

P_i and $\dot{Q}_i$ are considered constant over the time-step and $\dot{Q}_i$ is evaluated at the average zone temperature. Substituting into Eq. 6.4.1-63 yields:

$$\overline{P}_i - \frac{1}{R_{star,i}} \cdot T_{star,i} - \sum_{j=1}^{\substack{adjac.\,surfaces\\ zones\ i\ to\ j}} \sum m_{cp\lg} \cdot C_p \cdot \overline{T}_j =$$

$$-\left[\frac{1}{R_{star,i}} + \left(\dot{m}_{\inf,i} + \sum_{k}^{nvent} \dot{m}_{v,k,i} + \sum_{j=1}^{\substack{adjac.\,surfaces\\ zones\ i\ to\ j}} \sum m_{cp\lg} + \sum^{\substack{known\\ boundaries}} \dot{m}_{cp\lg}\right) C_p\right] \overline{T}_{req,i}$$ Eq. 6.4.1-64

$$-\frac{C_i}{\Delta t}\left(T_{set,i} - T_{\tau-\Delta t}\right) + \dot{m}_{\inf,i} \cdot C_p \cdot T_a + \sum_{k}^{nvent} \dot{m}_{v,k,i} \cdot C_p \cdot T_{v,k} + Q_{g,c,i} + \sum^{\substack{known\\ boundaries}} \dot{m}_{cp\lg,s} \cdot C_p \cdot T_{b,s}$$

Eq. 6.4.1-64 is substituted into the set of energy balances on all zones for any zone that is in the less than maximum heating or cooling region. The solution given by Eq. 6.4.1-58 is valid with the following substitutions for zones evaluated with Eq. 6.4.1-64.

$X'_{11,ij} = X_{11,ij}$ for $i \neq j$ Eq. 6.4.1-65

$X'_{11,ii} = 1.0$ Eq. 6.4.1-66

$X'_{12,ij} = X_{12,ij}$ Eq. 6.4.1-67

$X'_{22,ii} = X_{22,ii}$ Eq. 6.4.1-68

Eq. 6.4.1-39 is corrected by adding $\left(\frac{1}{R_{star,i}} T_{req,i}\right)$ to both sides of the equation, then

$X'_{21,ii} = 0$ Eq. 6.4.1-69

$Z'_{2,i} = Z_{2,i} - X_{11,ii} T_{req,i}$ Eq. 6.4.1-70

For any zone i connected to any zone m at a fixed set-point, the X' matrix and the Z' vector are modified as

$X'_{11,im} = 0$ Eq. 6.4.1-71

$Z'_i = Z'_i - X'_{im} T_{req,m}$ Eq. 6.4.1-72

The solution given by Eq. 6.4.1-58 using the adjusted matrix entries is valid with one further note. The temperature vector actually contains the required power instead of the average zone temperature, for those zones in the less than heating or cooling regions.

In order to determine the proper control regions for all zones, temperatures are calculated for the case of no heating or cooling. This allows a first estimate of the control. For zones where heating or cooling is required, the energy required to maintain the final zone temperature at the set temperature is determined. If the required energy is less than the maximum power available, then the zone is considered to be within the less than maximum heating or cooling region. Otherwise, the heating or cooling output is equal to the maximum. Elements of the X' matrix and Z' vector are set according to the control situation. The system of equations represented by the matrix Eq. 6.4.1-58 is solved. This process is repeated until the control is not changing. The energy requirements are then evaluated for the zones maintained at fixed setpoints.

6.4.1.14. Simulation Timestep versus Wall Timebase

Eq. 6.4.1-17 gives the heat transfer at the inside surface of a wall given the inside and outside air temperatures. Since it is based upon the time series (Eq. 6.4.1-6 and Eq. 6.4.1-7) it is only strictly correct when these temperatures represent averages over the time-base interval of the time series. The differential equation describing the rate of change of internal energy of the zone air, on the other hand, is solved over the simulation time-step. This may be less than or equal to the wall time-base. If the simulation time-step is less than the wall time-base, then the average heat transfer at the inside wall surface over the time-base is

$$\bar{\dot{q}}_{s,i,\Delta t_b} = B_s \bar{T}_{i,\Delta t_b} + C_s \bar{T}_{a,s,\Delta t_b} + D_s \qquad \text{Eq. 6.4.1-73}$$

where Δt_b refers to the wall time-base.

The average time-base air temperatures are

$$\bar{T}_{i,\Delta t_b} = \frac{\sum\limits^{\substack{over\\timebase}} T_{i,\Delta t}\Delta t}{\Delta t_b} \qquad \text{Eq. 6.4.1-74}$$

$$T_{a,s,\Delta t_b} = \frac{\sum\limits^{\substack{over\\timebase}} T_{a,s,\Delta t}\Delta t}{\Delta t_b} \qquad \text{Eq. 6.4.1-75}$$

If Eq. 6.4.1-74 and Eq. 6.4.1-75are substituted into Eq. 6.4.1-73, then

$$\dot{q}_{s,i,\Delta t_b} = \sum^{\substack{over\\timebase}} \left(B_s \bar{T}_{i,\Delta t} + C_s \bar{T}_{a,s,\Delta t} + D_s \right) \frac{\Delta t}{\Delta t_b} = \frac{\sum\limits^{\substack{over\\timebase}} \dot{q}_{s,i,\Delta t}\,\Delta t}{\Delta t_b} \qquad \text{Eq. 6.4.1-76}$$

The average heat flux over the wall time-base is equal to the average of the heat fluxes evaluated at the average temperatures over the simulation time-step. For the solution of the set of equations each time-step, the heat flux for any wall, as given by Eq. 6.4.1-17, is determined using the current conditions. However, the temperatures and heat fluxes characterizing the previous time history of the wall represent averages over the wall time-base. This leads to temperature steps in the period of the time-base value.

For heavy and thick walls the time-base can be set to two or more hours. If there are very thin walls in the same building, the TRNBUILD program stops with an error message. This is caused by the time constant of the light construction. If the time-constant is lower than the transfer function time-base, the response description will produce an error. In this case, thin walls should be replaced by a description using resistance layers. This procedure yields a heat flux over the wall time-base as given by Eq. 6.4.1-76.

6.4.2. Optical and Thermal Window Model

A detailed window model has been incorporated into the TYPE 56 component using output data from the WINDOW 4.1 program developed by Lawrence Berkeley Laboratory, USA [8]. This window model calculates transmission, reflection and absorption of solar radiation in detail for windows with up to six panes. External and internal shading devices and an edge correction for different glazing spacer types are considered. The optical and thermal window model is described below.

6.4.2.1. Description of the Window

Windows may consist of up to six individual glazings with five different gas fillings between them. Every window pane has its own temperature node and the inner window pane is coupled via the star network to the star node temperature of the building zone as described in the previous chapters. The outer window pane is coupled via convective heat transfer to the temperature of the ambient air and via long-wave radiative exchange with the fictive sky temperature, T_{fsky} , as described above. The heat capacity of the frame, the window panes and the gas fillings are neglected.

For each glazing of the window, the resulting temperature is calculated considering transmission, absorption and reflection of incoming direct and diffuse solar radiation, diffuse short-wave radiation being reflected from the walls of the zone or an internal shading device, convective, conductive and long-wave radiative heat transfer between the individual panes and with the inner and outer environment (see Figure 6.4.2-1).

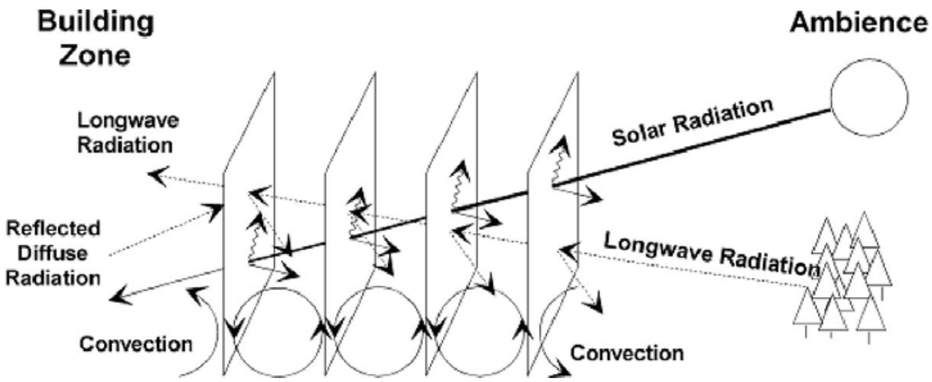


Figure 6.4.2-1: Detailed window model

6.4.2.2. 2-Band-Solar-Radiation-Window-Model

With Version 16 a 2-Band-Solar-Radiation-Window-Model was introduced. The model is only different in regard to the shortwave solar radiation. The model splits the external solar radiation into a visual part and a non visual part. The fraction of the visual part can be calculated with the radiation of a black body at a temperature of 5800 K for a wave length band between 380nm-780nm related to the total radiation of a black body at the same temperature. This leads to the following equations for the visual radiation:

$$I_{dif,visual} = 0.466\, I_{dif,solar} \quad \text{Eq. 6.4.2-1}$$

$$I_{dir,visual} = 0.466\, I_{dir,solar} \quad \text{Eq. 6.4.2-2}$$

The non visual part of the solar radiation can then be calculated with

$$I_{dif,non\_visual} = (1 - 0.466)\, I_{dif,solar} \quad \text{Eq. 6.4.2-3}$$

$$I_{dir,non\_visual} = (1 - 0.466)\, I_{dir,solar} \quad \text{Eq. 6.4.2-4}$$

The model reads now the visual transmission and in visual reflectance for front and backside from the W4-Library. Relative absorption values for total solar band will be taken for the distribution of the absorbed energy of the visual and non visual band on each individual pane as there is no better data available from W4-lib. All data taken from W4-lib in the type56 window model are shown in Chapter 6.2.4.3.2.

The model calculates then for the visual and for the non visual part separately the reflection, the absorption on single panes and the distribution within the zones including multiple reflection.

The absorbed and transmitted radiation is summed up to get the total solar absorbed or transmitted radiation. For all later energy and temperature calculations only the total solar radiation values are used.

6.4.2.3. Transmission of Solar Radiation

Each glazing absorbs and reflects a part of the incoming solar radiation depending on the glazing material and the incidence angle. In the program WINDOW 4.1, the detailed calculation of reflection between the individual panes and the absorption and transmission of each pane is performed hemispherically for diffuse radiation and in steps of 10° incidence angle for direct solar radiation. Together with the thermal properties of the gas fillings and the conductivity and emissivity of the glazings, the optical data for the window is written to an ASCII file by the WINDOW 4.1 program. This output file has a standard format, which makes the results available for thermal analysis programs such as DOE 2.1 and TRNSYS. For TRNSYS, a window library file was created using the WINDOW 4.1 program to have commonly-used glazing systems available for the user.

This data is read by the TYPE 56 component and interpolated using the interpolation of Akima /14/.

Using this interpolated data, the transmission of solar radiation and the total absorption of short-wave radiation for each window pane is calculated.

6.4.2.4. Heat Flux between Window Panes

The heat transport between the individual window panes is shown in the Figure 6.4.2-2. Conduction, convection and long-wave radiation are considered separately.

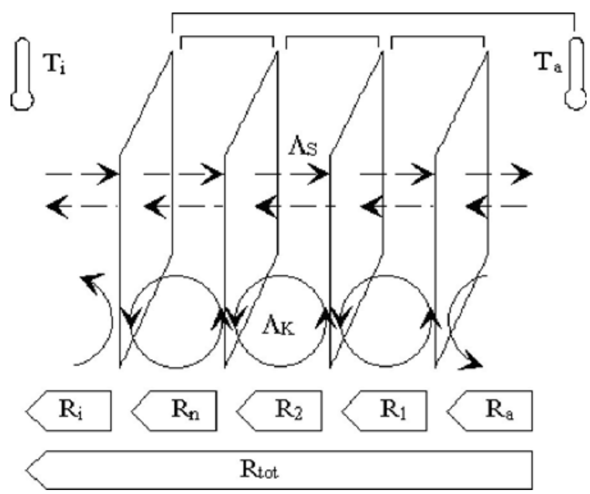


Figure 6.4.2-2: Resistance network between window panes.

The heat flux from the inner pane of the window the to ambient is calculated as:

$$\dot{Q}_{n-a} = U_{n-a} \cdot A \cdot (T_n - T_a) \qquad \text{Eq. 6.4.2-5}$$

with

$$U_{n-a} = \frac{1}{\sum_{ij} R_{ij} + R_a} \qquad \text{Eq. 6.4.2-6}$$

$$R_{jj} = \frac{1}{\Lambda_{jj}} \qquad \text{Eq. 6.4.2-7}$$

$$R_a = \frac{1}{\alpha_{c,a} + \alpha_{r,a}} \qquad \text{Eq. 6.4.2-8}$$

$$R_i = \frac{1}{\alpha_{c,i} + \alpha_{r,i}} \qquad \text{Eq. 6.4.2-9}$$

$$\Lambda_{jj} = \Lambda_{conv,jj} + \Lambda_{rad,jj} + \Lambda_{cond,jj} \qquad \text{Eq. 6.4.2-10}$$

The radiative heat exchange coefficient between glazings is calculated using

$$\Lambda_{rad} = \frac{4\sigma T_{mean}^3}{\frac{1}{\varepsilon_1} + \frac{1}{\varepsilon_2} - 1} \qquad \text{Eq. 6.4.2-11}$$

The convective heat exchange coefficient between the individual glazings is calculated considering the slope of the window using:

$$\Lambda_{conv} = \frac{Nu\ \lambda(T)}{s} \qquad \text{Eq. 6.4.2-12}$$

$$Nu = 1 + 1.44\left(1 - \frac{1708(\sin(1.8\beta))^{1.6}}{Ra\cos\beta}\right)\left(1 - \frac{1708}{Ra\cos\beta}\right)^{+} + \left(\left(\frac{Ra\cos\beta}{5830}\right)^{1/3} - 1\right)^{+} \qquad \text{Eq. 6.4.2-13}$$

$$Ra = \frac{g\ \Delta T\ L^3}{T\mu\alpha} \qquad \text{Eq. 6.4.2-14}$$

6.4.2.5. Absorption of Short-Wave Radiation

The absorption of short-wave radiation (direct and diffuse solar radiation, diffuse reflected radiation from the all the surfaces of the zone and the optional inner shading device) on the glazing system of the window leads to a heat flux from the pane to the zone which is given by

$$\dot{Q}_{abs,i} = \sum_{i \to n} \left(\left(I_{dir}\, abs_{dir,i} + I_{dif}\, abs_{dif,i} + \left(I_{ref,z} + I_{ref,sh} \right) abs_{dif,i,b} \right) \frac{R_{i-l} + R_a}{R_{tot}} \right) \quad \text{Eq. 6.4.2-15}$$

It can be shown that the total heat flux of such a glazing system can be split into a heat loss flux which is only dependent on the temperature differences and the pane absorption heat flux which is only dependent on the intensity of the short-wave radiation [5].

As the solar radiation reflected by the zone surfaces can only be calculated by TYPE 56 if the amount of transmitted solar radiation from all external and internal windows of the zone is known, an iterative loop for all windows of a zone is performed until all entered direct or diffuse solar radiation is either absorbed at an internal wall or frame surface or any window pane of an internal or external window or transmitted back to outside through an external window. After having distributed all entering solar radiation for all zones of the building including multiple reflections in a zone or between zones via internal windows, the calculations of surface temperatures and the window pane temperature calculations are performed.

6.4.2.6. Iterative Solution for Pane Temperatures

The absorption of short-wave radiation leads to a temperature increase of each individual window pane. This leads to a heat flux to adjacent window panes or to the inside (zone) and the outside (ambient) of the window and therefore to an additional change in pane temperatures. This iteration of pane temperatures is performed until the change of pane temperatures is lower than a specified tolerance.

6.4.2.7. Total Energy Flux through the Window Glazing

Having determined the individual pane temperatures and all of the heat fluxes through the glazings, the absorbed short-wave radiation is summed over the various window panes and distributed to the inner and outer window node. Based on the temperatures of the window nodes, the absorbed short-wave radiation of the window nodes are found to be

$$\dot{Q}_{abs,i} = 0.5\left(\dot{Q}_{abs} + h_i \left(T_i - T_{zone} \right) - h_{c,o} \left(T_0 - T_{amb} \right) - \dot{Q}_{sky} \right) \quad \text{Eq. 6.4.2-16}$$

$$\dot{Q}_{abs,a} = \dot{Q}_{abs} - \dot{Q}_{abs,i} \quad \text{Eq. 6.4.2-17}$$

These heat fluxes of the two-node model are used in the TYPE 56 heat balance algorithm to calculate the dynamic behavior of the multi-zone building.

6.4.2.8. Edge Correction and Window Frame

The calculations of the glazing temperatures of the window were performed for undisturbed center of glass values with no influence of the glazing edge. To take the cold bridge effect of the spacer at the edge of the glazing system into account, edge correction coefficients are calculated by the WINDOW 4.1 program for five different spacer materials. The edge of the glazing is defined as an 2.5 inch (63.5 mm) wide area along the perimeter of the glazing. These correction coefficients and the height and width of a glazing sample defined in the TRNBUILD program and the U-value of the glazing is calculated as a shunt circuit of center of glass value, u_{centr} and the U-value of the glazing edge, u_{edge}:

$$u_{edge} = c_{edge,1} + c_{edge,2} u_{centr} + c_{edge,3} u_{centr}^2 \qquad \text{Eq. 6.4.2-18}$$

This corrected U-value, uglass, is used in TYPE 56 for the thermal calculation of the window as it is defined in the building description.

In the building description, the ratio of the frame area to the total window area is defined. Additionally a U-value for the frame is given there. The total U-value of the window is calculated as the arithmetic mean value of glazing and frame U-value:

$$u_{window} = f_{frame} u_{frame} + \left(1 - f_{frame}\right) u_{glass} \qquad \text{Eq. 6.4.2-19}$$

The transmission of solar radiation is reduced by this fraction (to account for the opaque frame part of the window). In the heat balance algorithm of TYPE 56, all the heat flows and the resulting temperatures are related to the total window area.

6.4.2.9. External and Internal Shading Devices

External or internal shading devices may be defined for each external window of the building. For internal windows only an internal shading device for the surface defined as FRONT in the building description may be defined. External shading devices reduce the incoming solar radiation on the glazing area of the external window by a factor given in the building description. A thermal resistance that reduces the heat losses of the glazing to the ambient, if the external shading device is active, may be specified.

An internal shading device is specified giving the reduction of the transmitted solar radiation, a reflection coefficient for solar radiation for both faces of the shading device and a parameter defining the degree of additional convection to the air node of the zone. The model takes into account multiple reflections between the internal shading device and the window panes and calculates the absorption of reflected solar radiation from the internal shading on the different window panes. The multiple reflections between internal shading and window panes can be expanded into a endless series and expressed in a closed form for each face of the window resulting in

$$\dot{q}_{\text{int},sh} = \left[f_{\text{int},sh}(1 - refl_{sh,o}) + (1 - f_{\text{int},sh}) \left(\frac{refl_{win,i} f_{\text{int},sh} (1 - refl_{sh,i})}{1 - refl_{win,i} f_{\text{int},sh} refl_{sh,i}} \right) \right] I_{ref,z} + \\ + trans_{win} \left(\frac{f_{\text{int},sh} (1 - refl_{sh,i})}{1 - f_{\text{int},sh} refl_{sh,i} refl_{win,i}} \right) I \qquad \text{Eq. 6.4.2-20}$$

where

$f_{\text{int},sh}$ Non transparent fraction of internal shading related to the total glass area

$refl_{sh,i}$ solar reflection of internal shading facing the glass

$refl_{sh,o}$	solar reflection of internal shading facing the room
$refl_{win,i}$	solar reflection of glass surface facing the internal shading device
$trans_{win}$	solar transmittance of all window panes

This calculation is performed separately with the optical properties for direct and diffuse solar radiation and the total absorption of the internal shading device is given by the sum of absorption of direct and diffuse solar radiation parts.

With the internal shading device located behind the inner glazing an additional convection is started resulting in a chimney effect of warm air heated by the absorption of solar radiation on the shading device. The absorbed solar radiation on the inner shading is given as the product of the transmitted solar radiation and the fraction of the shaded glazing area considering the reflected radiation and the fraction which is transferred to the air node of the zone via the specified additional convection:

$$\dot{q}_{abs} = \dot{q}_{\text{int},sh}\left(1 - c_{conv,sh}\right) \qquad \text{Eq. 6.4.2-21}$$

The additional convective heat flow to the air node of the zone is therefore given as:

$$\dot{q}_{conv,sh} = \dot{q}_{\text{int},sh}\, c_{conv,sh} \qquad \text{Eq. 6.4.2-22}$$

6.4.2.10. Distribution of Solar Radiation

The incoming (primary) direct solar radiation is distributed according to the distribution coefficients (GEOSURF) defined in the building description. These values are distribution factors related to the total direct solar radiation entering the zone and not related to a surface area. The sum of GEOSURF values given for all inside surfaces of a zone should sum up to 1 at all times. The fraction of incoming direct solar that is absorbed by any surface i is given by the product of solar absorptance α_s value times the GEOSURF value given for this surface s. If the GEOSURF values for all surfaces of a zone are set to zero, all direct solar radiation entering this zone is treated as diffuse radiation (like in TRNSYS 14.2) and distributed with the absorptance-weighted area ratios described below.

> Note: As for the distribution of primary direct solar radiation there is no dependence on the surface area, it is possible to concentrate all direct solar to a small surface by giving it a high value of GEOSURF. This would result in very high surface temperatures and possible instabilities in solving the energy balance equations of TYPE 56!

With the GEOSURF values solar beam radiation might be distributed even when passing internal windows between zones up to two passages. After passing the second internal window all solar radiation is treated as diffuse radiation. To pass direct solar radiation over several zones like in a atria from the top zone to the middle zone to the bottom zone a fictive window between top and bottom zone might be used.

The incoming diffuse solar radiation and reflected primary direct solar radiation is distributed according to absorptance-weighted area ratios. The fraction of diffuse solar that is absorbed by any surface s is

$$f_{dif,s,s} = \frac{\alpha_s A_s}{\sum^{surfaces}(1-\rho_{d,s})A_s} \quad \text{Eq. 6.4.2-23}$$

where

α_s the solar absorptance of the surface (defined in the building description)

$\rho_{d,s}$ the reflectance for diffuse solar of the surface

for wall surfaces where

$$\tau_s = 0 \quad \text{Eq. 6.4.2-24}$$

$$\rho_{d,s} = (1-\alpha_s) \quad \text{Eq. 6.4.2-25}$$

For windows, the transmission losses are considered by

$$\tau_s = 1-\alpha_s-\rho_{d,s} \quad \text{Eq. 6.4.2-26}$$

where $\rho_{d,s}$ is the reflectance for diffuse solar from inside.

6.4.2.11. Distribution of Long-Wave Radiation

All surfaces are assumed to be black for longwave radiative exchange and radiative internal gains. These gains are distributed according to area ratios. The fraction of the internal radiative gains for any zone that is adsorbed by a surface s is

$$f_{1,s} = \frac{A_s}{\sum^{surfaces} A_s} \quad \text{Eq. 6.4.2-27}$$

6.4.3. Moisture Balance

In parallel with the sensible energy balance calculation, TYPE 56 calculates a moisture balance considering free floating humidity ratios or humidification/dehumidification to a certain set-point. In this case, TYPE56 calculates the latent load. There are two models for the calculation of the moisture balance available in TYPE 56. The first model considers sorption effects with an enlarged moisture capacity of the zone air the second, more sophisticated, model offers a surface and a deep moisture buffer in the walls of the zone.

6.4.3.1. Effective Capacitance Humidity Model

In the first model, the buffer effect of adsorptive and desorptive materials, soil areas, or plants is considered by an effective moisture capacitance which is defined as the product of the zone air mass and a moisture capacitance ratio:

$$M_{eff,i} = Ratio\ M_{air,i} \qquad \text{Eq. 6.4.3-1}$$

where

$M_{eff,i}$	effective moisture capacitance of the zone
$M_{eff,i}$	the mass of air in the zone
$Ratio$	multiplication factor generally in the range of 1 to 10.

A moisture balance for any zone results in the following differential equation:

$$M_{eff,i}\frac{d\omega_i}{dt} = \dot{m}_{\mathrm{inf},i}\left(\omega_a - \omega_i\right) + \sum_{k}^{nvent} \dot{m}_{v,k,i}\left(\omega_{v,k,i} - \omega_i\right) + W_{g,i} + \sum_{i-j}^{surfaces} m_{cp\mathrm{lg},s}\left(\omega_j - \omega_i\right) \qquad \text{Eq. 6.4.3-2}$$

where

$M_{eff,i}$	effective moisture capacitance of the zone
ω_i	the humidity ratio of the zone
ω_a	the ambient humidity ratio
$\omega_{v,k,i}$	the humidity ratio of the ventilation air from ventilation type k
$W_{g,i}$	internal moisture gains
ω_j	the humidity ratio of an adjacent zone j

In order to simplify the solution of the simultaneous set of differential equations, the values of ω at the end of the previous time-step are used in the above expression. Subroutine DIFFEQ is then used to independently solve for the final and average values of the humidity ratio over each timestep for each zone. If the average humidity ratio of the zone falls below or rises above a setpoint for humidification or dehumidification, then latent energy is added or removed to maintain the humidity ratio at the setpoint. It is assumed that the change in zone humidity ratio occurs instantly so that $\overline{\omega_i} = \omega_{\tau,i}$. In this case

$$Q_{lat,i} = h_v \left(\dot{m}_{\inf,i} \left(\omega_a - \omega_{req,i}\right) + \sum_k^{nvent} \dot{m}_{v,k,i} \left(\omega_{v,k,i} - \omega_{req,i}\right) + W_{g,i} \right.$$
$$\left. + \sum_{i-j}^{surfaces} m_{cplg,s} \left(\omega_{j,\tau-\Delta t} - \omega_{i,\tau-\Delta t}\right) - \frac{M_{eff,i}\left(\omega_{req,i} - \omega_{i,\tau-\Delta t}\right)}{\Delta t} \right) \quad \text{Eq. 6.4.3-3}$$

where

$Q_{lat,i}$	latent energy removed (positive for dehumidification, negative for humidification)
h_v	the heat of vaporization of water
$\omega_{req,i}$	the set-point for humidification or dehumidification

Between the two set-points, the humidity ratio is free floating.

6.4.3.2. Buffer Storage Humidity Model

The buffer storage model describes a separate humidity buffer divided into a surface and deep storage. These buffers are connected to each other as shown in Figure 6.4.3-1. The surface buffer is additionally connected with the zone node. Each buffer is defined with three parameters.

The first parameter is the gradient of the sorptive isothermal line κ of the material. These values represent the water storage capacity of the material. The second parameter is the mass of the material. The third parameter β controls the moisture transport from the storage to the zone node.

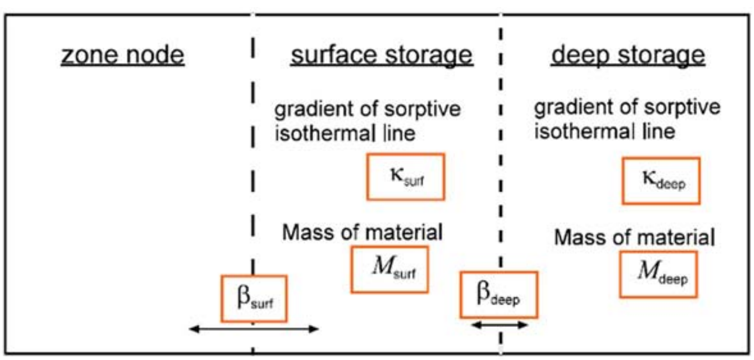


Figure 6.4.3-1: Buffer storage humidity model.

6.4.3.3. Mathematical Description of the Buffer Storage Humidity Model

The differential equation for the calculation of the zone humidity was extended by a term taking into account the exchange of moisture between the zone node and the surface storage. A comparison of the old and the new differential equations are shown below.

Effective Capacitance Model:

$$M_{air,i} \cdot W_{cap} \frac{d\omega_i}{dt} = \dot{m}_{\inf,i}(\omega_a - \omega_i) + \sum_{k}^{nvent} \dot{m}_{v,k,i}(\omega_{v,k,i} - \omega_i) + \dot{W}_{g,i} + \sum_{i-j} \dot{m}_{cp\lg,s}(\omega_j - \omega_i) \quad \text{Eq. 6.4.3-4}$$

Buffer Storage Model:

$$M_{air,i} \frac{d\omega_i}{dt} = \dot{m}_{\inf,i}(\omega_a - \omega_i) + \sum_{k}^{nvent} \dot{m}_{vk,,i}(\omega_{v,k,i} - \omega_i) + \dot{W}_{g,i} + \sum_{i-j} \dot{m}_{cp\lg,s}(\omega_j - \omega_i) + \beta_{surf}(\omega_{surf} - \omega_i) \quad \text{Eq. 6.4.3-5}$$

where

ω_i	the humidity ratio of zone i
ω_a	the ambient humidity ratio
$\omega_{v,k,i}$	the humidity ratio of the ventilation air from ventilation type k
ω_j	the humidity ratio of an adjacent zone j
ω_{surf}	the humidity ratio of the surface storage
$W_{g,i}$	internal moisture gains
$\dot{m}, \beta$	exchange coefficients

Additionally, two new differential equations were introduced to describe the dynamics of the water content of the surface and the deep storage.

$$M_{surf} \kappa_{surf} f(\varphi, \omega) \frac{d\omega_{surf}}{dt} = \beta_{surf}(\omega_i - \omega_{surf}) + \beta_{deep}(\omega_{deep} - \omega_{surf}) \quad \text{Eq. 6.4.3-6}$$

$$M_{deep} \kappa_{deep} f(\varphi, \omega) \frac{d\omega_{deep}}{dt} = \beta_{deep}(\omega_{surf} - \omega_{deep}) \quad \text{Eq. 6.4.3-7}$$

where

ω_{deep}	the humidity ratio of the deep storage
κ_{surf}	gradient of sorptive isothermal line of surface buffer [kg_{water} /$kg_{material}$ /rel. humidity]
κ_{deep}	gradient of sorptive isothermal line of deep buffer
$f(\varphi,\omega)$	conversion factor from relative humidity to humidity ratio
β_{surf}	the exchange coefficient between zone and surface storage
β_{deep}	the exchange coefficient surface between storage and deep storage

Initially, the user must assign the actual wall layers to the two humidity storage types. For the surface buffer, only the material with the lowest diffusion resistance is relevant. By means of the equation

$$\beta_{surf} = \frac{0.1\,A}{\dfrac{0.094}{\beta'} + \sum_i d_i \mu_i} \qquad \text{Eq. 6.4.3-8}$$

β_{surf} can be calculated. It depends on the surface size A in m², the steam-transition coefficient β' (≈12 m/h), the thickness d in m and the diffusion resistance μ of layer i. For the calculation of β_{deep}, the steam-transition coefficient can be neglected:

$$\beta_{deep} = \frac{0.1\,A}{\sum_i d_i \mu_i} \qquad \text{Eq. 6.4.3-9}$$

If the thickness d is chosen, the corresponding mass

$$M = 2dA\rho \qquad \text{Eq. 6.4.3-10}$$

of the buffer material and the coefficients β can easily be determined. To determine the size of the thickness *d* the following should be considered. If, for example, the surface buffer is defined only by the first millimeter of gypsum and the deep buffer by the second millimeter, the humidity storage of the wall surface is well described but the capacity of the deeper parts is neglected. Measurements of air humidity in an office have shown that the influence of walls can be well described if

$$\frac{\beta_{surf}}{A} = 3\left[kg_{air} / m^2 h\right] \qquad \text{Eq. 6.4.3-11}$$

$$\frac{\beta_{deep}}{A} = 1\left[kg_{air} / m^2 h\right] \qquad \text{Eq. 6.4.3-12}$$

The reason for this lies in the fact that the first value describes the mass flow within minutes and the second the mass flow within several hours. Measurements and detailed simulations have also shown that the moisture flow from central parts of the walls (walls of bricks and concrete) to the room air is so low that it can be neglected. The moisture flow from the surrounding to the zone is much higher and must be well defined by the infiltration parameters if the simulation time is longer than a few days.

The values mentioned above are recommendations. Of course the deep buffer can also be defined in a different way. A very small value of β/A can describe the moisture transport flow within a season. With Eq. 6.4.3-9, the thickness d and therefore the corresponding mass M then can easily be determined.

If only one kind of material is used for one storage (for example, concrete for the deep storage), the user has to put the corresponding parameters κ and M into the building description file *.BUI. If the user wishes to take into account different kinds of materials, i.e. concrete and gypsum, it is necessary to set one parameter to 1 and the other to the sum of the corresponding products of κ and M

$$\kappa_1 M_1 + \kappa_2 M_2 + \cdots \qquad \text{Eq. 6.4.3-13}$$

Table 6.4.3-1: Material data for buffer storage humidity model

Material	**Density ρ** [kg/m³]	κ $\left[\frac{kg_{water}/kg_{building\_material}}{rel\_humidity}\right]$	**Diffusion Resistance μ**
Heavy Concrete	2200	0.04	70-150
Porous o. Gas Concrete	600	0.05-0.08	5-10
Sand-Lime Brick	1900	0.03	15-25
Clay Brick	1600	0.005	5-10
Plaster	1800	0.02	5-20
Gypsum	900	0.015	8
Wood	600	0.20	40
Cork	100	0.03	5-10
Mineral Wool	100	0.01	1
HR-Foam	20	0.7	20-70

6.4.3.4. Buffer Storage Example

Air humidity and temperature have been measured for an office of 80 m³ air volume, surrounded by walls covered with layers from gypsum (thickness: 12 mm) and mineral wool (thickness 10 cm), with the ceiling and ground floor of concrete, for a period of two days. Periodically, the absolute air humidity was raised significantly.

From Table 6.4.3-1 the coefficient KSURF of gypsum can be determined:

KSURF= 0.015

The deep buffer takes into account different materials. Therefore the value of KDEEP is

KDEEP = 1

The size of the gypsum layers is 50 m². The penetration depth for the surface buffer amounts to d = 3 mm and therefore the corresponding mass is 270 kg:

MSURF = 50 m² x 6 mm x 900 kg/m³ = 270 kg

MDEEP = M1 x κ1+ M2 κ2 + M3 κ3

= M(gypsum) κ(gypsum) + M(mineral wool) κ (mineral wool) +M(concrete) κ(concrete)

= M(gypsum) κ(gypsum) + M(mineral wool) κ (mineral wool) +M(concrete) κ(concrete)

= 270 x 0.015 + 500 x 0.01 + 175 x 0.04 = 16

BSURF $= \frac{\beta_{surf}}{A} A = 3\left[kg/m^2 h\right] \times 50[m^2] = 150[kg/h]$

BDEEP $= \frac{\beta_{deep}}{A} A = 1\left[kg/m^2 h\right] \times 50[m^2] = 50[kg/h]$

The building description should contain the parameters in the following order (instead of the old parameter WCAPR):

KSURF = 0.015	MDEEP = 16
KDEEP = 1	BSURF = 150
MSURF = 270	BDEEP = 50

6.4.3.5. Comparison of Measurement and Simulation for the Buffer Storage Humidity Model

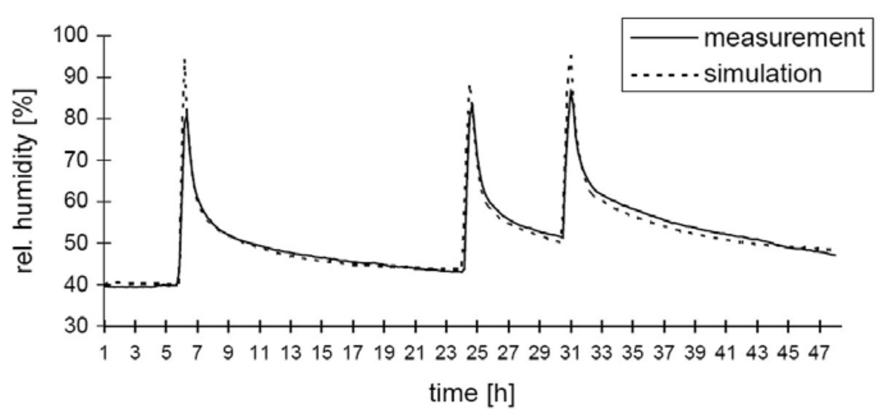


Figure 6.4.3-2: Results of measurement and simulation according to the described model.

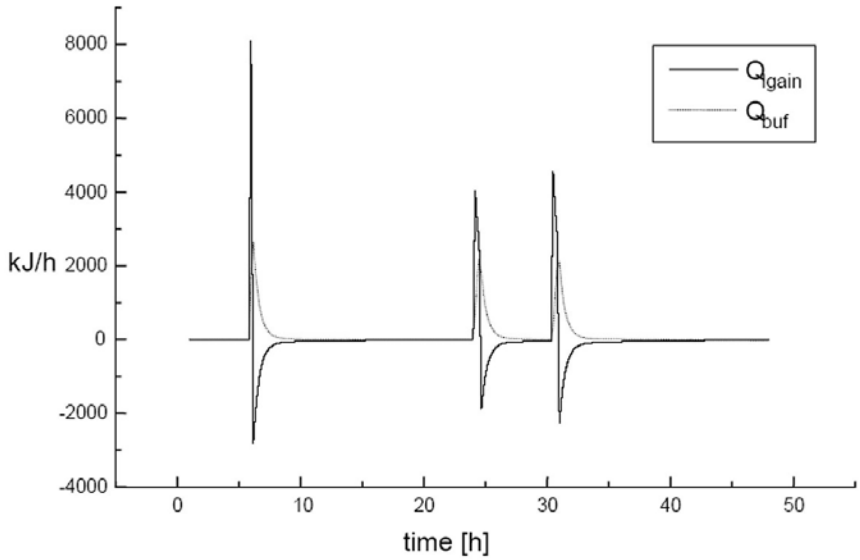


Figure 6.4.3-3: Results of outputs Q_{lgain} and Q_{buf}. Q_{buf} describes the energy flow to the surface buffer.

6.4.4. Integrated Model for Thermo-Active Building Elements

Thermo-active building elements (slabs or walls of a building) are used to condition buildings by integrating a fluid system into massive parts of the building itself. Examples are radiant floor heat or cooling systems, radiant ceilings or wall heating or cooling systems.

Due to the finite distance between pipes, a two-dimensional temperature field develops in the plane of the thermo-active construction element cross-section (see Figure 6.4.4-1 and Figure 6.4.4-2). Thermal input or output along piping loops causes a change in the water temperature within the pipe. This change affects the construction element temperature in the z direction. This means that all three dimensions have to be taken into account for the calculation of a thermo active construction element system. Multi-dimensional thermal conduction problems can usually be calculated by a Finite Difference Method (FD) or a Finite Element Method (FEM). Therefore, the region to be examined needs to be transformed into small three-dimensional grid cells. For each cell and for every point in time the required physical variables can be calculated step-by-step in dependency of the adjoining cells. To achieve a sufficiently high level of precision, the grid must be sufficiently dense. This makes calculations complex and usually results in long calculation times. Also, a certain level of experience is required for the collection of geometric data on the construction element and the pipes as well as for the creation of an effective grid design.

For these reasons, a powerful alternative method for the calculation of thermo active construction element systems was developed [9], integrated into the TYPE 56 building model, which will be described below.

6.4.4.1. Stationary solution in the x–y plane of a thermo-active construction element

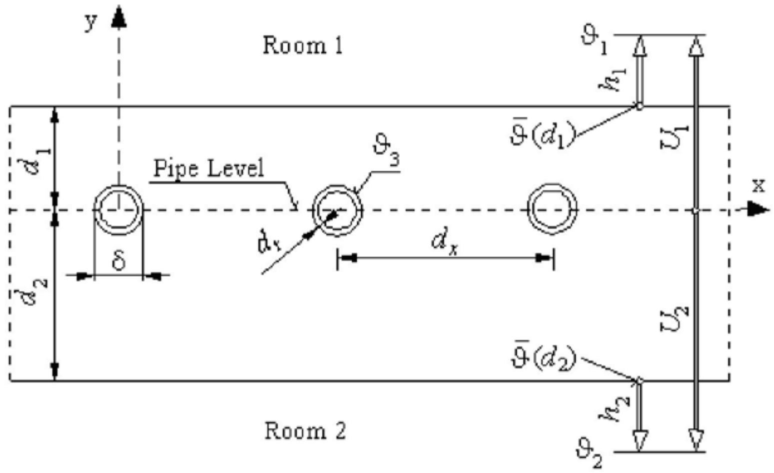


Figure 6.4.4-1: Structure of the thermo active construction element system.

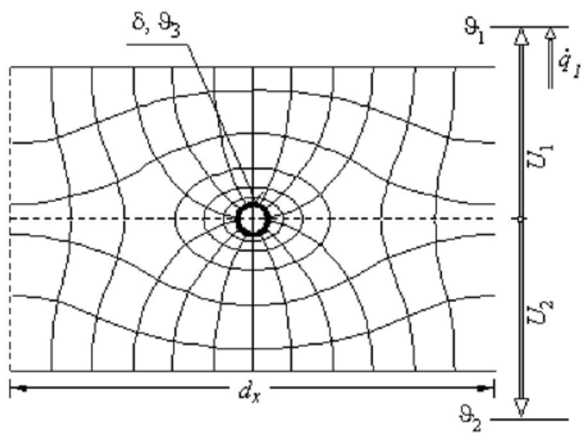


Figure 6.4.4-2: Heat flow in a cross section of a thermo active construction element

The stationary solution for temperature distribution in the x-y plane results, as described in [11], in the following formula for heat flow on the surface towards room 1:

$$\dot{q}_1 = \Phi \cdot U_1 \cdot (\vartheta_3 - \vartheta_1) + (1 - \Phi) \cdot \frac{U_1 \cdot U_2}{U_1 + U_2} \cdot (\vartheta_2 - \vartheta_1) \quad \text{Eq. 6.4.4-1}$$

The first term to the right of the equation sign in Eq. 6.4.4-1 describes the heat flow between temperature ϑ_3 on the outside surface of the pipe and temperature ϑ_1 within room 1. The temperature difference is multiplied by the proportionality factor $\Phi \cdot U_1$, which represents the coefficient of thermal transmittance for the pipe configuration. The physical variable Φ is used as correction factor. This variable resembles the shape factor and can be derived from the partial differential equation for thermal conduction (see references [10] and [11]). For the configuration of pipes, Φ becomes

$$\Phi = \frac{2 \cdot \pi \cdot \lambda_b \cdot \Gamma}{d_x \cdot (U_1 + U_2)}$$ Eq. 6.4.4-2

where

$$\Gamma = \left[\ln\left(\frac{d_x}{\pi \cdot \delta} \right) + \frac{2 \cdot \pi \cdot \lambda_b}{d_x \cdot (U_1 + U_2)} + \sum_{s=1}^{\infty} \frac{g_1(s) + g_2(s)}{s} \right]^{-1}$$ Eq. 6.4.4-3

To check the evidence of this formula, Eq. 6.4.4-3 can be calculated with $\Phi = 0$ as a borderline case, which means that the calculation is done for a construction element without pipes. The result is equal to the heat flow in the upper half of the construction element determined by the familiar calculation method using the U value:

$$\dot{q}_1 = \frac{U_1 \cdot U_2}{U_1 + U_2} \cdot (\vartheta_2 - \vartheta_1)$$ Eq. 6.4.4-4

The heat flow for the second side of the room can be determined in a similar way as in Eq. 6.4.4-1

$$\dot{q}_2 = \Phi \cdot U_2 (\vartheta_3 - \vartheta_2) + (1 - \Phi) \cdot \frac{U_1 \cdot U_2}{U_1 + U_2} \cdot (\vartheta_1 - \vartheta_2)$$ Eq. 6.4.4-5

Equations Eq. 6.4.4-1 and Eq. 6.4.4-5 can be represented by a network of resistances in a triangular arrangement (see Figure 6.4.4-3).

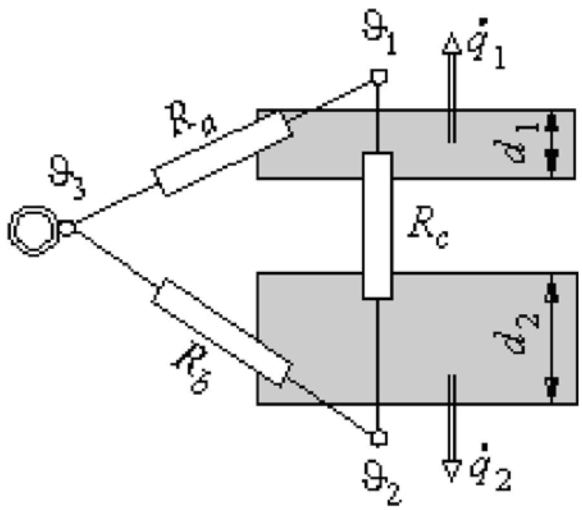


Figure 6.4.4-3: Network of resistances, triangular arrangement

The three resistances can be described as follows:

$$R_a = \frac{1}{\Phi \cdot U_1}$$ Eq. 6.4.4-6

$$R_b = \frac{1}{\Phi \cdot U_2}$$ Eq. 6.4.4-7

$$R_c = \frac{U_1 + U_2}{U_1 \cdot U_2 \cdot (1 - \Phi)}$$ Eq. 6.4.4-8

The triangular network can be transformed into an equivalent star network (see Figure 6.4.4-4) using the following relations:

$$R_1 = \frac{R_a \cdot R_c}{R_a + R_b + R_c}$$ Eq. 6.4.4-9

$$R_2 = \frac{R_b \cdot R_c}{R_a + R_b + R_c}$$ Eq. 6.4.4-10

$$R_x = \frac{R_a \cdot R_b}{R_a + R_b + R_c}$$ Eq. 6.4.4-11

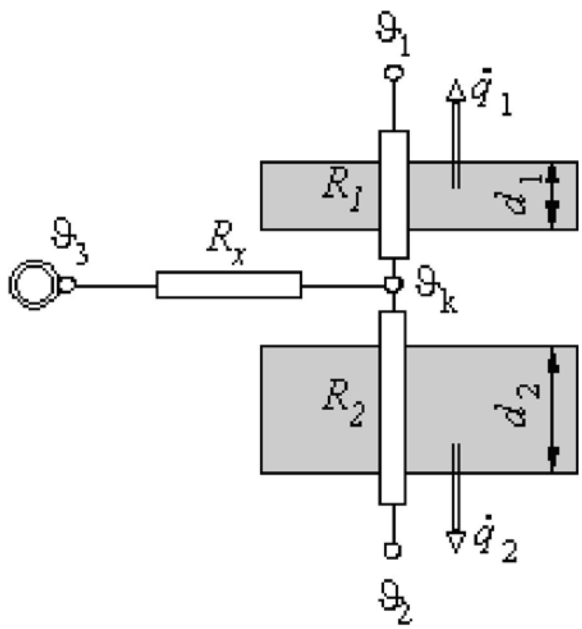


Figure 6.4.4-4: Network of resistances, star arrangement

Inserting the Eq. 6.4.4-6 to Eq. 6.4.4-8 into the equations Eq. 6.4.4-9 to Eq. 6.4.4-11 the following results are achieved for the star resistances:

$$R_1 = \frac{1}{U_1}$$ Eq. 6.4.4-12

$$R_2 = \frac{1}{U_2}$$ Eq. 6.4.4-13

$$R_x = \frac{(1-\Phi)}{\Phi \cdot (U_1 + U_2)}$$ Eq. 6.4.4-14

Due to the transformation of the triangular network into the equivalent star network the information on the pipes can be expressed by one single resistance, that is the R_x resistance. This means that the resistance of each construction element now depends solely on its U value. Despite the multi-dimensional nature of the problem, equations Eq. 6.4.4-12 and Eq. 6.4.4-13 prove that thermal transmittance through both halves of the construction element can be calculated by means of the one-dimensional equation for thermal conductance. When Φ is replaced in Eq. 6.4.4-14 by equation Eq. 6.4.4-2 and Eq. 6.4.4-3, the following equation is achieved after several transformations:

$$R_x = \frac{d_x \cdot \left[\ln\left(\frac{d_x}{\pi \cdot \delta} \right) + \sum_{s=1}^{\infty} \frac{g_1(s) + g_2(s)}{s} \right]}{2 \cdot \pi \cdot \lambda_b}$$ Eq. 6.4.4-15

The summation term in Eq. 6.4.4-15 served the purpose of adaptation to the boundary conditions when used in the differential equation in [10]. If

$\frac{d_i}{d_x} > 0.3$ and $\frac{\delta}{d_x} < 0.2$

the summation term is negligible for practical applications. Therefore, Eq. 6.4.4-15 can be simplified to the following:

$$R_x = \frac{d_x \cdot \left[\ln\left(\frac{d_x}{\pi \cdot \delta} \right) + \sum_{s=1}^{\infty} \frac{g_1(s) + g_2(s)}{s} \right]}{2 \cdot \pi \cdot \lambda_b}$$ Eq. 6.4.4-16

Thus, the resistance R_x depends only on two geometric variables, i.e., the distance between pipes d_x and the pipe diameter δ, and on the thermal conductivity of the material layer λ_b in the pipe plane. The transformation from triangular to star-shaped network results in the additional temperature ϑ_k for the center point of the star-network. This temperature equals the mean temperature in the pipe plane when $y = 0$ (see Figure 6.4.4-1) as is described in detail in [11]. This temperature is called core temperature.

Based on the above mentioned calculations of the thermal resistance several different Thermo-Active Building elements might be described:

	Resistance in x-direction	Criteria
Radiant heating or cooling system (ceiling or wall)	$R_x \approx \frac{d_x \cdot \ln\left(\frac{d_x}{\pi \cdot \delta}\right)}{2 \cdot \pi \cdot \lambda_b}$	$d_x \geq 5.8 * \delta$
Capillary tube system	$R_x \approx \frac{d_x \cdot \frac{1}{3} \cdot \left(\frac{d_x}{\pi \cdot \delta}\right)}{2 \cdot \pi \cdot \lambda_b}$	$dx < 5.8 * \delta$
Floor heating systems	$R_x = \frac{d_x \cdot \left(\ln\left(\frac{d_x}{\pi \cdot \delta}\right) + \sum_{s=1}^{100} \frac{g_1(s)}{s}\right)}{2 \cdot \pi \cdot \lambda_b}$ $g_1(s) = -\frac{\frac{\alpha_2}{\lambda_b} \cdot d_x - 2 \cdot \pi \cdot s}{\frac{\alpha_2}{\lambda_b} \cdot d_x + 2 \cdot \pi \cdot s} \cdot e^{\frac{-4 \cdot \pi \cdot s}{d_x} \cdot d_2}$	$\alpha_2 = \frac{\lambda_{Insulation}}{d_{Insulation}} < 1.212 \frac{W}{m^2 K}$ $\frac{\delta}{2} \leq d_2$; $\frac{d_1}{d_x} \leq 0.3$

6.4.4.2. Thermal transmittance through the pipe shell

Heat transfer from the fluid within the pipe with the temperature ϑ_w through the pipe shell to the concrete with the temperature ϑ_3 is called thermal transmittance. Thermal transmittance can be separated into two different processes, the process of convection and the process of thermal conductance. In the first step energy is being exchanged between the fluid and the pipe shell by forced convection. Then energy is transferred through the pipe shell by thermal conductance. Both forms of heat transfer can be described as a thermal resistance in proportion to the surface area of the construction element by $d_x \cdot l$. Thermal resistance by convection for cylindrical areas is expressed in the following formula:

$$R_w = \frac{d_x}{h_w \cdot (\delta - 2 \cdot d_r) \cdot \pi} \quad \text{Eq. 6.4.4-17}$$

The convective heat transfer coefficient h_w from the water to the pipe shell for turbulent flow $(\mathrm{Re} \geq 2300)$ can be calculated as follows

$$h_w = 2040 \cdot (1 + 0.015 \cdot \vartheta_w) \cdot \frac{w^{0.87}}{(\delta - 2 \cdot d_r)^{0.13}} \quad \text{Eq. 6.4.4-18}$$

with a sufficient level of precision, according to [11]. When Eq. 6.4.4-18 is inserted into Eq. 6.4.4-17 with $\vartheta_w = 20$ C the result after several transformations is the following:

$$R_w = \frac{d_x^{0.13}}{8.0 \cdot \pi} \cdot \left(\frac{\delta - 2 \cdot d_r}{\dot{m}_{sp} \cdot l} \right)^{0.87}$$ Eq. 6.4.4-19

This is the thermal resistance for heat transfer from the fluid to the pipe shell. The resistance for heat transfer through the pipe shell by thermal conduction can be determined in a similar way. The formula for the reference surface area $d_x \cdot l$ is

$$R_r = \frac{d_x \cdot \ln\left(\frac{\delta}{\delta - 2 \cdot d_r} \right)}{2 \cdot \lambda_r \cdot \pi}$$ Eq. 6.4.4-20

6.4.4.3. Mean water temperature in a pipe coil

So far, the above considerations referred only to a two-dimensional cross-section in the $x - y$ direction of the construction element. They were all based on the temperature ϑ_w of the fluid. However, this temperature is not constant, but changes along the pipe coil. With the longitudinal and the transverse heat transfer in the construction element being neglected and based on the equations Eq. 6.4.4-1 and Eq. 6.4.4-5 the change in the temperature ϑ_w can be calculated as follows:

$$-\dot{m} \cdot c \cdot d\vartheta_w(z) = \frac{\Phi}{1 + \Phi \cdot (U_1 + U_2) \cdot (R_w + R_r)} \cdot \left[U_1 (\vartheta_w(z) - \vartheta_1) + U_2 (\vartheta_w(z) - \vartheta_2) \right] \cdot d_x \cdot dz$$ Eq. 6.4.4-21

On the left side of equation Eq. 6.4.4-21 the change in temperature of the fluids $d\vartheta_w(z)$ is represented in each downstream-oriented step along the length dz (see Figure 6.4.4-5: Change in temperature in the pipe in z direction).

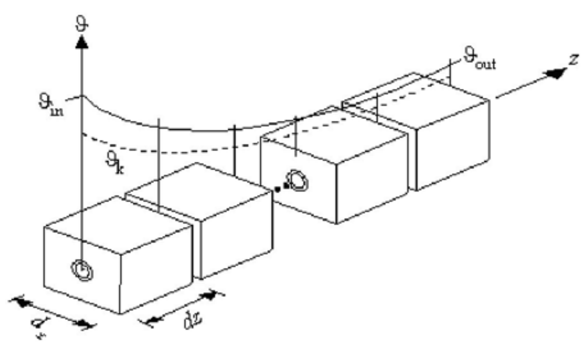


Figure 6.4.4-5: Change in temperature in the pipe in z direction

The integration of Eq. 6.4.4-21 results in a 'heat exchanger model' of the relation between the mean water temperature $\overline{\vartheta_w}$ in a pipe coil and the room temperatures ϑ_1 and ϑ_2. The formula for determining the mean water temperature is as follows:

$$\overline{\vartheta}_w = \frac{U_1 \cdot \vartheta_1 + U_2 \cdot \vartheta_2}{U_1 + U_2} + \Delta \vartheta_{lg}$$ Eq. 6.4.4-22

Several transformations, which are described to greater detail in [11], lead to the following formula for the heat flow between the water inlet temperature and the mean water temperature.

$$\dot{q} = f\left(R_w, R_r, R_x, U_i, \dot{m}_{sp}, c\right) \cdot \left(\vartheta_{in} - \overline{\vartheta}_w\right)$$ Eq. 6.4.4-23

The reciprocal value of the function $f\left(R_w...\right)$ can be interpreted as the thermal resistance in z direction and be expressed by the following formula:

$$R_z = \frac{1}{\dot{m}_{sp} \cdot c \cdot \left\{1 - \exp\left[-\left(\dot{m}_{sp} \cdot c \cdot \left(R_w + R_r + R_x + \frac{1}{U_1 + U_2}\right)\right)^{-1}\right]\right\}} - \left(R_w + R_r + R_x + \frac{1}{U_1 + U_2}\right)$$ Eq. 6.4.4-24

6.4.4.4. Total resistance

When placed in series, as shown in Figure 6.4.4-6, all of the single resistances can be summed up to form a total resistance:

$$R_t = R_z + R_w + R_r + R_x$$ Eq. 6.4.4-25

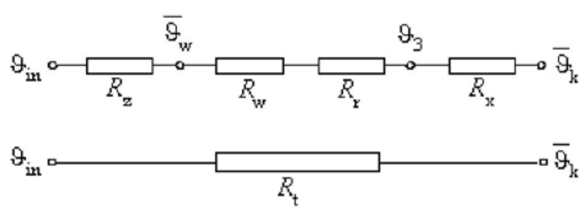


Figure 6.4.4-6: Total resistance between water inlet temperature and core temperature

The insertion of Eq. 6.4.4-24 into Eq. 6.4.4-25 results in the following formula for the total resistance:

$$R_t = \frac{1}{\dot{m}_{sp} \cdot c \cdot \left\{1 - \exp\left[-\left(\dot{m}_{sp} \cdot c \cdot \left(R_w + R_r + R_x + \frac{1}{U_1 + U_2}\right)\right)^{-1}\right]\right\}} - \frac{1}{U_1 + U_2}$$ Eq. 6.4.4-26

Figure 6.4.4-7 shows how the coefficient of thermal transmittance $U_1 + U_2$ and the specific mass flow rate $\dot{m}_{sp}$ affect the total resistance R_t as described in Eq. 6.4.4-26. The selected pipe dimension and the distance between pipes are both shown in the legend. The first number indicates the inside diameter, the second indicates the outside diameter.

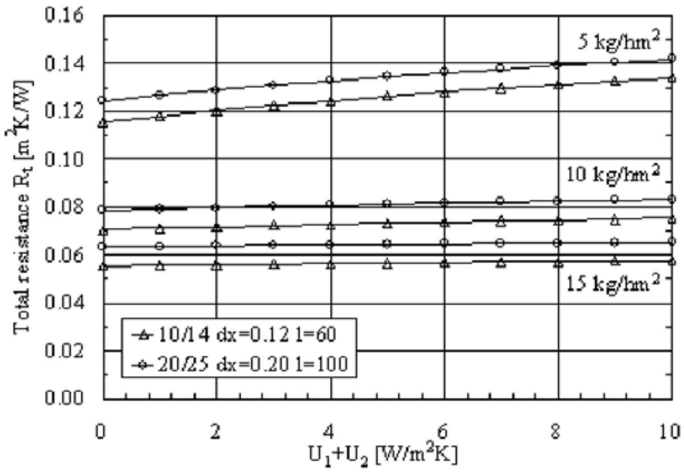


Figure 6.4.4-7: Thermal transmittance and mass flow affecting R_t

The higher the selected specific mass flow rate, the less relevant its dependency on $U_1 + U_2$. For $\dot{m}_{sp} = 5$ kg/hm^2 the total resistance R_t varies by 15 %, for $\dot{m}_{sp} = 10$ kg/hm^2 by 6 % and for $\dot{m}_{sp} = 15$ kg/hm^2 by 3 % in the region shown. For higher specific mass flow rates the sum of the coefficients of thermal transmittance $U_1 + U_2$ can be decreased without significant change in the total resistance R_t. When $U_1 + U_2 \to 0$ is inserted into Eq. 6.4.4-26 the total resistance is simplified to

$$R_t = \frac{1}{2 \cdot \dot{m}_{sp} \cdot c} + R_w + R_r + R_x$$ Eq. 6.4.4-27

When the coefficients of thermal transmittance $U_1 + U_2$, which apply to stationary calculations only, are eliminated from Eq. 6.4.4-26 the newly developed theory can also be used for dynamic (time-dependent) problems. In Eq. 6.4.4-27, the first term on the right side stands for the resistance in z direction:

$$R_z = \frac{1}{2 \cdot \dot{m}_{sp} \cdot c}$$ Eq. 6.4.4-28

This is equivalent to a linearization of the change in water temperature between the inlet and outlet as shown in Figure 6.4.4-5. However, this change of temperature shows a highly exponential character for very low mass flow rates. Linearization of an exponential curve like this results in a significant loss in precision. In certain orders of magnitude it can even result in conditions which are impossible with regard to physics.

According to [11] the criterion

$$\dot{m}_{sp} \cdot c \cdot \left(R_w + R_r + R_x\right) \geq \frac{1}{2}$$ Eq. 6.4.4-29

can be specified as the boundary condition. If this boundary condition cannot be met by the selected configuration, the pipe coil has to be split up into several sections. In a similar way as described above, the total resistance can be derived for each of the n sections from

$$R_{t,i} = \frac{1}{2 \cdot \dot{m}_{sp} \cdot n \cdot c} + R_w + R_r + R_x \qquad \text{Eq. 6.4.4-30}$$

The boundary condition of each section is expressed by

$$\dot{m}_{sp} \cdot c \cdot n \cdot \left(R_w + R_r + R_x\right) \geq \frac{1}{2} \qquad \text{Eq. 6.4.4-31}$$

For a regular pipe design of thermo-active construction element systems the criterion in Eq. 6.4.4-29 can be met for $\dot{m}_{sp} \geq$ 13 kg/hm^2. In this region even the simplification $U_1 + U_2 \rightarrow 0$ as specified in Figure 6.4.4-7: Thermal transmittance and mass flow affecting $R_t$leads to good results. When mass flow rates of less than 13 kg/hm^2 are used for certain designs, a minimum of two sections should be expected. Splitting the pipe coil up into n sections increases the specific mass flow rate of each section by the n-th multiple. This has a positive effect on the simplification $U_1 + U_2 \rightarrow 0$ in Eq. 6.4.4-26, because the approximation is closer to the exact result for higher specific mass flow rates.

Inserting the equations for each single resistance, i. e.Eq. 6.4.4-16, Eq. 6.4.4-19 and Eq. 6.4.4-20, into Eq. 6.4.4-30 for a turbulent current in the pipe and on the condition of Eq. 6.4.4-31 results in the following formula for the total resistance:

$$R_{t,i} = \frac{1}{2 \cdot \dot{m}_{sp} \cdot n \cdot c} + \frac{d_x^{0.13} \cdot \left(\frac{\delta - 2 \cdot d_r}{\dot{m}_{sp} \cdot l}\right)^{0.87}}{8.0 \cdot \pi} + \frac{d_x \cdot \ln\left(\frac{\delta}{\delta - 2 \cdot d_r}\right)}{2 \cdot \pi \cdot \lambda_r} + \frac{d_x \cdot \ln\left(\frac{d_x}{\pi \cdot \delta}\right)}{2 \cdot \pi \cdot \lambda_b} \qquad \text{Eq. 6.4.4-32}$$

where

$$\frac{d_i}{d_x} > 0.3 \quad \text{and} \quad \frac{\delta}{d_x} < 0.2$$

The variable $R_{t,i}$ in Eq. 6.4.4-32 contains all the relevant parameters required for the calculation of thermo-active construction element systems.

6.4.4.5. Comparing the calculation methods

The previous considerations show, that the newly developed method can also be applied to dynamic (time-dependent) calculations. The resistance $R_{t,i}$ which was newly introduced for this theory contains no variables which are only valid for stationary calculations. Consequently, the results achieved by this model must be equivalent to those achieved by an exact method. Therefore, the theory is checked against the FEM method. In the comparison with the FEM method the room temperature is considered to be a known. The boundary conditions for the calculation are specified in Figure 6.4.4-8.

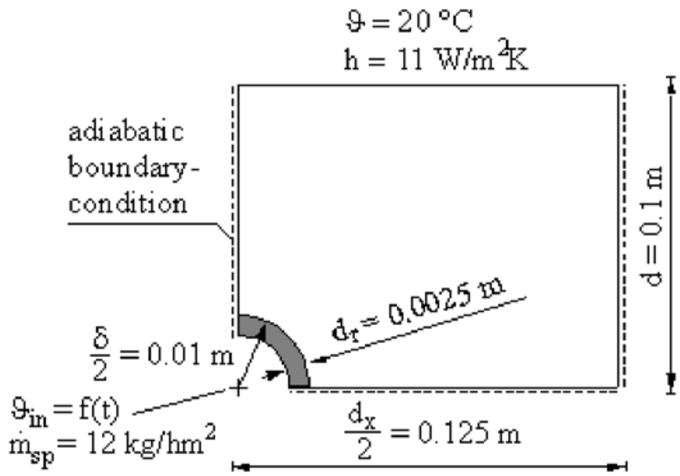


Figure 6.4.4-8: Simulated FEM section of a construction element with boundary conditions

In the beginning of the calculation the construction element has an even starting temperature of 20 °C. For Case 1 the inlet temperature is increased rapidly from 20 to 30 °C (see Figure 6.4.4-9). However, the room temperature is maintained at 20 °C.

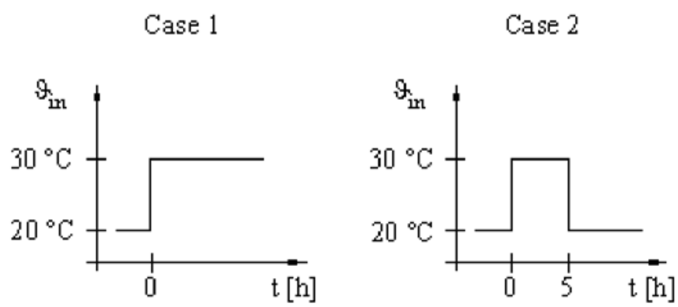


Figure 6.4.4-9: Temperatures for Case 1 and 2

Figure 6.4.4-10 shows the change in the core temperature and in the temperature on the surface. The close correspondence between the results of the model and the results of the exact FEM calculation become apparent in this figure.

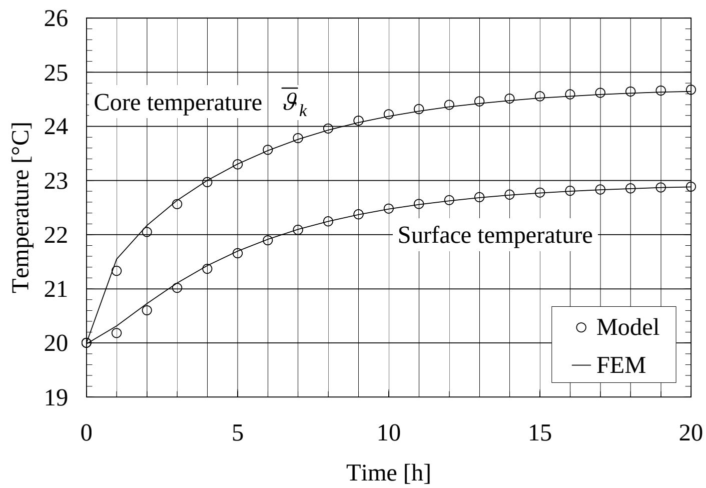


Figure 6.4.4-10: Comparison of the simplified model with the FEM calculation (Case 1)

For Case 2 the room temperature is also maintained at 20 °C, just as for Case 1. The water inlet temperature is increased from 20 to 30°C and maintained on that level for five hours (see Figure 6.4.4-9). After five hours the water temperature is decreased again to 20°C.

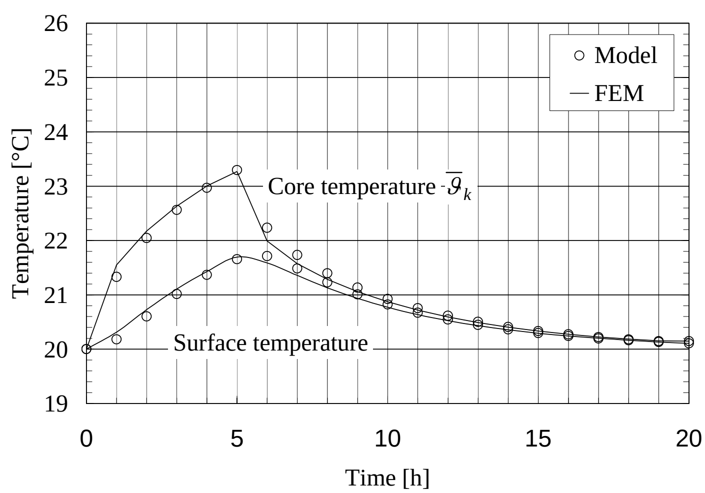


Figure 6.4.4-11: Comparison of the simplified model with the FEM calculation (Case 2)

Figure 6.4.4-11 shows that good correspondence between the simplified model and the FEM calculation is also achieved for Case 2.

6.4.4.6. Variables and Indices

Variables

c	$[J/kgK]$	Specific heat
d	$[m]$	Thickness
h	$[W/m^2K]$	heat transfer coefficient
l	$[m]$	Pipe length
$\dot{m}$	$[kg/s]$	Mass flow rate
n	[-]	Multiplier for pipe sections
R	$[m^2K/W]$	Thermal resistance
Re	[-]	Reynold's number
U	$[W/m^2K]$	Coefficient of thermal transmittance
w	$[m/s]$	Velocity
δ	$[m]$	Outside diameter
π	[-]	Number π
λ	$[W/mK]$	Thermal conductivity
ϑ	$[°C]$	Temperature
$\overline{\vartheta}$	$[°C]$	Mean temperature

Indices

1	Room side 1
2	Room side 2
3	Outside pipe surface
b	Construction element
k	Core
i	Room side
in	Inlet
r	Pipe shell
sp	Specific
t	Total
w	Water, fluid
x	x direction
y	y direction
z	z direction

6.4.5. Integrated Model for Chilled Ceiling Panels

Figure 6.4.5-1 shows a schematic drawing of a chilled ceiling panel.

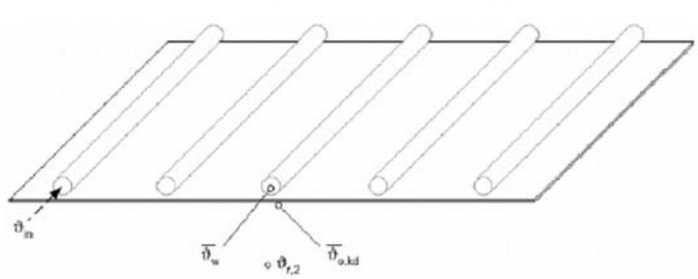


Figure 6.4.5-1: Chilled ceiling panel

$\overline{\vartheta}_w$	$[°C]$	Mean fluid temperature
$\overline{\vartheta}_{o,kd}$	$[°C]$	Mean surface temperature of chilled ceiling
$\vartheta_{r,2}$	$[°C]$	operative room temperature
ϑ_{in}	$[°C]$	fluid inlet temperature

The chilled ceiling model of TYPE56 needs results from a ceiling test according to DIN 4715-1 as Input. From this results and the known boundary conditions for the test the model calculates the resistance network at test conditions. Figure 6.4.5-2 shows the resistance model for chilled ceiling test conditions.

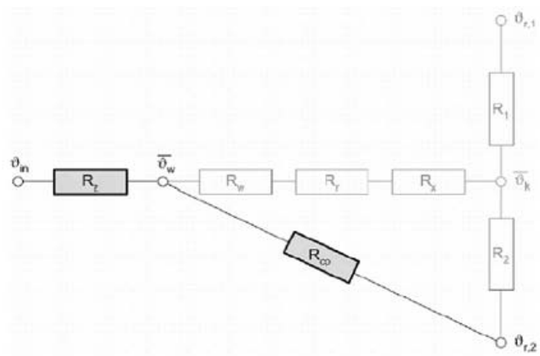


Figure 6.4.5-2: Resistance model for chilled ceiling test conditions after 4715-1.

R_w	$[m^2K/W]$	Thermal resistance fluid to pipe
R_r	$[m^2K/W]$	Thermal resistance pipe
R_x	$[m^2K/W]$	Thermal resistance in x-direction
R_{cp}	$[m^2K/W]$	Thermal resistance of chilled ceiling panel at test conditions
R_1	$[m^2K/W]$	Thermal resistance upper wall at test conditions well insulated
R_2	$[m^2K/W]$	Thermal resistance combined heat transfer to the room
$\overline{\vartheta}_w$	$[°C]$	Mean fluid temperature
$\overline{\vartheta}_k$	$[°C]$	Mean temperature of chilled ceiling
$\vartheta_{r,2}$	$[°C]$	Operative room temperature
$\vartheta_{r,1}$	$[°C]$	Operative outside temperature
U_{wrx}	$[kJ/hm^2K]$	Heat transfer coefficient

Besides the test results the heat transfer coefficient U_{wrx} = 1/ (R_w+R_r+ R_x) is needed. U_{wrx} can be calculated internally from the specific norm power using the following approximation for common used chilled ceiling panels:

$$U_{wrx} = 0.6 \exp\left(\frac{0.0469 P_{sp\_norm}}{3.6}\right) 3.6 \qquad \text{Eq. 6.4.5-1}$$

where P_{sp_norm} is the specific norm power after DIN 4715-1.

Also the temperature difference dT_{surf_norm} between mean fluid temperature $\overline{\vartheta}_w$ and mean surface temperature $\overline{\vartheta}_k$ if known for test conditions can be used to calculate the heat transfer coefficient U_{wrx} with the following equation:

$$U_{wrx} = \frac{P_{sp\_norm}}{dT_{surf\_norm}} \qquad \text{Eq. 6.4.5-2}$$

Table 6.4.5-1 shows for some chilled ceiling samples U_{wrx} and dT_{surf_norm} for measurement and the approximation used by TYPE 56. For non-ventilated chilled ceiling with a cooling power Q_n < 95 W/m² (of) a good agreement between measured values and the approximation used by TYPE 56 is achieved. For higher rate of performance the approx. values of the resistance (1/U_{wrx}) are unrealistically low. In general, the higher performance is due to ventilation. This fact cannot be handled by the approximation model.

Table 6.4.5-1: U_{wrx} and dT_{surf_norm} for different chilled ceiling panels

Producer	**Product**	Q_n **W/m^2]**	U_{wrx} **[**kJ/hm^2K**]**		dT_{surf_norm} **[K]**	
		Measurement	Measurement	Approximation	Measurement	Approximation
Zent - Frenger	Variocool Spectra M-plate	96	54.0476	54.14.01	1.8	1.8
	Variocool Spectra L-plate	92	44.1986	44.8792	2.1	2.0
Krantz	KKS-1 pipe spacing 90mm	91	42.1673	42.8230	2.2	2.1
Lindner	LMD Plafotherm B/E/K metal ceiling	92.5	45.2706	45.9441	2.0	2.0
	LMD Plafotherm FMA metal ceiling	90	40.2735	40.8609	2.2	2.2
Barcol-Air	CBA-FE-CU12/16	88.7	37.9951	38.4441	2.3	2.3
		Internet data	Guess value 2K	Approx.	Guess value 2K	approx
Zent-Frenger	Varicool Linea 3	98	49	59.5	2	1.6
EMCO	QL-tec RA 50	110	55	104.4	2	1.1

Gebr. Trox	WK-D-WF	153	76.5	784.4	2	1.2
Siegle + Epple	CuRo	153	76.5	784.4	2	0.2

R_r and R_x are characteristically for each chilled ceiling panel and independent from the conditions in the room or the massflow rate through the panel. The sum of both resistances is calculated with the following equation:

$$R_r + R_x = \frac{1}{U_{wrx}} - R_w$$ Eq. 6.4.5-3

According to [12], the thermal resistance R_w for heat transfer from a fluid ($\vartheta_w = 20°C$ and a density of fluid 1000 kg/m³) to the pipe shell for turbulent flow $(\mathrm{Re} \geq 2300)$ can be calculated as follows:

$$R_w = \frac{d_x^{0.13}}{8.0\pi}\left(\frac{\delta - 2d_r}{\dot{m}_{sp} l}\right)$$ Eq. 6.4.5-4

For laminar flow the following equation is used

$$R_w = \frac{d_x}{\pi\lambda_w}\left(49.03 + 4.17\frac{4\dot{m}_{sp} c\, d_x}{\pi\lambda_w}\right)^{-1/3}$$ Eq. 6.4.5-5

The thermal resistance of the chilled ceiling panel can be calculated from the specific norm power by the following equation:

$$R_{cp} = \frac{\vartheta_{r,2} - \overline{\vartheta}_w}{\dot{q}_{cp}} = \frac{10K}{\dot{q}_{n,cp}}$$ Eq. 6.4.5-6

The thermal resistance $R_{2,norm}$ for the combined heat transfer from the chilled ceiling panel to the room at test conditions can be calculated with

$$R_{2,norm} = R_{cp} - \frac{1}{U_{wrx}}$$ Eq. 6.4.5-7

The convective heat transfer coefficient from the panel to the room at test conditions can be calculated with:

$$\alpha_{conv,2,norm} = \frac{1}{R_{2,norm}} - 4\sigma T_{room}^3$$ Eq. 6.4.5-8

where T_{room} is given in K.

Using the parameters for the internal calculation heat transfer coefficients which are defined at properties for a chilled ceiling the convective heat transfer coefficient $\alpha_{conv\ flat\ ceiling\ norm}$ for a flat chilled ceiling panel at norm conditions can be calculated with:

$$\alpha_{conv,flat\_ceiling,norm} = K_{ce\_cooled}\left(10K - dT_{surf,norm}\right)^{e_{ce\_cooled}}$$ Eq. 6.4.5-9

The convective heat transfer of a flat panel is adjusted to the test results by the factor K_{korr_HTC} to fit the measured norm power, $P_{sp,norm}$. A factor greater than 1 is possible due to fins of a so called convective chilled ceiling.

$$K_{korr\_HTC} = \frac{\alpha_{conv,2,norm}}{\alpha_{conv,flat\_ceiling,norm}}$$ Eq. 6.4.5-10

The convective heat transfer coefficient from the panel to the room during the simulation is calculated with:

$$\alpha_{conv,ceiling\_cooled} = K_{korr\_HTC} K_{ce\_cooled}\left(\overline{\vartheta}_k - T_{air,ceiling}\right)^{e_{ce\_cooled}}$$ Eq. 6.4.5-11

$$\alpha_{conv,ceiling\_heated} = K_{korr\_HTC} K_{ce\_heated}\left(\overline{\vartheta}_k - T_{air,ceiling}\right)^{e_{ce\_heated}}$$ Eq. 6.4.5-12

This model assumes that the front and the backside of the chilled ceiling panel do have the same surface temperature $\overline{\vartheta}_k$. However in an expert mode additional heat transfer coefficients for upper and lower construction might be added which will modify the surface temperatures for front and back side but also the resulting cooling power of the chilled ceiling panel. The total resistance to the room during the simulation is calculated by the following equation:

$$R_{2,norm} = \frac{1}{\alpha_{conv,2} + 4\sigma T_{room}^3} + \frac{1}{U_{loconst}}$$ Eq. 6.4.5-13

The resistance R_1 between the chilled ceiling and ceiling for direct contact is calculated with the following equation:

$$R_1 = \frac{1}{9000} + \frac{1}{U_{upconst}}$$ Eq. 6.4.5-14

In Figure 6.4.5-3 the heat transfer model in the gap for a chilled ceiling with out direct contact is shown.

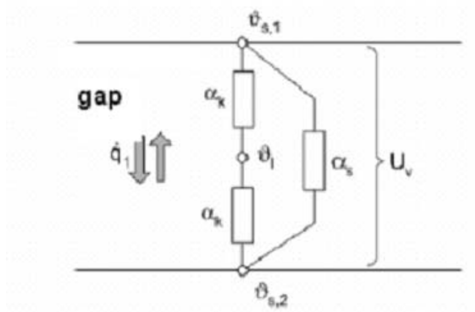


Figure 6.4.5-3: Assumed heat transfer in the gap between chilled ceiling and ceiling..

The resistance R_1 between chilled ceiling and ceiling for a gap can then calculated with the following equation:

$$R_1 = R_{gap} + \frac{1}{U_{upconst}}$$ Eq. 6.4.5-15

With the resistance R_{gap}, which is calculated depending the heat flux direction:

$$R_{gap} = \frac{1}{\left(4\sigma T_{room}^3 + 0.5 k_{down} \left(0.5 dT_{gap}\right)^{m_{down}}\right)}$$ Eq. 6.4.5-16

$$R_{gap} = \frac{1}{\left(4\sigma T_{room}^3 + 0.5 k_{up} \left(0.5 dT_{gap}\right)^{m_{up}}\right)}$$ Eq. 6.4.5-17

where dT_{gap} is the temperature difference between the chilled ceiling and ceiling. The coefficients to calculate the convective heat transfer k_{down}, k_{up}, m_{down}, and m_{up} can be changed from the default values to user-defined values in an expert mode.

According to the transformations shown in Section 6.4.4.4, the total resistance of an active layer can be calculated with the following equation:

$$R_t = \frac{1}{\dot{m}_{sp} c \left(1 - \exp\left(-\left(\dot{m}_{sp} c \left(R_w + R_r + R_x + \frac{1}{\frac{1}{R_1} + \frac{1}{R_2}}\right)\right)^{-1}\right)\right)} - \frac{1}{\frac{1}{R_1} + \frac{1}{R_2}}$$ Eq. 6.4.5-18

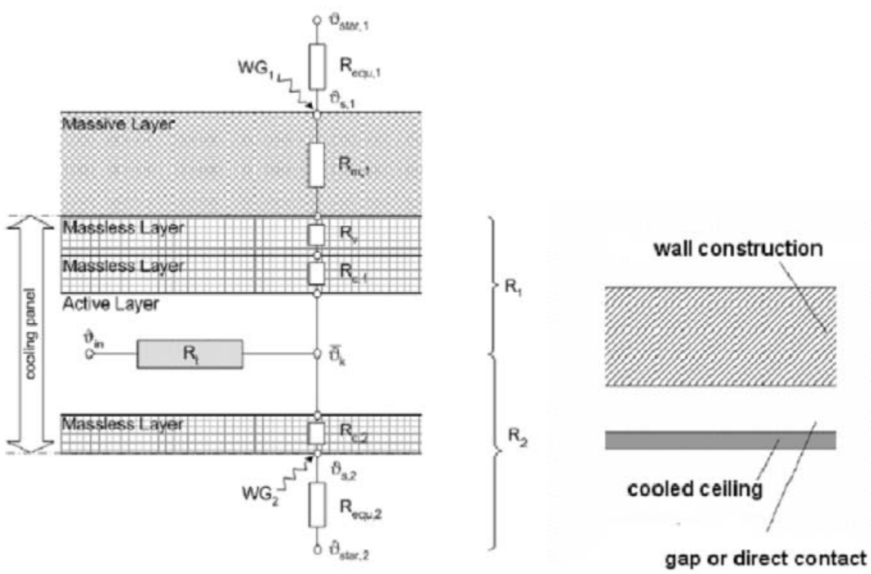


Figure 6.4.5-4: Resistance model chilled ceiling with additional construction and a gap

6.4.6. References

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6.5. Building Examples for TYPE 56

6.5.1. Simple Building Example: Restaurant

As an example, the heating requirements of a restaurant will be considered. The restaurant consists of three zones: the dining room, the kitchen, and a storage area. A floor plan of the building is shown in Figure 6.5.1-1. The dining room faces directly south and has a large double-glazed window. General data concerning the restaurant is as follows.

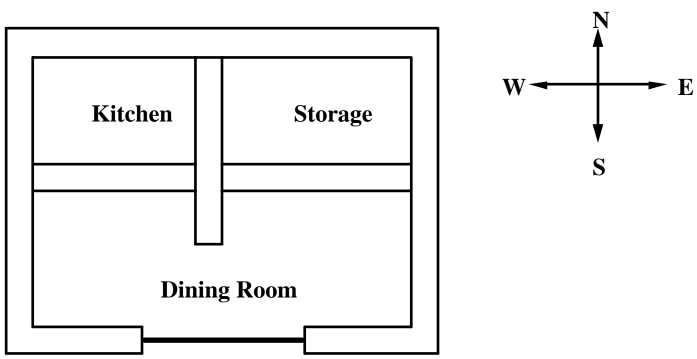

Figure 6.5.1-1: Floor Plan of Restaurant Example

1) <u>Structure</u> There are two types of walls: exterior and interior. The floor consists of a concrete slab on the ground, an insulation layer and stone tiling. The only window, located in the dining room, has two glazings. The flat roof has the following structure (from inside to outside): plaster board, air gap, insulation, concrete, roofing. The heat transfer coefficient at the outside of the exterior walls and roof varies with the windspeed. Note that the heat transfer coefficient of the floor is set to a very small value since we want to impose the surface temperature to be equal to the ground temperature (see section 6.2.10.6.9, Walls with Known Boundary Condition, for more details on this convention)

2) <u>Air Flows</u> The infiltration rate is fixed at a half an air change per hour during un-occupied times. For the dining room, there is an additional infiltration that follows the influx of customers and reaches a maximum of a quarter of an air change per hour. Part of this extra infiltration is considered to flow from the dining area to the kitchen. The maximum convective coupling from the dining room to the kitchen is 25 kilograms per hour. The kitchen is also ventilated during working hours at a rate of a half of an air change per hour.

3) <u>Gains</u> There are gains from people and lights in both the dining room and kitchen. The kitchen also has gains associated with the stoves. The lights are on whenever the building is occupied. The schedule of customers differs for weekdays and weekends. The storage room has fixed gains from a freezer.

4) <u>Heating</u> The kitchen and dining room are maintained at 20 degrees Celsius during occupied hours and at 15 degrees other times. The storage area is unheated.

5) <u>Cooling</u> A small room air conditioner is located in the kitchen which turns on if the temperature rises above 25 degrees Celsius.

Output from TRNBUILD and TRNSYS for this example can be found on the following pages. The input data necessary to describe the building along with appropriate comments is listed in the TRNBUILD output. Remember that comments are preceded by an asterisk (*) in the first column. If you like to add comments manually afterwards and which shall be kept by TRNBUILD use *#C instead. (Note: the comments will be moved from TRNBUILD automatically to the top of the input file). The deck and results are listed in the TRNSYS output.

A file named "RESTRANT.BUI" containing the building description was first created using the program TRNBUILD. After saving the bui-file . TRNBUILD generates three different output files: user information (RESTRANT.INF), building description (RESTRANT.BLD), and transfer functions (RESTRANT.TRN).

The "RESTRANT.BUI" is shown on the few next pages. Following the TRNSYS Input file “RESTRANT.DCK” is shown which contains the necessary TYPEs for carrying out the simulation. For the listing file look into the directory where the example is located. The result is shown at the end.

```
******************************************************************************************************************************************************
***************************************************************************
*  TRNBuild   1.0.92
******************************************************************************************************************************************************
***************************************************************************
*   BUILDING DESCRIPTIONS FILE TRNSYS
*   FOR BUILDING:   C:\Trnsys16_1_00\Examples\Restaurant\Restaurant.bui
*   GET BY WORKING WITH TRNBuild 1.0 for Windows
******************************************************************************************************************************************************
***************************************************************************
*
*---------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------
------------------------------------------------------------
* C o m m e n t s
*---------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------
------------------------------------------------------------
*---------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------
------------------------------------------------------------
* P r o j e c t
*---------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------
------------------------------------------------------------
*+++ PROJECT
*+++ TITLE=RESTAURANT EXAMPLE
*+++ DESCRIPTION=TRNSYS MAIN REFERENCE MANUAL
*+++ CREATED=SOLAR ENERGY LABORATORY
*+++ ADDRESS=MADISON, WI  USA
*+++ CITY=
*+++ SWITCH=UNDEFINED
*---------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------
------------------------------------------------------------
* P r o p e r t i e s
*---------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------
------------------------------------------------------------
PROPERTIES
 DENSITY=1.204 : CAPACITY=1.012 : HVAPOR=2454.0 : SIGMA=2.041e-007 : RTEMP=293.15
*--- alpha calculation -------------------
 KFLOORUP=7.2 : EFLOORUP=0.31 : KFLOORDOWN=3.888 : EFLOORDOWN=0.31
 KCEILUP=7.2 : ECEILUP=0.31 : KCEILDOWN=3.888 : ECEILDOWN=0.31
 KVERTICAL=5.76 : EVERTICAL=0.3
*
*++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++
++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++
++++++++++++++++++++++++
TYPES
*++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++
++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++
++++++++++++++++++++++++
```

```
*
*-----------------------------------------------------------------------------------------------------------------------------------------------------
---------------------------------------------
* L a y e r s
*-----------------------------------------------------------------------------------------------------------------------------------------------------
---------------------------------------------
LAYER GYPSUM
 CONDUCTIVITY=   2.62 : CAPACITY=   0.75 : DENSITY=   1601
LAYER INSULATION
 CONDUCTIVITY=  0.155 : CAPACITY=   0.75 : DENSITY=     32
LAYER STUCCO
 CONDUCTIVITY=   2.49 : CAPACITY=   0.75 : DENSITY=   1858
LAYER WOOD
 CONDUCTIVITY=  0.418 : CAPACITY=   2.25 : DENSITY=    592
LAYER CONCRETE
 CONDUCTIVITY=   6.23 : CAPACITY=   0.75 : DENSITY=   2242
LAYER STONE
 CONDUCTIVITY=   5.17 : CAPACITY=    1.5 : DENSITY=    881
LAYER CLAYTILE
 CONDUCTIVITY=      3 : CAPACITY=   0.84 : DENSITY=   1000
LAYER PLASTBOARD
 CONDUCTIVITY=    1.9 : CAPACITY=   0.84 : DENSITY=   1200
LAYER AIRSPACE
 RESISTANCE=     0.05
LAYER ROOFING
 CONDUCTIVITY=    2.5 : CAPACITY=      1 : DENSITY=   2100
*-----------------------------------------------------------------------------------------------------------------------------------------------------
---------------------------------------------
* I n p u t s
*-----------------------------------------------------------------------------------------------------------------------------------------------------
---------------------------------------------
INPUTS HOUTSIDE
*-----------------------------------------------------------------------------------------------------------------------------------------------------
---------------------------------------------
* S c h e d u l e s
*-----------------------------------------------------------------------------------------------------------------------------------------------------
---------------------------------------------
SCHEDULE WEEKDAY
 HOURS =0.000 8.000 10.000 12.000 14.000 17.000 22.000 24.0
 VALUES=0 5. 2. 10. 2. 10. 0 0
SCHEDULE WEEKEND
 HOURS =0.000 8.000 10.000 12.000 14.000 17.000 22.000 24.0
 VALUES=0 10. 5. 10. 4. 10. 0 0
SCHEDULE OCCUPANCY
 HOURS =0.000 7.000 22.000 24.0
 VALUES=0 1. 0 0
SCHEDULE CUSTOMERS
 DAYS=1 2 3 4 5 6 7
 HOURLY=WEEKDAY WEEKDAY WEEKDAY WEEKDAY WEEKDAY WEEKEND WEEKEND
*-----------------------------------------------------------------------------------------------------------------------------------------------------
---------------------------------------------
* W a l l s
*-----------------------------------------------------------------------------------------------------------------------------------------------------
---------------------------------------------
WALL OUTSIDE
 LAYERS   = GYPSUM INSULATION STUCCO
 THICKNESS= 0.019  0.076      0.025
 ABS-FRONT= 0.9   : ABS-BACK= 0.8
 HFRONT   = 11 : HBACK= INPUT 1*HOUTSIDE
WALL INSIDE
 LAYERS   = GYPSUM WOOD  GYPSUM
 THICKNESS= 0.019  0.058 0.019
 ABS-FRONT= 0.8   : ABS-BACK= 0.8
 HFRONT   = 11 : HBACK= 11
WALL FLOOR
 LAYERS   = STONE INSULATION CONCRETE
 THICKNESS= 0.025 0.076      0.102
 ABS-FRONT= 0.8   : ABS-BACK= 0
 HFRONT   = 11 : HBACK= 1e-005
WALL ROOF
```

```
 LAYERS   = PLASTBOARD AIRSPACE INSULATION CONCRETE ROOFING
 THICKNESS= 0.016      0        0.076      0.102    0.006
 ABS-FRONT= 0.8   : ABS-BACK= 0.9
 HFRONT   = 11 : HBACK= INPUT 1*HOUTSIDE
*--------------------------------------------------------------------------------------------------------------------------------------------------------
--------------------------------------------
* W i n d o w s
*--------------------------------------------------------------------------------------------------------------------------------------------------------
--------------------------------------------
WINDOW DOUBLE
 WINID=2001 : HINSIDE=11 : HOUTSIDE=72 : SLOPE=90 : SPACID=0 : WWID=0.77 : WHEIG=1.08 :
FFRAME=0.15 : UFRAME=8.17 : ABSFRAME=0.6 : RISHADE=0 : RESHADE=0 : REFLISHADE=0.5 :
REFLOSHADE=0.5 : ;
 CCISHADE=0.5
*--------------------------------------------------------------------------------------------------------------------------------------------------------
--------------------------------------------
* D e f a u l t  G a i n s
*--------------------------------------------------------------------------------------------------------------------------------------------------------
--------------------------------------------
*--------------------------------------------------------------------------------------------------------------------------------------------------------
--------------------------------------------
* O t h e r  G a i n s
*--------------------------------------------------------------------------------------------------------------------------------------------------------
--------------------------------------------
GAIN PEOPLE
 CONVECTIVE=150 : RADIATIVE=70 : HUMIDITY=0.058
GAIN LIGHTS
 CONVECTIVE=300 : RADIATIVE=1500 : HUMIDITY=0
GAIN STOVES
 CONVECTIVE=10000 : RADIATIVE=5000 : HUMIDITY=0.1
GAIN FREEZER
 CONVECTIVE=1500 : RADIATIVE=0 : HUMIDITY=0
*--------------------------------------------------------------------------------------------------------------------------------------------------------
--------------------------------------------
* C o m f o r t
*--------------------------------------------------------------------------------------------------------------------------------------------------------
--------------------------------------------
*--------------------------------------------------------------------------------------------------------------------------------------------------------
--------------------------------------------
* I n f i l t r a t i o n
*--------------------------------------------------------------------------------------------------------------------------------------------------------
--------------------------------------------
INFILTRATION SOUTH
 AIRCHANGE=SCHEDULE 0.03*CUSTOMERS+0.5
INFILTRATION NORTH
 AIRCHANGE=0.5
*--------------------------------------------------------------------------------------------------------------------------------------------------------
--------------------------------------------
* V e n t i l a t i o n
*--------------------------------------------------------------------------------------------------------------------------------------------------------
--------------------------------------------
VENTILATION KITCHEN
 TEMPERATURE=OUTSIDE
 AIRCHANGE=SCHEDULE 0.75*OCCUPANCY
 HUMIDITY=OUTSIDE
*--------------------------------------------------------------------------------------------------------------------------------------------------------
--------------------------------------------
* C o o l i n g
*--------------------------------------------------------------------------------------------------------------------------------------------------------
--------------------------------------------
COOLING KITCHEN
 ON=26
 POWER=50000
 HUMIDITY=100
*--------------------------------------------------------------------------------------------------------------------------------------------------------
--------------------------------------------
* H e a t i n g
*--------------------------------------------------------------------------------------------------------------------------------------------------------
--------------------------------------------
HEATING HEATER
```

```
 ON=SCHEDULE 5*OCCUPANCY+15
 POWER=50000
 HUMIDITY=0
 RRAD=0
*
*--------------------------------------------------------------------------------------------------------------------------------------------------------------
---------------------------------------------
* Z o n e s
*--------------------------------------------------------------------------------------------------------------------------------------------------------------
---------------------------------------------
ZONES DINING KITCHEN STORAGE
*--------------------------------------------------------------------------------------------------------------------------------------------------------------
---------------------------------------------
* O r i e n t a t i o n s
*--------------------------------------------------------------------------------------------------------------------------------------------------------------
---------------------------------------------
ORIENTATIONS NORTH SOUTH EAST WEST HORIZONTAL
*
*+++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++
+++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++
++++++++++++++++++++++
BUILDING
*+++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++
+++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++
++++++++++++++++++++++
*
*--------------------------------------------------------------------------------------------------------------------------------------------------------------
---------------------------------------------
* Z o n e  DINING  /  A i r n o d e  DINING
*--------------------------------------------------------------------------------------------------------------------------------------------------------------
---------------------------------------------
ZONE DINING
AIRNODE DINING
WALL  =OUTSIDE    : SURF=  1 : AREA=       35 : EXTERNAL : ORI=SOUTH : FSKY=0.5
WINDOW=DOUBLE     : SURF=  2 : AREA=       10 : EXTERNAL : ORI=SOUTH : FSKY=0.5
WALL  =OUTSIDE    : SURF=  3 : AREA=       35 : EXTERNAL : ORI=WEST : FSKY=0.5
WALL  =OUTSIDE    : SURF=  4 : AREA=       35 : EXTERNAL : ORI=EAST : FSKY=0.5
WALL  =INSIDE     : SURF=  5 : AREA=     22.5 : INTERNAL
WALL  =INSIDE     : SURF=  6 : AREA=     22.5 : ADJACENT=STORAGE : FRONT
WALL  =FLOOR      : SURF=  7 : AREA=    112.5 : BOUNDARY=10
WALL  =ROOF       : SURF=  8 : AREA=    112.5 : EXTERNAL : ORI=HORIZONTAL : FSKY=1
WALL  =INSIDE     : SURF=  9 : AREA=     22.5 : ADJACENT=KITCHEN : FRONT
 REGIME
 GAIN        = PEOPLE     : SCALE= SCHEDULE 5*CUSTOMERS
 GAIN        = LIGHTS     : SCALE= SCHEDULE 2*OCCUPANCY
 INFILTRATION= SOUTH
 HEATING     = HEATER
 CAPACITANCE = 500     : VOLUME= 337.5   : TINITIAL= 20      : PHINITIAL= 50      : WCAPR= 1
*--------------------------------------------------------------------------------------------------------------------------------------------------------------
---------------------------------------------
* Z o n e  KITCHEN  /  A i r n o d e  KITCHEN
*--------------------------------------------------------------------------------------------------------------------------------------------------------------
---------------------------------------------
ZONE KITCHEN
AIRNODE KITCHEN
WALL  =INSIDE     : SURF= 10 : AREA=      22.5 : ADJACENT=DINING : BACK : COUPL=SCHEDULE
2.5*CUSTOMERS
WALL  =OUTSIDE    : SURF= 11 : AREA=      22.5 : EXTERNAL : ORI=WEST : FSKY=0.5
WALL  =OUTSIDE    : SURF= 12 : AREA=      22.5 : EXTERNAL : ORI=NORTH : FSKY=0.5
WALL  =INSIDE     : SURF= 13 : AREA=      22.5 : ADJACENT=STORAGE : BACK
WALL  =FLOOR      : SURF= 14 : AREA=     56.25 : BOUNDARY=10
WALL  =ROOF       : SURF= 15 : AREA=     56.25 : EXTERNAL : ORI=HORIZONTAL : FSKY=1
 REGIME
 GAIN        = PEOPLE     : SCALE= SCHEDULE 0.5*CUSTOMERS
 GAIN        = LIGHTS     : SCALE= SCHEDULE 1*OCCUPANCY
 GAIN        = STOVES     : SCALE= SCHEDULE 1*OCCUPANCY
 INFILTRATION= NORTH
 VENTILATION = KITCHEN
 COOLING     = KITCHEN
 HEATING     = HEATER
```

```
 CAPACITANCE = 250    : VOLUME= 168.75  : TINITIAL= 20     : PHINITIAL= 50     : WCAPR= 1
*-----------------------------------------------------------------------------------------------------------------------------------------------------
----------------------------------------------
* Z o n e  STORAGE  /  A i r n o d e  STORAGE
*-----------------------------------------------------------------------------------------------------------------------------------------------------
----------------------------------------------
ZONE STORAGE
AIRNODE STORAGE
WALL  =INSIDE    : SURF= 16 : AREA=     22.5 : ADJACENT=DINING : BACK
WALL  =INSIDE    : SURF= 17 : AREA=     22.5 : ADJACENT=KITCHEN : FRONT
WALL  =OUTSIDE   : SURF= 18 : AREA=     22.5 : EXTERNAL : ORI=NORTH : FSKY=0.5
WALL  =OUTSIDE   : SURF= 19 : AREA=     22.5 : EXTERNAL : ORI=EAST : FSKY=0.5
WALL  =FLOOR     : SURF= 20 : AREA=    56.25 : BOUNDARY=10
WALL  =ROOF      : SURF= 21 : AREA=    56.25 : EXTERNAL : ORI=HORIZONTAL : FSKY=1
 REGIME
 GAIN       = FREEZER   : SCALE= 1
 INFILTRATION= NORTH
 CAPACITANCE = 250    : VOLUME= 168.75  : TINITIAL= 20     : PHINITIAL= 50     : WCAPR= 1
*-----------------------------------------------------------------------------------------------------------------------------------------------------
----------------------------------------------
* O u t p u t s
*-----------------------------------------------------------------------------------------------------------------------------------------------------
----------------------------------------------
OUTPUTS
 TRANSFER : TIMEBASE=1.000
 AIRNODES = DINING KITCHEN STORAGE
 NTYPES =   1 : TAIR - air temperature of zone
       =   2 : QSENS - sensible energy demand of zone, heating(-), cooling(+)
       =   3 : QCSURF - total convection to air from all surfaces within zone (incl. internal shading)
       =   4 : QINF - sensible infiltration energy gain of zone
       =   5 : QVENT - tsensible ventilation energy gain of zone
       =   6 : QCOUP - tsensible coupling energy gain of zone
       =   7 : QGCONV - internal convective gains of zone
       =   8 : DQAIR - change in internal sensible energy of zone air since beginning of simulation
 AIRNODES = DINING
 NTYPES =  17 : SURF = 1, 3, 4, 5, 6, 7, 8, 9, 2,  : TSI - inside surface temperature
*-----------------------------------------------------------------------------------------------------------------------------------------------------
----------------------------------------------
* E n d
*-----------------------------------------------------------------------------------------------------------------------------------------------------
----------------------------------------------
END

_EXTENSION_WINPOOL_START_
WINDOW 4.1  DOE-2 Data File : Multi Band Calculation
Unit System : SI
Name       : TRNSYS 15 WINDOW LIB
Desc       : Waermeschutzglas,Ar, 1.4 71/59
Window ID   : 2001
Tilt       : 90.0
Glazings    : 2
Frame      : 11                   2.270
Spacer     :  1 Class1              2.330  -0.010   0.138
Total Height: 1219.2 mm
Total Width :  914.4 mm
Glass Height: 1079.5 mm
Glass Width :  774.7 mm
Mullion     : None
Gap       Thick  Cond  dCond   Vis  dVis   Dens  dDens    Pr    dPr
1 Argon    16.0 0.01620  5.000  2.110  6.300  1.780 -0.0060  0.680 0.00066
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  0.426 0.428 0.422 0.413 0.402 0.380 0.333 0.244 0.113 0.000 0.354
Abs1  0.118 0.118 0.120 0.123 0.129 0.135 0.142 0.149 0.149 0.000 0.132
Abs2  0.190 0.192 0.198 0.201 0.200 0.199 0.199 0.185 0.117 0.000 0.191
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 0.266 0.262 0.260 0.262 0.269 0.286 0.326 0.422 0.621 1.000 0.314
Rbsol 0.215 0.209 0.207 0.210 0.219 0.237 0.272 0.356 0.560 0.999 0.260
Tvis  0.706 0.710 0.701 0.688 0.670 0.635 0.556 0.403 0.188 0.000 0.590
Rfvis 0.121 0.115 0.114 0.118 0.132 0.163 0.228 0.376 0.649 1.000 0.203
Rbvis 0.103 0.096 0.093 0.096 0.108 0.132 0.179 0.286 0.520 0.999 0.162
SHGC  0.589 0.593 0.591 0.586 0.574 0.551 0.505 0.405 0.218 0.000 0.518
SC: 0.55
Layer ID#       9052    9065      0      0      0      0
Tir            0.000   0.000      0      0      0      0
Emis F         0.840   0.140      0      0      0      0
Emis B         0.840   0.840      0      0      0      0
Thickness(mm)    4.0     4.0      0      0      0      0
Cond(W/m2-C    ) 225.0   225.0      0      0      0      0
Spectral File    None    None    None    None    None    None
Overall and Center of Glass Ig U-values (W/m2-C)
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-C)
0       0.00  12.25  3.25  7.62  1.54 1.54  1.31 1.31  1.35 1.35  1.47 1.47
0       6.71  25.47  3.21  7.64  1.62 1.62  1.36 1.36  1.40 1.40  1.53 1.53
783     0.00  12.25  3.39  7.99  1.69 1.69  1.54 1.54  1.51 1.51  1.54 1.54
783     6.71  25.47  3.30  7.81  1.79 1.79  1.63 1.63  1.58 1.58  1.59 1.59
*** END OF LIBRARY ***
*********************************************************************************************
*WinID   Description                      Design       U-Value g-value T-sol Rf-sol T-vis
*********************************************************************************************
  2001   Waermeschutzglas,Ar, 1.4 71/59          4/16/4         1.4  0.589  0.426  0.266  0.706
_EXTENSION_WINPOOL_END_
```

Following is the TRNSYS input file for this simple example.

```
VERSION 16.1
*******************************************************************************
*** TRNSYS input file (deck) generated by TrnsysStudio
*** on Thursday, March 23, 2006 at 22:30
*** from TrnsysStudio project: C:\Trnsys16\Examples\Restaurant\Restaurant.tpf
***
*** If you edit this file, use the File/Import TRNSYS Input File function in
*** TrnsysStudio to update the project.
***
*** If you have problems, questions or suggestions please contact your local
*** TRNSYS distributor or mailto:software@cstb.fr
***
*******************************************************************************


*******************************************************************************
*** Units
*******************************************************************************

*******************************************************************************
*** Control cards
*******************************************************************************
* START, STOP and STEP
CONSTANTS 3
START=0
STOP=744
STEP=1
* User defined CONSTANTS
```

```
SIMULATION          START    STOP     STEP     ! Start time          End time  Time step
TOLERANCES 0.001 0.001                         ! Integration          Convergence
LIMITS 30 30 30                                ! Max iterations      Max warnings       Trace limit
DFQ 1                                          ! TRNSYS numerical integration solver method
WIDTH 72                              ! TRNSYS output file width, number of characters
LIST                                           ! NOLIST statement
                                      ! MAP statement
SOLVER 0 1 1                                   ! Solver statement   Minimum relaxation factor      Maximum
relaxation factor
NAN_CHECK 0                                    ! Nan DEBUG statement
OVERWRITE_CHECK 0                              ! Overwrite DEBUG statement
TIME_REPORT 0                         ! disable time report
EQSOLVER 0                                     ! EQUATION SOLVER statement

* Model "Type109-TMY2" (Type 109)
*

UNIT 14 TYPE 109     Type109-TMY2
*$UNIT_NAME Type109-TMY2
*$MODEL .\Weather Data Reading and Processing\Standard Format\TMY2\Type109-TMY2.tmf
*$POSITION 48 157
*$LAYER Weather - Data Files #
PARAMETERS 4
2            ! 1 Data Reader Mode
36                   ! 2 Logical unit
4            ! 3 Sky model for diffuse radiation
1            ! 4 Tracking mode
INPUTS 9
0,0                  ! [unconnected] Ground reflectance
0,0                  ! [unconnected] Slope of surface-1
0,0                  ! [unconnected] Azimuth of surface-1
0,0                  ! [unconnected] Slope of surface-2
0,0                  ! [unconnected] Azimuth of surface-2
0,0                  ! [unconnected] Slope of surface-3
0,0                  ! [unconnected] Azimuth of surface-3
0,0                  ! [unconnected] Slope of surface-4
0,0                  ! [unconnected] Azimuth of surface-4
*** INITIAL INPUT VALUES
0.2 90 180 90 0 90 -90 90 90
*** External files
ASSIGN "C:\Trnsys16_1_00\Weather\Meteonorm\Europe\DE-Stuttgart-107370.tm2" 36
*|? Weather data file |1000
*------------------------------------------------------------------------------

* Model "Type33e" (Type 33)
*

UNIT 6 TYPE 33       Type33e
*$UNIT_NAME Type33e
*$MODEL .\Physical Phenomena\Thermodynamic Properties\Psychrometrics\Dry Bulb and Relative Humidity
Known\Type33e.tmf
*$POSITION 308 47
*$LAYER Main #
PARAMETERS 3
2            ! 1 Psychrometrics mode
1            ! 2 Wet bulb mode
2            ! 3 Error mode
INPUTS 3
14,1                 ! Type109-TMY2:Ambient temperature ->Dry bulb temp.
14,2                 ! Type109-TMY2:relative humidity ->Percent relative humidity
0,0                  ! [unconnected] Pressure
*** INITIAL INPUT VALUES
20 60 1
*------------------------------------------------------------------------------

* Model "Type69b" (Type 69)
*

UNIT 5 TYPE 69       Type69b
*$UNIT_NAME Type69b
```

```
*$MODEL .\Physical Phenomena\Sky Temperature\calculate cloudiness factor\Type69b.tmf
*$POSITION 508 156
*$LAYER Main #
PARAMETERS 2
0		! 1 mode for cloudiness factor
250			! 2 height over sea level
INPUTS 4
14,1			! Type109-TMY2:Ambient temperature ->Ambient temperature
6,8			! Type33e:Dew point temperature. ->Dew point temperature at ambient conditions
14,13			! Type109-TMY2:beam radiation on horitonzal ->Beam radiation on the horizontal
14,15			! Type109-TMY2:ground reflected diffuse radiation on horizontal ->Diffuse radiation on the
horizontal
*** INITIAL INPUT VALUES
23 20 0 0
*------------------------------------------------------------------------------

* Model "Type56a" (Type 56)
*

UNIT 7 TYPE 56	 Type56a
*$UNIT_NAME Type56a
*$MODEL .\Loads and Structures\Multi-Zone Building\With Standard Output Files\Type56a.tmf
*$POSITION 598 157
*$LAYER Main #
*$#
PARAMETERS 6
31			! 1 Logical unit for building description file (.bui)
1		! 2 Star network calculation switch
1		! 3 Weighting factor for operative temperature
32			! 4 Logical unit for monthly summary
33			! 5 Logical unit for hourly temperatures
34			! 6 Logical unit for hourly loads
INPUTS 19
14,1			! Type109-TMY2:Ambient temperature -> 1- TAMB
14,2			! Type109-TMY2:relative humidity -> 2- RELHUMAMB
5,1			! Type69b:Fictive sky temperature -> 3- TSKY
14,18			! Type109-TMY2:total radiation on tilted surface-1 -> 4- IT_NORTH
14,24			! Type109-TMY2:total radiation on tilted surface-2 -> 5- IT_SOUTH
14,30			! Type109-TMY2:total radiation on tilted surface-3 -> 6- IT_EAST
14,36			! Type109-TMY2:total radiation on tilted surface-4 -> 7- IT_WEST
14,12			! Type109-TMY2:total radiation on horizontal -> 8- IT_HORIZONTAL
14,19			! Type109-TMY2:beam radiation on tilted surface-1 -> 9- IB_NORTH
14,25			! Type109-TMY2:beam radiation on tilted surface-2 -> 10- IB_SOUTH
14,31			! Type109-TMY2:beam radiation on tilted surface-3 -> 11- IB_EAST
14,37			! Type109-TMY2:beam radiation on tilted surface-4 -> 12- IB_WEST
14,13			! Type109-TMY2:beam radiation on horitonzal -> 13- IB_HORIZONTAL
14,22			! Type109-TMY2:angle of incidence for tilted surface -1 -> 14- AI_NORTH
14,28			! Type109-TMY2:angle of incidence for tilted surface -2 -> 15- AI_SOUTH
14,34			! Type109-TMY2:angle of incidence for tilted surface -3 -> 16- AI_EAST
14,40			! Type109-TMY2:angle of incidence for tilted surface -4 -> 17- AI_WEST
14,16			! Type109-TMY2:angle of incidence on horizontal surface -> 18- AI_HORIZONTAL
0,0			! [unconnected]  19- HOUTSIDE
*** INITIAL INPUT VALUES
0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0
*** External files
ASSIGN "Restaurant.bui" 31
*|? Building description file (*.bui) |1000
ASSIGN "Bldg-Monthly.out" 32
*|? Monthly Summary File |1000
ASSIGN "Bldg-HourlyTemp.out" 33
*|? Hourly Temperatures |1000
ASSIGN "Bldg-HourlyLoads.out" 34
*|? Hourly Loads |1000
*------------------------------------------------------------------------------

* EQUATIONS "Equa"
*
EQUATIONS 4
DHEAT = MAX(-[7,4],0)
SHEAT = MAX(-[7,6],0)
```

```
KHEAT = MAX(-[7,5],0)
KCOOL = MAX([7,5],0)
*$UNIT_NAME Equa
*$LAYER Main
*$POSITION 400 61

*------------------------------------------------------------------------------


* Model "Type28b-3" (Type 28)
*

UNIT 13 TYPE 28     Type28b-3
*$UNIT_NAME Type28b-3
*$MODEL .\Output\Simulation Summary\Results to External File\Without Energy Balance\Type28b.tmf
*$POSITION 696 349
*$LAYER Main #
PARAMETERS 25
24              ! 1 Summary interval
0       ! 2 Summary start time
9000            ! 3 Summary stop time
39              ! 4 Logical unit for the output file
2       ! 5 Output mode
1       ! 6 Operation code-1
-11             ! 7 Operation code-2
-4      ! 8 Operation code-3
-12             ! 9 Operation code-4
7       ! 10 Operation code-5
8       ! 11 Operation code-6
-4      ! 12 Operation code-7
-12             ! 13 Operation code-8
8       ! 14 Operation code-9
-4      ! 15 Operation code-10
-13             ! 16 Operation code-11
-4      ! 17 Operation code-12
-14             ! 18 Operation code-13
-4      ! 19 Operation code-14
-15             ! 20 Operation code-15
-4      ! 21 Operation code-16
-16             ! 22 Operation code-17
-4      ! 23 Operation code-18
-17             ! 24 Operation code-19
-4      ! 25 Operation code-20
INPUTS 8
7,23            ! Type56a: 23- DQAIR_KITCHEN ->Summary input-1
KHEAT           ! Equa:KHEAT ->Summary input-2
KCOOL           ! Equa:KCOOL ->Summary input-3
7,8             ! Type56a: 8- QCSURF_KITCHEN ->Summary input-4
7,11            ! Type56a: 11- QINF_KITCHEN ->Summary input-5
7,14            ! Type56a: 14- QVENT_KITCHEN ->Summary input-6
7,17            ! Type56a: 17- QCOUP_KITCHEN ->Summary input-7
7,20            ! Type56a: 20- QGCONV_KITCHEN ->Summary input-8
*** INITIAL INPUT VALUES
0 0 0 0 0 0 0 0
LABELS  8
KDELU   KHEAT  KCOOL  KSURF  KINF  KVENT  KCPLG  KCONV
*** External files
ASSIGN "***.su3" 39
*|? File for the summary results |1000
*------------------------------------------------------------------------------

* Model "Type28b-2" (Type 28)
*

UNIT 12 TYPE 28     Type28b-2
*$UNIT_NAME Type28b-2
*$MODEL .\Output\Simulation Summary\Results to External File\Without Energy Balance\Type28b.tmf
*$POSITION 590 349
*$LAYER Main #
PARAMETERS 21
```

```
24                      ! 1 Summary interval
0               ! 2 Summary start time
9000                    ! 3 Summary stop time
38                      ! 4 Logical unit for the output file
2               ! 5 Output mode
1               ! 6 Operation code-1
-11                     ! 7 Operation code-2
-4              ! 8 Operation code-3
-12                     ! 9 Operation code-4
7               ! 10 Operation code-5
-4              ! 11 Operation code-6
-13                     ! 12 Operation code-7
-4              ! 13 Operation code-8
-14                     ! 14 Operation code-9
-4              ! 15 Operation code-10
-15                     ! 16 Operation code-11
-4              ! 17 Operation code-12
-16                     ! 18 Operation code-13
-4              ! 19 Operation code-14
-17                     ! 20 Operation code-15
-4              ! 21 Operation code-16
INPUTS 7
7,24                    ! Type56a: 24- DQAIR_STORAGE ->Summary input-1
SHEAT                   ! Equa:SHEAT ->Summary input-2
7,9                     ! Type56a: 9- QCSURF_STORAGE ->Summary input-3
7,12                    ! Type56a: 12- QINF_STORAGE ->Summary input-4
7,15                    ! Type56a: 15- QVENT_STORAGE ->Summary input-5
7,18                    ! Type56a: 18- QCOUP_STORAGE ->Summary input-6
7,21                    ! Type56a: 21- QGCONV_STORAGE ->Summary input-7
*** INITIAL INPUT VALUES
0 0 0 0 0 0 0
LABELS  7
SDELU   SHEAT  SSURF  SINF  SVENT  SCPLG  SCONV
*** External files
ASSIGN "***.su2" 38
*|? File for the summary results |1000
*------------------------------------------------------------------------------

* Model "TYPE28b" (Type 28)
*

UNIT 11 TYPE 28        TYPE28b
*$UNIT_NAME TYPE28b
*$MODEL .\Output\Simulation Summary\Results to External File\Without Energy Balance\TYPE28b.tmf
*$POSITION 494 349
*$LAYER Main #
PARAMETERS 21
24                      ! 1 Summary interval
0               ! 2 Summary start time
9000                    ! 3 Summary stop time
37                      ! 4 Logical unit for the output file
2               ! 5 Output mode
1               ! 6 Operation code-1
-11                     ! 7 Operation code-2
-4              ! 8 Operation code-3
-12                     ! 9 Operation code-4
7               ! 10 Operation code-5
-4              ! 11 Operation code-6
-13                     ! 12 Operation code-7
-4              ! 13 Operation code-8
-14                     ! 14 Operation code-9
-4              ! 15 Operation code-10
-15                     ! 16 Operation code-11
-4              ! 17 Operation code-12
-16                     ! 18 Operation code-13
-4              ! 19 Operation code-14
-17                     ! 20 Operation code-15
-4              ! 21 Operation code-16
INPUTS 7
7,22                    ! Type56a: 22- DQAIR_DINING ->Summary input-1
```

```
DHEAT                ! Equa:DHEAT ->Summary input-2
7,7                  ! Type56a: 7- QCSURF_DINING ->Summary input-3
7,10                 ! Type56a: 10- QINF_DINING ->Summary input-4
7,13                 ! Type56a: 13- QVENT_DINING ->Summary input-5
7,16                 ! Type56a: 16- QCOUP_DINING ->Summary input-6
7,19                 ! Type56a: 19- QGCONV_DINING ->Summary input-7
*** INITIAL INPUT VALUES
0 0 0 0 0 0 0
LABELS  7
DDELU   DHEAT  DSURF  DINF  DVENT  DCPLG  DCONV
*** External files
ASSIGN "***.sum" 37
*|? File for the summary results |1000
*------------------------------------------------------------------------------

* Model "TYPE65d" (Type 65)
*

UNIT 10 TYPE 65       TYPE65d
*$UNIT_NAME TYPE65d
*$MODEL .\Output\Online Plotter\Online Plotter Without File\TYPE65d.tmf
*$POSITION 707 157
*$LAYER Main #
PARAMETERS 12
3            ! 1 Nb. of left-axis variables
4            ! 2 Nb. of right-axis variables
-20                  ! 3 Left axis minimum
40                   ! 4 Left axis maximum
0            ! 5 Right axis minimum
80000                ! 6 Right axis maximum
1            ! 7 Number of plots per simulation
7            ! 8 X-axis gridpoints
0            ! 9 Shut off Online w/o removing
-1           ! 10 Logical unit for output file
0            ! 11 Output file units
0            ! 12 Output file delimiter
INPUTS 7
7,1                  ! Type56a: 1- TAIR_DINING ->Left axis variable-1
7,2                  ! Type56a: 2- TAIR_KITCHEN ->Left axis variable-2
7,3                  ! Type56a: 3- TAIR_STORAGE ->Left axis variable-3
DHEAT                ! Equa:DHEAT ->Right axis variable-1
KHEAT                ! Equa:KHEAT ->Right axis variable-2
SHEAT                ! Equa:SHEAT ->Right axis variable-3
KCOOL                ! Equa:KCOOL ->Right axis variable-4
*** INITIAL INPUT VALUES
DINING KITCHEN STORAGE HEAT-D HEAT-K HEAT-S COOL-K
LABELS  3
"Zone  Temperatures (C)"
"Zone  Loads (kJ/hr)"
"plot1"
*------------------------------------------------------------------------------

END
```

6.5.2. Advanced Building Example: 3-Zone Office

In this example by TRANSSOLAR (Stuttgart, Germany), a dynamic building simulation is carried out within TRNSYS using the TYPE 56 component in which the thermal behavior of buildings can be calculated very precisely. To simulate the thermal behavior, TYPE 56 requires a great deal of building data (geometrical data, wall construction data, etc.) and other data (radiation, ambient temperature, humidity, building schedules, etc.) which influence the building. The data for a calculation are first assembled and then defined for the TRNSYS simulation. Figure 6.5.2-1: Flow diagram for a dynamic building simulation using TRNSYS shows a schematic flow diagram for a thermal building simulation with TRNSYS.

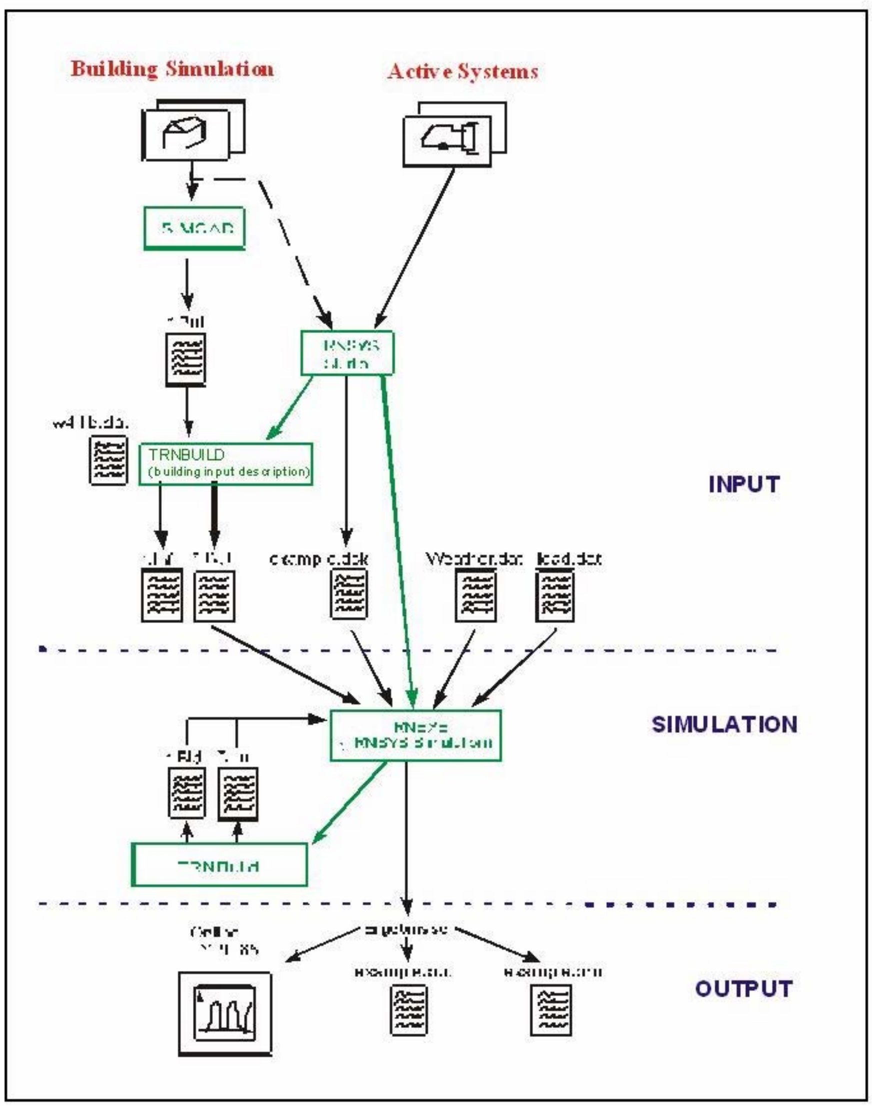

Figure 6.5.2-1: Flow diagram for a dynamic building simulation using TRNSYS

The steps shown in the flow diagram can described as follows:

1. Divide the building into thermal zones and determine the geometry from plans. This can either be done manually or using the program SIMCAD (ask your lokal TRNSYS distibutor for more details).

2. Enter the data (wall and window areas, ventilation, infiltration, etc.) with the preprocessor TRNBUILD.

3. Create a TRNSYS input file which describes the system to be simulated including the location of the building data for TYPE 56 with the preprocessor TRNSYS STUDIO.

Starting with a new project in the TRNSYS STUDIO, the included BUILDING WIZARD offers a fast way to come to the building description file and the TRNSYS input file (Step 2 an 3). The building wizard can be opened by klicking FILE -> NEW and then selecting BuildingProject (multizone). It is possible to pre-define several zones and their respective position, different control strategies for shading and ventilation as well as gains and heating/cooling types. The resulting building description and the TRNSYS input file can be easily modified and refined afterwards.

6.5.2.1. From Blueprints to Input File

First the building is divided into thermal zones like rooms having approximately the same temperatures or schedules. The office building, shown in Figure 6.5.2-2 and Figure 6.5.2-3, is divided into three thermal zones: first floor (Erdgeschoß), second floor (Obergeschoß), and a south-oriented office within the first floor.

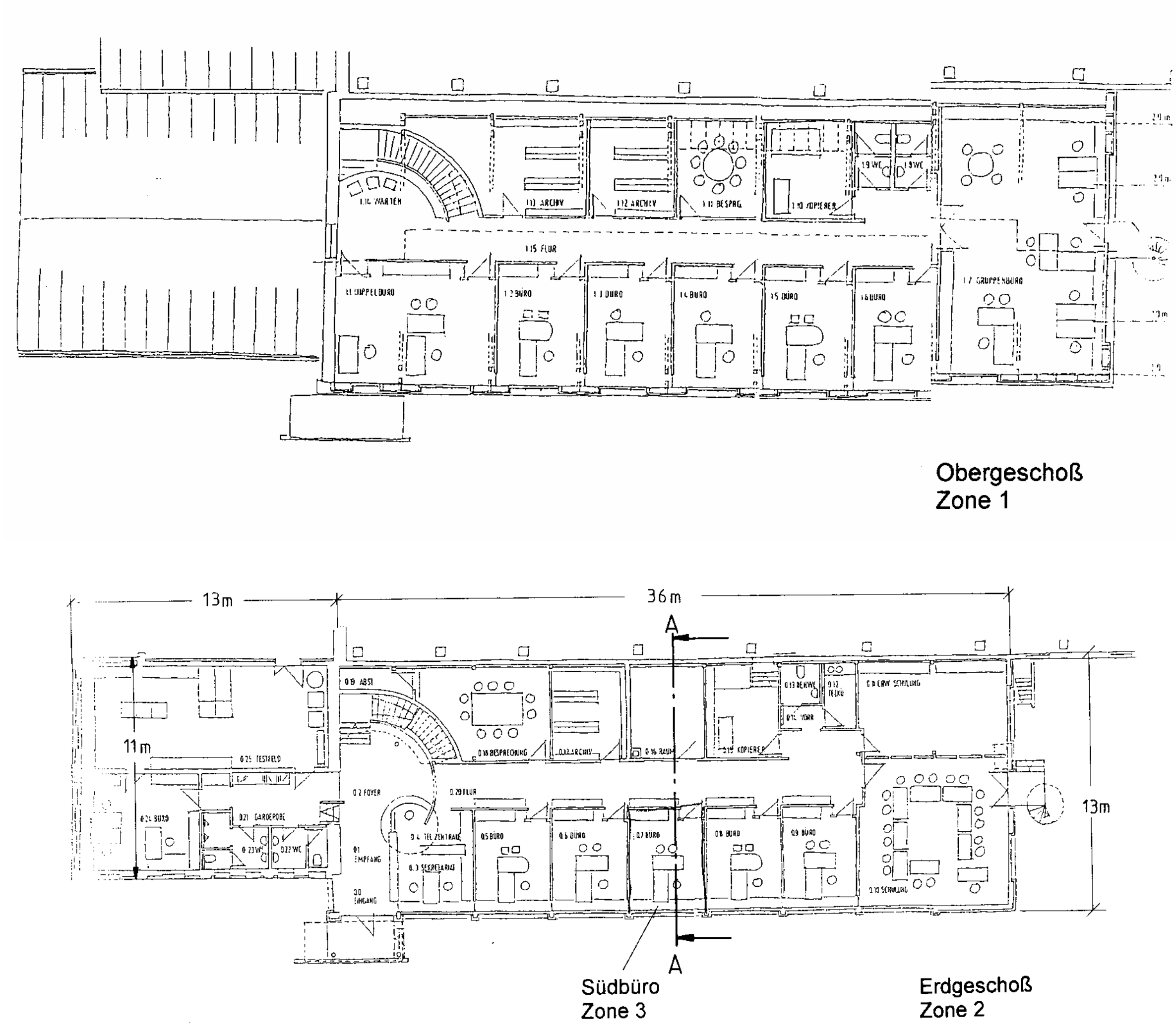

Figure 6.5.2-2: Blueprint of the office building

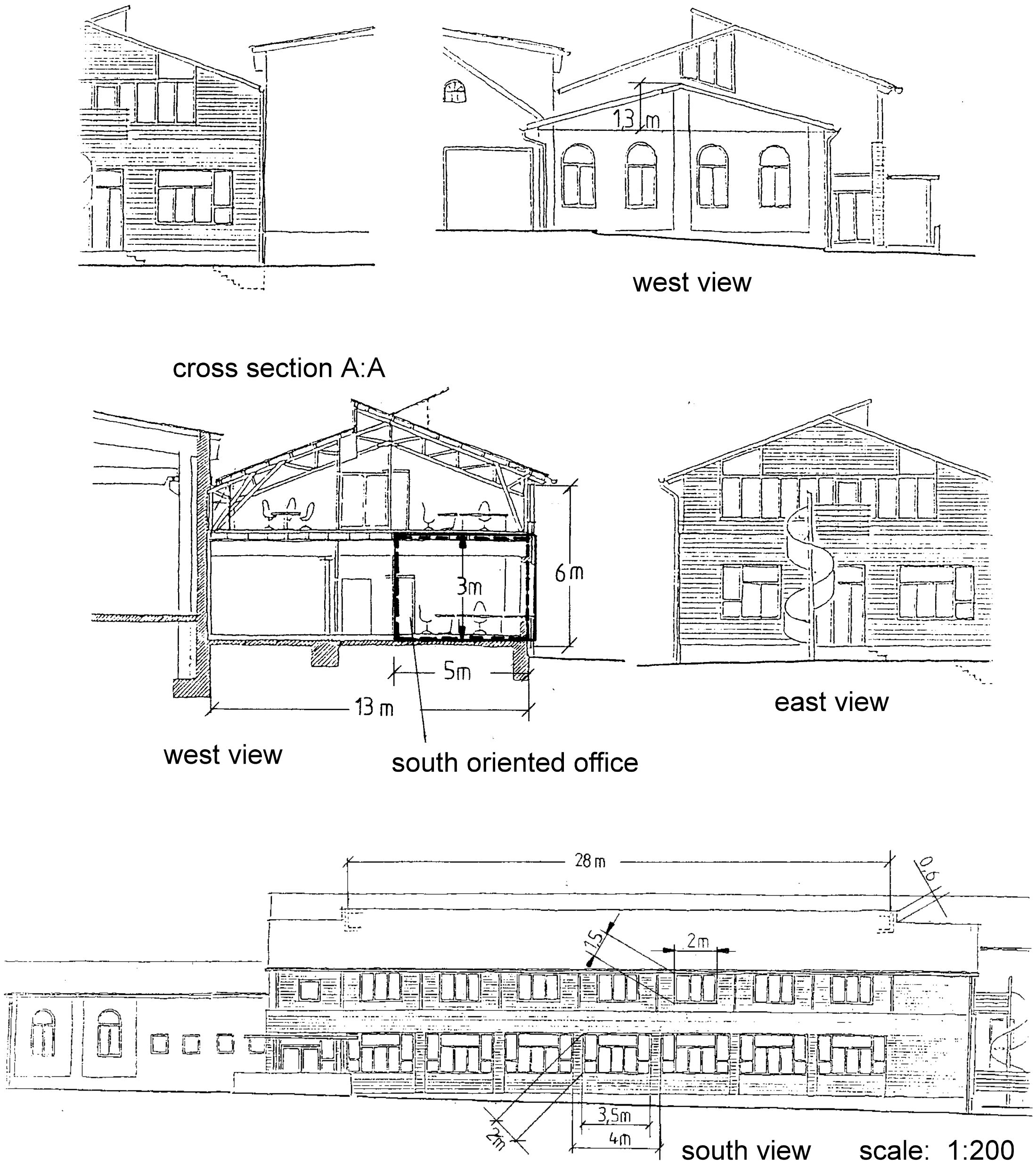

Figure 6.5.2-3: Various views of the office building

The reason for a separate definition of the south-oriented office is to allow for the possibility of making a statement for room temperatures in the summer (the office is likely to overheat during this season). From the building plans, the geometry and the orientation were determined. For the first and second floor zones, geometry and wall data for the office building are shown in Table 6.5.2-1.

Table 6.5.2-1: Geometry and wall data for the office building

Construction Element	Orientation	U-value	Area [m^2] Zone 1	Zone 2	Structure
Ground	-	0.32		591.6	
Outside Wall ground floor(Zone 2)	North	0.34		6.2	brick 24cm,+ 10cm insulation, plaster
	South	0.34		60.4	
	East	0.34		9.0	
	West	0.34		36.5	
Outside Wall first floor (Zone 1)	North	0.41	10.4		24cm brick + 8cm insulation, plaster
	South	0.41	41.5		
	East	0.41	44.8		
	West	0.41	11.2		
Windows (Variation 1)	North	1.4	-	2.9	double glazing
	South	1.4	38.4	66.8	
	East	1.4	16.8	6.0	
	West	1.4	9.0	17.1	
Windows (Variation 2)	North	1.4	-	2.9	low-e glazing
	South	1.4	38.4	66.8	
	East	1.4	16.8	6.0	
	West	1.4	9.0	17.1	
Window "Glass Door"	South	1.4	-	2.1	
	West	1.4	3.8	6.1	
Separate (adjacent to storage)	-	0.34	251.1	287.7	24cm brick, 10cm mineral wool
Intern	-	0.65	26.4	25.4	.
Ceiling (between ground floor and 1st floor)	-	0.74	461.1	461.1	floor, stone, silence,wood, airgap, wood
Roof	Horizontal	0.22	497.5	130.0	16cm mineral wool

6.5.2.2. Input of Building Data

The thermal behavior of a building in TRNSYS is described by transfer functions rather than heat loss coefficients (U-values). For the calculation of these functions the building data must be entered in a special format. The program TRNBUILD provides an easy way to enter the necessary input data which creates the building description file. The following pages show the file for the office building (BUILDING.BUI) with comments added for clarification (Note: the comments will be moved from TRNBUILD automatically to the top of the input file – so the “building.bui” file might look a bit different but it is the same).

```
*******************************************************************************************************************
*******************************************************************************
* TRNBuild   1.0.92
*******************************************************************************************************************
*******************************************************************************
*   BUILDING DESCRIPTIONS FILE TRNSYS
*   FOR BUILDING:   C:\Trnsys16\Examples\Building\building.bui
*   GET BY WORKING WITH TRNBuild 1.0 for Windows
*******************************************************************************************************************
*******************************************************************************
*
*-------------------------------------------------------------------------------------------------------------------------------
------------------------------------------------------------
* C o m m e n t s
*-------------------------------------------------------------------------------------------------------------------------------
------------------------------------------------------------
*#C --------------------------------------------------------------------------------------------- *
*#C BUILDING DESCRIPTIONS FILE TRNSYS
*#C FOR BUILDING:   BUILDING
*#C All units are in modified SI: Hours [h], Meter [m], Kilogramm [kg] and degree Celsius [ C]
*#C These are the properties for air [kg/m3], specific heat [kJ/kg C], water heat of vaporization
*#C [kJ/kg], Stephan-Boltzman Constant [kJ/hmýK4], and an approximate average room
*#C temperature.
*#C ----------------------------------------------------  TYPES --------------------------------- *
*#C ----------------------------------------------------LAYERS --------------------------------- *
*#C The Layer TYPES are used in the description of the Walls. Each Layer is given a name and
*#C associated property data. For layers with non-neglible mass, data is given for material
*#C thickness [m], thermal conductivity [kJ/hm C] specific heat [kJ/kg C] and density [kg/m3].
*#C The air gap is considered to be a pure resistance [hmý C/kJ]. Properties for these layers were
*#C taken from the ASHRAE handbook of fundamentals.
*#C
*#C ------------------------------------------------------- INPUTS ---------------------------- *
*#C
*#C These INPUTS which are defined below are for the purpose of ventilation and shading in
*#C summer. They depends on the outside temperature. The INPUT wind is used for a variable
*#C heat transfer coefficient of external walls.
*#C ----------------------------------------------------SCHEDULES ----------------------------- *
*#C
*#C The output of the schedule are used as scaling factors for the gains due to people and lights
*#C within the regimes and for heating, ventilation and shading control. The schedule for the staff
*#C is different for weekdays and weekends. The office buidling is occupied between 8 in the
*#C morning and 6 at night.
*#C


*#C ------------------------------------------------------- WALLS ----------------------------- *
*#C
*#C The wall description refer to previously defined LAYER TYPES. All walls,  floor, and roof
*#C have identical surface properties at the inside of zone. Layers are given from front of the
*#C wall to back. Where front corresponds to the inside of the zone for external walls and walls
*#C within specified boundary conditions (see buidling description) and is arbitrary otherwise.
*#C For walls between zones it is necessary to specify the correct side (front or back) for each
*#C zone within the building description.
*#C The ABS- values are set now in version 15 by their real properties and not any more for
*#C solar distribution and area weighted. For the not exact specified LAYER "Floor" the ABS value
*#C of Linoleum is set. For solar distribution see GEOSURF.
*#C
```

```
*#C ------------------------------------------------------ WINDOWS ------------------------------ *
*#C
*#C The window is double glazed and like the walls has a variable heat transfer coefficient at the
*#C outside. The window identification number (WINID) must exist in the window library file w4-
*#C tlib.dat which has to be assigned in the dck-file (e.g. ASSIGN  c:\trn142\bid\w4-tlib.dat  19).
*#C Values for fraction of the frame area to the total window area and the frame u-value are
*#C specified here. Additional heat resistances for internal / external shading, the reflection
*#C coefficient and the degree of convective coupling to the air node have to be specified here
*#C -------------------------------------------------------- GAINS ------------------------------ *
*#C
*#C The GAIN TYPE people represents the gain from one person. This along with gains from lights
*#C and computers are scaled within the zones.
*#C -------------------------------------------------------- COMFORT----------------------------- *
*#C
*#C If the the COMFORT TYPE is specified it is possibe to calculate the PMV and the PPD value
*#C according to ISO 7730. The specified values are set for "Sedentary activity (office, dwelling,
*#C school, laboratory)". The air velocity within the zone is assumed to be 0.1 m/s. It is only
*#C specified for zone "suedburo" (south office).
*#C
*#C --------------------------------------------------- INFILTRATION --------------------------- *
*#C
*#C Infiltration is fixed at a 1/4 an air change per hour during unoccupied times. During occupied
*#C times an additional infiltration is experienced of 3/4 that follows the customer using schedule
*#C USE. It reaches a maximum of 1 air change per hour.
*#C --------------------------------------------------- VENTILATION ---------------------------- *
*#C
*#C The office buidling is ventilated when the room temperatures reaches 24 C (determined by
*#C an external controler) with 3 air changes per hour.
*#C ------------------------------------------------------- HEATING ----------------------------- *
*#C
*#C The heater turns on during occupied times (SCHEDULE SETOFF) when the zone temperatures
*#C falls below 20  C. During unoccupied times the setpoint is 15  C. No air conditioner is
*#C necessary.
*#C ------------------------------------------------- ORIENTATIONS ----------------------------- *
*#C
*#C The orientation are for the roof and the walls
*#C
*#C -------------------------------------------------------- ZONES ------------------------------ *
*#C
*#C It is necessary to pre-define the zone names to be used in the building description
*#C
*#C
*#C ------------------------------------------------------ BUILDING ---------------------------- *
*#C  Shading values are specified for the glazing area of the windows only, the fraction of the
*#C frame are given above. For an internal shading device the actual reduction of the solar
*#C transmission caused by the device has to be given, TYPE 56 calculates the actual shading
*#C effect considering the reflection of the shading, the degree of convective coupling to the
*#C air node and the absorption of reflected diffuse solar radiation depending on the type of
*#C glazings used.. Standard values for FSKY are used: 0.5 for vertical surfaces, 1.0 for more or
*#C less horizontal surfaces
*#C ------------------------------ GEOSURF ----------------------------------------------------- *
*#C With GEOSURF it is possible to specify where to the direct solar radiation goes. So, e.g. in zone
*#C SUEDBURO the radiation hits the wall "GROUND" therefore 70% goes on this area. The other
values
*#C are assumed to be the same with 15%. Altogether it has to be 1 in each zone.
*#C The window does not get any direct radiation because of its the only window and oriented south.
*#C If you calculate the distribution factors manually (or may be with an external program) these
*#C values can given to TYPE 56 by specifying them as INPUTs.
*#C
*#C -------------------------------------------------- OUTPUTS --------------------------------- *
*#C
*#C Transferfunction calculation will be performed for all walls. Outputs from  the TYPE 56
```

```
*#C Model will include all zone energy quantities to perform energy balances. Also the zone
*#C temperatures the infiltration energy gains and total solar energy gain will be calculated.
*#C
*#C
*#C
*-------------------------------------------------------------------------------------------------------------------------------
--------------------------------------------------------------
* P r o j e c t
*-------------------------------------------------------------------------------------------------------------------------------
--------------------------------------------------------------
*+++ PROJECT
*+++ TITLE=EXAMPLE BUI FOR TRNSYS 16.1
*+++ DESCRIPTION=OFFICE BUILDING
*+++ CREATED=TRANSSOLAR
*+++ ADDRESS=CURIESTR.2
*+++ CITY=D-70563 STUTTGART
*+++ SWITCH=UNDEFINED
*-------------------------------------------------------------------------------------------------------------------------------
--------------------------------------------------------------
* P r o p e r t i e s
*--------------------------------------------------------------------------------------------------------------------


----------------------------------------------------------------------------
PROPERTIES
 DENSITY=1.204 : CAPACITY=1.012 : HVAPOR=2454.0 : SIGMA=2.041e-007 : RTEMP=293.15
*--- alpha calculation -------------------
 KFLOORUP=7.2 : EFLOORUP=0.31 : KFLOORDOWN=3.888 : EFLOORDOWN=0.31
 KCEILUP=7.2 : ECEILUP=0.31 : KCEILDOWN=3.888 : ECEILDOWN=0.31
 KVERTICAL=5.76 : EVERTICAL=0.3
*
*+++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++
++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++
++++++++++++++++++++++++++++++++++++++++++++
TYPES
*+++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++
++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++
++++++++++++++++++++++++++++++++++++++++++++
*
*-------------------------------------------------------------------------------------------------------------------------------
--------------------------------------------------------------
* L a y e r s
*-------------------------------------------------------------------------------------------------------------------------------
--------------------------------------------------------------
LAYER BRICK
 CONDUCTIVITY=    3.2 : CAPACITY=      1 : DENSITY=   1800
LAYER CONCRETE
 CONDUCTIVITY=   7.56 : CAPACITY=    0.8 : DENSITY=   2400
LAYER STONE
 CONDUCTIVITY=      5 : CAPACITY=      1 : DENSITY=   2000
LAYER PLASTER
 CONDUCTIVITY=      5 : CAPACITY=      1 : DENSITY=   2000
LAYER FLOOR
 CONDUCTIVITY=  0.252 : CAPACITY=      1 : DENSITY=    800
LAYER SILENCE
 CONDUCTIVITY=   0.18 : CAPACITY=   1.44 : DENSITY=     80
LAYER TILE
 CONDUCTIVITY=      3 : CAPACITY=      1 : DENSITY=   1800
LAYER GYPSUM
 CONDUCTIVITY=  0.756 : CAPACITY=      1 : DENSITY=   1200
LAYER WOOD
 CONDUCTIVITY=   0.54 : CAPACITY=      2 : DENSITY=    600
```

```
LAYER INSUL
 CONDUCTIVITY=  0.144 : CAPACITY=    0.8 : DENSITY=     40
LAYER AIRSPACE
 RESISTANCE=    0.047
*-----------------------------------------------------------------------------------------------------------------------------------
--------------------------------------------------------------
* I n p u t s
*-----------------------------------------------------------------------------------------------------------------------------------
--------------------------------------------------------------
INPUTS SHAD_SOUTH SHAD_EAST SHAD_WEST WIND ABLOG ABLEG ABLBU BRIGHT TLAGER
*-----------------------------------------------------------------------------------------------------------------------------------
--------------------------------------------------------------
* S c h e d u l e s
*-----------------------------------------------------------------------------------------------------------------------------------
--------------------------------------------------------------
SCHEDULE WORKDAY
 HOURS =0.000 8.000 18.000 24.0
 VALUES=0 1. 0 0
SCHEDULE WEEKEND
 HOURS =0.000 1.000 24.0
 VALUES=0 0 0
SCHEDULE WORKLIGHT
 HOURS =0.000 8.000 18.000 24.0
 VALUES=0 1. 0 0
SCHEDULE DAYNIGHT
 HOURS =0.000 6.000 18.000 24.0
 VALUES=0 1. 0 0
SCHEDULE USE
 DAYS=1 2 3 4 5 6 7
 HOURLY=WORKDAY WORKDAY WORKDAY WORKDAY WORKDAY WEEKEND WEEKEND
SCHEDULE LIGHT
 DAYS=1 2 3 4 5 6 7
 HOURLY=WORKLIGHT WORKLIGHT WORKLIGHT WORKLIGHT WORKLIGHT WEEKEND
WEEKEND
SCHEDULE SETOFF
 DAYS=1 2 3 4 5 6 7
 HOURLY=DAYNIGHT DAYNIGHT DAYNIGHT DAYNIGHT DAYNIGHT WEEKEND WEEKEND
*-----------------------------------------------------------------------------------------------------------------------------------
--------------------------------------------------------------
* W a l l s
*-----------------------------------------------------------------------------------------------------------------------------------
--------------------------------------------------------------
WALL GROUND
 LAYERS   = FLOOR STONE SILENCE CONCRETE INSUL
 THICKNESS= 0.005 0.06  0.04    0.24     0.08
 ABS-FRONT= 0.8   : ABS-BACK= 0.4
 HFRONT   = 11 : HBACK= 0.001
WALL OUTOG
 LAYERS   = BRICK INSUL PLASTER
 THICKNESS= 0.24  0.1   0.015
 ABS-FRONT= 0.75  : ABS-BACK= 0.3
 HFRONT   = 11 : HBACK= 64
WALL OUTEG
 LAYERS   = BRICK INSUL PLASTER
 THICKNESS= 0.24  0.08  0.015
 ABS-FRONT= 0.75  : ABS-BACK= 0.3
 HFRONT   = 11 : HBACK= 64
WALL SEPERATE
 LAYERS   = BRICK INSUL
 THICKNESS= 0.24  0.08
 ABS-FRONT= 0.75  : ABS-BACK= 0.4
 HFRONT   = 11 : HBACK= 11
```

```
WALL INTERN
 LAYERS   = WOOD
 THICKNESS= 0.012
 ABS-FRONT= 0.35  : ABS-BACK= 0.35
 HFRONT   = 11 : HBACK= 11
WALL IWALL
 LAYERS   = GYPSUM INSUL GYPSUM
 THICKNESS= 0.012  0.05  0.012
 ABS-FRONT= 0.6   : ABS-BACK= 0.6
 HFRONT   = 11 : HBACK= 11
WALL BETWEEN
 LAYERS   = FLOOR STONE SILENCE WOOD  AIRSPACE WOOD
 THICKNESS= 0.005 0.06  0.04    0.012 -1       0.012
 ABS-FRONT= 0.8   : ABS-BACK= 0.35
 HFRONT   = 11 : HBACK= 11
WALL ROOF
 LAYERS   = WOOD  INSUL WOOD  AIRSPACE TILE
 THICKNESS= 0.012 0.16  0.012 -1       0.03
 ABS-FRONT= 0.35  : ABS-BACK= 0.75
 HFRONT   = 11 : HBACK= 64
*----------------------------------------------------------------------------------------------------------------------------------------
---------------------------------------------------------------
* W i n d o w s
*----------------------------------------------------------------------------------------------------------------------------------------
---------------------------------------------------------------
WINDOW DOUBLE
 WINID=2001 : HINSIDE=11 : HOUTSIDE=INPUT 10.8*WIND+10.1 : SLOPE=90 : SPACID=0 :
WWID=0 : WHEIG=0 : FFRAME=0.2 : UFRAME=8.17 : ABSFRAME=0.6 : RISHADE=0 : RESHADE=0 :
REFLISHADE=0.5 : REFLOSHADE=0.5 : ;
 CCISHADE=0.5
WINDOW GLASDOOR
 WINID=2001 : HINSIDE=11 : HOUTSIDE=INPUT 10.8*WIND+10.1 : SLOPE=90 : SPACID=0 :
WWID=0 : WHEIG=0 : FFRAME=0.2 : UFRAME=8.17 : ABSFRAME=0.6 : RISHADE=0 : RESHADE=0 :
REFLISHADE=0.5 : REFLOSHADE=0.5 : ;
 CCISHADE=0.5
WINDOW DOPROL
 WINID=2001 : HINSIDE=11 : HOUTSIDE=64 : SLOPE=90 : SPACID=0 : WWID=0 : WHEIG=0 :
FFRAME=0.2 : UFRAME=8.17 : ABSFRAME=0.6 : RISHADE=0 : RESHADE=0 : REFLISHADE=0.5 :
REFLOSHADE=0.5 : CCISHADE=0.5
*----------------------------------------------------------------------------------------------------------------------------------------
---------------------------------------------------------------
* D e f a u l t  G a i n s
*----------------------------------------------------------------------------------------------------------------------------------------
---------------------------------------------------------------
*----------------------------------------------------------------------------------------------------------------------------------------
---------------------------------------------------------------
* O t h e r  G a i n s
*----------------------------------------------------------------------------------------------------------------------------------------
---------------------------------------------------------------
GAIN PERSON
 CONVECTIVE=150 : RADIATIVE=100 : HUMIDITY=0.058
GAIN LIGHT
 CONVECTIVE=INPUT 15*BRIGHT : RADIATIVE=INPUT 30*BRIGHT : HUMIDITY=0
GAIN COMPUTER
 CONVECTIVE=300 : RADIATIVE=60 : HUMIDITY=0
*----------------------------------------------------------------------------------------------------------------------------------------
---------------------------------------------------------------
* C o m f o r t
*----------------------------------------------------------------------------------------------------------------------------------------
---------------------------------------------------------------
COMFORT COM_SB
 CLOTHING=1 : MET=1.2 : WORK=0 : VELOCITY=0.1
```

```
*----------------------------------------------------------------------------------------------------------------------------------------------
--------------------------------------------------------------
* I n f i l t r a t i o n
*----------------------------------------------------------------------------------------------------------------------------------------------
--------------------------------------------------------------
INFILTRATION LEAKY
 AIRCHANGE=SCHEDULE 0.75*USE+0.25
*----------------------------------------------------------------------------------------------------------------------------------------------
--------------------------------------------------------------
* V e n t i l a t i o n
*----------------------------------------------------------------------------------------------------------------------------------------------
--------------------------------------------------------------
VENTILATION VENTOG
 TEMPERATURE=OUTSIDE
 AIRCHANGE=INPUT 3*ABLOG
 HUMIDITY=OUTSIDE
VENTILATION VENTEG
 TEMPERATURE=OUTSIDE
 AIRCHANGE=INPUT 3*ABLEG
 HUMIDITY=OUTSIDE
VENTILATION VBURO
 TEMPERATURE=OUTSIDE
 AIRCHANGE=INPUT 3*ABLBU
 HUMIDITY=OUTSIDE
*----------------------------------------------------------------------------------------------------------------------------------------------
--------------------------------------------------------------
* C o o l i n g
*----------------------------------------------------------------------------------------------------------------------------------------------
--------------------------------------------------------------
*----------------------------------------------------------------------------------------------------------------------------------------------
--------------------------------------------------------------
* H e a t i n g
*----------------------------------------------------------------------------------------------------------------------------------------------
--------------------------------------------------------------
HEATING HEATOG
 ON=SCHEDULE 5*SETOFF+15
 POWER=166000
 HUMIDITY=0
 RRAD=0
HEATING HEATEG
 ON=SCHEDULE 5*SETOFF+15
 POWER=213000
 HUMIDITY=0
 RRAD=0
HEATING HEATBURO
 ON=SCHEDULE 5*SETOFF+15
 POWER=7200
 HUMIDITY=0
 RRAD=0
*
*----------------------------------------------------------------------------------------------------------------------------------------------
--------------------------------------------------------------
* Z o n e s
*----------------------------------------------------------------------------------------------------------------------------------------------
--------------------------------------------------------------
ZONES OBERGE ERDGE SUEDBURO
*----------------------------------------------------------------------------------------------------------------------------------------------
--------------------------------------------------------------
* O r i e n t a t i o n s
*----------------------------------------------------------------------------------------------------------------------------------------------
--------------------------------------------------------------
ORIENTATIONS NORTH SOUTH EAST WEST HORIZONT
```

```
*
*++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++
++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++
++++++++++++++++++++++++++++++++++++++++++++
BUILDING
*++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++
++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++
++++++++++++++++++++++++++++++++++++++++++++
*
*-----------------------------------------------------------------------------------------------------------------------------------------------------------
---------------------------------------------------------------
* Z o n e  OBERGE  /  A i r n o d e  OBERGE
*-----------------------------------------------------------------------------------------------------------------------------------------------------------
---------------------------------------------------------------
ZONE OBERGE
AIRNODE OBERGE
WALL  =OUTOG     : SURF=  1 : AREA=     10.4 : EXTERNAL : ORI=NORTH : FSKY=0.5 :
GEOSURF=0.1
WALL  =OUTOG     : SURF=  2 : AREA=     41.5 : EXTERNAL : ORI=SOUTH : FSKY=0.5
WINDOW=DOUBLE    : SURF=  3 : AREA=     38.4 : EXTERNAL : ORI=SOUTH : FSKY=0.5 :
ESHADE=INPUT 0.7*SHAD_SOUTH
WALL  =OUTOG     : SURF=  4 : AREA=     44.8 : EXTERNAL : ORI=EAST : FSKY=0.5 :
GEOSURF=0.1
WALL  =OUTOG     : SURF=  5 : AREA=     11.2 : EXTERNAL : ORI=WEST : FSKY=0.5 :
GEOSURF=0.1
WINDOW=DOUBLE    : SURF=  6 : AREA=        9 : EXTERNAL : ORI=WEST : FSKY=0.5 :
ESHADE=INPUT 0.7*SHAD_WEST
WINDOW=GLASDOOR  : SURF=  7 : AREA=      3.8 : EXTERNAL : ORI=WEST : FSKY=0.5
WALL  =ROOF      : SURF=  8 : AREA=      498 : EXTERNAL : ORI=HORIZONT : FSKY=1
WALL  =BETWEEN   : SURF=  9 : AREA=      461 : ADJACENT=ERDGE : FRONT : GEOSURF=0.575
WALL  =BETWEEN   : SURF= 10 : AREA=       20 : ADJACENT=SUEDBURO : FRONT :
GEOSURF=0.025
WALL  =INTERN    : SURF= 11 : AREA=       26 : ADJACENT=ERDGE : FRONT :
COUPL=SCHEDULE 50*USE : GEOSURF=0.1
WALL  =SEPERATE  : SURF= 12 : AREA=      251 : BOUNDARY=INPUT 1*TLAGER
 REGIME
 GAIN       = PERSON    : SCALE= SCHEDULE 22*USE
 GAIN       = LIGHT     : SCALE= SCHEDULE 460*LIGHT
 GAIN       = COMPUTER  : SCALE= SCHEDULE 16*USE+4
 INFILTRATION= LEAKY
 VENTILATION = VENTOG
 HEATING    = HEATOG
 CAPACITANCE = 3360   : VOLUME= 1400   : TINITIAL= 20     : PHINITIAL= 50     : WCAPR= 1
*-----------------------------------------------------------------------------------------------------------------------------------------------------------
---------------------------------------------------------------
* Z o n e  ERDGE  /  A i r n o d e  ERDGE
*-----------------------------------------------------------------------------------------------------------------------------------------------------------
---------------------------------------------------------------
ZONE ERDGE
AIRNODE ERDGE
WALL  =OUTEG     : SURF= 13 : AREA=      6.2 : EXTERNAL : ORI=NORTH : FSKY=0.5 :
GEOSURF=0.1
WINDOW=DOPROL    : SURF= 14 : AREA=      2.9 : EXTERNAL : ORI=NORTH : FSKY=0.5
WALL  =OUTEG     : SURF= 15 : AREA=     60.4 : EXTERNAL : ORI=SOUTH : FSKY=0.5
WINDOW=DOUBLE    : SURF= 16 : AREA=     66.8 : EXTERNAL : ORI=SOUTH : FSKY=0.5 :
ESHADE=INPUT 0.7*SHAD_SOUTH
WINDOW=GLASDOOR  : SURF= 17 : AREA=      2.1 : EXTERNAL : ORI=SOUTH : FSKY=0.5
WALL  =OUTEG     : SURF= 18 : AREA=        9 : EXTERNAL : ORI=EAST : FSKY=0.5 :
GEOSURF=0.1
WINDOW=DOUBLE    : SURF= 19 : AREA=        6 : EXTERNAL : ORI=EAST : FSKY=0.5 :
ESHADE=INPUT 0.7*SHAD_EAST
```

```
WALL  =OUTEG      : SURF= 20 : AREA=      36.5 : EXTERNAL : ORI=WEST : FSKY=0.5 :
GEOSURF=0.1
WINDOW=DOUBLE     : SURF= 21 : AREA=      17.2 : EXTERNAL : ORI=WEST : FSKY=0.5 :
ESHADE=INPUT 0.7*SHAD_WEST
WINDOW=GLASDOOR   : SURF= 22 : AREA=       6.1 : EXTERNAL : ORI=WEST : FSKY=0.5
WALL  =ROOF       : SURF= 23 : AREA=       130 : EXTERNAL : ORI=HORIZONT : FSKY=1
WALL  =GROUND     : SURF= 24 : AREA=       591 : BOUNDARY=15 : GEOSURF=0.6
WALL  =SEPERATE   : SURF= 25 : AREA=       287 : BOUNDARY=INPUT 1*TLAGER :
GEOSURF=0.05
WALL  =INTERN     : SURF= 26 : AREA=        26 : ADJACENT=OBERGE : BACK :
COUPL=SCHEDULE 50*USE
WALL  =BETWEEN    : SURF= 27 : AREA=       461 : ADJACENT=OBERGE : BACK
WALL  =IWALL      : SURF= 28 : AREA=        42 : ADJACENT=SUEDBURO : BACK :
COUPL=SCHEDULE 18*USE : GEOSURF=0.05
 REGIME
 GAIN        = PERSON     : SCALE= SCHEDULE 25*USE
 GAIN        = LIGHT      : SCALE= SCHEDULE 590*LIGHT
 GAIN        = COMPUTER   : SCALE= SCHEDULE 18*USE+3
 INFILTRATION= LEAKY
 VENTILATION = VENTEG
 HEATING     = HEATEG
 CAPACITANCE = 4248    : VOLUME= 1770    : TINITIAL= 20      : PHINITIAL= 50      : WCAPR= 1
*----------------------------------------------------------------------------------------------------------------------------------------
--------------------------------------------------------------
* Z o n e  SUEDBURO  /  A i r n o d e  SUEDBURO
*----------------------------------------------------------------------------------------------------------------------------------------
--------------------------------------------------------------
ZONE SUEDBURO
AIRNODE SUEDBURO
WALL  =GROUND     : SURF= 29 : AREA=        20 : BOUNDARY=15 : GEOSURF=0.7
WALL  =OUTEG      : SURF= 30 : AREA=         5 : EXTERNAL : ORI=SOUTH : FSKY=0.5 :
GEOSURF=0.15
WINDOW=DOUBLE     : SURF= 31 : AREA=         7 : EXTERNAL : ORI=SOUTH : FSKY=0.5 :
ISHADE=INPUT 0.7*SHAD_SOUTH
WALL  =IWALL      : SURF= 32 : AREA=        42 : ADJACENT=ERDGE : FRONT : COUPL=SCHEDULE
18*USE : GEOSURF=0.15
WALL  =BETWEEN    : SURF= 33 : AREA=        20 : ADJACENT=OBERGE : BACK
 REGIME
 GAIN        = PERSON     : SCALE= SCHEDULE 2*USE
 GAIN        = LIGHT      : SCALE= SCHEDULE 20*LIGHT
 GAIN        = COMPUTER   : SCALE= SCHEDULE 2*USE
 COMFORT     = COM_SB
 INFILTRATION= LEAKY
 VENTILATION = VBURO
 HEATING     = HEATBURO
 CAPACITANCE = 144     : VOLUME= 60      : TINITIAL= 20      : PHINITIAL= 50
 KSURF       = 0.015   : KDEEP = 1
 MSURF       = 270     : MDEEP = 16
 BSURF       = 150     : BDEEP = 50
*----------------------------------------------------------------------------------------------------------------------------------------
--------------------------------------------------------------
* O u t p u t s
*----------------------------------------------------------------------------------------------------------------------------------------
--------------------------------------------------------------
OUTPUTS
 TRANSFER : TIMEBASE=1.000
 AIRNODES = OBERGE ERDGE SUEDBURO
 NTYPES =   1 : TAIR - air temperature of zone
       =   2 : QSENS - sensible energy demand of zone, heating(-), cooling(+)
       =   4 : QINF - sensible infiltration energy gain of zone
       =  12 : QSOLTR - total shortwave solar radiation transmitted through external windows of zone (but
not kept 100 % in Zone)
```

```
 AIRNODES = OBERGE
 NTYPES =  28 : SCHEDULE = WORKDAY, WEEKEND, WORKLIGHT, DAYNIGHT, USE, LIGHT,
SETOFF,  : - - values of all schedules
 AIRNODES = OBERGE ERDGE SUEDBURO
 NTYPES =   6 : QCOUP - tsensible coupling energy gain of zone
       =  37 : SQCOUP - sum of sensible coupling energy gains for group of zones
 AIRNODES = SUEDBURO
 NTYPES =  47 : SQVAPW - sum of heat of vapour adsorption in walls for group of zones
       =   9 : RELHUM - relativ humidity of zone air
 AIRNODES = SUEDBURO
 NTYPES =  25 : TOP - operative zone temperature
       =  62 : PMV - predicted mean vote (PMV) value of zone
       =  63 : PPD - predicted percentage of dissatisfied persons (PPD) of zone
*-----------------------------------------------------------------------------------------------------------------------------------------
------------------------------------------------------------
*  E n d
*-----------------------------------------------------------------------------------------------------------------------------------------
------------------------------------------------------------
END

_EXTENSION_WINPOOL_START_
WINDOW 4.1  DOE-2 Data File : Multi Band Calculation
Unit System : SI
Name       : TRNSYS 16 WINDOW LIB
Desc       : Einfachglas, 5.8
Window ID   : 1001
Tilt       : 90.0
Glazings    : 1
Frame      : 11                  2.270
Spacer     :  5 Class5              0.000   1.000   0.000
Total Height: 1219.2 mm
Total Width :  914.4 mm
Glass Height: 1079.5 mm
Glass Width :  774.7 mm
Mullion     : None
Gap       Thick   Cond  dCond    Vis   dVis   Dens   dDens     Pr     dPr
1            0      0      0      0      0      0       0      0       0
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  0.830 0.829 0.827 0.823 0.813 0.792 0.744 0.632 0.384 0.000 0.749
Abs1  0.095 0.096 0.098 0.101 0.105 0.109 0.114 0.117 0.114 0.000 0.106
Abs2     0     0     0     0     0     0     0     0     0     0     0
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 0.075 0.074 0.075 0.076 0.082 0.099 0.142 0.251 0.502 1.000 0.135
Rbsol 0.075 0.074 0.075 0.076 0.082 0.099 0.142 0.251 0.502 1.000 0.135
Tvis  0.901 0.901 0.900 0.897 0.890 0.871 0.824 0.706 0.441 0.000 0.823
Rfvis 0.081 0.081 0.082 0.083 0.090 0.108 0.155 0.271 0.536 1.000 0.146
Rbvis 0.081 0.081 0.082 0.083 0.090 0.108 0.155 0.271 0.536 1.000 0.146
SHGC  0.855 0.855 0.853 0.849 0.841 0.821 0.774 0.663 0.414 0.000 0.777
SC: 0.78
Layer ID#        9052       0       0       0       0       0
Tir            0.000       0       0       0       0       0
Emis F          0.840       0       0       0       0       0
Emis B          0.840       0       0       0       0       0
Thickness(mm)      4.0       0       0       0       0       0
Cond(W/m2-C     ) 225.0       0       0       0       0       0
```

```
Spectral File    None    None    None    None    None    None
Overall and Center of Glass Ig U-values (W/m2-C)
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-C)
0      0.00  12.25  3.42  8.23  5.27 5.27  4.95 4.95  4.94 4.94  5.53 5.53
0      6.71  25.47  3.33  8.29  6.26 6.26  5.73 5.73  5.68 5.68  6.46 6.46
783      0.00  12.25  3.49  8.17  5.25 5.25  4.58 4.58  5.24 5.24  5.66 5.66
783      6.71  25.47  3.37  8.27  6.25 6.25  5.53 5.53  5.95 5.95  6.57 6.57
WINDOW 4.1  DOE-2 Data File : Multi Band Calculation
Unit System : SI
Name       : TRNSYS 16 WINDOW LIB
Desc       : Waermeschutzglas,Ar, 1.4 71/59
Window ID   : 2001
Tilt       : 90.0
Glazings    : 2
Frame      : 11                    2.270
Spacer     :  1 Class1              2.330  -0.010   0.138
Total Height: 1219.2 mm
Total Width :  914.4 mm
Glass Height: 1079.5 mm
Glass Width :  774.7 mm
Mullion    : None
Gap       Thick  Cond  dCond   Vis  dVis   Dens  dDens    Pr    dPr
1 Argon    16.0 0.01620  5.000  2.110  6.300  1.780 -0.0060  0.680 0.00066
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  0.426 0.428 0.422 0.413 0.402 0.380 0.333 0.244 0.113 0.000 0.354
Abs1  0.118 0.118 0.120 0.123 0.129 0.135 0.142 0.149 0.149 0.000 0.132
Abs2  0.190 0.192 0.198 0.201 0.200 0.199 0.199 0.185 0.117 0.000 0.191
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 0.266 0.262 0.260 0.262 0.269 0.286 0.326 0.422 0.621 1.000 0.314
Rbsol 0.215 0.209 0.207 0.210 0.219 0.237 0.272 0.356 0.560 0.999 0.260
Tvis  0.706 0.710 0.701 0.688 0.670 0.635 0.556 0.403 0.188 0.000 0.590
Rfvis 0.121 0.115 0.114 0.118 0.132 0.163 0.228 0.376 0.649 1.000 0.203
Rbvis 0.103 0.096 0.093 0.096 0.108 0.132 0.179 0.286 0.520 0.999 0.162
SHGC  0.589 0.593 0.591 0.586 0.574 0.551 0.505 0.405 0.218 0.000 0.518
SC: 0.55
Layer ID#        9052     9065       0       0       0       0
Tir            0.000    0.000       0       0       0       0
Emis F          0.840    0.140       0       0       0       0
Emis B          0.840    0.840       0       0       0       0
Thickness(mm)      4.0      4.0       0       0       0       0
Cond(W/m2-C     ) 225.0    225.0       0       0       0       0
Spectral File    None    None    None    None    None    None
Overall and Center of Glass Ig U-values (W/m2-C)
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-C)
0      0.00  12.25  3.25  7.62  1.54 1.54  1.31 1.31  1.35 1.35  1.47 1.47
0      6.71  25.47  3.21  7.64  1.62 1.62  1.36 1.36  1.40 1.40  1.53 1.53
783      0.00  12.25  3.39  7.99  1.69 1.69  1.54 1.54  1.51 1.51  1.54 1.54
783      6.71  25.47  3.30  7.81  1.79 1.79  1.63 1.63  1.58 1.58  1.59 1.59
WINDOW 4.1  DOE-2 Data File : Multi Band Calculation
Unit System : SI
Name       : TRNSYS 16 WINDOW LIB
```

```
Desc       : Waermeschutzglas,Ar, 1.4 74/62
Window ID  : 2004
Tilt       : 90.0
Glazings   : 2
Frame      : 11                  2.270
Spacer     :  1 Class1              2.330  -0.010   0.138
Total Height: 1219.2 mm
Total Width :  914.4 mm
Glass Height: 1079.5 mm
Glass Width :  774.7 mm
Mullion    : None
Gap      Thick  Cond  dCond   Vis   dVis   Dens   dDens    Pr    dPr
1 Argon    16.0 0.01620  5.000  2.110  6.300  1.780 -0.0060  0.680 0.00066
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  0.462 0.465 0.458 0.448 0.436 0.412 0.360 0.263 0.121 0.000 0.384
Abs1  0.114 0.114 0.116 0.120 0.125 0.132 0.139 0.146 0.147 0.000 0.128
Abs2  0.186 0.188 0.195 0.199 0.198 0.197 0.199 0.186 0.118 0.000 0.189
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 0.237 0.232 0.231 0.233 0.241 0.260 0.303 0.406 0.614 1.000 0.289
Rbsol 0.179 0.172 0.170 0.173 0.183 0.202 0.239 0.328 0.542 0.999 0.227
Tvis  0.749 0.754 0.743 0.730 0.711 0.674 0.589 0.428 0.200 0.000 0.626
Rfvis 0.121 0.115 0.114 0.118 0.132 0.163 0.228 0.376 0.649 1.000 0.203
Rbvis 0.109 0.102 0.099 0.102 0.115 0.140 0.188 0.296 0.529 0.999 0.170
SHGC  0.622 0.626 0.625 0.619 0.606 0.581 0.532 0.424 0.226 0.000 0.546
SC: 0.58
Layer ID#       9052    9054      0      0      0      0
Tir          0.000    0.000      0      0      0      0
Emis F         0.840    0.140      0      0      0      0
Emis B         0.840    0.840      0      0      0      0
Thickness(mm)      4.0      4.0      0      0      0      0
Cond(W/m2-C    ) 225.0    225.0      0      0      0      0
Spectral File    None     None     None     None     None     None
Overall and Center of Glass Ig U-values (W/m2-C)
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-C)
0       0.00  12.25  3.25  7.62  1.54 1.54  1.31 1.31  1.35 1.35  1.47 1.47
0       6.71  25.47  3.21  7.64  1.62 1.62  1.36 1.36  1.40 1.40  1.53 1.53
783       0.00  12.25  3.39  7.96  1.69 1.69  1.54 1.54  1.51 1.51  1.54 1.54
783       6.71  25.47  3.30  7.78  1.79 1.79  1.63 1.63  1.57 1.57  1.59 1.59
*** END OF LIBRARY ***
****************************************************************************************************
*WinID   Description                        Design       U-Value g-value T-sol Rf-sol T-vis
****************************************************************************************************
  1001  Einfachglas, 5.8                     4            5.68  0.855  0.83  0.075  0.901
  2001  Waermeschutzglas,Ar, 1.4 71/59         4/16/4          1.4  0.589  0.426  0.266  0.706
  2004  Waermeschutzglas,Ar, 1.4 74/62         4/16/4          1.4  0.622  0.462  0.237  0.749
_EXTENSION_WINPOOL_END_
```

By saving the building description file in TRNBUILD three new files are generated. One of them, the *.inf file, besides the building input description from the *.bui, is giving informations about transfer function coeffcients and U-vaules of the walls as well as the required inputs and the desired outputs for the TRNSYS simulation. Since version 16.1 the format of the *.inf file has been changed to a more readable one like listed below:

```
(......)

  ************* REQUIRED INPUTS *************


*:InpNR | Label                | UNIT        | INPUT DESCRIPTION                                            | Old label

*  |   1 | TAMB                 | C           | AMBIENT TEMPERATURE                                          | TAMB
*  |   2 | RELHUMAMB            | %           | RELATIVE AMBIENT HUMIDITY                                    | ARELHUM
*  |   3 | TSKY                 | C           | FIKTIVE SKY TEMPERATURE                                      | TSKY
*  |   4 | IT_NORTH             | kJ/hr.m^2   | INCIDENT RADIATION FOR ORIENTATION NORTH                     | ITNORTH
*  |   5 | IT_SOUTH             | kJ/hr.m^2   | INCIDENT RADIATION FOR ORIENTATION SOUTH                     | ITSOUTH
*  |   6 | IT_EAST              | kJ/hr.m^2   | INCIDENT RADIATION FOR ORIENTATION EAST                      | ITEAST
*  |   7 | IT_WEST              | kJ/hr.m^2   | INCIDENT RADIATION FOR ORIENTATION WEST                      | ITWEST
*  |   8 | IT_HORIZONT          | kJ/hr.m^2   | INCIDENT RADIATION FOR ORIENTATION HORIZONT                  | ITHORIZONT
*  |   9 | IB_NORTH             | kJ/hr.m^2   | INCIDENT BEAM RADIATION FOR ORIENTATION NORTH                | IBNORTH
*  |  10 | IB_SOUTH             | kJ/hr.m^2   | INCIDENT BEAM RADIATION FOR ORIENTATION SOUTH                | IBSOUTH
*  |  11 | IB_EAST              | kJ/hr.m^2   | INCIDENT BEAM RADIATION FOR ORIENTATION EAST                 | IBEAST
*  |  12 | IB_WEST              | kJ/hr.m^2   | INCIDENT BEAM RADIATION FOR ORIENTATION WEST                 | IBWEST
*  |  13 | IB_HORIZONT          | kJ/hr.m^2   | INCIDENT BEAM RADIATION FOR ORIENTATION HORIZONT             | IBHORIZONT
*  |  14 | AI_NORTH             | degrees     | ANGLE OF INCIDENCE FOR ORIENTATION NORTH                     | AINORTH
*  |  15 | AI_SOUTH             | degrees     | ANGLE OF INCIDENCE FOR ORIENTATION SOUTH                     | AISOUTH
*  |  16 | AI_EAST              | degrees     | ANGLE OF INCIDENCE FOR ORIENTATION EAST                      | AIEAST
*  |  17 | AI_WEST              | degrees     | ANGLE OF INCIDENCE FOR ORIENTATION WEST                      | AIWEST
*  |  18 | AI_HORIZONT          | degrees     | ANGLE OF INCIDENCE FOR ORIENTATION HORIZONT                  | AIHORIZONT
*  |  19 | SHAD_SOUTH           | any         | INPUT                                                        | SHAD_SOUTH
*  |  20 | SHAD_EAST            | any         | INPUT                                                        | SHAD_EAST
*  |  21 | SHAD_WEST            | any         | INPUT                                                        | SHAD_WEST
*  |  22 | WIND                 | any         | INPUT                                                        | WIND
*  |  23 | ABLOG                | any         | INPUT                                                        | ABLOG
*  |  24 | ABLEG                | any         | INPUT                                                        | ABLEG
*  |  25 | ABLBU                | any         | INPUT                                                        | ABLBU
*  |  26 | BRIGHT               | any         | INPUT                                                        | BRIGHT
*  |  27 | TLAGER               | any         | INPUT                                                        | TLAGER




  ************* DESIRED OUTPUTS *************


*:OutNr | Label                     | Unit        | ZNr | Zone           | SurfNr| OUTPUT DESCRIPTION

*  |   1 | TAIR_OBERGE               | C           |   1 | OBERGE         |       | air temperature of zone
*  |   2 | TAIR_ERDGE                | C           |   2 | ERDGE          |       | air temperature of zone
*  |   3 | TAIR_SUEDBURO             | C           |   3 | SUEDBURO       |       | air temperature of zone
*  |   4 | QSENS_OBERGE              | kJ/hr       |   1 | OBERGE         |       | sens. energy demand of zone, heating(-),
*  |   5 | QSENS_ERDGE               | kJ/hr       |   2 | ERDGE          |       | sens. energy demand of zone, heating(-),
*  |   6 | QSENS_SUEDBURO            | kJ/hr       |   3 | SUEDBURO       |       | sens. energy demand of zone, heating(-),
*  |   7 | QINF_OBERGE               | kJ/hr       |   1 | OBERGE         |       | sens. infiltration energy gain of zone
*  |   8 | QINF_ERDGE                | kJ/hr       |   2 | ERDGE          |       | sens. infiltration energy gain of zone
*  |   9 | QINF_SUEDBURO             | kJ/hr       |   3 | SUEDBURO       |       | sens. infiltration energy gain of zone
*  |  10 | QSOLTR_OBERGE             | kJ/hr       |   1 | OBERGE         |       | total s-wave solar radiation through ext
*  |  11 | QSOLTR_ERDGE              | kJ/hr       |   2 | ERDGE          |       | total s-wave solar radiation through ext
*  |  12 | QSOLTR_SUEDBURO           | kJ/hr       |   3 | SUEDBURO       |       | total s-wave solar radiation through ext
*  |  13 | SCHED_WORKDAY             | -           |     |                |       | values of schedule WORKDAY
*  |  14 | SCHED_WEEKEND             | -           |     |                |       | values of schedule WEEKEND
*  |  15 | SCHED_WORKLIGHT           | -           |     |                |       | values of schedule WORKLIGHT
*  |  16 | SCHED_DAYNIGHT            | -           |     |                |       | values of schedule DAYNIGHT
*  |  17 | SCHED_USE                 | -           |     |                |       | values of schedule USE
*  |  18 | SCHED_LIGHT               | -           |     |                |       | values of schedule LIGHT
*  |  19 | SCHED_SETOFF              | -           |     |                |       | values of schedule SETOFF
*  |  20 | QCOUP_OBERGE              | kJ/hr       |   1 | OBERGE         |       | sens. coupling energy gain of zone
*  |  21 | QCOUP_ERDGE               | kJ/hr       |   2 | ERDGE          |       | sens. coupling energy gain of zone
*  |  22 | QCOUP_SUEDBURO            | kJ/hr       |   3 | SUEDBURO       |       | sens. coupling energy gain of zone
*  |  23 | SQCOUP_1                  | kJ/hr       |     |                |       | sum of coupling gains of , OBERGE, ERDGE
*  |  24 | SQVAPW_1                  | kJ/hr       |     |                |       | sum of heat of vapor adsorption of , SUE
*  |  25 | RELHUM_SUEDBURO           | %           |   3 | SUEDBURO       |       | relativ humidity of zone air
*  |  26 | TOP_SUEDBURO              | C           |   3 | SUEDBURO       |       | operative room temperature
*  |  27 | PMV_SUEDBURO              | -           |   3 | SUEDBURO       |       | predicted mean vote (PMV)
*  |  28 | PPD_SUEDBURO              | %           |   3 | SUEDBURO       |       | predicted percentage of dissatisfied per
```

6.5.2.3. TRNSYS Input File, Simulation, Results

For the simuation the TRNSYS Input file has to be generated. For the office building example the input file, generated in the STUDIO is listed below:

```
VERSION 16.1
*******************************************************************************
*** TRNSYS input file (deck) generated by TrnsysStudio
*** on Thursday, March 23, 2006 at 15:56
*** from TrnsysStudio project: C:\Trnsys16\Examples\Building\building.TPF
***
*** If you edit this file, use the File/Import TRNSYS Input File function in
*** TrnsysStudio to update the project.
***
*** If you have problems, questions or suggestions please contact your local
*** TRNSYS distributor or mailto:software@cstb.fr
***
*******************************************************************************


*******************************************************************************
*** Units
*******************************************************************************

*******************************************************************************
*** Control cards
*******************************************************************************
* START, STOP and STEP
CONSTANTS 3
START=0.0
STOP=8760
STEP=1
* User defined CONSTANTS

SIMULATION 	 START	 STOP	 STEP	! Start time	End time	Time step
TOLERANCES 0.001 0.001			! Integration	 Convergence
LIMITS 30 30 30				! Max iterations	Max warnings	Trace limit
DFQ 1					! TRNSYS numerical integration solver method
WIDTH 72				! TRNSYS output file width, number of characters
LIST 					! NOLIST statement
MAP 					! MAP statement
SOLVER 0 1 1				! Solver statement	Minimum relaxation factor
  Maximum relaxation factor
NAN_CHECK 0				! Nan DEBUG statement
OVERWRITE_CHECK 0			! Overwrite DEBUG statement
TIME_REPORT 0				! disable time report
EQSOLVER 0				! EQUATION SOLVER statement

* EQUATIONS "Ch_units_1"
*
EQUATIONS 6
eglobh = [4,12]/3.6
eg-s = [4,24]/3.6
eg-ost = [4,30]/3.6
e-west = [4,36]/3.6
Q-Sol = ([8,10]+[8,11])
```

```
Q-Inf = ([8,7]+[8,8])
*$UNIT_NAME Ch_units_1
*$LAYER Main
*$POSITION 585 202

*------------------------------------------------------------------------------

* Model "Type109-User" (Type 109)
*

UNIT 4 TYPE 109    Type109-User
*$UNIT_NAME Type109-User
*$MODEL .\Weather Data Reading and Processing\User Format\Type109-User.tmf
*$POSITION 52 146
*$LAYER Weather / Data Files #
PARAMETERS 4
1              ! 1 Data Reader Mode
38                       ! 2 Logical unit
1              ! 3 Sky model for diffuse radiation
1              ! 4 Tracking mode
INPUTS 9
0,0                      ! [unconnected] Ground reflectance
0,0                      ! [unconnected] Slope of surface-1
0,0                      ! [unconnected] Azimuth of surface-1
0,0                      ! [unconnected] Slope of surface-2
0,0                      ! [unconnected] Azimuth of surface-2
0,0                      ! [unconnected] Slope of surface-3
0,0                      ! [unconnected] Azimuth of surface-3
0,0                      ! [unconnected] Slope of surface-4
0,0                      ! [unconnected] Azimuth of surface-4
*** INITIAL INPUT VALUES
0.2 90 180 90 0 90 -90 90 90
*** External files
ASSIGN "iwec_geneva.109" 38
*|? Weather data file |1000
*------------------------------------------------------------------------------

* Model "Type33e" (Type 33)
*

UNIT 6 TYPE 33      Type33e
*$UNIT_NAME Type33e
*$MODEL .\Physical Phenomena\Thermodynamic Properties\Psychrometrics\Dry Bulb and Relative
Humidity Known\Type33e.tmf
*$POSITION 184 188
*$LAYER Weather / Data Files #
PARAMETERS 3
2              ! 1 Psychrometrics mode
1              ! 2 Wet bulb mode
1              ! 3 Error mode
INPUTS 3
4,1                      ! Type109-User:Ambient temperature ->Dry bulb temp.
4,2                      ! Type109-User:relative humidity ->Percent relative humidity
0,0                      ! [unconnected] Pressure
*** INITIAL INPUT VALUES
25 50 1
*------------------------------------------------------------------------------

* Model "Type69b" (Type 69)
*

UNIT 7 TYPE 69      Type69b
```

```
*$UNIT_NAME Type69b
*$MODEL .\Physical Phenomena\Sky Temperature\calculate cloudiness factor\Type69b.tmf
*$POSITION 184 277
*$LAYER Weather / Data Files #
PARAMETERS 2
0          ! 1 mode for cloudiness factor
50                 ! 2 height over sea level
INPUTS 4
4,1                ! Type109-User:Ambient temperature ->Ambient temperature
6,8                ! Type33e:Dew point temperature. ->Dew point temperature at ambient
conditions
4,13               ! Type109-User:beam radiation on horitonzal ->Beam radiation on the horizontal
4,14               ! Type109-User:sky diffuse radiation on horizontal ->Diffuse radiation on the
horizontal
*** INITIAL INPUT VALUES
0 0 0 0
*------------------------------------------------------------------------------

* Model "Type56b" (Type 56)
*

UNIT 8 TYPE 56     Type56b
*$UNIT_NAME Type56b
*$MODEL .\Loads and Structures\Multi-Zone Building\Without Standard Output Files\Type56b.tmf
*$POSITION 361 325
*$LAYER Main #
*$#
PARAMETERS 3
33                 ! 1 Logical unit for building description file (.bui)
0          ! 2 Star network calculation switch
0.5                ! 3 Weighting factor for operative temperature
INPUTS 27
4,1                ! Type109-User:Ambient temperature -> 1- TAMB
4,2                ! Type109-User:relative humidity -> 2- RELHUMAMB
7,1                ! Type69b:Fictive sky temperature -> 3- TSKY
4,18               ! Type109-User:total radiation on tilted surface-1 -> 4- IT_NORTH
4,24               ! Type109-User:total radiation on tilted surface-2 -> 5- IT_SOUTH
4,30               ! Type109-User:total radiation on tilted surface-3 -> 6- IT_EAST
4,36               ! Type109-User:total radiation on tilted surface-4 -> 7- IT_WEST
4,12               ! Type109-User:total radiation on horizontal -> 8- IT_HORIZONT
4,19               ! Type109-User:beam radiation on tilted surface-1 -> 9- IB_NORTH
4,25               ! Type109-User:beam radiation on tilted surface-2 -> 10- IB_SOUTH
4,31               ! Type109-User:beam radiation on tilted surface-3 -> 11- IB_EAST
4,37               ! Type109-User:beam radiation on tilted surface-4 -> 12- IB_WEST
4,13               ! Type109-User:beam radiation on horitonzal -> 13- IB_HORIZONT
4,22               ! Type109-User:angle of incidence for tilted surface -1 -> 14- AI_NORTH
4,28               ! Type109-User:angle of incidence for tilted surface -2 -> 15- AI_SOUTH
4,34               ! Type109-User:angle of incidence for tilted surface -3 -> 16- AI_EAST
4,40               ! Type109-User:angle of incidence for tilted surface -4 -> 17- AI_WEST
4,16               ! Type109-User:angle of incidence on horizontal surface -> 18- AI_HORIZONT
22,1               ! Shad_south:Output control function -> 19- SHAD_SOUTH
23,1               ! Shad_east:Output control function -> 20- SHAD_EAST
24,1               ! Shad_west:Output control function -> 21- SHAD_WEST
4,3                ! Type109-User:wind velocity -> 22- WIND
9,1                ! Abluft OG:Output control function -> 23- ABLOG
10,1               ! Abluft EG:Output control function -> 24- ABLEG
11,1               ! Abluft SB:Output control function -> 25- ABLBU
15,1               ! BRIGHT:Output control function -> 26- BRIGHT
TLager             ! TLager:TLager -> 27- TLAGER
*** INITIAL INPUT VALUES
0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 10
*** External files
```

```
ASSIGN "building.BUI" 33
*|? Building description file (*.bui) |1000
*------------------------------------------------------------------------------

* Model "Abluft OG" (Type 2)
*

UNIT 9 TYPE 2       Abluft OG
*$UNIT_NAME Abluft OG
*$MODEL .\Controllers\Differential Controller w_ Hysteresis\for Temperatures\Solver 0 (Successive
Substitution) Control Strategy\TYPE2b.tmf
*$POSITION 288 456
*$LAYER Controls #
*$# NOTE: This control strategy can only be used with solver 0 (Successive substitution)
*$#
PARAMETERS 2
5           ! 1 No. of oscillations
95                  ! 2 High limit cut-out
INPUTS 6
8,1                 ! Type56b: 1- TAIR_OBERGE ->Upper input temperature Th
0,0                 ! [unconnected] Lower input temperature Tl
0,0                 ! [unconnected] Monitoring temperature Tin
9,1                 ! Abluft OG:Output control function ->Input control function
0,0                 ! [unconnected] Upper dead band dT
0,0                 ! [unconnected] Lower dead band dT
*** INITIAL INPUT VALUES
15 24 0 0 0 -3.4
*------------------------------------------------------------------------------

* Model "Abluft EG" (Type 2)
*

UNIT 10 TYPE 2      Abluft EG
*$UNIT_NAME Abluft EG
*$MODEL .\Controllers\Differential Controller w_ Hysteresis\for Temperatures\Solver 0 (Successive
Substitution) Control Strategy\TYPE2b.tmf
*$POSITION 459 456
*$LAYER Controls #
*$# NOTE: This control strategy can only be used with solver 0 (Successive substitution)
*$#
PARAMETERS 2
5           ! 1 No. of oscillations
95                  ! 2 High limit cut-out
INPUTS 6
8,2                 ! Type56b: 2- TAIR_ERDGE ->Upper input temperature Th
0,0                 ! [unconnected] Lower input temperature Tl
0,0                 ! [unconnected] Monitoring temperature Tin
10,1                ! Abluft EG:Output control function ->Input control function
0,0                 ! [unconnected] Upper dead band dT
0,0                 ! [unconnected] Lower dead band dT
*** INITIAL INPUT VALUES
15 24 0 0 0 -3.4
*------------------------------------------------------------------------------

* Model "Abluft SB" (Type 2)
*

UNIT 11 TYPE 2      Abluft SB
*$UNIT_NAME Abluft SB
*$MODEL .\Controllers\Differential Controller w_ Hysteresis\for Temperatures\Solver 0 (Successive
Substitution) Control Strategy\TYPE2b.tmf
*$POSITION 619 456
```

```
*$LAYER Controls #
*$# NOTE: This control strategy can only be used with solver 0 (Successive substitution)
*$#
PARAMETERS 2
5		! 1 No. of oscillations
95			! 2 High limit cut-out
INPUTS 6
8,3			! Type56b: 3- TAIR_SUEDBURO ->Upper input temperature Th
0,0			! [unconnected] Lower input temperature Tl
0,0			! [unconnected] Monitoring temperature Tin
11,1			! Abluft SB:Output control function ->Input control function
0,0			! [unconnected] Upper dead band dT
0,0			! [unconnected] Lower dead band dT
*** INITIAL INPUT VALUES
15 24 0 0 0 -3.4
*------------------------------------------------------------------------------

* Model "Shad_south" (Type 2)
*

UNIT 22 TYPE 2	 Shad_south
*$UNIT_NAME Shad_south
*$MODEL .\Controllers\Differential Controller w_ Hysteresis\generic\Solver 0 (Successive
Substitution) Control Strategy\Type2d.tmf
*$POSITION 273 444
*$LAYER Controls #
*$# NOTE: This controller can only be used with Solver 0 (Successive substitution)
*$#
PARAMETERS 2
5		! 1 No. of oscillations
14			! 2 High limit cut-out
INPUTS 6
4,24			! Type109-User:total radiation on tilted surface-2 ->Upper input value
0,0			! [unconnected] Lower input value
4,3			! Type109-User:wind velocity ->Monitoring value
22,1			! Shad_south:Output control function ->Input control function
0,0			! [unconnected] Upper dead band
0,0			! [unconnected] Lower dead band
*** INITIAL INPUT VALUES
20.0 0 0 0 720 540
*------------------------------------------------------------------------------

* Model "Shad_east" (Type 2)
*

UNIT 23 TYPE 2	 Shad_east
*$UNIT_NAME Shad_east
*$MODEL .\Controllers\Differential Controller w_ Hysteresis\generic\Solver 0 (Successive
Substitution) Control Strategy\Type2d.tmf
*$POSITION 445 445
*$LAYER Main #
*$# NOTE: This controller can only be used with Solver 0 (Successive substitution)
*$#
PARAMETERS 2
5		! 1 No. of oscillations
14			! 2 High limit cut-out
INPUTS 6
4,30			! Type109-User:total radiation on tilted surface-3 ->Upper input value
0,0			! [unconnected] Lower input value
4,3			! Type109-User:wind velocity ->Monitoring value
23,1			! Shad_east:Output control function ->Input control function
0,0			! [unconnected] Upper dead band
```

```
0,0                     ! [unconnected] Lower dead band
*** INITIAL INPUT VALUES
20.0 0 0 0 720 540
*------------------------------------------------------------------------------

* Model "Shad_west" (Type 2)
*

UNIT 24 TYPE 2      Shad_west
*$UNIT_NAME Shad_west
*$MODEL .\Controllers\Differential Controller w_ Hysteresis\generic\Solver 0 (Successive
Substitution) Control Strategy\Type2d.tmf
*$POSITION 620 445
*$LAYER Main #
*$# NOTE: This controller can only be used with Solver 0 (Successive substitution)
*$#
PARAMETERS 2
5             ! 1 No. of oscillations
14                      ! 2 High limit cut-out
INPUTS 6
4,36                    ! Type109-User:total radiation on tilted surface-4 ->Upper input value
0,0                     ! [unconnected] Lower input value
4,3                     ! Type109-User:wind velocity ->Monitoring value
24,1                    ! Shad_west:Output control function ->Input control function
0,0                     ! [unconnected] Upper dead band
0,0                     ! [unconnected] Lower dead band
*** INITIAL INPUT VALUES
20.0 0 0 0 720 540
*------------------------------------------------------------------------------

* Model "BRIGHT" (Type 2)
*

UNIT 15 TYPE 2      BRIGHT
*$UNIT_NAME BRIGHT
*$MODEL .\Controllers\Differential Controller w_ Hysteresis\for Temperatures\Solver 0 (Successive
Substitution) Control Strategy\TYPE2b.tmf
*$POSITION 366 581
*$LAYER Controls #
*$# NOTE: This control strategy can only be used with solver 0 (Successive substitution)
*$#
PARAMETERS 2
5             ! 1 No. of oscillations
3959.683                ! 2 High limit cut-out
INPUTS 6
0,0                     ! [unconnected] Upper input temperature Th
4,12                    ! Type109-User:total radiation on horizontal ->Lower input temperature Tl
0,0                     ! [unconnected] Monitoring temperature Tin
15,1                    ! BRIGHT:Output control function ->Input control function
0,0                     ! [unconnected] Upper dead band dT
0,0                     ! [unconnected] Lower dead band dT
*** INITIAL INPUT VALUES
900 432 0 0 0 -90
*------------------------------------------------------------------------------

* EQUATIONS "TLager"
*
EQUATIONS 1
TLager = MAX([4,1],5)
*$UNIT_NAME TLager
*$LAYER Main
*$POSITION 491 484
```

```
*------------------------------------------------------------------------------

* Model "TYPE28b" (Type 28)
*

UNIT 16 TYPE 28    TYPE28b
*$UNIT_NAME TYPE28b
*$MODEL .\Output\Simulation Summary\Results to External File\Without Energy
Balance\TYPE28b.tmf
*$POSITION 689 222
*$LAYER Outputs #
PARAMETERS 49
-1              ! 1 Summary interval
0       ! 2 Summary start time
10000           ! 3 Summary stop time
34              ! 4 Logical unit for the output file
2       ! 5 Output mode
-11             ! 6 Operation code-1
-1              ! 7 Operation code-2
-3600           ! 8 Operation code-3
2       ! 9 Operation code-4
-4              ! 10 Operation code-5
-12             ! 11 Operation code-6
-1              ! 12 Operation code-7
-3600           ! 13 Operation code-8
2       ! 14 Operation code-9
-4              ! 15 Operation code-10
-13             ! 16 Operation code-11
-1              ! 17 Operation code-12
-3600           ! 18 Operation code-13
2       ! 19 Operation code-14
-4              ! 20 Operation code-15
-11             ! 21 Operation code-16
-12             ! 22 Operation code-17
3       ! 23 Operation code-18
-13             ! 24 Operation code-19
3       ! 25 Operation code-20
-1              ! 26 Operation code-21
-3600           ! 27 Operation code-22
2       ! 28 Operation code-23
-4              ! 29 Operation code-24
-15             ! 30 Operation code-25
-1              ! 31 Operation code-26
-3600           ! 32 Operation code-27
2       ! 33 Operation code-28
-4              ! 34 Operation code-29
-16             ! 35 Operation code-30
-1              ! 36 Operation code-31
3600            ! 37 Operation code-32
2       ! 38 Operation code-33
-4              ! 39 Operation code-34
-17             ! 40 Operation code-35
-1              ! 41 Operation code-36
-3600           ! 42 Operation code-37
2       ! 43 Operation code-38
-4              ! 44 Operation code-39
-18             ! 45 Operation code-40
-1              ! 46 Operation code-41
3600            ! 47 Operation code-42
2       ! 48 Operation code-43
```

```
-4                      ! 49 Operation code-44
INPUTS 8
8,4                     ! Type56b: 4- QSENS_OBERGE ->Summary input-1
8,5                     ! Type56b: 5- QSENS_ERDGE ->Summary input-2
8,6                     ! Type56b: 6- QSENS_SUEDBURO ->Summary input-3
0,0                     ! [unconnected] Summary input-4
Q-Inf                   ! Ch_units_1:Q-Inf ->Summary input-5
Q-Sol                   ! Ch_units_1:Q-Sol ->Summary input-6
8,9                     ! Type56b: 9- QINF_SUEDBURO ->Summary input-7
8,12                    ! Type56b: 12- QSOLTR_SUEDBURO ->Summary input-8
*** INITIAL INPUT VALUES
0 0 0 0 0 0 0 0
LABELS   8
Q-OG   Q-EG QBuero Q-tot Q-Inf Q-Sol QInfSb QSolSb
*** External files
ASSIGN "***.out" 34
*|? File for the summary results |1000
*------------------------------------------------------------------------------

* Model "Type25b" (Type 25)
*

UNIT 17 TYPE 25    Type25b
*$UNIT_NAME Type25b
*$MODEL .\Output\Printer\User-Supplied Units\Type25b.tmf
*$POSITION 689 402
*$LAYER Outputs #
PARAMETERS 10
1           ! 1 Printing interval
START                   ! 2 Start time
STOP                    ! 3 Stop time
35                      ! 4 Logical unit
1           ! 5 Units printing mode
0           ! 6 Relative or absolute start time
-1                      ! 7 Overwrite or Append
-1                      ! 8 Print header
0           ! 9 Delimiter
1           ! 10 Print labels
INPUTS 6
4,1                     ! Type109-User:Ambient temperature ->Input to be printed-1
8,3                     ! Type56b: 3- TAIR_SUEDBURO ->Input to be printed-2
8,26                    ! Type56b: 26- TOP_SUEDBURO ->Input to be printed-3
8,25                    ! Type56b: 25- RELHUM_SUEDBURO ->Input to be printed-4
8,27                    ! Type56b: 27- PMV_SUEDBURO ->Input to be printed-5
8,28                    ! Type56b: 28- PPD_SUEDBURO ->Input to be printed-6
*** INITIAL INPUT VALUES
Tamb TBuero TOP-SB rH-SB PMV PPD
C     C    C    %    -    %
*** External files
ASSIGN "***.prn" 35
*|? Output file for printed results |1000
*------------------------------------------------------------------------------

* Model "Type65d" (Type 65)
*

UNIT 18 TYPE 65    Type65d
*$UNIT_NAME Type65d
*$MODEL .\Output\Online Plotter\Online plotter without file\Type65d.tmf
*$POSITION 685 130
*$LAYER Outputs #
PARAMETERS 12
```

```
4          ! 1 Nb. of left-axis variables
4          ! 2 Nb. of right-axis variables
-15                ! 3 Left axis minimum
35                 ! 4 Left axis maximum
0          ! 5 Right axis minimum
1200               ! 6 Right axis maximum
-1                 ! 7 Number of plots per simulation
14                 ! 8 X-axis gridpoints
0          ! 9 Shut off Online w/o removing
-1                 ! 10 Logical unit for output file
0          ! 11 Output file units
0          ! 12 Output file delimiter
INPUTS 8
4,1                ! Type109-User:Ambient temperature ->Left axis variable-1
8,1                ! Type56b: 1- TAIR_OBERGE ->Left axis variable-2
8,2                ! Type56b: 2- TAIR_ERDGE ->Left axis variable-3
8,3                ! Type56b: 3- TAIR_SUEDBURO ->Left axis variable-4
eglobh             ! Ch_units_1:eglobh ->Right axis variable-1
eg-s               ! Ch_units_1:eg-s ->Right axis variable-2
eg-ost             ! Ch_units_1:eg-ost ->Right axis variable-3
e-west             ! Ch_units_1:e-west ->Right axis variable-4
*** INITIAL INPUT VALUES
Tamb T_OG T_EG TBuero Ihoriz Isouth Ieast Iwest
LABELS  3
"Temperatures"
"Heat transfer rates"
"Graph 1"
*------------------------------------------------------------------------------

* EQUATIONS "Ch_units_2"
*
EQUATIONS 4
POG = [8,4]/-3600
PEG = [8,5]/-3600
PSB = [8,6]/-3600
Ptot = POG+PEG+PSB
*$UNIT_NAME Ch_units_2
*$LAYER Outputs
*$POSITION 610 504

*------------------------------------------------------------------------------


* Model "Type65d-2" (Type 65)
*

UNIT 20 TYPE 65    Type65d-2
*$UNIT_NAME Type65d-2
*$MODEL .\Output\Online Plotter\Online plotter without file\Type65d.tmf
*$POSITION 700 504
*$LAYER Outputs #
PARAMETERS 12
1          ! 1 Nb. of left-axis variables
3          ! 2 Nb. of right-axis variables
0          ! 3 Left axis minimum
60                 ! 4 Left axis maximum
0          ! 5 Right axis minimum
30                 ! 6 Right axis maximum
31                 ! 7 Number of plots per simulation
14                 ! 8 X-axis gridpoints
0          ! 9 Shut off Online w/o removing
-1                 ! 10 Logical unit for output file
```

```
0            ! 11 Output file units
0            ! 12 Output file delimiter
INPUTS 4
Ptot                  ! Ch_units_2:Ptot ->Left axis variable
POG                   ! Ch_units_2:POG ->Right axis variable-1
PEG                   ! Ch_units_2:PEG ->Right axis variable-2
PSB                   ! Ch_units_2:PSB ->Right axis variable-3
*** INITIAL INPUT VALUES
Ptot POG PEG PSB
LABELS  3
"Heat transfer rates"
"Heat transfer rates"
"Graph 2"
*------------------------------------------------------------------------------

END
```

During the simulation the following screen output will be produced by two TYPE 65 (Online). The first online shows room temperatures as well as the radiation for different orientations.

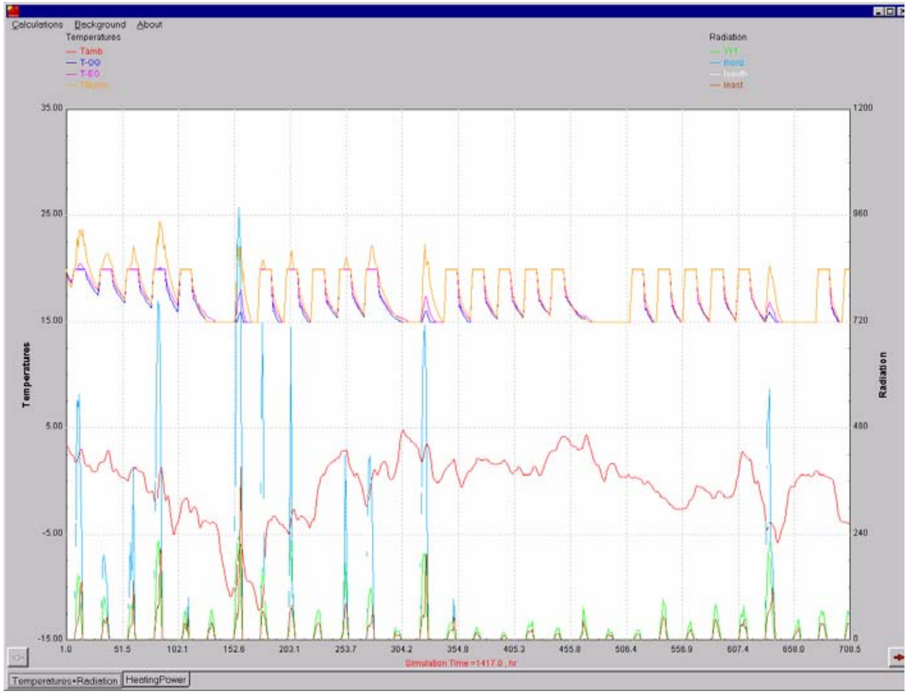

Figure 6.5.2-4: Ambient and room temperatures for the specified zones as well as the radiation for different surface orientations

Figure 6.5.2-5: total heating power and heating power for each zone

After the simulation, several output messages are produced in the list file (BUILDING.LST). Besides information on the Types included and their respective connections, warnings and if need be error messages are printed here. Warnings and notices not in every case mean that there is an error but might give valuable informations to the user.

For example, if an NTYPE for humidity is specified in the list file (*.lst) Warnings are printed if condensations on surfaces appears. Also an additional information is printed which NTYPE can be used for an further investigation of the condensation behaviour.

```
TRANSIENT SIMULATION        STARTING AT TIME =  0.0000000000000000E+00
                            STOPPING AT TIME =  8.7600000000000000E+03
                            TIMESTEP =        1 /       1
        DIFFERENTIAL EQUATION ERROR TOLERANCE =  1.0000000000000002E-03
            ALGEBRAIC CONVERGENCE TOLERANCE =  1.0000000000000002E-03

(....)

DIFFERENTIAL EQUATIONS SOLVED BY MODIFIED EULER

*** Notice at time        :        0.000000
   Generated by Unit     : Not applicable or not available
   Generated by Type     : Not applicable or not available
   Message               : The following Types were loaded from TRNDll.dll: Type109, Type33, Type69,
Type56, Type2, Type28, Type25, Type65


*** Notice at time        :        0.000000
   Generated by Unit     : Not applicable or not available
   Generated by Type     : Not applicable or not available
```

```
   Message              : "Type157_demo_release.dll" was found but did not contain any components from
the input file.


*** Notice at time        :         0.000000
   Generated by Unit     : Not applicable or not available
   Generated by Type     : Not applicable or not available
   TRNSYS Message    199 : TRNSYS found at least one user DLL in the UserLib directory. (Note: Only
DLL's including Types that are used in the simulation are loaded)
   Reported information  : 0 user DLLs were loaded after searching in
"C:\Trnsys16\UserLib\ReleaseDLLs"


*** Notice at time        :         0.000000
   Generated by Unit     :     4
   Generated by Type     :   109
   Message               :

 VARIABLE            COLUMN # IPOL     MULTIPLIER    ADD_FACTOR   SAMPLING
 --------------------------------------------------------------------------
 ==> IBEAM_H           2       -        1.0000       0.0000       -1
 ==> IDIFF_H           3       -        1.0000       0.0000       -1
 ==> TAMB              4       2        1.0000       0.0000        0
 ==> WSPEED            5       1        1.0000       0.0000        0
 ==> RHUM              6       1        1.0000       0.0000        0
 ==> WDIR              7       0        1.0000       0.0000       -1
     CCOVER            8       1        1.0000       0.0000        0
 --------------------------------------------------------------------------
 LONGITUDE              -6.13
 LATITUDE               46.25
 TIME SHIFT TO GMT          1
 DATA TIME STEP          1.00
 STARTTIME FOR DATA        1.00
 SAMPLING FOR RAD. DATA    -1.00
 --------------------------------------------------------------------------
 RADIATION MODE: IBEAM_H AND IDIFF_H ARE INPUTS

 (.....)


*** The TRNSYS components will be called in the following order:
     Unit #    4   Type #  109
     Unit #    6   Type #   33
     Unit #    7   Type #   69
     Unit #    8   Type #   56
     Unit #    9   Type #    2
     Unit #   10   Type #    2
     Unit #   11   Type #    2
     Unit #   22   Type #    2
     Unit #   23   Type #    2
     Unit #   24   Type #    2
     Unit #   15   Type #    2
     Unit #   16   Type #   28
     Unit #   17   Type #   25
     Unit #   18   Type #   65
     Unit #   20   Type #   65

*** Warning at time       :      8760.000000
   Generated by Unit     :     8
   Generated by Type     :    56
   Message               : Information on surface condensation: Surface outputs ntype 48,49 for
inside/outside surface(s) may be  used for further investigation on time dependant behaviour!
```

```
*** Warning at time      :     8760.000000
   Generated by Unit    :    8
   Generated by Type    :    56
   Message              : Information on surface condensation: In Zone   3 at window   1 condensation on
outside surface  during        56 timesteps occurred!

================================================================================
===========
TYPE56 TIME REPORT: (for debugging purpose)
-----------------------------------------------------------------------------------------
time_report_unit:   6
time_filter:       .8760E+07 [ms]
================================================================================
===========
Level0     Level1     Level2     Level3     Level4       Counter DTime[ms]  TTime[ms]
================================================================================
===========


*****************************************************************************************************************
The Following UNIT Numbers, TYPE Numbers, and Logical Units Were Used in the Supplied TRNSYS
Input File:
               4          2             4
               6         25             6
               7         28             9
               8         33            33
               9         56            34
              10         65            35
              11         69            38
              15        109            39
              16                       40
              17
              18
              20
              22
              23
              24


*****************************************************************************************************************
Total TRNSYS Calculation Time:                    2380.7400 Seconds
```

The output file of the building example (BUILDING.OUT) contains the output results from the simulation (in this case the output data are in kilowatt*hours [kWh]).

Instead of using a TYPE 28 for e.g heating demand it is also possible to produce a standard output report from TYPE 56 for the most interesting variables by specifying optional logical unit numbers (LU) for PAR (4) to PAR(6). The following reports are available

PAR(4) > 0 simulation summary gives

```
 ****************************************************************
  *       *
  *           MONTHLY SUMMARY STANDARD REPORT        *
  *       *
  ****************************************************************
```

SUMMARY VALUES FOR ALL ZONES COMBINED
****

MONTH	HEATING	COOLING	INFILTR.	VENTILAT.	SOLAR_RAD.	INT_GAINS
-	[KWH]	[KWH]	[KWH]	[KWH]	[KWH]	
JAN	7.415E+03	0.000E+00	-6.463E+03	-8.022E+00	7.767E+02	5.034E+03
FEB	6.391E+03	0.000E+00	-5.400E+03	-2.561E+01	1.133E+03	3.971E+03
MAR	4.860E+03	0.000E+00	-4.678E+03	-4.975E+01	1.751E+03	3.412E+03
APR	2.100E+03	0.000E+00	-3.114E+03	-5.360E+01	1.908E+03	2.978E+03
MAY	1.089E+03	0.000E+00	-2.373E+03	-1.527E+02	1.958E+03	2.800E+03
JUN	1.114E+01	0.000E+00	-1.679E+03	-6.473E+02	1.937E+03	2.349E+03
JUL	0.000E+00	0.000E+00	-9.287E+02	-2.435E+03	1.996E+03	2.730E+03
AUG	0.000E+00	0.000E+00	-1.036E+03	-2.252E+03	1.960E+03	2.867E+03
SEP	6.870E+00	0.000E+00	-1.834E+03	-4.518E+02	1.843E+03	2.868E+03
OCT	1.477E+03	0.000E+00	-3.271E+03	-5.129E+01	1.412E+03	4.245E+03
NOV	5.517E+03	0.000E+00	-5.206E+03	-1.546E+01	9.428E+02	4.653E+03
DEC	6.794E+03	0.000E+00	-5.710E+03	0.000E+00	6.764E+02	4.747E+03
SUM	3.566E+04	0.000E+00	-4.169E+04	-6.142E+03	1.829E+04	4.265E+04

ZONE NUMBER IS 1
****

MONTH	HEATING	COOLING	INFILTR.	VENTILAT.	SOLAR_RAD.	INT_GAINS
-	[KWH]	[KWH]	[KWH]	[KWH]	[KWH]	
JAN	3.409E+03	0.000E+00	-2.798E+03	0.000E+00	2.491E+02	2.265E+03
FEB	2.931E+03	0.000E+00	-2.337E+03	0.000E+00	3.623E+02	1.797E+03
MAR	2.218E+03	0.000E+00	-2.022E+03	0.000E+00	5.591E+02	1.566E+03
APR	9.392E+02	0.000E+00	-1.348E+03	0.000E+00	6.102E+02	1.376E+03
MAY	4.791E+02	0.000E+00	-1.051E+03	-5.779E+01	6.234E+02	1.304E+03
JUN	4.146E+00	0.000E+00	-7.462E+02	-4.021E+02	6.159E+02	1.106E+03
JUL	0.000E+00	0.000E+00	-4.190E+02	-1.319E+03	6.355E+02	1.273E+03
AUG	0.000E+00	0.000E+00	-4.605E+02	-1.212E+03	6.241E+02	1.333E+03
SEP	5.150E-01	0.000E+00	-8.083E+02	-2.153E+02	5.871E+02	1.328E+03
OCT	6.570E+02	0.000E+00	-1.414E+03	0.000E+00	4.503E+02	1.926E+03
NOV	2.503E+03	0.000E+00	-2.252E+03	0.000E+00	3.031E+02	2.097E+03
DEC	3.083E+03	0.000E+00	-2.473E+03	0.000E+00	2.175E+02	2.139E+03
SUM	1.622E+04	0.000E+00	-1.813E+04	-3.207E+03	5.838E+03	1.951E+04

(.......)

PAR(5) > 0 air and operative temperature printer file produces:

TIME	TAMB	T_AIR	T_OP	1_T_AIR	1_T_OP	2_T_AIR	2_T_OP	3_T_AIR	3_T_OP
[HR]	[C]	[C]	[C]	[C]	[C]	[C]	[C]	[C]	[C]
0.00	0.00	20.00	20.00	20.00	20.00	20.00	20.00	20.00	20.00
1.00	-2.80	19.27	19.39	19.36	19.48	19.22	19.32	19.04	19.09
2.00	-2.08	18.67	18.95	18.82	19.08	18.57	18.86	18.25	18.45
3.00	-1.55	18.64	18.85	18.76	18.96	18.57	18.79	18.13	18.26
4.00	-1.37	18.43	18.66	18.52	18.73	18.38	18.62	17.80	17.96
5.00	-1.44	18.27	18.49	18.32	18.53	18.25	18.48	17.61	17.76
6.00	-1.60	18.09	18.31	18.11	18.32	18.10	18.33	17.37	17.52
7.00	-1.82	19.01	18.82	19.01	18.81	19.02	18.85	18.64	18.30
8.00	-1.60	20.00	19.44	20.00	19.43	20.00	19.47	20.00	19.25
9.00	-1.20	20.00	19.63	20.00	19.60	20.00	19.66	20.00	19.53
10.00	-0.80	20.00	19.81	20.00	19.75	20.00	19.85	20.00	19.87
11.00	-0.30	20.02	19.92	20.00	19.82	20.00	19.95	21.25	21.36
12.00	0.50	20.03	19.96	20.00	19.86	20.00	19.99	21.73	21.65

(........)

The first column is the ambient temperature (except for the first hour). The 2nd and 3rd column shows the mean air temperature of the whole building. Then follows for each zone the air temperature and the operative temperature. The zone can be identified by the figure in front of the label. So, the air temp. of zone one is 1_T_AIR the operative temp. is 1_T_OP . The values are given in °C. Up to 50 zones can be printed.

PAR(6) > 0 heating and cooling power printer file gives

TIME	TAMB	HEAT	COOL	1_HEAT	1_COOL	2_HEAT	2_COOL	3_HEAT	3_COOL
[HR]	[C]	[KW]	[KW]	[KW]	[KW]	[KW]	[KW]	[KW]	[KW]
0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
1.00	-2.80	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
2.00	-2.08	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
3.00	-1.55	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
4.00	-1.37	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
5.00	-1.44	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
6.00	-1.60	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
7.00	-1.82	12.88	0.00	5.63	0.00	6.85	0.00	0.40	0.00
8.00	-1.60	16.19	0.00	7.12	0.00	8.54	0.00	0.53	0.00
9.00	-1.20	20.29	0.00	8.92	0.00	11.01	0.00	0.36	0.00
10.00	-0.80	16.41	0.00	7.51	0.00	8.74	0.00	0.16	0.00
11.00	-0.30	14.00	0.00	6.63	0.00	7.37	0.00	0.00	0.00
12.00	0.50	12.47	0.00	5.96	0.00	6.51	0.00	0.00	0.00

(..........)

The first column shows also the ambient temperature (except for the first hour). The 2nd and 3rd column shows the total heating and cooling power of the whole building. Then follows for each zone the heating and cooling power. The zone can be identified by the figure in front of the label. So, the heating power of zone one is 1_HEAT the cooling power is 1_COOL . The values are given in kW. Up to 50 zones can be printed.