

TRNSYS 16

a TRAnsient SYstem Simulation program

Volume 3

Standard Component Library Overview



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About This Manual

The information presented in this manual is intended to provide a quick overview of the Standard Component Library in TRNSYS 16. This manual is not intended to provide detailed reference information about the TRNSYS simulation software and its utility programs. More details 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
- 2005-02 For TRNSYS 16.00.0037
- 2006-01 For TRNSYS 16.01.0000

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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Contributors to the building model (Type 56) and its interface (TRNBuild) are listed in Volume 6.

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3. STANDARD COMPONENT LIBRARY OVERVIEW

3.1. Introduction

About one hundred models are included in the Standard TRNSYS Library. This document is intended to give users a quick overview of the available components. It should be used together with the following Volumes of the TRNSYS documentation:

- Volume 4: Input - Output - Parameter Reference

Volume 4 has a list of inputs, outputs and parameters for all components in the library. It is intended as a reference for users who do not use the Simulation Studio and as a quick overview of all variables for Studio users.

- Volume 5: Mathematical reference

Volume 5 gives the mathematical reference of all models included in the Standard library of components.

This volume is organized in 3 main sections that explore the tree of available components from the trunk to the smaller branches in order to allow users to quickly find the component they need. Note that Simulation Studio users are invited to use the "Direct Access Tool" in the Studio, which will give them access to a "live" version of the component tree.

Volume 3 and 4 are organized according to the user interface of each component ("proformas" in the Simulation Studio), while Volume 5 is organized according to the models on which components are based. Models are known as Types and correspond to a Fortran file. The same model can (and often does) have different proformas associated with it. Example: The Flat-plate Solar collector model using a quadratic efficiency curve (Type 1) has 5 operating modes, which correspond to 5 proformas in the Studio. It has 5 entries in Volumes 3 and 4. There are about 300 available proformas for about 100 Fortran routines.

3.2. Main categories of components

The Standard Component Library is organized in 14 categories:

1. Controllers

This category contains various general purpose controllers and thermostats.

2. Electrical

This category contains components that generate or store electricity and their accessories: solar photovoltaic (PV) systems. Wind Energy Conversion Systems (WECS, or wind turbines), Diesel engines, Power conversion systems, batteries.

3. Heat Exchangers

This category contains various types of heat exchanger and energy recovery devices.

4. HVAC

This category contains several auxiliary heating and cooling devices, including absorption cooling machines.

5. Hydrogen Systems

Most components from the HYDROGEMS library are in this category (some components have been moved to the "electrical" category). The HYDROGEMS library provides models to simulate Hydrogen-based systems: fuel cells, electrolyzers, Hydrogen storage devices, etc.

6. Hydronics

Fans, pumps, pipes, ducts and flow diverters or mixers can be found here

7. Loads and Structures

This category includes Type 56, the multizone building model (see Volume 6) but also different monozone models of increasing complexity.

8. Obsolete

Components that have been made obsolete in TRNSYS 16 have been moved here. Those components were kept for backwards compatibility but they should not be used as they may not be supported in further TRNSYS releases.

9. Output

Printers and online plotters are in this category, as well as components that realize a simulation summary or further analyze simulation results.

10. Physical Phenomena

This category groups utility components that model physical phenomena. It includes psychrometrics calculations and the well-known solar radiation processor (note that users should consider using the combined data reader and radiation processor, see category 14). It also includes shading calculations, sky temperature and convection coefficients.

11. Solar Thermal Collectors

This category includes models for different types of solar thermal collectors: flat-plate collectors, evacuated tube collectors, Concentrating Parabolic Collectors (CPC), etc.

12. Thermal Storage

Various models of storage devices are available: stratified or plug-flow water tanks with optional heat exchangers, rock beds, etc.

13. Utility

This category groups utility components such as unit conversion, forcing functions, input value recall, etc. It also hosts components calling external programs such as EES, Excel or Matlab, and the important "Data Reader" group.

14. Weather Data Reading and Processing

This category gives easy access to the combined data reader and solar radiation processor that allows users to easily read standard or user-format weather files and calculate the incident solar radiation on any surface.

3.3. *Subcategories of components*

Each category of components is subdivided in main subcategories, which are listed here below.

1. **Controllers**

- 3-Stage Room Thermostat
- 5-Stage Room Thermostat
- Differential Controller w_ Hysteresis
- Iterative Feedback Controller
- Microprocessor Controller
- PID Controller

2. **Electrical**

- Batteries
- Busbar
- Diesel Engine (DEGS)
- Photovoltaic Panels
- Power Conditioning
- Regulators and Inverters
- Wind Turbines

3. **Heat Exchangers**

- Constant Effectiveness
- Counter Flow
- Cross Flow
- Parallel Flow
- Shell and Tube
- Waste Heat Recovery

4. **HVAC**

- Absorption Chiller (Hot-Water Fired, Single Effect)
- Auxiliary Cooling Unit
- Auxiliary Heaters
- Conditioning Equipment
- Cooling Coils
- Cooling Towers
- Dual Source Heat Pumps
- Furnace
- Parallel Chillers
- Part Load Performance

5. **Hydrogen Systems**

- Compressed Gas Storage
- Compressor
- Controllers
- Electrolyzer
- Fuel Cells

6. Hydronics

- Fans
- Flow Diverter
- Flow Mixer
- Pipe_Duct
- Pressure Relief Valve
- Pumps
- Tee-Piece
- Tempering Valve

7. Loads and Structures

- Attached Sunspace
- Multi-Zone Building
- Overhang and Wingwall Shading
- Pitched Roof and Attic
- Single Zone Models
- Thermal Storage Wall
- Window

8. Obsolete

- Absorption Air Conditioners (Type7)
- Calling External DLLs (Type61)
- CSTB Weather Data - TRNSYS 15 (Type9)
- Plotter (Type26)
- Radiation Processors With Smoothing (Type16)

9. Output

- Economics
- Histogram Plotter
- Online Plotter
- Printer
- Simulation Summary

10. Physical Phenomena

- Collector Array Shading
- Convection Coefficient Calculation
- Radiation Processors

- Shading Masks
- Sky Temperature
- Thermodynamic Properties
- Weather Generators

11. Solar Thermal Collectors

- CPC Collector
- Evacuated Tube Collector
- Performance Map Collector
- Quadratic Efficiency Collector
- Theoretical Flat-Plate Collector
- Thermosyphon Collector with Integral Storage

12. Thermal Storage

- Detailed Fluid Storage Tank
- Plug-Flow Tank
- Rock Bed Storage
- Stratified Storage Tank
- Variable Volume Tank

13. Utility

- Calling External Programs
- Convergence Promoter
- Data Readers
- Forcing Function Sequencers
- Forcing Functions
- Holiday Calculator
- Input Value Recall
- Integrators
- Parameter replacement
- Unit Conversion Routine
- Utility Rate Schedule Processors

14. Weather Data Reading and Processing

- Standard Format
- User Format

3.4. Overview of available components in each category

This section gives a description of available components in all categories and subcategories. The section is organized according to the components proformas. For each component, the exact location of the proforma is specified and the corresponding TRNSYS model (or Type) is given.

3.4.1. Controllers

3.4.1.1. 3-Stage Room Thermostat

3-STAGE ROOM THERMOSTAT

Proforma: Controllers\3-Stage Room Thermostat\Type8.tmf
TRNSYS Model: Type 8
A three stage room thermostat is modeled to output three on/off control functions that can be used to control a system having a solar heat source, an auxiliary heater, and a cooling system. This controller is to be used to control systems on temperature levels and is compatible with the TYPE 12 mode 4 and the TYPE 19 mode 2 loads. The controller commands cooling at high room temperatures, first stage (solar source) heating at lower room temperatures, and second stage (auxiliary source) heating at even lower room temperatures. The user has the option, through parameter ISTG, to disable first stage heating during second stage heating and the capability, through parameter Tmin, to disable first stage heating whenever the source temperature is too low. Although solar heating is specified in the decription of this component, any three-stage heating system may be controlled using the TYPE 8 routine.

W_ HEATING SET BACK

Proforma: Controllers\3-Stage Room Thermostat\w_ heating set back\Type8a.tmf
TRNSYS Model: Type 8
A three stage room thermostat is modeled to output three on/off control functions that can be used to control a system having a solar heat source, an auxiliary heater, and a cooling system. This controller is to be used to control systems on temperature levels and is compatible with the TYPE 12 mode 4 and the TYPE 19 mode 2 loads. The controller commands cooling at high room temperatures, first stage (solar source) heating at lower room temperatures, and second stage (auxiliary source) heating at even lower room temperatures. The user has the option, through parameter ISTG, to disable first stage heating during second stage heating and the capability, through parameter Tmin, to disable first stage heating whenever the source temperature is too low. Although solar heating is specified in the decription of this component, any three-stage heating system may be controlled using the TYPE 8 routine. In many heating applications, the desired room temperature may depend on the time of day or the day of the week. This variation of the heating on/off temperatures is modeled in this instance of Type8 using an optional set back control function gset and set back temperature difference DTset. When this option is used, the usual temperatures at which first and second stage heating are commanded are both reduced by gset . DTset. Typically, gset is calculated by a TYPE I4 time-dependent function generator. Hysteresis effects can be included in the model by supplying the optional dead band temperature difference DTdb. A single value of DTdb, if

supplied, is applied to all three output control functions. Parameter 1, NSTK, sets the number of oscillations permitted within a timestep before the output state of the controller is stuck. It is recommended that NSTK be set to 3 or 5. For a discussion of controller stability problems, see Section 4.4 of Volume 1 of the TRNSYS documentation set.

Mathematical Description:

If hysteresis is not used, then DTdb is set to zero. Similarly, when the set back option is not used, gset and DTset are zero. The heating and cooling on/off temperatures are set as follows:

$$TH1' = TH1 + g1 * DTdb - gset * DTset$$

$$TH2' = TH2 + g2 * DTdb - gset * DTset$$

$$TC' = TC - g3 * DTdb$$

When the first stage source temperature Th is greater than or equal to Tmin, the first stage enable function ge is set to 1. Otherwise, ge = 0.

W_ HEATING SET BACK AND TEMP DEADBAND

Proforma: Controllers\3-Stage Room Thermostat\w_ heating set back and temp deadband\Type8b.tmf

TRNSYS Model: Type 8

A three stage room thermostat is modeled to output three on/off control functions that can be used to control a system having a solar heat source, an auxiliary heater, and a cooling system. This controller is to be used to control systems on temperature levels and is compatible with the TYPE 12 mode 4 and the TYPE 19 mode 2 loads. The controller commands cooling at high room temperatures, first stage (solar source) heating at lower room temperatures, and second stage (auxiliary source) heating at even lower room temperatures. The user has the option, through parameter ISTG, to disable first stage heating during second stage heating and the capability, through parameter Tmin, to disable first stage heating whenever the source temperature is too low. Although solar heating is specified in the description of this component, any three-stage heating system may be controlled using the TYPE 8 routine.

In many heating applications, the desired room temperature may depend on the time of day or the day of the week. This variation of the heating on/off temperatures is modeled in this instance of Type8 using an optional set back control function gset and set back temperature difference DTset. When this option is used, the usual temperatures at which first and second stage heating are commanded are both reduced by gset . DTset.

Typically, gset is calculated by a TYPE I4 time-dependent function generator.

In this instance, hysteresis effects can be included in the model by supplying the optional dead band temperature difference DTdb. A single value of DTdb, if supplied, is applied to all three output control functions.

3.4.1.2. 5-Stage Room Thermostat

5-STAGE ROOM THERMOSTAT

Proforma: Controllers\5-Stage Room Thermostat\Type108.tmf

TRNSYS Model: Type 108

A five stage room thermostat is modeled to output five on/off control functions that can be used to control a system having a two stage heat source, an auxiliary heater, and a two-stage cooling system. The controller commands 1st stage cooling at moderately high room temperatures, second stage cooling at higher room temperatures, first stage heating at low room temperatures, second stage heating at lower room temperatures, and auxiliary heating at even lower room temperatures. The user has the option to disable first stage heating during second stage and auxiliary heating, disable second stage heating during auxiliary heating, and disable first stage cooling during second stage cooling.

Note: care should be taken when choosing deadbands and setpoints. Deadbands that are greater than the temperature difference between the setpoints will cause controller convergence problems.

3.4.1.3. Differential Controller w_ Hysteresis

FOR TEMPERATURES - SOLVER 0 (SUCCESSIVE SUBSTITUTION) CONTROL STRATEGY

Proforma: Controllers\Differential Controller w_ Hysteresis\for Temperatures\Solver 0 (Successive Substitution) Control Strategy\Type2b.tmf
TRNSYS Model: Type 2
<p>The on/off differential controller generates a control function which can have a value of 1 or 0. The value of the control signal is chosen as a function of the difference between upper and lower temperatures T_h and T_l, compared with two dead band temperature differences DTI and DTI. The new value of the control function depends on the value of the input control function at the previous timestep. The controller is normally used with the input control signal connected to the output control signal, providing a hysteresis effect. However, control signals from different components may be used as the input control signal for this component if a more detailed form of hysteresis is desired.</p> <p>For safety considerations, a high limit cut-out is included with this controller. Regardless of the dead band conditions, the control function will be set to zero if the high limit condition is exceeded. This controller is not restricted to sensing temperatures, even though temperature notation is used. This controller instance uses unit descriptions of degC so that it is readily usable as a thermostatic differential controller.</p> <p>This instance of the Type2 controller is intended for use with the standard TRNSYS SOLVER 0 (Successive Substitution)</p>

FOR TEMPERATURES - SOLVER 1 (POWELL) CONTROL STRATEGY

Proforma: Controllers\Differential Controller w_ Hysteresis\for Temperatures\Solver 1 (Powell) Control Strategy\Type2a.tmf
TRNSYS Model: Type 2
<p>The on/off differential controller generates a control function which can have a value of 1 or 0. The value of the control signal is chosen as a function of the difference between upper and lower temperatures T_h and T_l, compared with two dead band temperature differences DTI and DTI. The new value of the control function depends on the value of the input control function at the previous timestep. The controller is normally used with the input control signal connected to the output control signal, providing a hysteresis effect. However, control signals from different components may be used as the input control signal for this component if a more detailed form of hysteresis is desired.</p> <p>For safety considerations, a high limit cut-out is included with this controller. Regardless of the dead band conditions, the control function will be set to zero if the high limit condition is exceeded. This controller is not restricted to sensing temperatures, even though temperature notation is used. This controller instance uses unit descriptions of degC so that it is readily usable as a thermostatic differential controller.</p> <p>This instance of the Type2 controller is intended for use with TRNSYS SOLVER 1 (Powel's method), appropriate for systems that have little or no capacitance in them.</p>

GENERIC - SOLVER 0 (SUCCESSIVE SUBSTITUTION) CONTROL STRATEGY

Proforma: Controllers\Differential Controller w_ Hysteresis\generic\Solver 0 (Successive Substitution) Control Strategy\Type2d.tmf
TRNSYS Model: Type 2
<p>The on/off differential controller generates a control function which can have a value of 1 or 0. The value of the control signal is chosen as a function of the difference between upper and lower temperatures T_h and T_l, compared with two dead band temperature differences DTI and DTI. The new value of the control function depends on the value of the input control function at the previous timestep. The controller is normally used with the input control signal connected to the output control signal, providing a hysteresis effect. However, control signals from different components may be used as the input control signal for this component if a more</p>

detailed form of hysteresis is desired.

For safety considerations, a high limit cut-out is included with this controller. Regardless of the dead band conditions, the control function will be set to zero if the high limit condition is exceeded. This controller is not restricted to sensing temperatures, even though temperature notation is used. This controller instance avoids reference to unit descriptions (degC, kg/hr, etc.) so that it can be used as a generic differential controller. This instance of the Type2 controller is intended for use with the standard TRNSYS SOLVER 0 (Successive Substitution)

GENERIC - SOLVER 1 (POWELL) CONTROL STRATEGY

Proforma: Controllers\Differential Controller w_ Hysteresis\generic\Solver 1 (Powell) Control Strategy\Type2c.tmf

TRNSYS Model: Type 2

The on/off differential controller generates a control function which can have a value of 1 or 0. The value of the control signal is chosen as a function of the difference between upper and lower temperatures T_h and T_l , compared with two dead band temperature differences DTI and DTI . The new value of the control function depends on the value of the input control function at the previous timestep. The controller is normally used with the input control signal connected to the output control signal, providing a hysteresis effect. However, control signals from different components may be used as the input control signal for this component if a more detailed form of hysteresis is desired.

For safety considerations, a high limit cut-out is included with this controller. Regardless of the dead band conditions, the control function will be set to zero if the high limit condition is exceeded. This controller is not restricted to sensing temperatures, even though temperature notation is used. This controller instance avoids reference to unit descriptions (degC, kg/hr, etc.) so that it can be used as a generic differential controller. This instance of the Type2 controller is intended for use with TRNSYS SOLVER 1 (Powel's method), appropriate for systems that have little or no capacitance in them.

3.4.1.4. Iterative Feedback Controller

ITERATIVE FEEDBACK CONTROLLER

Proforma: Controllers\Iterative Feedback Controller\Type22.tmf

TRNSYS Model: Type 22

The iterative feedback controller calculates the control signal (u) required to maintain the controlled variable (y) at the setpoint (y_{Set}). It uses TRNSYS iterations to provide accurate setpoint tracking. This controller can be used to model a real feedback controller (e.g. PID) that would adapt its control signal continuously or using a discrete time step much shorter than the TRNSYS simulation time step. The controller has an ON/OFF signal and bounds can be fixed for the control signal. The iterative feedback controller uses a secant method to calculate the control signal that zeroes (or minimizes) the tracking error ($e = y_{Set} - y$).

Note: Type 22 uses TRNSYS iterations and its performance is sensitive to some simulations settings such as component order and convergence tolerances. Please see the manual and examples for more details.

3.4.1.5. Microprocessor Controller

MICROPROCESSOR CONTROLLER

Proforma: Controllers\Microprocessor Controller\Type40.tmf

TRNSYS Model: Type 40

3.4.1.6. *PID Controller*

PID CONTROLLER

Proforma: Controllers\PID Controller\Type23.tmf

TRNSYS Model: Type 23

The PID controller calculates the control signal (u) required to maintain the controlled variable (y) at the setpoint (y_{Set}). Its control signal is proportional to the tracking error, as well as to the integral and the derivative of that tracking error. It is based on state-of-the-art discrete algorithms for PID controllers and implements anti windup for the integrator.

The PID controller can operate in two modes: mode 0 implements a "real life" (non-iterative) controller, and mode 1 implements an iterative controller (Note that the Iterative Feedback Controller, Type 22, might be easier to use in that configuration). Please see the manuals and the description of parameter 1 (mode) for more details.

Note on the transposition of parameter tuning to real-world controllers: even if your simulation uses a very short time step and if you use mode 0, the tuned parameters may be different from the ones you would need to use in a real controller applied to the simulated system. Optimal parameters depend on the algorithm used in the PID, for which different implementations are available. Please check the manual for more information on this component's algorithm.

3.4.2. Electrical

3.4.2.1. Batteries

CURRENT AS AN INPUT - SHEPHERD EQUATION

Proforma: Electrical\Batteries\Current as an input\Shepherd Equation\Type47d.tmf
TRNSYS Model: Type 47
This model of a lead-acid storage battery operates in conjunction with solar cell array and power conditioning components. It specifies how the battery state of charge varies over time, given the rate of charge or discharge. This proforma corresponds to Mode 4 This mode utilizes formulas relating battery voltage, current and State Of Charge. The equations are those devised by Shepherd. The Shepherd model is relatively simple and the Hyman model (Mode 3 and 5) is more realistic at very low currents. In this mode, the current is given as input.

CURRENT AS AN INPUT - SHEPHERD MODIFIED HYMAN EQUATION

Proforma: Electrical\Batteries\Current as an input\Shepherd modified Hyman Equation\Type47e.tmf
TRNSYS Model: Type 47
This model of a lead-acid storage battery operates in conjunction with solar cell array and power conditioning components. It specifies how the battery state of charge varies over time, given the rate of charge or discharge. This proforma corresponds to Mode 5 This mode utilizes formulas relating battery voltage, current and State Of Charge. The equations are those devised by Hyman (modified Shepherd) In this mode, the current is given as input.

POWER AS AN INPUT - $DQ_{DT}=P_{EFF}$

Proforma: Electrical\Batteries\Power as an input\dQ_dt=P eff\Type47a.tmf
TRNSYS Model: Type 47
This model of a lead-acid storage battery operates in conjunction with solar cell array and power conditioning components. It specifies how the battery state of charge varies over time, given the rate of charge or discharge. This proforma corresponds to Mode 1, based on a simple energy balance of the battery. The power is simply taken as input. This model does not calculate nor output any values of current or voltage.

POWER AS AN INPUT - SHEPHERD EQUATION

Proforma: Electrical\Batteries\Power as an input\Shepherd Equation\Type47b.tmf
TRNSYS Model: Type 47
This model of a lead-acid storage battery operates in conjunction with solar cell array and power conditioning components. It specifies how the battery state of charge varies over time, given the rate of charge or discharge. This proforma corresponds to Mode 2 This mode utilizes formulas relating battery voltage, current and State Of Charge. The equations are those devised by Shepherd. The Shepherd model is relatively simple and the Hyman model (Mode 3 and 5) is more realistic at very low currents.

In this mode, the power is given as input.

POWER AS AN INPUT - SHEPHERD MODIFIED HYMAN EQUATION

Proforma: Electrical\Batteries\Power as an input\Shepherd modified Hyman Equation\Type47c.tmf
TRNSYS Model: Type 47
This model of a lead-acid storage battery operates in conjunction with solar cell array and power conditioning components. It specifies how the battery state of charge varies over time, given the rate of charge or discharge. This proforma corresponds to Mode 3 This mode utilizes formulas relating battery voltage, current and State Of Charge. The equations are those devised by Hyman (modified Shepherd) In this mode, the power is given as input.

WITH GASSING CURRENT EFFECTS

Proforma: Electrical\Batteries\With Gassing Current Effects\Type185.tmf
TRNSYS Model: Type 185
TYPE185 is a quasi-static mathematical model of lead-acid battery, or Pb-accumulator. The model uses a simple equivalent circuit that relates the electrical currents, voltages, resistance (related to the concentration-overvoltage), and capacity. The main features of the model include gassing current losses, polarization effects (during charging and discharging), and calculation of equilibrium voltage at various states of charge (Saupe, 1993; Ulleberg, 1998).

3.4.2.2. Busbar

AC-BUSBAR

Proforma: Electrical\Busbar\AC-busbar\Type188a.tmf
TRNSYS Model: Type 188
This subroutine performs the energy balance calculations for a mini-grid for a renewable energy (RE) hydrogen (H2) storage system, where wind and solar (PV) energy are the primary sources and an electrolyzer and a fuel cell are the main power components of the H2-storage system.

3.4.2.3. Diesel Engine (DEGS)

DEGS DISPATCH CONTROLLER

Proforma: Electrical\Diesel Engine (DEGS)\DEGS Dispatch Controller\Type102a.tmf
TRNSYS Model: Type 102
This subroutine contains the control functions for one or several diesel engine generator sets (DEGS) operating in decentralized power mini-grids. TYPE102 determines the total number of DEGS and the power per DEGS required to meet a given load. In this model, all of the DEGS are assumed to be identical and the maximum number of DEGS that can be handled by the controller is limited to 5.

GENERIC MODEL

Proforma: Electrical\Diesel Engine (DEGS)\Generic Model\Type120a.tmf
TRNSYS Model: Type 120
<p>TYPE120 is a mathematical model for a diesel engine generator set (DEGS). The model is based on an empirical relation (1st order polynomial) for the fuel consumption expressed as a function of the electrical power output (normalized). Electrical and fuel efficiencies are both calculated. In this instance, Type120 is used to predict the performance of a generic DEGS in the power range 5-500 kW. The generic model extrapolates from a reference fuel efficiency curve (average of 5 different DEGS). The generic model incorporates a correction factor derived from actual data measurements on DEGS for 20 remote area power systems (RAPS) with average operating powers in the range 5-186 kW (Lloyd, 1999). The default fuel is diesel (liquid), but a database with fuel properties (Adler et al., 1986; McCarthy, 1982) included in TYPE120 make it possible to calculate the equivalent fuel flow rates (liquid or gas) for 5 alternative fuels: liquefied gas (LPG), propane (C3H8), methane (CH4), natural gas, or hydrogen (H2).</p>

SPECIFIC DEGS

Proforma: Electrical\Diesel Engine (DEGS)\Specific DEGS\Type120b.tmf
TRNSYS Model: Type 120
<p>TYPE120 is a mathematical model for a diesel engine generator set (DEGS). The model is based on an empirical relation (1st order polynomial) for the fuel consumption expressed as a function of the electrical power output (normalized). Electrical and fuel efficiencies are both calculated. In this instance, Type120 can be used to predict the performance of a specific DEGS, provided a fuel consumption curve is supplied.</p>

3.4.2.4. Photovoltaic Panels

PV MODULE WITH 5-PARAMETERS MODEL

Proforma: Electrical\Photovoltaic Panels\5-Parameter Model\Type194.tmf
TRNSYS Model: Type 194
<p>This component determines the electrical performance of a photovoltaic array. The model is based on the calculation method presented by DeSoto et al (2005). Type 194 may be used in simulations involving electrical storage batteries, direct load coupling, and utility grid connections. The model determines the current and power of the array at a specified voltage. Other OUTPUTS include current and voltage at the maximum power point.</p> <p>Notes: Parameters 1-8 are not currently used. These parameters are needed to calculate the five reference parameters provided in parameters 18-22. This version of the model assumes that the reference parameters have been determined and appropriate numerical values are provided. An EES program is available to do these calculations</p> <p>Plugin use:</p> <ol style="list-style-type: none"> 1. Click on the icon on the lower left corner. 2. Enter the required parameters in the application. 3. Press 'Calculate'. 4. Use the results to specify Parameters 18 - 22.

CRYSTALLINE MODULES

Proforma: Electrical\Photovoltaic Panels\Crystalline Modules\Type94a.tmf
TRNSYS Model: Type 94
<p>In this mode of Type94, the slope of the IV characteristic at the short circuit current point is positive, effectively modeling single or polycrystalline silicon photovoltaic panels.</p> <p>This component models the electrical performance of a photovoltaic array. TYPE 94 may be used in simulations involving electrical storage batteries, direct load coupling, and utility grid connections. It employs equations for an empirical equivalent circuit model to predict the current-voltage characteristics of a single module. This circuit consists of a DC current source, diode, and either one or two resistors. The strength of the current source is dependent on solar radiation and the IV characteristics of the diode are temperature-dependent. The results for a single module equivalent circuit are extrapolated to predict the performance of a multi-module array.</p> <p>For crystalline modules (either single crystal or polycrystalline technology), TYPE 94 employs a "four-parameter" equivalent circuit. The values of these parameters (not to be confused with formal component PARAMETERS in TRNSYS) cannot be obtained directly from manufacturers' catalogs. However, TYPE 94 will automatically calculate them from available data. A second equivalent circuit model involving five mathematical parameters is available for amorphous/thin-film PV modules. Again, the component will determine these values from manufactures' catalog data. TYPE 94 also includes an optional incidence angle modifier correlation to calculate how the reflectance of the PV module surface varies with the angle of incidence of solar radiation.</p> <p>TYPE 94 determines PV current as a function of load voltage. Other OUTPUTS include current and voltage at the maximum power point along the IV curve, open-circuit voltage, and short circuit current.</p>

PV-THERMAL COLLECTORS - CONCENTRATING COLLECTORS - CONSTANT LOSSES - CELL OPERATING V IS INPUT

Proforma: Electrical\Photovoltaic Panels\PV-Thermal Collectors\Concentrating Collectors\Constant Losses\Cell Operating V is input\Type50g.tmf
TRNSYS Model: Type 50
<p>This Type a supplement to the TRNSYS Type1 (Solar collector), adding a PV module to the standard flat-plate collector. It simulates a combined collector and incorporates both the analysis and work of Florschuetz for flat plate collectors operated at peak power, and an analysis given in a report of the Arizona State University, for concentrating combined collectors. The latter analysis makes use of the I-V curves of the cells (or array) in solving for peak power or for current output at some imposed voltage.</p> <p>Modes 1 to 4 are used to model flat-plate collectors and provide an increasing level of complexity in the losses calculation.</p> <p>Modes 5 to 8 are used to model concentrating collectors.</p> <p>This proforma corresponds to Mode 7.</p>

PV-THERMAL COLLECTORS - CONCENTRATING COLLECTORS - CONSTANT LOSSES - NO CELL OPERATING VOLTAGE

Proforma: Electrical\Photovoltaic Panels\PV-Thermal Collectors\Concentrating Collectors\Constant Losses\No cell operating voltage\Type50e.tmf
TRNSYS Model: Type 50
<p>This Type a supplement to the TRNSYS Type1 (Solar collector), adding a PV module to the standard flat-plate collector. It simulates a combined collector and incorporates both the analysis and work of Florschuetz for flat plate collectors operated at peak power, and an analysis given in a report of the Arizona State University, for concentrating combined collectors. The latter analysis makes use of the I-V curves of the cells (or array) in solving for peak power or for current output at some imposed voltage.</p> <p>Modes 1 to 4 are used to model flat-plate collectors and provide an increasing level of complexity in the losses calculation.</p> <p>Modes 5 to 8 are used to model concentrating collectors.</p>

This proforma corresponds to Mode 5.

PV-THERMAL COLLECTORS - CONCENTRATING COLLECTORS - TOP LOSS F(WIND, TEMP) - CELL OPERATING VOLTAGE IS INPUT

Proforma: Electrical\Photovoltaic Panels\PV-Thermal Collectors\Concentrating Collectors\Top Loss f(Wind, Temp)\Cell operating voltage is input\Type50h.tmf

TRNSYS Model: Type 50

This Type a supplement to the TRNSYS Type1 (Solar collector), adding a PV module to the standard flat-plate collector. It simulates a combined collector and incorporates both the analysis and work of Florschuetz for flat plate collectors operated at peak power, and an analysis given in a report of the Arizona State University, for concentrating combined collectors. The latter analysis makes use of the I-V curves of the cells (or array) in solving for peak power or for current output at some imposed voltage.
 Modes 1 to 4 are used to model flat-plate collectors and provide an increasing level of complexity in the losses calculation.
 Modes 5 to 8 are used to model concentrating collectors.
 This proforma corresponds to Mode 8.

PV-THERMAL COLLECTORS - CONCENTRATING COLLECTORS - TOP LOSS F(WIND, TEMP) - NO CELL OPERATING VOLTAGE

Proforma: Electrical\Photovoltaic Panels\PV-Thermal Collectors\Concentrating Collectors\Top Loss f(Wind, Temp)\No cell operating voltage\Type50f.tmf

TRNSYS Model: Type 50

This Type a supplement to the TRNSYS Type1 (Solar collector), adding a PV module to the standard flat-plate collector. It simulates a combined collector and incorporates both the analysis and work of Florschuetz for flat plate collectors operated at peak power, and an analysis given in a report of the Arizona State University, for concentrating combined collectors. The latter analysis makes use of the I-V curves of the cells (or array) in solving for peak power or for current output at some imposed voltage.
 Modes 1 to 4 are used to model flat-plate collectors and provide an increasing level of complexity in the losses calculation.
 Modes 5 to 8 are used to model concentrating collectors.
 This proforma corresponds to Mode 6.

PV-THERMAL COLLECTORS - FLAT PLATE COLLECTORS - ANGULAR DEPENDENCE OF TRANSMITTANCE

Proforma: Electrical\Photovoltaic Panels\PV-Thermal Collectors\Flat Plate Collectors\Angular dependence of Transmittance\Type50c.tmf

TRNSYS Model: Type 50

This Type a supplement to the TRNSYS Type1 (Solar collector), adding a PV module to the standard flat-plate collector. It simulates a combined collector and incorporates both the analysis and work of Florschuetz for flat plate collectors operated at peak power, and an analysis given in a report of the Arizona State University, for concentrating combined collectors. The latter analysis makes use of the I-V curves of the cells (or array) in solving for peak power or for current output at some imposed voltage.
 Modes 1 to 4 are used to model flat-plate collectors and provide an increasing level of complexity in the losses calculation.
 Modes 5 to 8 are used to model concentrating collectors.
 This proforma corresponds to Mode 3.

PV-THERMAL COLLECTORS - FLAT PLATE COLLECTORS - CONSTANT LOSSES

Proforma: Electrical\Photovoltaic Panels\PV-Thermal Collectors\Flat Plate Collectors\Constant Losses\Type50a.tmf
TRNSYS Model: Type 50
<p>This Type a supplement to the TRNSYS Type1 (Solar collector), adding a PV module to the standard flat-plate collector. It simulates a combined collector and incorporates both the analysis and work of Florschuetz for flat plate collectors operated at peak power, and an analysis given in a report of the Arizona State University, for concentrating combined collectors. The latter analysis makes use of the I-V curves of the cells (or array) in solving for peak power or for current output at some imposed voltage.</p> <p>Modes 1 to 4 are used to model flat-plate collectors and provide an increasing level of complexity in the losses calculation.</p> <p>Modes 5 to 8 are used to model concentrating collectors.</p> <p>This proforma corresponds to Mode 1: constant loss coefficient (UL) and transmission coefficient (to).</p>

PV-THERMAL COLLECTORS - FLAT PLATE COLLECTORS - LOSS=F(T,WS,G) AND T=F(ANGLE)

Proforma: Electrical\Photovoltaic Panels\PV-Thermal Collectors\Flat Plate Collectors\Loss=f(T,WS,G) and t=f(angle)\Type50d.tmf
TRNSYS Model: Type 50
<p>This Type a supplement to the TRNSYS Type1 (Solar collector), adding a PV module to the standard flat-plate collector. It simulates a combined collector and incorporates both the analysis and work of Florschuetz for flat plate collectors operated at peak power, and an analysis given in a report of the Arizona State University, for concentrating combined collectors. The latter analysis makes use of the I-V curves of the cells (or array) in solving for peak power or for current output at some imposed voltage.</p> <p>Modes 1 to 4 are used to model flat-plate collectors and provide an increasing level of complexity in the losses calculation.</p> <p>Modes 5 to 8 are used to model concentrating collectors.</p> <p>This proforma corresponds to Mode 4.</p>

PV-THERMAL COLLECTORS - FLAT PLATE COLLECTORS - LOSSES=F(TEMP, WIND, GEOMETRY)

Proforma: Electrical\Photovoltaic Panels\PV-Thermal Collectors\Flat Plate Collectors\Losses=f(Temp, wind, geometry)\Type50b.tmf
TRNSYS Model: Type 50
<p>This Type a supplement to the TRNSYS Type1 (Solar collector), adding a PV module to the standard flat-plate collector. It simulates a combined collector and incorporates both the analysis and work of Florschuetz for flat plate collectors operated at peak power, and an analysis given in a report of the Arizona State University, for concentrating combined collectors. The latter analysis makes use of the I-V curves of the cells (or array) in solving for peak power or for current output at some imposed voltage.</p> <p>Modes 1 to 4 are used to model flat-plate collectors and provide an increasing level of complexity in the losses calculation.</p> <p>Modes 5 to 8 are used to model concentrating collectors.</p> <p>This proforma corresponds to Mode 2: the thermal loss coefficient of the collector is calculated as a function of the operating temperatures, windspeed and collector construction details.</p>

THIN FILM MODULES

Proforma: Electrical\Photovoltaic Panels\Thin Film Modules\Type94b.tmf
TRNSYS Model: Type 94
<p>In this mode of Type94, the slope of the IV characteristic at the short circuit current point is negative, effectively modeling a thin film or amorphous silicon photovoltaic panel.</p> <p>This component models the electrical performance of a photovoltaic array. TYPE 94 may be used in simulations involving electrical storage batteries, direct load coupling, and utility grid connections. It employs equations for an empirical equivalent circuit model to predict the current-voltage characteristics of a single module. This circuit consists of a DC current source, diode, and either one or two resistors. The strength of the current source is dependent on solar radiation and the IV characteristics of the diode are temperature-dependent. The results for a single module equivalent circuit are extrapolated to predict the performance of a multi-module array.</p> <p>For crystalline modules (either single crystal or polycrystalline technology), TYPE 94 employs a "four-parameter" equivalent circuit. The values of these parameters (not to be confused with formal component PARAMETERS in TRNSYS) cannot be obtained directly from manufacturers' catalogs. However, TYPE 94 will automatically calculate them from available data. A second equivalent circuit model involving five mathematical parameters is available for amorphous/thin-film PV modules. Again, the component will determine these values from manufactures' catalog data. TYPE 94 also includes an optional incidence angle modifier correlation to calculate how the reflectance of the PV module surface varies with the angle of incidence of solar radiation.</p> <p>TYPE 94 determines PV current as a function of load voltage. Other OUTPUTS include current and voltage at the maximum power point along the IV curve, open-circuit voltage, and short circuit current.</p>

WITH DATA FILE - MPPT=OFF - TCMODE=1

Proforma: Electrical\Photovoltaic Panels\With Data File\MPPT=OFF\TCMODE=1\Type180b.tmf
TRNSYS Model: Type 180
<p>TYPE180 is a mathematical model for a photovoltaic (PV) generator, based on an equivalent circuit of a one-diode model. The model is primarily intended for PV-arrays consisting of silicon cells, but can also be used for other types of materials. The electrical model used in is described in (Duffie and Beckman, 1991).</p> <p>A dynamic thermal model has also been included (Ulleberg, 1997; 1998). In this instance of Type180, the PV array is assumed NOT to include a maximum power point tracker. The temperature of the PV-array is supplied by the user as an input.</p>

WITH DATA FILE - MPPT=OFF - TCMODE=2

Proforma: Electrical\Photovoltaic Panels\With Data File\MPPT=OFF\TCMODE=2\Type180d.tmf
TRNSYS Model: Type 180
<p>TYPE180 is a mathematical model for a photovoltaic (PV) generator, based on an equivalent circuit of a one-diode model. The model is primarily intended for PV-arrays consisting of silicon cells, but can also be used for other types of materials. The electrical model used in is described in (Duffie and Beckman, 1991).</p> <p>A dynamic thermal model has also been included (Ulleberg, 1997; 1998). In this instance of Type180, the PV array is assumed NOT to include a maximum power point tracker. The temperature of the PV-array is calculated based on an overall heat loss coefficient (UL) determined from performance at NOCT (Nominal Operating Cell Temperature).</p>

WITH DATA FILE - MPPT=OFF - TCMODE=3

Proforma: Electrical\Photovoltaic Panels\With Data File\MPPT=OFF\TCMODE=3\Type180f.tmf
TRNSYS Model: Type 180
<p>TYPE180 is a mathematical model for a photovoltaic (PV) generator, based on an equivalent circuit of a one-diode model. The model is primarily intended for PV-arrays consisting of silicon cells, but can also be used</p>

for other types of materials. The electrical model used in is described in (Duffie and Beckman, 1991). A dynamic thermal model has also been included (Ulleberg, 1997; 1998). In this instance of Type180, the PV array is assumed NOT to include a maximum power point tracker. The temperature of the PV-array is calculated based on an overall heat loss coefficient (UL) and the thermal capacitance (CT) of the PV-array (usually determined from experiments).

WITH DATA FILE - MPPT=ON - TCMODE=1

Proforma: Electrical\Photovoltaic Panels\With Data File\MPPT=ON\TCMODE=1\Type180a.tmf
TRNSYS Model: Type 180
TYPE180 is a mathematical model for a photovoltaic (PV) generator, based on an equivalent circuit of a one-diode model. The model is primarily intended for PV-arrays consisting of silicon cells, but can also be used for other types of materials. The electrical model used in is described in (Duffie and Beckman, 1991). A dynamic thermal model has also been included (Ulleberg, 1997; 1998). In this instance of Type180, the PV array is assumed to include a maximum power point tracker. The temperature of the PV-array is supplied by the user as an input.

WITH DATA FILE - MPPT=ON - TCMODE=2

Proforma: Electrical\Photovoltaic Panels\With Data File\MPPT=ON\TCMODE=2\Type180c.tmf
TRNSYS Model: Type 180
TYPE180 is a mathematical model for a photovoltaic (PV) generator, based on an equivalent circuit of a one-diode model. The model is primarily intended for PV-arrays consisting of silicon cells, but can also be used for other types of materials. The electrical model used in is described in (Duffie and Beckman, 1991). A dynamic thermal model has also been included (Ulleberg, 1997; 1998). In this instance of Type180, the PV array is assumed to include a maximum power point tracker. The temperature of the PV-array is calculated based on an overall heat loss coefficient (UL) determined from performance at NOCT (Nominal Operating Cell Temperature).

WITH DATA FILE - MPPT=ON - TCMODE=3

Proforma: Electrical\Photovoltaic Panels\With Data File\MPPT=ON\TCMODE=3\Type180e.tmf
TRNSYS Model: Type 180
TYPE180 is a mathematical model for a photovoltaic (PV) generator, based on an equivalent circuit of a one-diode model. The model is primarily intended for PV-arrays consisting of silicon cells, but can also be used for other types of materials. The electrical model used in is described in (Duffie and Beckman, 1991). A dynamic thermal model has also been included (Ulleberg, 1997; 1998). In this instance of Type180, the PV array is assumed to include a maximum power point tracker. The temperature of the PV-array is calculated based on an overall heat loss coefficient (UL) and the thermal capacitance (CT) of the PV-array (usually determined from experiments).

3.4.2.5. Power Conditioning

POWER INPUT IS KNOWN

Proforma: Electrical\Power Conditioning\Power INPUT is known\Type175a.tmf
TRNSYS Model: Type 175

TYPE175 is a mathematical model for a power conditioning unit. The model is based on empirical efficiency curves for electrical converters (DC/DC) or inverters (DC/AC or AC/DC). The empirical relationship used in TYPE175 was first proposed by (Laukamp, 1988) and further improved by (Ulleberg, 1998). In this instance of Type175, it is assumed that the available input power is known. Corresponding output power is calculated.

POWER OUTPUT IS KNOWN

Proforma: Electrical\Power Conditioning\Power OUTPUT is known\Type175b.tmf

TRNSYS Model: Type 175

TYPE175 is a mathematical model for a power conditioning unit. The model is based on empirical efficiency curves for electrical converters (DC/DC) or inverters (DC/AC or AC/DC). The empirical relationship used in TYPE175 was first proposed by (Laukamp, 1988) and further improved by (Ulleberg, 1998). In this instance of Type175, it is assumed that the required output power is known. Corresponding input power is calculated.

3.4.2.6. Regulators and Inverters

SYSTEM W_ BATTERY STORAGE - ARRAY V = BATTERY V

Proforma: Electrical\Regulators and Inverters\System w_ battery storage\Array V = Battery V\Type48d.tmf

TRNSYS Model: Type 48

In photovoltaic power systems, two power conditioning devices are needed. The first of these is a regulator, which distributes DC power from the solar cell array to and from a battery (in systems with energy storage) and to the second component, the inverter. If the battery is fully charged or needs only a taper charge, excess power is either dumped or not collected by turning off parts of the array. The inverter converts the DC power to AC and sends it to the load and/or feeds it back to the utility.

TYPE 48 models both the regulator and inverter, and can operate in one of four modes. Modes 0 and 3 are based upon the "no battery/feedback system" and "direct charge system," respectively. Modes 1 and 2 are modifications of the "parallel maximum power tracker system" in the same reference.

This proforma corresponds to Mode 3: Collector voltage equal to battery voltage, current instead of power distribution, monitoring of battery state of charge and voltage.

SYSTEM W_ BATTERY STORAGE - MPP TRACKING - SOC AND SOV MONITORING

Proforma: Electrical\Regulators and Inverters\System w_ battery storage\MPP Tracking\SOC and SOV monitoring\Type48c.tmf

TRNSYS Model: Type 48

In photovoltaic power systems, two power conditioning devices are needed. The first of these is a regulator, which distributes DC power from the solar cell array to and from a battery (in systems with energy storage) and to the second component, the inverter. If the battery is fully charged or needs only a taper charge, excess power is either dumped or not collected by turning off parts of the array. The inverter converts the DC power to AC and sends it to the load and/or feeds it back to the utility.

TYPE 48 models both the regulator and inverter, and can operate in one of four modes. Modes 0 and 3 are based upon the "no battery/feedback system" and "direct charge system," respectively. Modes 1 and 2 are modifications of the "parallel maximum power tracker system" in the same reference.

This proforma corresponds to Mode 2: Peak-power tracking collector, battery, monitoring of battery state of charge and voltage

SYSTEM W_ BATTERY STORAGE - MPP TRACKING - SOC MONITORING ONLY

Proforma: Electrical\Regulators and Inverters\System w_ battery storage\MPP Tracking\SOC monitoring only\Type48b.tmf
TRNSYS Model: Type 48
<p>In photovoltaic power systems, two power conditioning devices are needed. The first of these is a regulator, which distributes DC power from the solar cell array to and from a battery (in systems with energy storage) and to the second component, the inverter. If the battery is fully charged or needs only a taper charge, excess power is either dumped or not collected by turning off parts of the array. The inverter converts the DC power to AC and sends it to the load and/or feeds it back to the utility.</p> <p>TYPE 48 models both the regulator and inverter, and can operate in one of four modes. Modes 0 and 3 are based upon the "no battery/feedback system" and "direct charge system," respectively. Modes 1 and 2 are modifications of the "parallel maximum power tracker system" in the same reference.</p> <p>This proforma corresponds to Mode 1: Peak-power tracking collector, battery, monitoring of state of charge.</p>

SYSTEM W_ O BATTERY STORAGE

Proforma: Electrical\Regulators and Inverters\System w_o battery storage\Type48a.tmf
TRNSYS Model: Type 48
<p>In photovoltaic power systems, two power conditioning devices are needed. The first of these is a regulator, which distributes DC power from the solar cell array to and from a battery (in systems with energy storage) and to the second component, the inverter. If the battery is fully charged or needs only a taper charge, excess power is either dumped or not collected by turning off parts of the array. The inverter converts the DC power to AC and sends it to the load and/or feeds it back to the utility.</p> <p>TYPE 48 models both the regulator and inverter, and can operate in one of four modes. Modes 0 and 3 are based upon the "no battery/feedback system" and "direct charge system," respectively. Modes 1 and 2 are modifications of the "parallel maximum power tracker system" in the same reference.</p> <p>This proforma corresponds to Mode 0: Peak-power tracking collector, no battery, power is feedback to a utility.</p>

3.4.2.7. Wind Turbines

WIND TURBINES

Proforma: Electrical\Wind Turbines\Type90.tmf
TRNSYS Model: Type 90
<p>Type 90 is a mathematical model for a wind energy conversion system (WECS).The model calculates the power output of a WECS based on a power versus wind speed characteristic (provided on table form in an external file). The impact of air density changes and wind speed increases with height is also modeled. The main equations used in this model is based on the work of (Quinlan, 2000; Quinlan et al., 1996).</p>

3.4.3. Heat Exchangers

3.4.3.1. Constant Effectiveness

CONSTANT EFFECTIVENESS

Proforma: Heat Exchangers\Constant Effectiveness\Type91.tmf
TRNSYS Model: Type 91
A zero capacitance sensible heat exchanger is modelled as a constant effectiveness device which is independent of the system configuration. For the constant effectiveness mode, the maximum possible heat transfer is calculated based on the minimum capacity rate fluid and the cold side and hot side fluid inlet temperatures. In this mode the effectiveness is input as a parameter and the concept of an overall heat transfer coefficient for the heat exchanger is not used.

3.4.3.2. Counter Flow

COUNTER FLOW

Proforma: Heat Exchangers\Counter Flow\Type5b.tmf
TRNSYS Model: Type 5
A zero capacitance sensible heat exchanger is modelled in various configurations. In this instance, a counter flow heat exchanger is modeled. Given the hot and cold side inlet temperatures and flow rates, the effectiveness is calculated for a given fixed value of the overall heat transfer coefficient.

3.4.3.3. Cross Flow

BOTH FLUIDS MIXED

Proforma: Heat Exchangers\Cross Flow\Both Fluids Mixed\Type5f.tmf
TRNSYS Model: Type 5
A zero capacitance sensible heat exchanger is modelled in various configurations. In this instance a cross flow heat exchanger with both hot (source) and cold (load) side mixed is modeled. Given the hot and cold side inlet temperatures and flow rates, the effectiveness is calculated for a given fixed value of the overall heat transfer coefficient.

BOTH FLUIDS UNMIXED

Proforma: Heat Exchangers\Cross Flow\Both Fluids Unmixed\Type5e.tmf
TRNSYS Model: Type 5
A zero capacitance sensible heat exchanger is modelled in various configurations. In this instance a cross flow heat exchanger with both hot (source) and cold (load) side unmixed is modeled. Given the hot and cold side inlet

temperatures and flow rates, the effectiveness is calculated for a given fixed value of the overall heat transfer coefficient.

COLD SIDE MIXED

Proforma: Heat Exchangers\Cross Flow\Cold Side Mixed\Type5c.tmf

TRNSYS Model: Type 5

A zero capacitance sensible heat exchanger is modelled in various configurations. In this instance a cross flow heat exchanger with cold (load) side mixed is modeled. Given the hot and cold side inlet temperatures and flow rates, the effectiveness is calculated for a given fixed value of the overall heat transfer coefficient.

HOT SIDE MIXED

Proforma: Heat Exchangers\Cross Flow\Hot Side Mixed\Type5d.tmf

TRNSYS Model: Type 5

A zero capacitance sensible heat exchanger is modelled in various configurations. In this instance a cross flow heat exchanger with hot (source) side mixed is modeled. Given the hot and cold side inlet temperatures and flow rates, the effectiveness is calculated for a given fixed value of the overall heat transfer coefficient.

3.4.3.4. Parallel Flow

PARALLEL FLOW

Proforma: Heat Exchangers\Parallel Flow\Type5a.tmf

TRNSYS Model: Type 5

A zero capacitance sensible heat exchanger is modelled in various configurations. In this instance, a parallel flow heat exchanger is modeled. Given the hot and cold side inlet temperatures and flow rates, the effectiveness is calculated for a given fixed value of the overall heat transfer coefficient.

3.4.3.5. Shell and Tube

SHELL AND TUBE

Proforma: Heat Exchangers\Shell and Tube\Type5g.tmf

TRNSYS Model: Type 5

A zero capacitance sensible heat exchanger is modelled in various configurations. In this instance a shell and tube device is modeled. Given the hot and cold side inlet temperatures and flow rates, the effectiveness is calculated for a given fixed value of the overall heat transfer coefficient.

3.4.3.6. Waste Heat Recovery

WASTE HEAT RECOVERY

Proforma: Heat Exchangers\Waste Heat Recovery\Type17.tmf

TRNSYS Model: Type 17

This component models a cascaded waste heat recovery system (WHR). Energy recovery may occur through up to 5 secondary heat exchangers and be delivered across a single primary heat exchanger. Optionally, some secondary heat exchangers may deliver, rather than recover energy. The analysis used for each heat exchanger is identical to that of the TYPE 5 component. The user is referred to the TYPE 5 documentation for description of the four possible heat-exchanger modes and the mathematical analysis.

The TYPE 17 iteratively solves the system of equations representing the heat exchangers. Convergence is assumed when the outlet temperature of the hot side of the primary heat exchanger, changes between successive iterations by less than a user specified amount, TOL. If convergence is not attained within NSTICK iterations, any oscillating controlled pumps are turned off. There are three possible control strategies for the primary and secondary heat exchangers as follows. 1) NO CONTROL - Energy is transferred into or out of the WHR loop, 2) ENERGY RECOVERY - Energy is transferred into the WHR loop, and 3) ENERGY DELIVERY - Energy is transferred from the WHR loop. At the end of the simulation, summaries of the percentages of timesteps that NSTICK was exceeded and that convergence was not attained in NSTICK+5 iterations is printed.

3.4.4. HVAC

3.4.4.1. Absorption Chiller (Hot-Water Fired, Single Effect)

ABSORPTION CHILLER (HOT-WATER FIRED, SINGLE EFFECT)

Proforma: HVAC\Absorption Chiller (Hot-Water Fired, Single Effect)\Type107.tmf
TRNSYS Model: Type 107
Type107 uses a normalized catalog data lookup approach to model a single-effect hot-water fired absorption chiller. "Hot Water-Fired" indicates that the energy supplied to the machine's generator comes from a hot water stream. Because the data files are normalized, the user may model any size chiller using a given set of data files. Example files are provided.

3.4.4.2. Auxiliary Cooling Unit

AUXILIARY COOLING UNIT

Proforma: HVAC\Auxiliary Cooling Unit\Type92.tmf
TRNSYS Model: Type 92
An auxiliary cooling device is modeled to reduce the temperature of a flowstream using either internal control, external control or a combination of both types of control. The cooling device is designed to remove energy from the flowstream at a user-designated rate (Q_{max}) whenever the external control input is equal to one and the cooling device outlet temperature is less than a user-specified maximum (T_{set}). By specifying a constant value of the control function of one and specifying a sufficiently large value of Q_{max} , this routine will perform like a domestic cold water auxiliary with internal control to maintain an outlet temperature of T_{set} . By providing a control function of zero or one from a thermostat or controller, this routine will perform like a device removing energy at a rate of Q_{max} but not dropping below an outlet temperature of T_{set} . In this application, a constant outlet temperature is not sought and T_{set} may be thought of as an arbitrary safety limit.

3.4.4.3. Auxiliary Heaters

AUXILIARY HEATERS

Proforma: HVAC\Auxiliary Heaters\Type6.tmf
TRNSYS Model: Type 6
An auxiliary heater is modeled to elevate the temperature of a flowstream using either internal control, external control or a combination of both types of control. The heater is designed to add heat to the flowstream at a user-designated rate (Q_{max}) whenever the external control input is equal to one and the heater outlet temperature is less than a user-specified maximum (T_{set}). By specifying a constant value of the control function of one and specifying a sufficiently large value of Q_{max} , this routine will perform like a domestic hot water auxiliary with internal control to maintain an outlet temperature of T_{set} . By providing a control function of zero or one from a thermostat or controller, this routine will perform like a furnace adding heat at a rate of Q_{max} but not

exceeding an outlet temperature of T_{set} . In this application, a constant outlet temperature is not sought and T_{set} may be thought of as an arbitrary safety limit.

3.4.4.4. Conditioning Equipment

1 INDEPENDENT VARIABLE

Proforma: HVAC\Conditioning Equipment\1 Independent Variable\Type42c.tmf

TRNSYS Model: Type 42

This component models any piece of equipment whose performance can be characterized in terms of one independent variables and between 1 and 5 dependent performance variables. Examples include an ambient source heat pump whose heating capacity and COP depend only on the outdoor air temperature. Equipment performance is determined from user-supplied steady-state data. Reduced performance associated with frequent cycling or other means of controlling capacity are not considered. These effects can be accounted for through the use of the TYPE 43 Part Load Performance component. The equipment is controlled by a single control input, Y. The values of the dependent variables output by this component are just the product of each performance variable evaluated at the current conditions and the control function. If Y is 0, then all outputs are 0. If Y is 1, then the outputs are the interpolated values from the user supplied data. The equipment performance data is read and interpolated using the standard TRNSYS Data Reading routine.

2 INDEPENDENT VARIABLES

Proforma: HVAC\Conditioning Equipment\2 Independent Variables\Type42b.tmf

TRNSYS Model: Type 42

This component models any piece of equipment whose performance can be characterized in terms of two independent variables and between 1 and 5 dependent performance variables. Examples include an air conditioner whose cooling capacity and COP depend upon the ambient temperature and humidity. Equipment performance is determined from user-supplied steady-state data. Reduced performance associated with frequent cycling or other means of controlling capacity are not considered. These effects can be accounted for through the use of the TYPE 43 Part Load Performance component. The equipment is controlled by a single control input, Y. The values of the dependent variables output by this component are just the product of each performance variable evaluated at the current conditions and the control function. If Y is 0, then all outputs are 0. If Y is 1, then the outputs are the interpolated values from the user supplied data. The equipment performance data is read and interpolated using the standard TRNSYS Data Reading routine.

3 INDEPENDENT VARIABLES

Proforma: HVAC\Conditioning Equipment\3 Independent Variables\Type42a.tmf

TRNSYS Model: Type 42

This component models any piece of equipment whose performance can be characterized in terms of three independent variables and between 1 and 5 dependent performance variables. Examples include a chemical heat pump whose performance is characterized in terms of generator, evaporator, and condenser conditions. Equipment performance is determined from user-supplied steady-state data. Reduced performance associated with frequent cycling or other means of controlling capacity are not considered. These effects can be accounted for through the use of the TYPE 43 Part Load Performance component. The equipment is controlled by a single control input, Y. The values of the dependent variables output by this component are just the product of each performance variable evaluated at the current conditions and the control function. If Y is 0, then all outputs are 0. If Y is 1, then the outputs are the interpolated values from the user

supplied data. The equipment performance data is read and interpolated using the standard TRNSYS Data Reading routine.

3.4.4.5. Cooling Coils

DETAILED - ANNULAR FINS

Proforma: HVAC\Cooling Coils\Detailed\Annular Fins\Type52a.tmf

TRNSYS Model: Type 52

This component models the performance of a dehumidifying cooling coil using the effectiveness model outlined by Braun. The user must specify the geometry of the cooling coil and air duct. In this instance of Type52, annular fins are specified. The model does not account for ice formation on the coils during icing conditions. Either a simple or detailed level of analysis may be chosen by the user. The level of detail determines the method used in modeling a coil operating under partially wet and dry conditions. In the detailed analysis a separate analysis is used for each of the dry and wet portions of the coil. In the simple level of analysis, the partially dry and wet coil is assumed to be either all wet or all dry. This is explained further in the mathematical description. The simple analysis provides a faster calculation of coil performance with normally only a small decrease in accuracy.

DETAILED - RECTANGULAR FINS

Proforma: HVAC\Cooling Coils\Detailed\Rectangular Fins\Type52b.tmf

TRNSYS Model: Type 52

This component models the performance of a dehumidifying cooling coil using the effectiveness model outlined by Braun. The user must specify the geometry of the cooling coil and air duct. In this instance of Type52, continuous flat plate fins are specified. The model does not account for ice formation on the coils during icing conditions. Either a simple or detailed level of analysis may be chosen by the user. The level of detail determines the method used in modeling a coil operating under partially wet and dry conditions. In the detailed analysis a separate analysis is used for each of the dry and wet portions of the coil. In the simple level of analysis, the partially dry and wet coil is assumed to be either all wet or all dry. This is explained further in the mathematical description. The simple analysis provides a faster calculation of coil performance with normally only a small decrease in accuracy.

SIMPLIFIED

Proforma: HVAC\Cooling Coils\Simplified\Type32.tmf

TRNSYS Model: Type 32

This component models the performance of a chilled water cooling coil. It may be used with a component that calculates a total cooling capacity, such as the TYPE 42 Conditioning Equipment, and a component which models a space to be cooled, such as the TYPE 19 Zone. Its purpose is to separate the cooling input into sensible (temperature) and latent (humidity) effects. The analysis is based upon empirical relationships taken from an ASHRAE publication (1). Note that TYPE 52 is a more sophisticated cooling coil model.

3.4.4.6. Cooling Towers

EXTERNAL PERFORMANCE FILE

Proforma: HVAC\Cooling Towers\External Performance File\Type51a.tmf

TRNSYS Model: Type 51

In a cooling tower, a hot water stream is in direct contact with an air stream and cooled as a result of sensible heat transfer due to temperature differences with the air and mass transfer resulting from evaporation to the air. The air and water streams may be configured in either counterflow or crossflow arrangements. Ambient air is drawn upward through the falling water. Most towers contain a fill material which increases the water surface area in contact with the air. A cooling tower is usually composed of several tower cells that are in parallel and share a common sump. Water loss from the tower cells is replaced with make-up water to the sump. This component models the performance of a multiple-cell counterflow or crossflow cooling tower and sump. There are two primary modes for this model. In this instance (MODE 2), the user enters overall performance data for the cooling tower and the model determines the parameters c and n that provide a best fit to the data in a least-squares sense. Values for c and n are output and can be used in subsequent simulations instead of the program recalculating them.

USER-SUPPLIED COEFFICIENTS

Proforma: HVAC\Cooling Towers\User-Supplied Coefficients\Type51b.tmf

TRNSYS Model: Type 51

In a cooling tower, a hot water stream is in direct contact with an air stream and cooled as a result of sensible heat transfer due to temperature differences with the air and mass transfer resulting from evaporation to the air. The air and water streams may be configured in either counterflow or crossflow arrangements. Ambient air is drawn upward through the falling water. Most towers contain a fill material which increases the water surface area in contact with the air. A cooling tower is usually composed of several tower cells that are in parallel and share a common sump. Water loss from the tower cells is replaced with make-up water to the sump. This component models the performance of a multiple-cell counterflow or crossflow cooling tower and sump. There are two primary modes for this model. In this instance (MODE 1) the user enters the coefficients of the mass transfer correlation, c and n . Although this data is difficult to obtain, the ASHRAE Equipment Guide (1) and Simpson and Sherwood (2) give some typical data.

3.4.4.7. Dual Source Heat Pumps

DUAL SOURCE HEAT PUMPS

Proforma: HVAC\Dual Source Heat Pumps\Type20.tmf

TRNSYS Model: Type 20

This component models the performance of a heat pump having two evaporators; a liquid source to utilize heat from a solar system or other processes, and an ambient air source to be used when the outdoor temperature exceeds the liquid source temperature or if the liquid source temperature approaches its freezing point. The model also allows a direct heating mode in which the hot liquid source bypasses the heat pump and delivers energy across a heat exchanger whenever its temperature exceeds a user specified minimum, T_{dh} . The entire system is controlled by a single control input, Y_{htr} . If the value of this control function is 0, then no heating is required and the heat pump delivers no energy. If, on the other hand, Y_{htr} is 1, then an internal controller determines the heating mode. Direct liquid source heating occurs if the source temperature is greater than T_{dh} . Otherwise, heat pump heating occurs using either the liquid or ambient source, whichever has the higher temperature. If, however, either source temperature falls below user specified minimums, then the heat is not allowed to operate in that (or both) mode(s).

3.4.4.8. Furnace

HUMIDITY RATIO INPUTS

Proforma: HVAC\Furnace\Humidity Ratio Inputs\Type121a.tmf
TRNSYS Model: Type 121
Much like Type6 does for fluids, this component represents an air heating device that can be controlled either externally, or set to automatically try and attain a set point temperature. The furnace is bound by a heating capacity and an efficiency. Thermal losses from the furnace are based on the average air temperature. The outlet state of the air is determined by an enthalpy based energy balance that takes pressure effects into account.

RH INPUTS

Proforma: HVAC\Furnace\RH Inputs\Type121b.tmf
TRNSYS Model: Type 121
Much like Type6 does for fluids, this component represents an air heating device that can be controlled either externally, or set to automatically try and attain a set point temperature. The furnace is bound by a heating capacity and an efficiency. Thermal losses from the furnace are based on the average air temperature. The outlet state of the air is determined by an enthalpy based energy balance that takes pressure effects into account.

3.4.4.9. Parallel Chillers

PARALLEL CHILLERS

Proforma: HVAC\Parallel Chillers\Type53.tmf
TRNSYS Model: Type 53
This component models the thermal performance and power requirements of identical motor driven chillers that are oriented in parallel. Each of the operating chillers is assumed to be controlled to maintain a specified chilled water supply temperature through modulation of the compressor capacity (either vane control or variable speed). The inputs to the component are the temperatures and total flow rates of the evaporator and condenser water, the desired chilled water set point, and the total number of chillers operating. The flow rates are divided equally between each of the operating chillers so as to give identical loading and heat rejection for each chiller. The model relies on an empirical curve-fit to performance data. The user must create an external file containing performance data for a single chiller. The component parameter list specifies the fortran logical unit associated with the data file and the number of operating points in the file. Each line of input in the data file has three items. "X" the ratio of chiller load to a specified design load, "Y" the ratio of the temperature difference between the condenser water outlet and the evaporator water outlet relative to a specified design temperature difference, and "Z", the ratio of the measured power relative to the power at the specified design conditions.

3.4.4.10. Part Load Performance

LINEAR WITH LOAD

Proforma: HVAC\Part Load Performance\Linear with Load\Type43b.tmf
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TRNSYS Model: Type 43

This component determines purchased energy requirements and average operating efficiency (or COP) for heating or cooling equipment that is operating at less than full capacity. This condition generally results from the capacity of a machine being modulated in some manner to match the energy requirement or load of some process. The full-load capacity and efficiency, along with the load (or part-load capacity) are required as inputs to this component. Energy loads for buildings may be calculated as outlined in the Building Loads and Structures Section of the TRNSYS documentation set using energy rate control. The user must also provide a relationship between the part-load factor (PLF) and the reciprocal of the duty cycle. In this instance of Type43, the relationship between PLF and the reciprocal of the duty cycle is assumed to be linear. The user must specify the slope of the relation as a parameter to the model.

PERFORMANCE FROM EXTERNAL FILE

Proforma: HVAC\Part Load Performance\Performance from External File\Type43a.tmf

TRNSYS Model: Type 43

This component determines purchased energy requirements and average operating efficiency (or COP) for heating or cooling equipment that is operating at less than full capacity. This condition generally results from the capacity of a machine being modulated in some manner to match the energy requirement or load of some process. The full-load capacity and efficiency, along with the load (or part-load capacity) are required as inputs to this component. Energy loads for buildings may be calculated as outlined in the Building Loads and Structures Section of the TRNSYS documentation set using energy rate control. The user must also provide a relationship between the part-load factor (PLF) and the reciprocal of the duty cycle in an external data file that will be read by the standard TRNSYS Data Reading routine.

3.4.5. Hydrogen Systems

3.4.5.1. Compressed Gas Storage

HYDROGEN - IDEAL GAS

Proforma: Hydrogen Systems\Compressed Gas Storage\Hydrogen\Ideal Gas\Type164a.tmf
TRNSYS Model: Type 164
TYPE164 is a compressed gas storage model. This instance of the model calculates the pressure in the storage based on the ideal gas law.

HYDROGEN - REAL GAS

Proforma: Hydrogen Systems\Compressed Gas Storage\Hydrogen\Real Gas\Type164b.tmf
TRNSYS Model: Type 164
TYPE164 is a compressed gas storage model. This instance of the model calculates the pressure in the storage based on the van der Waals equation of state for real gases (Çengel and Boles, 1989; Ulleberg, 1998).

3.4.5.2. Compressor

COMPRESSOR

Proforma: Hydrogen Systems\Compressor\Type167.tmf
TRNSYS Model: Type 167
The compressor is modelled as an multi-stage polytropic compression process with between one and five intermediate stages.

3.4.5.3. Controllers

ELECTROLYZER - CONSTANT POWER MODE

Proforma: Hydrogen Systems\Controllers\Electrolyzer\Constant Power Mode\Type100b.tmf
TRNSYS Model: Type 100
This subroutine is a gathering of a set of control functions for an electrolyzer of an integrated mini-grid connected wind/electrolyzer/H ₂ -storage/fuel cell system. In this instance, the electrolyzer is designed to operate in a constant power mode.

ELECTROLYZER - VARIABLE POWER MODE

Proforma: Hydrogen Systems\Controllers\Electrolyzer\Variable Power Mode\Type100a.tmf
TRNSYS Model: Type 100
This subroutine is a gathering of a set of control functions for an electrolyzer of an integrated mini-grid connected wind/electrolyzer/H ₂ -storage/fuel cell system. In this instance, the electrolyzer is designed to operate in a variable power mode.

MASTER CONTROL

Proforma: Hydrogen Systems\Controllers\Master Control\Type105a.tmf
TRNSYS Model: Type 105
This subroutine contains the control functions for a fuel cell (FC) and electrolyzer (ELY) operating in a remote area diesel engine generator system (DEGS) power mini-grid. Hysterisis for the fuel cell and electrolyzer on/off-switching is introduced. Note that 'off' in this case actually means that the unit is idling until the hydrogen storage pressure level, or state of charge(SOC), has reached its predefined set point. TYPE105 determines the total number of DEGS and the power per DEGS required , the fuel cell power, and electrolyzer power to meet a given load. Maximum (rated) and minimum (iliding) powers for the fuel cell and electrolyzer are taken into consideration.

3.4.5.4. Electrolyzer

ADVANCED ALKALINE - TMODE=1

Proforma: Hydrogen Systems\Electrolyzer\Advanced Alkaline\TMODE=1\Type160a.tmf
TRNSYS Model: Type 160
TYPE160 is a mathematical model for a high pressure alkaline water electrolyzer. The model is based on a combination of fundamental thermodynamics, heat transfer theory, and empirical electrochemical relationships. A dynamic thermal model is also included. A temperature dependent current-voltage curve for a given pressure and a Faraday efficiency relation independent of temperature and pressure form the basis of the electrochemical model. The electrolyzer temperature can be given as input, or calculated from a simple or detailed thermal model (Ulleberg, 1998; 2001). This instance of Type160 the user is asked to provide the electrolyzer temperature as an input (TMODE 1).

ADVANCED ALKALINE - TMODE=2

Proforma: Hydrogen Systems\Electrolyzer\Advanced Alkaline\TMODE=2\Type160b.tmf
TRNSYS Model: Type 160
TYPE160 is a mathematical model for a high pressure alkaline water electrolyzer. The model is based on a combination of fundamental thermodynamics, heat transfer theory, and empirical electrochemical relationships. A dynamic thermal model is also included. A temperature dependent current-voltage curve for a given pressure and a Faraday efficiency relation independent of temperature and pressure form the basis of the electrochemical model. The electrolyzer temperature can be given as input, or calculated from a simple or detailed thermal model (Ulleberg, 1998; 2001). This instance of Type160 uses a simple thermal energy balance (TMODE 2) for its tempeature calculations.

ADVANCED ALKALINE - TMODE=3

Proforma: Hydrogen Systems\Electrolyzer\Advanced Alkaline\TMODE=3\Type160c.tmf
TRNSYS Model: Type 160
TYPE160 is a mathematical model for a high pressure alkaline water electrolyzer. The model is based on a combination of fundamental thermodynamics, heat transfer theory, and empirical electrochemical relationships. A dynamic thermal model is also included. A temperature dependent current-voltage curve for a given pressure and a Faraday efficiency relation independent of temperature and pressure form the basis of the electrochemical model. The electrolyzer temperature can be given as input, or calculated from a simple or detailed thermal model (Ulleberg, 1998; 2001). This instance of Type160 uses a complex thermal energy balance (TMODE 3) for its temperature calculations.

3.4.5.5. Fuel Cells

AFC - AIR-H2

Proforma: Hydrogen Systems\Fuel Cells\AFC\Air-H2\Type173a.tmf
TRNSYS Model: Type 173
TYPE173 is a simple mathematical model for an alkaline fuel cell (AFC). The electrochemical model is based on an empirical relationship for the current-voltage characteristic at normal operating temperature. The heat generated by the AFC-stack is calculated, but no detailed dynamic thermal model is included. TYPE173 has been modeled with a specific AFC from ZeTek in mind (Brown, 2001; ZeTek, 2001). This instance of Type173 assumes that there is air (as opposed to pure oxygen) on the cathode side.

AFC - O2-H2

Proforma: Hydrogen Systems\Fuel Cells\AFC\O2-H2\Type173b.tmf
TRNSYS Model: Type 173
TYPE173 is a simple mathematical model for an alkaline fuel cell (AFC). The electrochemical model is based on an empirical relationship for the current-voltage characteristic at normal operating temperature. The heat generated by the AFC-stack is calculated, but no detailed dynamic thermal model is included. TYPE173 has been modeled with a specific AFC from ZeTek in mind (Brown, 2001; ZeTek, 2001). This instance of Type173 assumes that there is pure oxygen (as opposed to air) on the cathode side.

PEMFC - AIR-H2 - TMODE=1 - RTCTMODE=1

Proforma: Hydrogen Systems\Fuel Cells\PEMFC\Air-H2\TMODE=1\RTCTMODE=1\Type170a.tmf
TRNSYS Model: Type 170
TYPE170 is a generic mathematical model for a proton exchange membrane fuel cell (PEMFC). The model is largely mechanistic, with most terms being derived from theory or including coefficients that have a theoretical basis. The major nonmechanistic term is the ohmic overvoltage that is primarily empirically based. The main equations of the electrochemical model are described in published literature (Mann et al., 2000). A thermal dynamic model is also included. The theory behind the thermal model is found in previous PEMFC-modeling work (Ulleberg, 1998), while the recommended thermal coefficients were derived from two sources (Amphlett et al., 1996; Ulleberg, 2001). In this instance of Type170, the following assumptions are made: There is air on the cathode side, the stack temperature is provided by the user and simplified calculations of R_t and C_t are used.

PEMFC - Air-H2 - TMODE=1 - RTCTMODE=2

Proforma: Hydrogen Systems\Fuel Cells\PEMFC\Air-H2\TMODE=1\RTCTMODE=2\Type170b.tmf

TRNSYS Model: Type 170

TYPE170 is a generic mathematical model for a proton exchange membrane fuel cell (PEMFC). The model is largely mechanistic, with most terms being derived from theory or including coefficients that have a theoretical basis. The major nonmechanistic term is the ohmic overvoltage that is primarily empirically based. The main equations of the electrochemical model are described in published literature (Mann et al., 2000). A thermal dynamic model is also included. The theory behind the thermal model is found in previous PEMFC-modeling work (Ulleberg, 1998), while the recommended thermal coefficients were derived from two sources (Amphlett et al., 1996; Ulleberg, 2001). In this instance of Type170, the following assumptions are made: There is air on the cathode side, the stack temperature is provided by the user and detailed calculations of R_t and C_t are used.

PEMFC - Air-H2 - TMODE=1 - RTCTMODE=3

Proforma: Hydrogen Systems\Fuel Cells\PEMFC\Air-H2\TMODE=1\RTCTMODE=3\Type170c.tmf

TRNSYS Model: Type 170

TYPE170 is a generic mathematical model for a proton exchange membrane fuel cell (PEMFC). The model is largely mechanistic, with most terms being derived from theory or including coefficients that have a theoretical basis. The major nonmechanistic term is the ohmic overvoltage that is primarily empirically based. The main equations of the electrochemical model are described in published literature (Mann et al., 2000). A thermal dynamic model is also included. The theory behind the thermal model is found in previous PEMFC-modeling work (Ulleberg, 1998), while the recommended thermal coefficients were derived from two sources (Amphlett et al., 1996; Ulleberg, 2001). In this instance of Type170, the following assumptions are made: There is air on the cathode side, and user supplied values of stack temperature, R_t and C_t are used.

PEMFC - Air-H2 - TMODE=2 - RTCTMODE=1

Proforma: Hydrogen Systems\Fuel Cells\PEMFC\Air-H2\TMODE=2\RTCTMODE=1\Type170d.tmf

TRNSYS Model: Type 170

TYPE170 is a generic mathematical model for a proton exchange membrane fuel cell (PEMFC). The model is largely mechanistic, with most terms being derived from theory or including coefficients that have a theoretical basis. The major nonmechanistic term is the ohmic overvoltage that is primarily empirically based. The main equations of the electrochemical model are described in published literature (Mann et al., 2000). A thermal dynamic model is also included. The theory behind the thermal model is found in previous PEMFC-modeling work (Ulleberg, 1998), while the recommended thermal coefficients were derived from two sources (Amphlett et al., 1996; Ulleberg, 2001). In this instance of Type170, the following assumptions are made: There is air on the cathode side, the stack temperature is calculated internally and simplified calculations of R_t and C_t are used.

PEMFC - Air-H2 - TMODE=2 - RTCTMODE=2

Proforma: Hydrogen Systems\Fuel Cells\PEMFC\Air-H2\TMODE=2\RTCTMODE=2\Type170e.tmf

TRNSYS Model: Type 170

TYPE170 is a generic mathematical model for a proton exchange membrane fuel cell (PEMFC). The model is largely mechanistic, with most terms being derived from theory or including coefficients that have a theoretical basis. The major nonmechanistic term is the ohmic overvoltage that is primarily empirically

based. The main equations of the electrochemical model are described in published literature (Mann et al., 2000). A thermal dynamic model is also included. The theory behind the thermal model is found in previous PEMFC-modeling work (Ulleberg, 1998), while the recommended thermal coefficients were derived from two sources (Amphlett et al., 1996; Ulleberg, 2001). In this instance of Type170, the following assumptions are made: There is air on the cathode side, the stack temperature is calculated internally and detailed calculations of R_t and C_t are used.

PEMFC - AIR-H2 - TMODE=2 - RTCTMODE=3

Proforma: Hydrogen Systems\Fuel Cells\PEMFC\Air-H2\TMODE=2\RTCTMODE=3\Type170f.tmf

TRNSYS Model: Type 170

TYPE170 is a generic mathematical model for a proton exchange membrane fuel cell (PEMFC). The model is largely mechanistic, with most terms being derived from theory or including coefficients that have a theoretical basis. The major nonmechanistic term is the ohmic overvoltage that is primarily empirically based. The main equations of the electrochemical model are described in published literature (Mann et al., 2000). A thermal dynamic model is also included. The theory behind the thermal model is found in previous PEMFC-modeling work (Ulleberg, 1998), while the recommended thermal coefficients were derived from two sources (Amphlett et al., 1996; Ulleberg, 2001). In this instance of Type170, the following assumptions are made: There is air on the cathode side, the stack temperature is calculated internally and user supplied values of R_t and C_t are used.

PEMFC - O2-H2 - TMODE=1 - RTCTMODE=1

Proforma: Hydrogen Systems\Fuel Cells\PEMFC\O2-H2\TMODE=1\RTCTMODE=1\Type170g.tmf

TRNSYS Model: Type 170

TYPE170 is a generic mathematical model for a proton exchange membrane fuel cell (PEMFC). The model is largely mechanistic, with most terms being derived from theory or including coefficients that have a theoretical basis. The major nonmechanistic term is the ohmic overvoltage that is primarily empirically based. The main equations of the electrochemical model are described in published literature (Mann et al., 2000). A thermal dynamic model is also included. The theory behind the thermal model is found in previous PEMFC-modeling work (Ulleberg, 1998), while the recommended thermal coefficients were derived from two sources (Amphlett et al., 1996; Ulleberg, 2001). In this instance of Type170, the following assumptions are made: There is oxygen on the cathode side, the stack temperature is provided by the user and simplified calculations of R_t and C_t are used.

PEMFC - O2-H2 - TMODE=1 - RTCTMODE=2

Proforma: Hydrogen Systems\Fuel Cells\PEMFC\O2-H2\TMODE=1\RTCTMODE=2\Type170h.tmf

TRNSYS Model: Type 170

TYPE170 is a generic mathematical model for a proton exchange membrane fuel cell (PEMFC). The model is largely mechanistic, with most terms being derived from theory or including coefficients that have a theoretical basis. The major nonmechanistic term is the ohmic overvoltage that is primarily empirically based. The main equations of the electrochemical model are described in published literature (Mann et al., 2000). A thermal dynamic model is also included. The theory behind the thermal model is found in previous PEMFC-modeling work (Ulleberg, 1998), while the recommended thermal coefficients were derived from two sources (Amphlett et al., 1996; Ulleberg, 2001). In this instance of Type170, the following assumptions are made: There is oxygen on the cathode side, the stack temperature is provided by the user and detailed calculations of R_t and C_t are used.

PEMFC - O2-H2 - TMODE=1 - RTCTMODE=3

Proforma: Hydrogen Systems\Fuel Cells\PEMFC\O2-H2\TMODE=1\RTCTMODE=3\Type170i.tmf
TRNSYS Model: Type 170
TYPE170 is a generic mathematical model for a proton exchange membrane fuel cell (PEMFC). The model is largely mechanistic, with most terms being derived from theory or including coefficients that have a theoretical basis. The major nonmechanistic term is the ohmic overvoltage that is primarily empirically based. The main equations of the electrochemical model are described in published literature (Mann et al., 2000). A thermal dynamic model is also included. The theory behind the thermal model is found in previous PEMFC-modeling work (Ulleberg, 1998), while the recommended thermal coefficients were derived from two sources (Amphlett et al., 1996; Ulleberg, 2001). In this instance of Type170, the following assumptions are made: There is oxygen on the cathode side, and user supplied values of stack temperature, R_t and C_t are used.

PEMFC - O2-H2 - TMODE=2 - RTCTMODE=1

Proforma: Hydrogen Systems\Fuel Cells\PEMFC\O2-H2\TMODE=2\RTCTMODE=1\Type170j.tmf
TRNSYS Model: Type 170
TYPE170 is a generic mathematical model for a proton exchange membrane fuel cell (PEMFC). The model is largely mechanistic, with most terms being derived from theory or including coefficients that have a theoretical basis. The major nonmechanistic term is the ohmic overvoltage that is primarily empirically based. The main equations of the electrochemical model are described in published literature (Mann et al., 2000). A thermal dynamic model is also included. The theory behind the thermal model is found in previous PEMFC-modeling work (Ulleberg, 1998), while the recommended thermal coefficients were derived from two sources (Amphlett et al., 1996; Ulleberg, 2001). In this instance of Type170, the following assumptions are made: There is oxygen on the cathode side, the stack temperature is calculated internally and simplified calculations of R_t and C_t are used.

PEMFC - O2-H2 - TMODE=2 - RTCTMODE=2

Proforma: Hydrogen Systems\Fuel Cells\PEMFC\O2-H2\TMODE=2\RTCTMODE=2\Type170k.tmf
TRNSYS Model: Type 170
TYPE170 is a generic mathematical model for a proton exchange membrane fuel cell (PEMFC). The model is largely mechanistic, with most terms being derived from theory or including coefficients that have a theoretical basis. The major nonmechanistic term is the ohmic overvoltage that is primarily empirically based. The main equations of the electrochemical model are described in published literature (Mann et al., 2000). A thermal dynamic model is also included. The theory behind the thermal model is found in previous PEMFC-modeling work (Ulleberg, 1998), while the recommended thermal coefficients were derived from two sources (Amphlett et al., 1996; Ulleberg, 2001). In this instance of Type170, the following assumptions are made: There is oxygen on the cathode side, the stack temperature is calculated internally and detailed calculations of R_t and C_t are used.

PEMFC - O2-H2 - TMODE=2 - RTCTMODE=3

Proforma: Hydrogen Systems\Fuel Cells\PEMFC\O2-H2\TMODE=2\RTCTMODE=3\Type170l.tmf
TRNSYS Model: Type 170
TYPE170 is a generic mathematical model for a proton exchange membrane fuel cell (PEMFC). The model is largely mechanistic, with most terms being derived from theory or including coefficients that have a theoretical basis. The major nonmechanistic term is the ohmic overvoltage that is primarily empirically based. The main equations of the electrochemical model are described in published literature (Mann et al., 2000). A thermal dynamic model is also included. The theory behind the thermal model is

found in previous PEMFC-modeling work (Ulleberg, 1998), while the recommended thermal coefficients were derived from two sources (Amphlett et al., 1996; Ulleberg, 2001). In this instance of Type170, the following assumptions are made: There is oxygen on the cathode side, the stack temperature is calculated internally and user supplied values of R_t and C_t are used.

3.4.6. Hydronics

3.4.6.1. Fans

SINGLE SPEED - HUMIDITY RATIO INPUTS

Proforma: Hydronics\Fans\Single Speed\Humidity Ratio Inputs\Type112a.tmf
TRNSYS Model: Type 112
Type112 models a fan that is able to spin at a single speed and thereby maintain a constant mass flow rate of air. As with most pumps and fans in TRNSYS, Type112 takes mass flow rate as an input but ignores the value except in order to perform mass balance checks. Type112 sets the downstream flow rate based on its rated flow rate parameter and the current value of its control signal input.

SINGLE SPEED - NO HUMIDITY

Proforma: Hydronics\Fans\Single Speed\No Humidity\Type3a.tmf
TRNSYS Model: Type 3
This fan model computes a mass flow rate using a variable control function, which must have a value between 1 and 0, and a fixed (user-specified) maximum flow capacity. In this instance of Type3, fan power may also be calculated, either as a linear function of mass flow rate or by a user-defined relationship between mass flow rate and power consumption. A user-specified portion of the fan power is converted to air stream thermal energy. NOTE: This component sets the flow rate for the rest of the components in the flow loop by multiplying the maximum flow rate (Parameter 1) by the control signal (Input 3). The mass flow rate input of this component is only for visualization purposes; it is not used except for convergence checking.

SINGLE SPEED - NO HUMIDITY - NO POWER COEFFICIENTS

Proforma: Hydronics\Fans\Single Speed\No Humidity - No Power Coefficients\Type3c.tmf
TRNSYS Model: Type 3
This fan model computes a mass flow rate using a variable control function, which must have a value between 1 and 0, and a fixed (user-specified) maximum flow capacity. In this instance of Type3, fan power consumption is simply set to the rated value whenever the control signal indicates that the fan is in operation. A user-specified portion of the fan power is converted to air stream thermal energy. NOTE: This component sets the flow rate for the rest of the components in the flow loop by multiplying the maximum flow rate (Parameter 1) by the control signal (Input 3). The mass flow rate input of this component is only for visualization purposes; it is not used except for convergence checking.

SINGLE SPEED - RELATIVE HUMIDITY INPUTS

Proforma: Hydronics\Fans\Single Speed\Relative Humidity Inputs\Type112b.tmf
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TRNSYS Model: Type 112

Type112 models a fan that is able to spin at a single speed and thereby maintain a constant mass flow rate of air. As with most pumps and fans in TRNSYS, Type112 takes mass flow rate as an input but ignores the value except in order to perform mass balance checks. Type112 sets the downstream flow rate based on its rated flow rate parameter and the current value of its control signal input. This instance of Type112 takes inlet air relative humidity as an input.

VARIABLE SPEED - HUMIDITY RATIO INPUTS

Proforma: Hydraulics\Fans\Variable Speed\Humidity Ratio Inputs\Type111a.tmf

TRNSYS Model: Type 111

Type111 models a fan that is able to turn at any speed between 0 (full stop) and its rated speed. While the mass flow rate of air moved by the fan is linearly related to the control signal, the power drawn by the fan at a given flow rate can be any polynomial expression of the control signal. As with most pumps and fans in TRNSYS, Type111 takes mass flow rate as an input but ignores the value except in order to perform mass balance checks. Type111 sets the downstream flow rate based on its rated flow rate parameters and the current value of its control signal inputs. This instance of Type111 takes inlet air humidity ratio as an input.

VARIABLE SPEED - RH INPUTS

Proforma: Hydraulics\Fans\Variable Speed\RH Inputs\Type111b.tmf

TRNSYS Model: Type 111

Type111 models a fan that is able to turn at any speed between 0 (full stop) and its rated speed. While the mass flow rate of air moved by the fan is linearly related to the control signal, the power drawn by the fan at a given flow rate can be any polynomial expression of the control signal. As with most pumps and fans in TRNSYS, Type111 takes mass flow rate as an input but ignores the value except in order to perform mass balance checks. Type111 sets the downstream flow rate based on its rated flow rate parameters and the current value of its control signal inputs. This instance of Type111 takes relative humidity as an input.

3.4.6.2. Flow Diverter**MOIST AIR**

Proforma: Hydraulics\Flow Diverter\Moist Air\Type11e.tmf

TRNSYS Model: Type 11

The use of pipe or duct tee-pieces, mixers, and diverters which are subject to external control is often necessary in thermal systems. This component has ten modes of operation. Modes 1 through 5 are normally used for fluids with only one important property, such as temperature. Modes 6 through 10 are for fluids, such as moist air, with two important properties, such as temperature and humidity.

This instance of the Type11 model uses mode 7 to model a flow diverter in which a single inlet air stream is split according to a user specified damper setting into two air outlet streams.

OTHER FLUIDS

Proforma: Hydraulics\Flow Diverter\Other Fluids\Type11f.tmf

TRNSYS Model: Type 11

The use of pipe or duct tee-pieces, mixers, and diverters which are subject to external control is often necessary in thermal systems. This component has ten modes of operation. Modes 1 through 5 are normally used for fluids with only one important property, such as temperature. Modes 6 through 10 are for fluids, such as moist air, with two important properties, such as temperature and humidity.
 This instance of the Type11 model uses mode 2 to model a flow diverter in which a single inlet liquid stream is split according to a user specified valve setting into two liquid outlet streams.

3.4.6.3. Flow Mixer

MOIST AIR

Proforma: Hydronics\Flow Mixer\Moist Air\Type11c.tmf
TRNSYS Model: Type 11
The use of pipe or duct tee-pieces, mixers, and diverters which are subject to external control is often necessary in thermal systems. This component has ten modes of operation. Modes 1 through 5 are normally used for fluids with only one important property, such as temperature. Modes 6 through 10 are for fluids, such as moist air, with two important properties, such as temperature and humidity. This instance of the Type11 model uses mode 8 to model a controlled flow mixer in which two inlet air streams are mixed together according to an internally calculated control function so as to maintain the mixed outlet temperature at or below a user specified value.

OTHER FLUIDS

Proforma: Hydronics\Flow Mixer\Other Fluids\Type11d.tmf
TRNSYS Model: Type 11
The use of pipe or duct tee-pieces, mixers, and diverters which are subject to external control is often necessary in thermal systems. This component has ten modes of operation. Modes 1 through 5 are normally used for fluids with only one important property, such as temperature. Modes 6 through 10 are for fluids, such as moist air, with two important properties, such as temperature and humidity. This instance of the Type11 model uses mode 3 to model a controlled flow mixer in which two inlet liquid streams are mixed together according to an internally calculated control function so as to maintain the mixed outlet temperature at or below a user specified value.

3.4.6.4. Pipe_Duct

PIPE_DUCT

Proforma: Hydronics\Pipe_Duct\Type31.tmf
TRNSYS Model: Type 31
This component models the thermal behavior of fluid flow in a pipe or duct using variable size segments of fluid. Entering fluid shifts the position of existing segments. The mass of the new segment is equal to the flow rate times the simulation timestep. The new segment's temperature is that of the incoming fluid. The outlet of this pipe is a collection of the elements that are pushed out by the inlet flow. This plug-flow model does not consider mixing or conduction between adjacent elements. A maximum of 25 segments is allowed in the pipe. When the maximum is reached, the two adjacent segments with the closest temperatures are combined to make one segment.

3.4.6.5. Pressure Relief Valve

PRESSURE RELIEF VALVE

Proforma: Hydronics\Pressure Relief Valve\Type13.tmf
TRNSYS Model: Type 13
Thermal systems which employ a liquid (e.g. water) as a heat transfer medium typically include a pressure relief valve to discard the vapor (e.g. steam) if the liquid begins to boil. This component can be used to describe a pipe relief valve or a tank relief valve. This model monitors inlet temperature, flow rate, and a comparison temperature. Energy is discarded whenever the comparison temperature is greater than the specified boiling temperature of the fluid. Loss of mass when the relief valve is open is assumed negligible; the outlet flow is always equal to the inlet flow rate.

3.4.6.6. Pumps

SINGLE SPEED

Proforma: Hydronics\Pumps\Single Speed\Type114.tmf
TRNSYS Model: Type 114
Type114 models a single (constant) speed pump that is able to maintain a constant fluid outlet mass flow rate. Pump starting and stopping characteristics are not modeled, nor are pressure drop effects. As with most pumps and fans in TRNSYS, Type114 takes mass flow rate as an input but ignores the value except in order to perform mass balance checks. Type114 sets the downstream flow rate based on its rated flow rate parameter and the current value of its control signal input.

SINGLE SPEED

Proforma: Hydronics\Pumps\Single Speed\Type3b.tmf
TRNSYS Model: Type 3
This pump model computes a mass flow rate using a variable control function, which must have a value between 1 and 0, and a fixed (user-specified) maximum flow capacity. In this instance of Type3, pump power may also be calculated, either as a linear function of mass flow rate or by a user-defined relationship between mass flow rate and power consumption. A user-specified portion of the pump power is converted to fluid thermal energy. NOTE: This component sets the flow rate for the rest of the components in the flow loop by multiplying the maximum flow rate (Parameter 1) by the control signal (Input 3). The mass flow rate input of this component is only for visualization purposes; it is not used except for convergence checking.

SINGLE SPEED - NO POWERCOEFFICIENTS

Proforma: Hydronics\Pumps\Single Speed - No Powercoefficients\Type3d.tmf
TRNSYS Model: Type 3
This pump model computes a mass flow rate using a variable control function, which must have a value between 1 and 0, and a fixed (user-specified) maximum flow capacity. In this instance of Type3, pump power consumption is simply set to the rated value whenever the control signal indicates that the pump is in operation. A user-specified portion of the pump power is converted to fluid thermal energy. NOTE: This component sets the flow rate for the rest of the components in the flow loop by multiplying the maximum flow rate (Parameter 1) by the

control signal (Input 3). The mass flow rate input of this component is only for visualization purposes; it is not used except for convergence checking.

VARIABLE SPEED

Proforma: Hydraulics\Pumps\Variable Speed\Type110.tmf
TRNSYS Model: Type 110
Type110 models a variable speed pump that is able to maintain any outlet mass flow rate between zero and a rated value. The mass flow rate of the pump varies linearly with control signal setting. Pump power draw, however, is modeled using a polynomial. Pump starting and stopping characteristics are not modeled, nor are pressure drop effects. As with most pumps and fans in TRNSYS, Type110 takes mass flow rate as an input but ignores the value except in order to perform mass balance checks. Type110 sets the downstream flow rate based on its rated flow rate parameter and the current value of its control signal input.

3.4.6.7. Tee-Piece

MOIST AIR

Proforma: Hydraulics\Tee-Piece\Moist Air\Type11g.tmf
TRNSYS Model: Type 11
The use of pipe or duct tee-pieces, mixers, and diverters which are subject to external control is often necessary in thermal systems. This component has ten modes of operation. Modes 1 through 5 are normally used for fluids with only one important property, such as temperature. Modes 6 through 10 are for fluids, such as moist air, with two important properties, such as temperature and humidity. This instance of the Type11 model uses mode 6 to model a tee piece in which two inlet air streams are mixed together into a single air outlet stream.

OTHER FLUIDS

Proforma: Hydraulics\Tee-Piece\Other Fluids\Type11h.tmf
TRNSYS Model: Type 11
The use of pipe or duct tee-pieces, mixers, and diverters which are subject to external control is often necessary in thermal systems. This component has ten modes of operation. Modes 1 through 5 are normally used for fluids with only one important property, such as temperature. Modes 6 through 10 are for fluids, such as moist air, with two important properties, such as temperature and humidity. This instance of the Type11 model uses mode 1 to model a tee piece in which two inlet liquid streams are mixed together into a single liquid outlet stream.

3.4.6.8. Tempering Valve

MOIST AIR

Proforma: Hydraulics\Tempering Valve\Moist Air\Type11a.tmf
TRNSYS Model: Type 11
The use of pipe or duct tee-pieces, mixers, and diverters which are subject to external control is often necessary

in thermal systems. This component has ten modes of operation. Modes 1 through 5 are normally used for fluids with only one important property, such as temperature. Modes 6 through 10 are for fluids, such as moist air, with two important properties, such as temperature and humidity.
 This instance of the Type11 model uses mode 9 or mode 10 to model a temperature controlled air flow diverter. In mode 9 the entire flow stream is sent through outlet 1 when $T_h < T_i$. In mode 10, the entire flow stream is sent through outlet 2 under these circumstances.

OTHER FLUIDS

Proforma: Hydraulics\Tempering Valve\Other Fluids\Type11b.tmf
TRNSYS Model: Type 11
<p>The use of pipe or duct tee-pieces, mixers, and diverters which are subject to external control is often necessary in thermal systems. This component has ten modes of operation. Modes 1 through 5 are normally used for fluids with only one important property, such as temperature. Modes 6 through 10 are for fluids, such as moist air, with two important properties, such as temperature and humidity. This instance of the Type11 model uses mode 4 or mode 5 to model a temperature controlled liquid flow diverter. In mode 4 the entire flow stream is sent through outlet 1 when $T_h < T_i$. In mode 5, the entire flow stream is sent through outlet 2 under these circumstances.</p>

3.4.7. Loads and Structures

3.4.7.1. Attached Sunspace

ADDITIONAL THERMAL MASS

Proforma: Loads and Structures\Attached Sunspace\Additional Thermal Mass\Type37a.tmf
TRNSYS Model: Type 37
<p>An attached sunspace can be thought of as a large solar collector where the space between the glazing and absorbing surface is large enough to be used as additional living space. After passing through the glazing(s), solar radiation is absorbed by the sunspace wall and floor. Absorbed solar radiation reaches the attached building by conduction through the common wall. In addition, optional wall vents allow convection of heated sunspace air into the building. The sunspace loses energy to the ground by conduction through the floor and to ambient by conduction, convection, radiation, and infiltration through the glazed surfaces.</p> <p>The losses through the glazings may be reduced by using moveable insulation. A user supplied control function governs the use of the insulation. When glazing insulation is in use, no solar radiation is allowed to enter the sunspace. Venting of the sunspace air is also controlled by user supplied inputs. A control function determines the venting air sink: ambient or building conditions, and another input controls the venting air mass flow rate. In this instance of Type37, additional thermal mass storage devices may be included in the sunspace.</p>

NO ADDITIONAL THERMAL MASS

Proforma: Loads and Structures\Attached Sunspace\No Additional Thermal Mass\Type37b.tmf
TRNSYS Model: Type 37
<p>An attached sunspace can be thought of as a large solar collector where the space between the glazing and absorbing surface is large enough to be used as additional living space. After passing through the glazing(s), solar radiation is absorbed by the sunspace wall and floor. Absorbed solar radiation reaches the attached building by conduction through the common wall. In addition, optional wall vents allow convection of heated sunspace air into the building. The sunspace loses energy to the ground by conduction through the floor and to ambient by conduction, convection, radiation, and infiltration through the glazed surfaces.</p> <p>The losses through the glazings may be reduced by using moveable insulation. A user supplied control function governs the use of the insulation. When glazing insulation is in use, no solar radiation is allowed to enter the sunspace. Venting of the sunspace air is also controlled by user supplied inputs. A control function determines the venting air sink: ambient or building conditions, and another input controls the venting air mass flow rate. In this instance of Type37, additional thermal mass storage devices may NOT be included in the sunspace.</p>

3.4.7.2. Multi-Zone Building

WITH STANDARD OUTPUT FILES

Proforma: Loads and Structures\Multi-Zone Building\With Standard Output Files\Type56a.tmf
TRNSYS Model: Type 56
<p>This component models the thermal behaviour of a building having up to 25 thermal zones. The building description is read by this component from a set of external files having the extensions *.bui, *.bld, and *.trn. The files can be generated based on user supplied information by running the preprocessor program called TRNBuild (known as Prebid in TRNSYS versions prior to the release of v. 16.0). This instance of Type56 generates its own</p>

set of monthly and hourly summary output files.

WITHOUT STANDARD OUTPUT FILES

Proforma: Loads and Structures\Multi-Zone Building\Without Standard Output Files\Type56b.tmf

TRNSYS Model: Type 56

This component models the thermal behaviour of a building having up to 25 thermal zones. The building description is read by this component from a set of external files having the extensions *.bui, *.bld, and *.trn. The files can be generated based on user supplied information by running the preprocessor program called TRNBuild (known as Prebid in TRNSYS versions prior to the release of v. 16.0). This instance of Type56 does not generate its own output files. The user is free to print and plot whatever Type56 variables are of interest using standard TRNSYS output devices.

3.4.7.3. Overhang and Wingwall Shading

OVERHANG AND WINGWALL SHADING

Proforma: Loads and Structures\Overhang and Wingwall Shading\Type34.tmf

TRNSYS Model: Type 34

Buildings directly heated by solar radiation often include a shading device to shield receiver surfaces from direct radiation in summer months. This component computes the solar radiation on a vertical receiver shaded by an overhang and/or wingwall. A shaded receiver may include left and/or right hand wing walls that extend above and/or below the receiver. The receiver may also include an overhang that can be placed at the top or above the receiver. The overhang may extend to the right and left of the receiver. Type34 performs its own calculation of incident diffuse radiation assuming an isotropic sky model. Care should therefore be taken in choosing an appropriate mode of Type 16 for use with this component.

3.4.7.4. Pitched Roof and Attic

PITCHED ROOF AND ATTIC

Proforma: Loads and Structures\Pitched Roof and Attic\Type18.tmf

TRNSYS Model: Type 18

A transfer function pitched roof and attic model has been developed to furnish a TYPE 19 room with a ceiling heat loss calculation. This model is far less expensive (computationally) to run than other finite-difference (nodal) models. Transfer function coefficients have been built into this model since several geometric assumptions are necessary.

3.4.7.5. Single Zone Models

DETAILED SINGLE ZONE (TYPE19)

Proforma: Loads and Structures\Single Zone Models\Detailed Single Zone (Type19)\Surfaces*.tmf
TRNSYS Model: Type 19
Note: Type 19 has many proformas due to its very special configuration. Please refer to Volume 05 for a description of Type 19.

ENERGY (DEGREE DAY) SPACE LOAD (TYPE12) - ENERGY RATE CONTROL - HEATING AND COOLING

Proforma: Loads and Structures\Single Zone Models\Energy (Degree Day) Space Load (Type12)\Energy Rate Control\Heating and Cooling\Type12b.tmf
TRNSYS Model: Type 12
The energy/(degree-day) concept has been shown by ASHRAE [1] to be useful in estimating the monthly heating load of a structure. In this space heating load model, the energy/(degree-day), or more appropriately the energy/(degree-hour), concept is extended to estimate the hour by hour heating load of a structure. It is generally recognized that the hour by hour space heating load estimated in this manner may be significantly in error. The model however does provide an estimate of the space heating load with minimal computational effort. There are four modes of operation in Type12. This instance (Mode 3) is compatible with energy rate control. This mode allows the room temperature to float between a set points for heating and cooling, Tmin and Tmax. A single lumped capacitance is used in this analysis. If the room temperature would rise above Tmax or fall below Tmin, then the energy required to maintain either limit is output as the cooling or heating requirement.

ENERGY (DEGREE DAY) SPACE LOAD (TYPE12) - ENERGY RATE CONTROL - HEATING ONLY

Proforma: Loads and Structures\Single Zone Models\Energy (Degree Day) Space Load (Type12)\Energy Rate Control\Heating Only\Type12a.tmf
TRNSYS Model: Type 12
The energy/(degree-day) concept has been shown by ASHRAE [1] to be useful in estimating the monthly heating load of a structure. In this space heating load model, the energy/(degree-day), or more appropriately the energy/(degree-hour), concept is extended to estimate the hour by hour heating load of a structure. It is generally recognized that the hour by hour space heating load estimated in this manner may be significantly in error. The model however does provide an estimate of the space heating load with minimal computational effort. There are four modes of operation in Type12. This instance (Mode 2) is compatible with energy rate control. This mode models a zero capacitance structure maintained at a constant set temperature for heating.

ENERGY (DEGREE DAY) SPACE LOAD (TYPE12) - TEMPERATURE LEVEL CONTROL

Proforma: Loads and Structures\Single Zone Models\Energy (Degree Day) Space Load (Type12)\Temperature Level Control\Type12c.tmf
TRNSYS Model: Type 12
The energy/(degree-day) concept has been shown by ASHRAE [1] to be useful in estimating the monthly heating load of a structure. In this space heating load model, the energy/(degree-day), or more appropriately the energy/(degree-hour), concept is extended to estimate the hour by hour heating load of a structure. It is generally recognized that the hour by hour space heating load estimated in this manner may be significantly in

error. The model however does provide an estimate of the space heating load with minimal computational effort. There are four modes of operation in Type12. This instance (Mode 4) models a single lumped capacitance house compatible with temperature level control. Normally heating and/or cooling equipment and a controller are used in conjunction with this mode.

LUMPED CAPACITANCE BUILDING (TYPE 88)

Proforma: Loads and Structures\Single Zone Models\Lumped Capacitance Building (Type 88)\Type88.tmf

TRNSYS Model: Type 88

This component models a simple lumped capacitance single zone structure subject to internal gains. It differs from the Type12 simple building model in that it makes no assumption about the control scheme. Furthermore, it neglects solar gains and assumes an overall U value for the entire structure. Its usefulness comes from the speed with which a building heating and/or cooling load can be added to a system simulation.

3.4.7.6. Thermal Storage Wall

FLOWRATE AS INPUT, TRANSMITTANCE CALCULATED INTERNALLY

Proforma: Loads and Structures\Thermal Storage Wall\Flowrate as Input, Transmittance Calculated Internally\Type36c.tmf

TRNSYS Model: Type 36

A thermal storage wall is essentially a high capacitance solar collector directly coupled to the room. Absorbed solar radiation reaches the room by either of two paths. One path is conduction through the wall. From the inside wall surface, the energy is convected and radiated into the room. The second path is convection from the hot outer wall surface to air in the gap. Room air flowing through the gap is heated, carrying energy into the room. The wall also loses energy by conduction, convection and radiation to the environment through the glazing covers.

This component offers four modes of operation. In this instance (Mode 3), the mass flow rate of air is input and the transmittance of beam and diffuse radiation are considered separately. The transmittance-absorptance product is determined in function subroutine TAU_ALFA, described in the main TRNSYS documentation set.

FLOWRATE CALCULATED INTERNALLY, TRANSMITTANCE AS INPUT

Proforma: Loads and Structures\Thermal Storage Wall\Flowrate Calculated Internally, Transmittance as Input\Type36b.tmf

TRNSYS Model: Type 36

A thermal storage wall is essentially a high capacitance solar collector directly coupled to the room. Absorbed solar radiation reaches the room by either of two paths. One path is conduction through the wall. From the inside wall surface, the energy is convected and radiated into the room. The second path is convection from the hot outer wall surface to air in the gap. Room air flowing through the gap is heated, carrying energy into the room. The wall also loses energy by conduction, convection and radiation to the environment through the glazing covers.

This component offers four modes of operation. In this instance (Mode 2), the total solar radiation and glazing transmittance are inputs as is the mass flow rate of air in the gap. However, the mass flow rate is driven by air temperature differences and is computed internally.

FLOWRATE, TRANSMITTANCE AS INPUTS

Proforma: Loads and Structures\Thermal Storage Wall\Flowrate, Transmittance as Inputs\Type36a.tmf

TRNSYS Model: Type 36
<p>A thermal storage wall is essentially a high capacitance solar collector directly coupled to the room. Absorbed solar radiation reaches the room by either of two paths. One path is conduction through the wall. From the inside wall surface, the energy is convected and radiated into the room. The second path is convection from the hot outer wall surface to air in the gap. Room air flowing through the gap is heated, carrying energy into the room. The wall also loses energy by conduction, convection and radiation to the environment through the glazing covers.</p> <p>This component offers four modes of operation. In this instance (Mode 1), the total solar radiation and glazing transmittance are inputs as is the mass flow rate of air in the gap.</p>

FLOWRATE, TRANSMITTANCE CALCULATED INTERNALLY

Proforma: Loads and Structures\Thermal Storage Wall\Flowrate, Transmittance Calculated Internally\Type36d.tmf
TRNSYS Model: Type 36
<p>A thermal storage wall is essentially a high capacitance solar collector directly coupled to the room. Absorbed solar radiation reaches the room by either of two paths. One path is conduction through the wall. From the inside wall surface, the energy is convected and radiated into the room. The second path is convection from the hot outer wall surface to air in the gap. Room air flowing through the gap is heated, carrying energy into the room. The wall also loses energy by conduction, convection and radiation to the environment through the glazing covers.</p> <p>This component offers four modes of operation. In this instance, (Mode 4) , the mass flow rate of air is input and the transmittance of beam and diffuse radiation are considered separately. The transmittance-absorptance product is determined in function subroutine TAU_ALFA, described in the main TRNSYS documentation set. However, the mass flow rate of air in the gap is driven by temperature differences and computed internally.</p>

3.4.7.7. Window

MEASURED DATA

Proforma: Loads and Structures\Window\Measured Data\Type35a.tmf
TRNSYS Model: Type 35
<p>This component models the window transmittance of solar radiation and the thermal energy transfer across the window. The total heat transfer coefficient of the window is an input, allowing changes of the coefficient due to insulating curtains on the window. In this instance of Type35, the window transmittance is provided as a time dependent input to the model.</p>

THEORETICAL

Proforma: Loads and Structures\Window\Theoretical\Type35b.tmf
TRNSYS Model: Type 35
<p>This component models the window transmittance of solar radiation and the thermal energy transfer across the window. The total heat transfer coefficient of the window is an input, allowing changes of the coefficient due to insulating curtains on the window. In this instance of Type35, the window transmittance is calculated internally based on user specified physical properties such as number of window panes, pane extinction coefficient, pane thickness, index of refraction, etc.</p>

3.4.8. Obsolete

3.4.8.1. Absorption Air Conditioners (Type7)

ENERGY RATE CONTROL

Proforma: Obsolete\Absorption Air Conditioners (Type7)\Energy Rate Control\Type7b.tmf

TRNSYS Model: Type 7

This component is obsolete in TRNSYS 16. It should be removed from your simulation. This absorption chiller model has been replaced by a much more flexible absorption chiller model (Type107). Type7 will be retained for one version cycle and will not be included in TRNSYS 17.

TEMPERATURE LEVEL CONTROL

Proforma: Obsolete\Absorption Air Conditioners (Type7)\Temperature Level Control\Type7a.tmf

TRNSYS Model: Type 7

This component is obsolete in TRNSYS 16. It should be removed from your simulation. This absorption chiller model has been replaced by a much more flexible absorption chiller model (Type107). Type7 will be retained for one version cycle and will not be included in TRNSYS 17.

3.4.8.2. Calling External DLLs (Type61)

CALLING EXTERNAL DLLS (TYPE61)

Proforma: Obsolete\Calling External DLLs (Type61)\Type61.tmf

TRNSYS Model: Type 61

This component is obsolete in TRNSYS 16. It should be removed from your simulation. The purpose of this Type in TRNSYS version 15 was to allow users to write components in languages other than Fortran. Because the architecture of TRNSYS was changed with the release of v. 16.0 to allow for drop in DLLs, this component was deemed to be obsolete (any component can be written in any language). It was not possible to maintain backwards compatibility for this Type.

3.4.8.3. Convergence Promoter (Type44)

CONVERGENCE PROMOTER (TYPE44)

Proforma: Obsolete\Convergence Promoter (Type44)\Type44.tmf

TRNSYS Model: Type 44

Prior to the addition of SOLVER 1, Type44 was used to improve convergence of systems having little or no capacitance. The output of the Type44 convergence promoter is x , while the response to that output is $f(x)$. The solution to the set of equations occurs for $f(x)-x$ equal to zero. The TYPE 44 uses a secant method to find this zero point. Initial values of x and $f(x)$ are determined by successive substitution. After N_c iterations (specified by

the user), the two most recent values of x and $f(x) - x$ are used to estimate a straight-line solution.

3.4.8.4. **CSTB Weather Data - TRNSYS 15 (Type9)**

CSTB WEATHER DATA - TRNSYS 15 (TYPE9)

Proforma: Obsolete\CSTB Weather Data - TRNSYS 15 (Type9)\Type9f.tmf

TRNSYS Model: Type 9

This component is used to read the weather data files provided with TRNSYS 15 by CSTB. It is in TRNSYS 16 for backwards compatibility reasons but we recommend that you use TMY2 files generated with Meteororm for your TRNSYS 16 simulations

3.4.8.5. **Plotter (Type26)**

PLOTTER (TYPE26)

Proforma: Obsolete\Plotter (Type26)\Type26.tmf

TRNSYS Model: Type 26

This component is obsolete in TRNSYS 16. It should be removed from your simulation. The purpose of this plotter component was to produce a digitized plot of one or more selected system variables against TIME. With the release of TRNSYS 16, the combination of Type25 and Type65 was deemed to be more powerful and flexible than Type26. It will be retained for one version cycle and will not be included in TRNSYS 17.

3.4.8.6. **Radiation Processors With Smoothing (Type16)**

BEAM AND DIFFUSE KNOWN (MODE=3)

Proforma: Obsolete\Radiation Processors With Smoothing (Type16)\Beam and Diffuse Known (Mode=3)\Type16f.tmf

TRNSYS Model: Type 16

Solar insolation data is generally taken at one hour intervals and on a horizontal surface. In most TRNSYS simulations, estimates of radiation at time intervals other than one hour are required. This component interpolates radiation data, calculates several quantities related to the position of the sun, and estimates insolation on a number of surfaces of either fixed or variable orientation.

This instance of Type16 takes hourly integrated values of total horizontal and beam radiation as inputs. It can use various algorithms to compute radiation on tilted surfaces such as Hay and Davies, Perez, Reindl, etc. Data can be entered in solar or in local time. This version of Type16 performs radiation "smoothing" in which numerical methods are used to clean up spikes in recorded data. It is highly recommended that you plot values of smoothed solar radiation using an online plotter as these smoothing algorithms can generate physically unreasonable values under certain circumstances.

TOTAL HORIZ ONLY KNOWN (MODE=1)

Proforma: Obsolete\Radiation Processors With Smoothing (Type16)\Total Horiz Only Known (Mode=1)\Type16b.tmf

TRNSYS Model: Type 16
<p>Solar insolation data is generally taken at one hour intervals and on a horizontal surface. In most TRNSYS simulations, estimates of radiation at time intervals other than one hour are required. This component interpolates radiation data, calculates several quantities related to the position of the sun, and estimates insolation on a number of surfaces of either fixed or variable orientation.</p> <p>This instance of Type16 takes hourly integrated values of total horizontal solar radiation and estimates diffuse fraction internally. It can use various algorithms to compute radiation on tilted surfaces such as Hay and Davies, Perez, Reindl, etc. Data can be entered in solar or in local time. This version of Type16 performs radiation "smoothing" in which numerical methods are used to clean up spikes in recorded data. It is highly recommended that you plot values of smoothed solar radiation usign an online plotter as these smoothing algorithms can generate physically unreasonable values under certain circumstances.</p>

TOTAL HORIZ TEMP AND HUMIDITY KNOWN (MODE=2)

Proforma: Obsolete\Radiation Processors With Smoothing (Type16)\Total Horiz Temp and Humidity Known (Mode=2)\Type16d.tmf
TRNSYS Model: Type 16
<p>Solar insolation data is generally taken at one hour intervals and on a horizontal surface. In most TRNSYS simulations, estimates of radiation at time intervals other than one hour are required. This component interpolates radiation data, calculates several quantities related to the position of the sun, and estimates insolation on a number of surfaces of either fixed or variable orientation.</p> <p>This instance of Type16 takes hourly integrated values of total horizontal solar radiation and computes the diffuse fraction using an algorithm that estimates cloudiness based on dry bulb and dew point temperature. It can use various algorithms to compute radiation on tilted surfaces such as Hay and Davies, Perez, Reindl, etc. Data can be entered in solar or in local time. This version of Type16 performs radiation "smoothing" in which numerical methods are used to clean up spikes in recorded data. It is highly recommended that you plot values of smoothed solar radiation usign an online plotter as these smoothing algorithms can generate physically unreasonable values under certain circumstances.</p>

TOTAL HORIZ, DIRECT NORMAL KNOWN (MODE=4)

Proforma: Obsolete\Radiation Processors With Smoothing (Type16)\Total Horiz, Direct Normal Known (Mode=4)\Type16h.tmf
TRNSYS Model: Type 16
<p>Solar insolation data is generally taken at one hour intervals and on a horizontal surface. In most TRNSYS simulations, estimates of radiation at time intervals other than one hour are required. This component interpolates radiation data, calculates several quantities related to the position of the sun, and estimates insolation on a number of surfaces of either fixed or variable orientation.</p> <p>This instance of Type16 takes hourly integrated values of total horizontal and direct normal radiation as inputs. It can use various algorithms to compute radiation on tilted surfaces such as Hay and Davies, Perez, Reindl, etc. Data can be entered in solar or in local time. This version of Type16 performs radiation "smoothing" in which numerical methods are used to clean up spikes in recorded data. It is highly recommended that you plot values of smoothed solar radiation usign an online plotter as these smoothing algorithms can generate physically unreasonable values under certain circumstances.</p>

TOTAL HORIZ, HORIZ DIFFUSE KNOWN (MODE=5)

Proforma: Obsolete\Radiation Processors With Smoothing (Type16)\Total Horiz, Horiz Diffuse Known (Mode=5)\Type16j.tmf
TRNSYS Model: Type 16

Solar insolation data is generally taken at one hour intervals and on a horizontal surface. In most TRNSYS simulations, estimates of radiation at time intervals other than one hour are required. This component interpolates radiation data, calculates several quantities related to the position of the sun, and estimates insolation on a number of surfaces of either fixed or variable orientation.

This instance of Type16 takes hourly integrated values of total horizontal and horizontal diffuse radiation as inputs. It can use various algorithms to compute radiation on tilted surfaces such as Hay and Davies, Perez, Reindl, etc. Data can be entered in solar or in local time. This version of Type16 performs radiation "smoothing" in which numerical methods are used to clean up spikes in recorded data. It is highly recommended that you plot values of smoothed solar radiation using an online plotter as these smoothing algorithms can generate physically unreasonable values under certain circumstances.

3.4.9. Output

3.4.9.1. Economics

DETAILED ANALYSIS

Proforma: Output\Economics\Detailed Analysis\Type29b.tmf

TRNSYS Model: Type 29

TYPE 29 is called only twice in each simulation, once at the beginning of the simulation to check its parameter list, and again at the end to perform a standard life cycle cost analysis based on the simulation of one year of solar system operation. It compares the capital and back-up fuel costs of a solar system to the fuel costs of a conventional non-solar system. It is assumed that the solar back-up system is identical to the conventional heating system, in that only the incremental costs of adding solar to the conventional system are considered. The detail of the economic output is dependent on the mode and parameters used. In this instance (Mode 2) various economic parameters are used to calculate the yearly cash flows, life cycle costs, life cycle savings and payback periods. It also provides the user with options to calculate the rate of return on the solar investment, to consider income producing buildings, and to include federal and state tax credits.

P1,P2 METHOD

Proforma: Output\Economics\P1,P2 Method\Type29a.tmf

TRNSYS Model: Type 29

TYPE 29 is called only twice in each simulation, once at the beginning of the simulation to check its parameter list, and again at the end to perform a standard life cycle cost analysis based on the simulation of one year of solar system operation. It compares the capital and back-up fuel costs of a solar system to the fuel costs of a conventional non-solar system. It is assumed that the solar back-up system is identical to the conventional heating system, in that only the incremental costs of adding solar to the conventional system are considered. The detail of the economic output is dependent on the mode and parameters used. In this instance (Mode 1) uses the simplest method of calculating the life cycle costs and life cycle savings (the P1 and P2 method as described by Brandemuehl and Beckman, and Duffie and Beckman).

3.4.9.2. Histogram Plotter

TIME INTERVALS - RESULTS TO EXTERNAL FILE

Proforma: Output\Histogram Plotter\Time Intervals\Results to External File\Type27a.tmf

TRNSYS Model: Type 27

The TYPE 27 Histogram Plotter prints tabulated, user-specified time or frequency distributions for a series of inputs, and plots histograms for a more visual representation of the same information. There are two modes of Type27. In this instance (Mode 2) the user specifies a daily time range for each INPUT, consisting of a start time, a stop time and the number of intervals between. For each INPUT, TYPE 27 will print (and plot) the total integrated values of the INPUT that were present within each of the corresponding time intervals. This mode can be used, for example, to determine the daily distribution of an energy flux. For meaningful results in Mode 2, the user should specify the start and stop times and the number of intervals such that an integer number of time steps occur in each interval. In this instance of Type27, outputs are printed to a user defined external data file.

TIME INTERVALS - RESULTS TO LIST FILE

Proforma: Output\Histogram Plotter\Time Intervals\Results to List File\Type27b.tmf

TRNSYS Model: Type 27

The TYPE 27 Histogram Plotter prints tabulated, user-specified time or frequency distributions for a series of inputs, and plots histograms for a more visual representation of the same information. There are two modes of Type27. In this instance (Mode 2) the user specifies a daily time range for each INPUT, consisting of a start time, a stop time and the number of intervals between. For each INPUT, TYPE 27 will print (and plot) the total integrated values of the INPUT that were present within each of the corresponding time intervals. This mode can be used, for example, to determine the daily distribution of an energy flux. For meaningful results in Mode 2, the user should specify the start and stop times and the number of intervals such that an integer number of time steps occur in each interval. In this instance of Type27, outputs are printed directly to the list file.

VALUE INTERVALS - RESULTS TO EXTERNAL FILE

Proforma: Output\Histogram Plotter\Value Intervals\Results to External File\Type27c.tmf

TRNSYS Model: Type 27

The TYPE 27 Histogram Plotter prints tabulated, user-specified time or frequency distributions for a series of inputs, and plots histograms for a more visual representation of the same information. There are two modes of Type27. In this instance (Mode 1) the user specifies a range for each INPUT consisting of a minimum, a maximum, and the number of intervals between. TYPE 27 will print (and plot) the total integrated time (hours) that the INPUT variable was within each of the corresponding intervals. This mode can be used, for example, to determine the frequency distribution of a system temperature, or to assess the frequency of occurrence of various system modes or control functions. In this instance of Type27, outputs are printed to a user defined external file.

VALUE INTERVALS - RESULTS TO LIST FILE

Proforma: Output\Histogram Plotter\Value Intervals\Results to List File\Type27d.tmf

TRNSYS Model: Type 27

The TYPE 27 Histogram Plotter prints tabulated, user-specified time or frequency distributions for a series of inputs, and plots histograms for a more visual representation of the same information. There are two modes of Type27. In this instance (Mode 1) the user specifies a range for each INPUT consisting of a minimum, a maximum, and the number of intervals between. TYPE 27 will print (and plot) the total integrated time (hours) that the INPUT variable was within each of the corresponding intervals. This mode can be used, for example, to determine the frequency distribution of a system temperature, or to assess the frequency of occurrence of various system modes or control functions. In this instance of Type27, outputs are printed directly

to the list file.

3.4.9.3. *Online Plotter*

ONLINE PLOTTER WITH FILE - NO UNITS

Proforma: Output\Online Plotter\Online Plotter With File\No Units\Type65c.tmf

TRNSYS Model: Type 65

The online graphics component is used to display selected system variables while the simulation is progressing. This component is highly recommended and widely used since it provides valuable variable information and allows users to immediately see if the system is not performing as desired. The selected variables will be displayed in a separate plot window on the screen. In this instance of the Type65 online plotter, data sent to the online plotter is automatically printed, once per time step to a user defined external file. Unit descriptors (kJ/hr, kg/s, degC, etc.) are NOT printed to the output file.

ONLINE PLOTTER WITH FILE - TRNSYS-SUPPLIED UNITS

Proforma: Output\Online Plotter\Online Plotter With File\TRNSYS-Supplied Units\Type65a.tmf

TRNSYS Model: Type 65

The online graphics component is used to display selected system variables while the simulation is progressing. This component is highly recommended and widely used since it provides valuable variable information and allows users to immediately see if the system is not performing as desired. The selected variables will be displayed in a separate plot window on the screen. In this instance of the Type65 online plotter, data sent to the online plotter is automatically printed, once per time step to a user defined external file. TRNSYS supplied unit descriptors (kJ/hr, kg/s, degC, etc.), if available, will be printed along with each column of data in the output file.

ONLINE PLOTTER WITH FILE - USER-SUPPLIED UNITS

Proforma: Output\Online Plotter\Online Plotter With File\User-Supplied Units\Type65b.tmf

TRNSYS Model: Type 65

The online graphics component is used to display selected system variables while the simulation is progressing. This component is highly recommended and widely used since it provides valuable variable information and allows users to immediately see if the system is not performing as desired. The selected variables will be displayed in a separate plot window on the screen. In this instance of the Type65 online plotter, data sent to the online plotter is automatically printed, once per time step to a user defined external file. The user is required to supply unit descriptors (kJ/hr, kg/s, degC, etc.), which will be printed along with each column of data in the output file.

ONLINE PLOTTER WITHOUT FILE

Proforma: Output\Online Plotter\Online Plotter Without File\Type65d.tmf

TRNSYS Model: Type 65

The online graphics component is used to display selected system variables while the simulation is progressing. This component is highly recommended and widely used since it provides valuable variable information and allows users to immediately see if the system is not performing as desired. The selected variables will be displayed in a separate plot window on the screen. In this instance of the Type65 online plotter, no output data

file is generated.

3.4.9.4. *Printer*

No UNITS

Proforma: Output\Printer\No Units\Type25c.tmf

TRNSYS Model: Type 25

The printer component is used to output (or print) selected system variables at specified (even) intervals of time. In this mode, unit descriptors (kJ/hr, degC, W, etc.) are NOT printed to the output file with each column heading. Output can be printed in even time intervals starting relative to the simulation start time or can be printed in absolute time. If relative printing is chosen with a one hour print interval and the simulation starts at time 0.5, values will be printed at times 0.5, 1.5, 2.5, etc. If absolute printing is selected, for the same simulation, values will be printed at times 0.5, 1.0, 2.0, 3.0, etc. Type25 is also able to print simulation information as a header to the output file (name of input file, and time of simulation run). It is further able to append new data to an existing file or can be set to overwrite the existing file.

TRNSYS-SUPPLIED UNITS

Proforma: Output\Printer\TRNSYS-Supplied Units\Type25a.tmf

TRNSYS Model: Type 25

The printer component is used to output (or print) selected system variables at specified (even) intervals of time. In this mode, TRNSYS supplied units descriptors (kJ/hr, degC, W, etc.) if available, are printed to the output file along with each column heading. Output can be printed in even time intervals starting relative to the simulation start time or can be printed in absolute time. If relative printing is chosen with a one hour print interval and the simulation starts at time 0.5, values will be printed at times 0.5, 1.5, 2.5, etc. If absolute printing is selected, for the same simulation, values will be printed at times 0.5, 1.0, 2.0, 3.0, etc. Type25 is also able to print simulation information as a header to the output file (name of input file, and time of simulation run). It is further able to append new data to an existing file or can be set to overwrite the existing file.

USER-SUPPLIED UNITS

Proforma: Output\Printer\User-Supplied Units\Type25b.tmf

TRNSYS Model: Type 25

The printer component is used to output (or print) selected system variables at specified (even) intervals of time. In this mode, the user is required to supply units descriptors (kJ/hr, degC, W, etc.) which are printed to the output file along with each column heading. Output can be printed in even time intervals starting relative to the simulation start time or can be printed in absolute time. If relative printing is chosen with a one hour print interval and the simulation starts at time 0.5, values will be printed at times 0.5, 1.5, 2.5, etc. If absolute printing is selected, for the same simulation, values will be printed at times 0.5, 1.0, 2.0, 3.0, etc. Type25 is also able to print simulation information as a header to the output file (name of input file, and time of simulation run). It is further able to append new data to an existing file or can be set to overwrite the existing file.

3.4.9.5. *Simulation Summary*

RESULTS TO EXTERNAL FILE - WITH ENERGY BALANCE

Proforma: Output\Simulation Summary\Results to External File\With Energy Balance\Type28a.tmf
TRNSYS Model: Type 28
Type 28 can be conveniently used to generate daily, weekly, monthly or seasonal summaries of information computed in a simulation. Its output can be displayed either in a boxed format or as a table. Type 28 integrates its inputs over the time interval of the summary, performs user specified arithmetic operations on the integrals, and prints the results. This configuration prints results to an external file and includes an energy balance check

RESULTS TO EXTERNAL FILE - WITHOUT ENERGY BALANCE

Proforma: Output\Simulation Summary\Results to External File\Without Energy Balance\Type28b.tmf
TRNSYS Model: Type 28
Type 28 can be conveniently used to generate daily, weekly, monthly or seasonal summaries of information computed in a simulation. Its output can be displayed either in a boxed format or as a table. Type 28 integrates its inputs over the time interval of the summary, performs user specified arithmetic operations on the integrals, and prints the results. This configuration prints results to an external file

RESULTS TO LIST FILE - WITH ENERGY BALANCE

Proforma: Output\Simulation Summary\Results to List File\With Energy Balance\Type28c.tmf
TRNSYS Model: Type 28
This configuration is not recommended. Please use a mode of Type28 that prints results to an external file. Type 28 can be conveniently used to generate daily, weekly, monthly or seasonal summaries of information computed in a simulation. Its output can be displayed either in a boxed format or as a table. Type 28 integrates its inputs over the time interval of the summary, performs user specified arithmetic operations on the integrals, and prints the results. This configuration prints results to the listing file and includes an energy balance check

RESULTS TO LIST FILE - WITHOUT ENERGY BALANCE

Proforma: Output\Simulation Summary\Results to List File\Without Energy Balance\Type28d.tmf
TRNSYS Model: Type 28
This configuration is not recommended. Please use a mode of Type28 that prints results to an external file. Type 28 can be conveniently used to generate daily, weekly, monthly or seasonal summaries of information computed in a simulation. Its output can be displayed either in a boxed format or as a table. Type 28 integrates its inputs over the time interval of the summary, performs user specified arithmetic operations on the integrals, and prints the results. This configuration prints results to the listing file.

3.4.10. Physical Phenomena

3.4.10.1. Collector Array Shading

FLAT PLATE ARRAYS

Proforma: Physical Phenomena\Collector Array Shading\Flat Plate Arrays\Type30a.tmf

TRNSYS Model: Type 30

This component determines incident radiation upon an array of collectors that shade one another. There are two possible modes to Type30. This instance (MODE 1) considers fixed, flat plate collectors in a sloped field Incident shaded total, beam, and diffuse radiation are output.

PARABOLIC TROUGH ARRAYS - AXES IN PLANE OF SURFACE

Proforma: Physical Phenomena\Collector Array Shading\Parabolic Trough Arrays\Axes in Plane of Surface\Type30b.tmf

TRNSYS Model: Type 30

This component determines incident radiation upon an array of collectors that shade one another. There are two possible modes modled by Type30. This instance of Type30 (MODE 2) is for single axis tracking parabolic trough collectors that utilize beam radiation only. The tracking axis is assumed to be in the plane of the collector surfaces (not parallel to the ground)

PARABOLIC TROUGH ARRAYS - HORIZONTAL AXES

Proforma: Physical Phenomena\Collector Array Shading\Parabolic Trough Arrays\Horizontal Axes\Type30c.tmf

TRNSYS Model: Type 30

This component determines incident radiation upon an array of collectors that shade one another. There are two possible modes modled by Type30. This instance of Type30 (MODE 2) is for single axis tracking parabolic trough collectors that utilize beam radiation only. The tracking axis is assumed to be horizontal (parallel to the ground)

3.4.10.2. Convection Coefficient Calculation

HORIZONTAL SURFACE - DEFAULT COEFFICIENTS

Proforma: Physical Phenomena\Convection Coefficient Calculation\Horizontal Surface\Default Coefficients\Type80a.tmf

TRNSYS Model: Type 80

This routine calculates the convective heat transfer coefficient for up to 10 surfaces and is of particular use in conjunction with the radiant surface feature in Type56 that allows users to define walls or floors that contain either hot or cold water pipes for radiant heating or cooling. This instance of Type80 assumes that the surface is horizontal and uses default values of algorithm constant and exponent coefficients in its calculations.

HORIZONTAL SURFACE - USER DEFINED COEFFICIENTS

Proforma: Physical Phenomena\Convection Coefficient Calculation\Horizontal Surface\User Defined Coefficients\Type80b.tmf
TRNSYS Model: Type 80
This routine calculates the convective heat transfer coefficient for up to 10 surfaces and is of particular use in conjunction with the radiant surface feature in Type56 that allows users to define walls or floors that contain either hot or cold water pipes for radiant heating or cooling. This instance of Type80 assumes that the surface is horizontal and requires that the user provide algorithm constant and exponent coefficient values as parameters to the model.

VERTICAL SURFACE - DEFAULT COEFFICIENTS

Proforma: Physical Phenomena\Convection Coefficient Calculation\Vertical Surface\Default Coefficients\Type80c.tmf
TRNSYS Model: Type 80
This routine calculates the convective heat transfer coefficient for up to 10 surfaces and is of particular use in conjunction with the radiant surface feature in Type56 that allows users to define walls or floors that contain either hot or cold water pipes for radiant heating or cooling. This instance of Type80 assumes that the surface is vertical and uses default values of algorithm constant and exponent coefficients in its calculations.

VERTICAL SURFACE - USER DEFINED COEFFICIENTS

Proforma: Physical Phenomena\Convection Coefficient Calculation\Vertical Surface\User Defined Coefficients\Type80d.tmf
TRNSYS Model: Type 80
This routine calculates the convective heat transfer coefficient for up to 10 surfaces and is of particular use in conjunction with the radiant surface feature in Type56 that allows users to define walls or floors that contain either hot or cold water pipes for radiant heating or cooling. This instance of Type80 assumes that the surface is vertical and requires that the user provide algorithm constant and exponent coefficient values as parameters to the model.

3.4.10.3. Radiation Processors

BEAM AND DIFFUSE KNOWN (MODE=3)

Proforma: Physical Phenomena\Radiation Processors\Beam and Diffuse Known (Mode=3)\Type16e.tmf
TRNSYS Model: Type 16
Solar insolation data is generally taken at one hour intervals and on a horizontal surface. In most TRNSYS simulations, estimates of radiation at time intervals other than one hour are required. This component interpolates radiation data, calculates several quantities related to the position of the sun, and estimates insolation on a number of surfaces of either fixed or variable orientation. This instance of Type16 takes hourly integrated values of total horizontal and beam radiation as inputs. It can use various algorithms to compute radiation on tilted surfaces such as Hay and Davies, Perez, Reindl, etc. Data can be entered in solar or in local time. This version of Type16 DOES NOT perform radiation "smoothing" in which numerical methods are used to clean up spikes in recorded data.

TOTAL HORIZ ONLY KNOWN (MODE=1)

Proforma: Physical Phenomena\Radiation Processors\Total Horiz Only Known (Mode=1)\Type16a.tmf
TRNSYS Model: Type 16
Solar insolation data is generally taken at one hour intervals and on a horizontal surface. In most TRNSYS simulations, estimates of radiation at time intervals other than one hour are required. This component interpolates radiation data, calculates several quantities related to the position of the sun, and estimates insolation on a number of surfaces of either fixed or variable orientation. This instance of Type16 takes hourly integrated values of total horizontal solar radiation and estimates diffuse fraction internally. It can use various algorithms to compute radiation on tilted surfaces such as Hay and Davies, Perez, Reindl, etc. Data can be entered in solar or in local time. This version of Type16 DOES NOT perform radiation "smoothing" in which numerical methods are used to clean up spikes in recorded data.

TOTAL HORIZ TEMP AND HUMIDITY KNOWN (MODE=2)

Proforma: Physical Phenomena\Radiation Processors\Total Horiz Temp and Humidity Known (Mode=2)\Type16c.tmf
TRNSYS Model: Type 16
Solar insolation data is generally taken at one hour intervals and on a horizontal surface. In most TRNSYS simulations, estimates of radiation at time intervals other than one hour are required. This component interpolates radiation data, calculates several quantities related to the position of the sun, and estimates insolation on a number of surfaces of either fixed or variable orientation. This instance of Type16 takes hourly integrated values of total horizontal solar radiation and computes the diffuse fraction using an algorithm that estimates cloudiness based on dry bulb and dew point temperature. It can use various algorithms to compute radiation on tilted surfaces such as Hay and Davies, Perez, Reindl, etc. Data can be entered in solar or in local time. This version of Type16 DOES NOT perform radiation "smoothing" in which numerical methods are used to clean up spikes in recorded data.

TOTAL HORIZ, DIRECT NORMAL KNOWN (MODE=4)

Proforma: Physical Phenomena\Radiation Processors\Total Horiz, Direct Normal Known (Mode=4)\Type16g.tmf
TRNSYS Model: Type 16
Solar insolation data is generally taken at one hour intervals and on a horizontal surface. In most TRNSYS simulations, estimates of radiation at time intervals other than one hour are required. This component interpolates radiation data, calculates several quantities related to the position of the sun, and estimates insolation on a number of surfaces of either fixed or variable orientation. This instance of Type16 takes hourly integrated values of total horizontal and direct normal radiation as inputs. It can use various algorithms to compute radiation on tilted surfaces such as Hay and Davies, Perez, Reindl, etc. Data can be entered in solar or in local time. This version of Type16 DOES NOT perform radiation "smoothing" in which numerical methods are used to clean up spikes in recorded data.

TOTAL HORIZ, HORIZ DIFFUSE KNOWN (MODE=5)

Proforma: Physical Phenomena\Radiation Processors\Total Horiz, Horiz Diffuse Known (Mode=5)\Type16i.tmf
TRNSYS Model: Type 16
Solar insolation data is generally taken at one hour intervals and on a horizontal surface. In most TRNSYS simulations, estimates of radiation at time intervals other than one hour are required. This component interpolates radiation data, calculates several quantities related to the position of the sun, and estimates insolation on a number of surfaces of either fixed or variable orientation.

This instance of Type16 takes hourly integrated values of total horizontal and horizontal diffuse radiation as inputs. It can use various algorithms to compute radiation on tilted surfaces such as Hay and Davies, Perez, Reindl, etc. Data can be entered in solar or in local time. This version of Type16 DOES NOT perform radiation "smoothing" in which numerical methods are used to clean up spikes in recorded data.

3.4.10.4. Shading Masks

SHADING MASKS: SHADING BY EXTERNAL OBJECT WITH SINGLE SHADING MASK

Proforma: Physical Phenomena\Shading Masks\Type64.tmf
TRNSYS Model: Type 64
Type64 reads a file containing the angular heights of obstructions that shade a series of openings. This component uses a single shading mask for all of the openings. For each opening, a numerical ID in ascending order is provided on the first line of the data file. The second line contains the slope of each opening. The third line contains the azimuth of each opening. The fourth line contains a series of absolute surface angles; angles for which obstruction heights will later be provided. The fifth and subsequent lines of the data file each contain the angular height of an arbitrary obstruction as seen from the center of an aperture while looking in the direction of one of the above provided surface azimuth angles. Type64 takes two inputs that give the angle of the sun, two inputs that give total and diffuse radiation on the horizontal and then two inputs for each opening that give the beam and diffuse radiation on each opening. The component returns ten outputs for each opening in the file. The first output is the fraction of beam radiation that is visible from the opening. The second is the shaded beam radiation on the opening. The third output is the fraction of diffuse radiation incident on the surface. The fourth and fifth outputs give the shaded diffuse and shaded total radiation respectively (both on the plane of the opening). Outputs six through eleven (for each opening) give the same values in the plane of the horizontal.

SHADING MASKS: SHADING BY EXTERNAL OBJECT ON OPENING AND HORIZONTAL SURFACE

Proforma: Physical Phenomena\Shading Masks\Type67.tmf
TRNSYS Model: Type 67
Type67 reads a file containing the angular heights of obstructions that shade a series of openings. For each opening, a numerical ID in ascending order is provided on the first line of the data file. The second line contains the slope of each opening. The third line contains the azimuth of each opening. The fourth line contains a series of absolute surface angles; angles for which obstruction heights will later be provided. The fifth and subsequent lines of the data file each contain the angular height of an arbitrary obstruction as seen from the center of an aperture while looking in the direction of one of the above provided surface azimuth angles. Type67 takes two inputs that give the angle of the sun, two inputs that give total and diffuse radiation on the horizontal and then two inputs for each opening that give the beam and diffuse radiation on each opening. The component returns ten outputs for each opening in the file. The first output is the fraction of beam radiation that is visible from the opening. The second is the shaded beam radiation on the opening. The third output is the fraction of diffuse radiation incident on the surface. The fourth and fifth outputs give the shaded diffuse and shaded total radiation respectively (both on the plane of the opening). Outputs six through eleven (for each opening) give the same values in the plane of the horizontal.

SHADING MASKS: SHADING BY EXTERNAL OBJECT

Proforma: Physical Phenomena\Shading Masks\Type68.tmf
TRNSYS Model: Type 68
<p>NOTE: An upgraded version of this component can be found in Type67, which calculates the shading on the horizontal surface corresponding to each opening or facade. Type68 was kept for backwards compatibility, but it will be made obsolete in future versions of TRNSYS.</p> <p>-----</p> <p>Type68 reads a file containing the angular heights of obstructions that shade a series of openings. For each opening, a numerical ID in ascending order is provided on the first line of the data file. The second line contains the slope of each opening. The third line contains the azimuth of each opening. The fourth line contains a series of surface angles; angles for which obstruction heights will later be provided. The fifth and subsequent lines of the data file each contain the angular height of an arbitrary obstruction as seen from the center of an aperture while looking in the direction of one of the above provided surface azimuth angles.</p> <p>Type68 takes two inputs which give the angle of the sun and return five outputs for each opening in the file. The first output is the fraction of diffuse radiation that is visible from the opening. The second output for each opening is a flag which has a value of 1 if the beam radiation is visible from the opening and 0 if it is not. The remaining outputs are the shaded diffuse, beam and total radiation incident on each opening.</p>

3.4.10.5. Simple Ground Temperature Model

SIMPLE GROUND TEMPERATURE MODEL

Proforma: Physical Phenomena\Simple Ground Temperature Model\Type77.tmf
TRNSYS Model: Type 77
<p>Refer to the document: ".\Tess Models\Documentation\Utility Library\Type501.pdf " for a complete technical description of this component.</p> <p>This subroutine models the vertical temperature distribution of the ground given the mean ground surface temperature for the year, the amplitude of the ground surface temperature for the year, the time difference between the beginning of the calendar year and the occurrence of the minimum surface temperature, and the thermal diffusivity of the soil. These values may be found in a variety of sources including the ASHRAE Handbooks (refer to soil temperature).</p>

3.4.10.6. Sky Temperature

CALCULATE CLOUDINESS FACTOR

Proforma: Physical Phenomena\Sky Temperature\calculate cloudiness factor\Type69b.tmf
TRNSYS Model: Type 69
<p>This component determines an effective sky temperature, which is used to calculate the long-wave radiation exchange between an arbitrary external surface and the atmosphere. The effective sky temperature is always lower than the current ambient temperature. The black sky on a clear night for example, is assigned a low effective sky temperature to account for the additional radiative losses from a surface exposed to the sky. In this instance of Type69, the cloudiness of the sky is calculated based on user provided dry bulb and dew point temperatures.</p>

READ IN CLOUDINESS FACTOR

Proforma: Physical Phenomena\Sky Temperature\read in cloudiness factor\Type69a.tmf
TRNSYS Model: Type 69
This component determines an effective sky temperature, which is used to calculate the long-wave radiation exchange between an arbitrary external surface and the atmosphere. The effective sky temperature is always lower than the current ambient temperature. The black sky on a clear night for example, is assigned a low effective sky temperature to account for the additional radiative losses from a surface exposed to the sky. In this instance of Type69, the cloudiness of the sky must be provided as an input to the model.

3.4.10.7. Thermodynamic Properties**PSYCHROMETRICS - DRY BULB AND DEW POINT KNOWN**

Proforma: Physical Phenomena\Thermodynamic Properties\Psihrometrics\Dry Bulb and Dew Point Known\Type33d.tmf
TRNSYS Model: Type 33
This component takes as input the dry bulb temperature and dew point temperature of moist air and calls the TRNSYS Psychrometrics routine, returning the following corresponding moist air properties: dry bulb temperature, dew point temperature, wet bulb temperature, relative humidity, absolute humidity ratio, and enthalpy.

PSYCHROMETRICS - DRY BULB AND ENTHALPY KNOWN

Proforma: Physical Phenomena\Thermodynamic Properties\Psihrometrics\Dry Bulb and Enthalpy Known\Type33b.tmf
TRNSYS Model: Type 33
This component takes as input the dry bulb temperature and enthalpy of moist air and calls the TRNSYS Psychrometrics routine, returning the following corresponding moist air properties: dry bulb temperature, dew point temperature, wet bulb temperature, relative humidity, absolute humidity ratio, and enthalpy.

PSYCHROMETRICS - DRY BULB AND HUMIDITY RATIO KNOWN

Proforma: Physical Phenomena\Thermodynamic Properties\Psihrometrics\Dry Bulb and Humidity Ratio Known\Type33c.tmf
TRNSYS Model: Type 33
This component takes as input the dry bulb temperature and humidity ratio of moist air and calls the TRNSYS Psychrometrics routine, returning the following corresponding moist air properties: dry bulb temperature, dew point temperature, wet bulb temperature, relative humidity, absolute humidity ratio, and enthalpy.

PSYCHROMETRICS - DRY BULB AND RELATIVE HUMIDITY KNOWN

Proforma: Physical Phenomena\Thermodynamic Properties\Psihrometrics\Dry Bulb and Relative Humidity Known\Type33e.tmf
TRNSYS Model: Type 33

This component takes as input the dry bulb temperature and relative humidity of moist air and calls the TRNSYS Psychrometrics routine, returning the following corresponding moist air properties: dry bulb temperature, dew point temperature, wet bulb temperature, relative humidity, absolute humidity ratio, and enthalpy.

PSYCHROMETRICS - DRY BULB AND WET BULB KNOWN

Proforma: Physical Phenomena\Thermodynamic Properties\Psihchrometrics\Dry Bulb and Wet Bulb Known\Type33f.tmf

TRNSYS Model: Type 33

This component takes as input the dry bulb temperature and wet bulb temperature of moist air and calls the TRNSYS Psychrometrics routine, returning the following corresponding moist air properties: dry bulb temperature, dew point temperature, wet bulb temperature, relative humidity, absolute humidity ratio, and enthalpy.

PSYCHROMETRICS - HUMIDITY RATIO AND ENTHALPY KNOWN

Proforma: Physical Phenomena\Thermodynamic Properties\Psihchrometrics\Humidity ratio and Enthalpy Known\Type33a.tmf

TRNSYS Model: Type 33

This component takes as input the humidity ratio and enthalpy of moist air and calls the TRNSYS Psychrometrics routine, returning the following corresponding moist air properties: dry bulb temperature, dew point temperature, wet bulb temperature, relative humidity, absolute humidity ratio, and enthalpy.

REFRIGERANT AND STEAM PROPERTIES

Proforma: Physical Phenomena\Thermodynamic Properties\Refrigerant and Steam Properties\Type58.tmf

TRNSYS Model: Type 58

This component takes as input two unique independent state properties of a refrigerant and calculates the remaining state properties. It calls the TRNSYS Fluid Properties routine and the TRNSYS Steam Properties Routine to calculate the thermodynamic properties. The available refrigerants for this routine are: R-11, R-12, R-13, R-14, R-22, R-114A, R-134A, R-500, R-502, ammonia (R-717) and steam (R-718).

3.4.10.8. Weather Generators

DEFAULT RANDOM NUMBER SEEDS

Proforma: Physical Phenomena\Weather Generators\Default Random Number Seeds\Type54a.tmf

TRNSYS Model: Type 54

This component generates hourly weather data given the monthly average values of solar radiation, dry bulb temperature, humidity ratio, and windspeed. The data are generated in a manner such that their associated statistics are approximately equal to the long-term statistics at the specified location. The purpose of this method is to generate a single year of typical data, similar to a Typical Meteorological Year. This component allows TRNSYS to be used for any location for which standard yearly average weather statistics are known. However, many of the correlations used in the model were developed from primarily temperate climate data. For other climates, e.g., tropical climates, the generated data are less accurate and the user may wish to make some modifications. In this instance of Type54, predefined random number seeds are used as the basis of the

generation of hourly values. It reads monthly average values of temperature, solar radiation, and humidity ratio. If desired, the user may enter values of monthly average wind speed as parameters to the model.

DEFAULT RANDOM NUMBER SEEDS - NO EXTERNAL FILE

Proforma: Physical Phenomena\Weather Generators\Default Random Number Seeds\No External File\TYPE54c.tmf
TRNSYS Model: Type 54
This component generates hourly weather data given the monthly average values of solar radiation, dry bulb temperature, humidity ratio, and windspeed. The data are generated in a manner such that their associated statistics are approximately equal to the long-term statistics at the specified location. The purpose of this method is to generate a single year of typical data, similar to a Typical Meteorological Year. This component allows TRNSYS to be used for any location for which standard yearly average weather statistics are known. However, many of the correlations used in the model were developed from primarily temperate climate data. For other climates, e.g., tropical climates, the generated data are less accurate and the user may wish to make some modifications. In this instance of Type54, predefined random number seeds are used as the basis of the generation of hourly values. It reads monthly average values of temperature, solar radiation, and humidity ratio directly from the input file instead of from an external data file.

USER-SUPPLIED RANDOM NUMBER SEEDS

Proforma: Physical Phenomena\Weather Generators\User-Supplied Random Number Seeds\Type54b.tmf
TRNSYS Model: Type 54
This component generates hourly weather data given the monthly average values of solar radiation, dry bulb temperature, humidity ratio, and windspeed. The data are generated in a manner such that their associated statistics are approximately equal to the long-term statistics at the specified location. The purpose of this method is to generate a single year of typical data, similar to a Typical Meteorological Year. This component allows TRNSYS to be used for any location for which standard yearly average weather statistics are known. However, many of the correlations used in the model were developed from primarily temperate climate data. For other climates, e.g., tropical climates, the generated data are less accurate and the user may wish to make some modifications. In this instance of Type54, the user is required to provide the random number seeds on which the generation of hourly values will be based. It reads monthly average values of temperature, solar radiation, and humidity ratio. If desired, the user may enter values of monthly average wind speed as parameters to the model.

USER-SUPPLIED RANDOM NUMBER SEEDS - NO EXTERNAL FILE

Proforma: Physical Phenomena\Weather Generators\User-Supplied Random Number Seeds\No External File\TYPE54d.tmf
TRNSYS Model: Type 54
This component generates hourly weather data given the monthly average values of solar radiation, dry bulb temperature, humidity ratio, and windspeed. The data are generated in a manner such that their associated statistics are approximately equal to the long-term statistics at the specified location. The purpose of this method is to generate a single year of typical data, similar to a Typical Meteorological Year. This component allows TRNSYS to be used for any location for which standard yearly average weather statistics are known. However, many of the correlations used in the model were developed from primarily temperate climate data. For other climates, e.g., tropical climates, the generated data are less accurate and the user may wish to make some modifications. In this instance of Type54, the user is required to provide the random number seeds on which the generation of hourly values will be based. It reads monthly average values of temperature, solar radiation, and humidity ratio directly from the input file instead of from an external data file.

3.4.11. Solar Thermal Collectors

3.4.11.1. CPC Collector

CPC COLLECTOR

Proforma: Solar Thermal Collectors\CPC Collector\Type74.tmf

TRNSYS Model: Type 74

This component models the thermal performance of a compound parabolic concentrating (CPC) solar collector. A CPC collector consists of a concentrating reflector and an absorber. The walls of a two-dimensional (trough-like) CPC are parabolic in shape. The focus of each parabola coincides with the intersection of the absorber and the opposite wall. The CPC collects both beam and diffuse radiation which approach the aperture within a critical angle called the half-acceptance angle (θ_c). A full CPC is one in which the walls extend upward to a height h which gives an aperture area of $1/\sin(\theta_c)$ times the absorber area. Optimal concentration is achieved in a full CPC, but a very large reflector area is required. In practice, most CPC's are truncated to a height of h_{bar} which is less than h . A CPC collector can be modeled in three steps. First, the total beam and diffuse radiation within the acceptance angle are determined. Next, reflector concentration and reflective losses are considered and the effective radiation striking the absorber is calculated. This effective radiation is then used to find the energy transferred to the collector flowstream and the resulting outlet temperature.

There are two possible orientations considered for a CPC receiver. First of all, the CPC may be located in a vertical plane than contains the surface azimuth. This is termed the longitudinal plane. Alternatively, the CPC receiver may be located in a transverse plane 90 degrees from the longitudinal plane.

3.4.11.2. Evacuated Tube Collector

EVACUATED TUBE COLLECTOR

Proforma: Solar Thermal Collectors\Evacuated Tube Collector\Type71.tmf

TRNSYS Model: Type 71

Because the Solar Ratings and Certification Commission (SRCC) defines the efficiency of an evacuated tube collector bank using the same equations as those for a flat plate, the main difference (from a modeling point of view) between an evacuated tube collector and a flat plate collector is in the treatment of incidence angle modifiers (IAMs). Type 71 is therefore based on the Type 1 code with the major difference being that Type 71 reads a text file containing a list of transverse and longitudinal IAMs. This component models the thermal performance of a variety of an evacuated tube collector types using theory. The total collector array may consist of collectors connected in series and in parallel. The thermal performance of the total collector array is determined by the number of modules in series and the characteristics of each module. The user must provide results from standard tests of efficiency versus a ratio of fluid temperature minus ambient temperature to radiation (DT/IT). The fluid temperature may be an inlet, average, or outlet temperature. The model assumes that the efficiency vs. DT/IT curve can be modeled as a quadratic equation. (Changed from version 13 where efficiency vs. DT/IT was assumed linear.) Corrections are applied to the slope, intercept, and curvature parameters to account for identical collectors in series, and flow rates other than those at test conditions. The effects of off-normal solar incidence are modeled by the provision of a bi-axial incidence angle modifier data file.

3.4.11.3. Performance Map Collector

2ND-ORDER INCIDENCE ANGLE MODIFIERS

Proforma: Solar Thermal Collectors\Performance Map Collector\2nd-Order Incidence Angle Modifiers\Type72b.tmf
TRNSYS Model: Type 72
<p>This component models the thermal performance of a solar collector using performance data read from an external file. The total collector array may consist of collectors connected in series and in parallel. The thermal performance of the total collector array is determined by the number of modules in series and the characteristics of each module. The user must enter a performance map of collector efficiency as a function of DT/IT, radiation, and wind speed. This is useful for collectors with non-linear efficiency vs. DT/IT relationships, concentrating collectors whose performance may depend strongly upon the level of radiation, or coverless collectors that are sensitive to wind speed. If imaging collectors, which use only beam radiation, are considered then only beam radiation should be provided as an input to this component.</p> <p>In Type72, there are five possibilities for considering the effects of off-normal solar incidence. In this instance of Type72, a second order quadratic function is used to compute the incidence angle modifier. The coefficients of the function are supplied by an ASHRAE test.</p>

BIAXIAL INCIDENCE ANGLE MODIFIERS

Proforma: Solar Thermal Collectors\Performance Map Collector\Biaxial Incidence Angle Modifiers\Type72e.tmf
TRNSYS Model: Type 72
<p>This component models the thermal performance of a solar collector using performance data read from an external file. The total collector array may consist of collectors connected in series and in parallel. The thermal performance of the total collector array is determined by the number of modules in series and the characteristics of each module. The user must enter a performance map of collector efficiency as a function of DT/IT, radiation, and wind speed. This is useful for collectors with non-linear efficiency vs. DT/IT relationships, concentrating collectors whose performance may depend strongly upon the level of radiation, or coverless collectors that are sensitive to wind speed. If imaging collectors, which use only beam radiation, are considered then only beam radiation should be provided as an input to this component.</p> <p>In Type72, there are five possibilities for considering the effects of off-normal solar incidence. In this instance of Type72, the incidence angle modifiers are read from an external data file as a function of the transverse abd of the longitudinal incidence angle.</p>

COVER AND ABSORBER PROPERTIES

Proforma: Solar Thermal Collectors\Performance Map Collector\Cover and Absorber Properties\Type72d.tmf
TRNSYS Model: Type 72
<p>This component models the thermal performance of a solar collector using performance data read from an external file. The total collector array may consist of collectors connected in series and in parallel. The thermal performance of the total collector array is determined by the number of modules in series and the characteristics of each module. The user must enter a performance map of collector efficiency as a function of DT/IT, radiation, and wind speed. This is useful for collectors with non-linear efficiency vs. DT/IT relationships, concentrating collectors whose performance may depend strongly upon the level of radiation, or coverless collectors that are sensitive to wind speed. If imaging collectors, which use only beam radiation, are considered then only beam radiation should be provided as an input to this component.</p> <p>In Type72, there are five possibilities for considering the effects of off-normal solar incidence. In this instance of Type72, the incidence angle modifiers are calculated from user supplied cover and absorber properties such as extinction coefficient, cover thickness, and index of refraction.</p>

MODIFERS=F(INCIDENCE ANGLE)

Proforma: Solar Thermal Collectors\Performance Map Collector\Modifiers=f(Incidence Angle)\Type72c.tmf
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TRNSYS Model: Type 72

This component models the thermal performance of a solar collector using performance data read from an external file. The total collector array may consist of collectors connected in series and in parallel. The thermal performance of the total collector array is determined by the number of modules in series and the characteristics of each module. The user must enter a performance map of collector efficiency as a function of DT/IT, radiation, and wind speed. This is useful for collectors with non-linear efficiency vs. DT/IT relationships, concentrating collectors whose performance may depend strongly upon the level of radiation, or coverless collectors that are sensitive to wind speed. If imaging collectors, which use only beam radiation, are considered then only beam radiation should be provided as an input to this component.

In Type72, there are five possibilities for considering the effects of off-normal solar incidence. In this instance of Type72, the incidence angle modifiers are read from an external data file as a function of the transverse incidence angle.

NO INCIDENCE ANGLE MODIFICATION

Proforma: Solar Thermal Collectors\Performance Map Collector\No Incidence Angle Modification\Type72a.tmf

TRNSYS Model: Type 72

This component models the thermal performance of a solar collector using performance data read from an external file. The total collector array may consist of collectors connected in series and in parallel. The thermal performance of the total collector array is determined by the number of modules in series and the characteristics of each module. The user must enter a performance map of collector efficiency as a function of DT/IT, radiation, and wind speed. This is useful for collectors with non-linear efficiency vs. DT/IT relationships, concentrating collectors whose performance may depend strongly upon the level of radiation, or coverless collectors that are sensitive to wind speed. If imaging collectors, which use only beam radiation, are considered then only beam radiation should be provided as an input to this component.

In Type72, there are five possibilities for considering the effects of off-normal solar incidence. In this particular instance of Type72 no off-normal incidence effects are considered.

3.4.11.4. Quadratic Efficiency Collector***2ND-ORDER INCIDENCE ANGLE MODIFIERS***

Proforma: Solar Thermal Collectors\Quadratic Efficiency Collector\2nd-Order Incidence Angle Modifiers\Type1b.tmf

TRNSYS Model: Type 1

This component models the thermal performance of a flat-plate solar collector. The solar collector array may consist of collectors connected in series and in parallel. The thermal performance of the collector array is determined by the number of modules in series and the characteristics of each module. The user must provide results from standard tests of collector efficiency versus a ratio of fluid temperature minus ambient temperature to solar radiation. The fluid temperature may be the inlet temperature, the average temperature, or the outlet temperature. In Type1, there are 5 possibilities for considering the effects of off-normal solar incidence. In this instance of Type1, a second order quadratic function is used to compute the incidence angle modifier. The coefficients of the function are supplied by an ASHRAE or equivalent test (see manual).

BIAXIAL INCIDENCE ANGLE MODIFIERS

Proforma: Solar Thermal Collectors\Quadratic Efficiency Collector\Biaxial Incidence Angle Modifiers\Type1e.tmf

TRNSYS Model: Type 1

This component models the thermal performance of a flat-plate solar collector. The solar collector array may consist of collectors connected in series and in parallel. The thermal performance of the collector array is determined by the number of modules in series and the characteristics of each module. The user must provide results from standard tests of collector efficiency versus a ratio of fluid temperature minus ambient temperature to solar radiation. The fluid temperature may be the inlet temperature, the average temperature, or the outlet temperature. In Type1, there are 5 possibilities for considering the effects of off-normal solar incidence. In this instance of Type1, the incidence angle modifiers are read from an external data file as a function of the transversal and longitudinal incidence angles (see manual). This mode is generally used for evacuated tube collectors, for which it is recommended to use Type 71.

COVER AND ABSORBER PROPERTIES

Proforma: Solar Thermal Collectors\Quadratic Efficiency Collector\Cover and Absorber Properties\Type1d.tmf

TRNSYS Model: Type 1

This component models the thermal performance of a flat-plate solar collector. The solar collector array may consist of collectors connected in series and in parallel. The thermal performance of the collector array is determined by the number of modules in series and the characteristics of each module. The user must provide results from standard tests of collector efficiency versus a ratio of fluid temperature minus ambient temperature to solar radiation. The fluid temperature may be the inlet temperature, the average temperature, or the outlet temperature. In Type1, there are 5 possibilities for considering the effects of off-normal solar incidence. In this instance of Type1, the incidence angle modifiers are calculated from user supplied cover and absorber properties such as extinction coefficient, cover thickness, and index of refraction.

MODIFERS=F(INCIDENCE ANGLE)

Proforma: Solar Thermal Collectors\Quadratic Efficiency Collector\Modifiers=f(Incidence Angle)\Type1c.tmf

TRNSYS Model: Type 1

This component models the thermal performance of a flat-plate solar collector. The solar collector array may consist of collectors connected in series and in parallel. The thermal performance of the collector array is determined by the number of modules in series and the characteristics of each module. The user must provide results from standard tests of collector efficiency versus a ratio of fluid temperature minus ambient temperature to solar radiation. The fluid temperature may be the inlet temperature, the average temperature, or the outlet temperature. In Type1, there are 5 possibilities for considering the effects of off-normal solar incidence. In this instance of Type1, the incidence angle modifiers are read from an external data file as a function of the transversal and longitudinal incidence angles (see manual). In this instance of Type1, the incidence angle modifiers are read from an external data file as a function of the incidence angle (the collector is assumed to be symmetrical, see manual).

NO INCIDENCE ANGLE MODIFICATION

Proforma: Solar Thermal Collectors\Quadratic Efficiency Collector\No Incidence Angle Modification\Type1a.tmf

TRNSYS Model: Type 1

This component models the thermal performance of a flat-plate solar collector. The solar collector array may consist of collectors connected in series and in parallel. The thermal performance of the collector array is determined by the number of modules in series and the characteristics of each module. The user must provide results from standard tests of collector efficiency versus a ratio of fluid temperature minus ambient temperature to solar radiation. The fluid temperature may be the inlet temperature, the average temperature, or the outlet temperature. In Type1, there are 5 possibilities for considering the effects of off-normal solar incidence. In this instance of Type1 no off-normal incidence effects are considered.

3.4.11.5. Theoretical Flat-Plate Collector

THEORETICAL FLAT-PLATE COLLECTOR

Proforma: Solar Thermal Collectors\Theoretical Flat-Plate Collector\Type73.tmf

TRNSYS Model: Type 73

This component models the thermal performance of a theoretical flat plate collector. The total collector array may consist of collectors connected in series and in parallel. The thermal performance of the total collector array is determined by the number of modules in series and the characteristics of each module. This model provides for the theoretical analyses of a flat plate. The Hottel-Whillier steady-state model is used for evaluating the thermal performance.

3.4.11.6. Thermosyphon Collector with Integral Storage

EXTERNAL FILE FOR HEAD VS. FLOWRATE

Proforma: Solar Thermal Collectors\Thermosyphon Collector with Integral Storage\External File for Head vs. Flowrate\Type45.tmf

TRNSYS Model: Type 45

This component models the thermosyphon solar collector system. The system consists of a flat-plate solar collector, a stratified storage tank (either vertical or horizontal cylinder) located physically above the collector plate, a check valve to prevent reverse flow, and water as the working fluid. Flow in the loop is assumed to be steady-state. The system is analyzed by dividing the thermosyphon loop into a number of segments normal to the flow direction and applying Bernoulli's equation for incompressible flow to each segment. The flow rate is obtained by numerical solution of the resulting set of equations. The stratification in the storage tank is modeled using the Type 38 Algebraic tank component. The advantage of the Type 38 model over fixed node models (Type 4) is that large simulation time steps can be used. A time step of 1 hour in the Type 38 tank model is sufficient for many stratified tank systems, whereas simulation time steps of a few minutes are necessary in a Type 4 model with a large number of fixed nodes. This instance of Type45 reads head vs. flow rate in the thermosyphon system from an external data file.

HEAD VS FLOWRATE CALCULATED INTERNALLY

Proforma: Solar Thermal Collectors\Thermosyphon Collector with Integral Storage\Head vs Flowrate Calculated Internally\Type45a.tmf

TRNSYS Model: Type 45

This component models the thermosyphon solar collector system. The system consists of a flat-plate solar collector, a stratified storage tank (either vertical or horizontal cylinder) located physically above the collector plate, a check valve to prevent reverse flow, and water as the working fluid. Flow in the loop is assumed to be steady-state. The system is analyzed by dividing the thermosyphon loop into a number of segments normal to the flow direction and applying Bernoulli's equation for incompressible flow to each segment. The flow rate is obtained by numerical solution of the resulting set of equations. The stratification in the storage tank is modeled using the Type 38 Algebraic tank component. The advantage of the Type 38 model over fixed node models (Type 4) is that large simulation time steps can be used. A time step of 1 hour in the Type 38 tank model is sufficient for many stratified tank systems, whereas simulation time steps of a few minutes are necessary in a Type 4 model with a large number of fixed nodes. This instance of Type45 uses a curve fit to internally calculate head vs. flow rate in the thermosyphon system.

3.4.12. Thermal Storage

3.4.12.1. Detailed Fluid Storage Tank

TYPE 60

Proforma: Thermal Storage\Detailed Fluid Storage Tank\Type60*.tmf

TRNSYS Model: Type 60

Please note that Type 60 has many proformas due to its complex configuration.

Like Type4, Type60 models a stratified liquid storage tank. It includes numerous features beyond the scope of Type4 such as allowing for multiple heat exchangers within the tank and allowing for unmatched numbers of inlet and outlet flows.

Please refer to Volume 05 for a description of Type 60

3.4.12.2. Plug-Flow Tank

PLUG-FLOW TANK

Proforma: Thermal Storage\Plug-Flow Tank\Type38.tmf

TRNSYS Model: Type 38

This component models the behaviour of a temperature stratified storage tank using variable size segments of fluid. The size of segments is governed by the simulation time step, the magnitude of collector and load flow rates, heat losses and auxiliary input. The main advantage over fixed node simulation techniques (eg. TYPE 4) is that temperature stratification can be modeled with small segments in the temperature gradient zone without the need to use small simulation time steps to obtain a good solution. This model is most appropriate for tanks that exhibit a large degree of stratification.

There are two modes of operation. In mode 1, the tank has fixed inlet positions and the flow mixes with adjacent segments if its temperature is within 1/2 degree. Otherwise a new segment is created and temperature inversions are corrected by mixing appropriate segments above or below the inlets. In mode 2, the tank has variable inlet positions and new segments are inserted at the levels which produce no temperature inversions. This allows a maximum degree of stratification and is equivalent to the TYPE 4 model with a large number of nodes.

3.4.12.3. Rock Bed Storage

ROCK BED STORAGE

Proforma: Thermal Storage\Rock Bed Storage\Type10.tmf

TRNSYS Model: Type 10

Rock bed thermal storage can be described by the relations governing heat transfer for fluid flow in packed beds. Neglecting temperature gradients within the rocks, axial conduction and assuming a uniform flow distribution of air through the bed, two partial differential equations describe the air and rock temperatures as a function of bed position and time. These equations can be solved by finite difference methods. However, small time steps and many nodes are required to maintain accuracy.

Note that the mathematical model is only valid if one of the flows (up or down) is positive. You will get an error

message if both flows are positive.

3.4.12.4. Stratified Storage Tank

FIXED INLETS - NON-UNIFORM LOSSES

Proforma: Thermal Storage\Stratified Storage Tank\Fixed Inlets\Non-uniform Losses\Type4b.tmf

TRNSYS Model: Type 4

The thermal performance of a fluid-filled sensible energy storage tank, subject to thermal stratification, can be modelled by assuming that the tank consists of N ($N \leq 15$) fully-mixed equal volume segments. The degree of stratification is determined by the value of N . If N is equal to 1, the storage tank is modelled as a fully-mixed tank and no stratification effects are possible. This instance of Type 4 models a stratified tank having fixed inlet positions defined within the code. Fluid entering the hot side of the tank is added to the tank node below the first auxiliary heater. Fluid entering the cold side of the tank enters the bottom node. The node sizes in this instance need not be equal. Temperature deadband on heater thermostats are available. This instance further assumes that losses from each tank node are equal and does not compute losses to the gas flue of the auxiliary heater.

FIXED INLETS - UNIFORM LOSSES

Proforma: Thermal Storage\Stratified Storage Tank\Fixed Inlets\Uniform Losses\Type4a.tmf

TRNSYS Model: Type 4

The thermal performance of a fluid-filled sensible energy storage tank, subject to thermal stratification, can be modelled by assuming that the tank consists of N ($N \leq 15$) fully-mixed equal volume segments. The degree of stratification is determined by the value of N . If N is equal to 1, the storage tank is modelled as a fully-mixed tank and no stratification effects are possible. This instance of Type 4 models a stratified tank having fixed inlet positions defined within the code. Fluid entering the hot side of the tank is added to the tank node below the first auxiliary heater. Fluid entering the cold side of the tank enters the bottom node. The node sizes in this instance need not be equal. Temperature deadband on heater thermostats are available. This instance further assumes that losses from each tank node are equal and does not compute losses to the gas flue of the auxiliary heater.

USER-DESIGNATED INLETS - NON-UNIFORM LOSSES

Proforma: Thermal Storage\Stratified Storage Tank\User-Designated Inlets\Non-uniform Losses\Type4f.tmf

TRNSYS Model: Type 4

The thermal performance of a fluid-filled sensible energy storage tank, subject to thermal stratification, can be modelled by assuming that the tank consists of N ($N \leq 15$) fully-mixed equal volume segments. The degree of stratification is determined by the value of N . If N is equal to 1, the storage tank is modelled as a fully-mixed tank and no stratification effects are possible. This instance of Type 4 models a stratified tank having user defined inlet positions. The node sizes in this instance need not be equal. Temperature deadband on heater thermostats are available. This instance does not compute losses to the gas flue of the auxiliary heater but does allow the user to define losses on a per node basis. Thus the losses from each node need not be uniform.

USER-DESIGNATED INLETS - UNIFORM LOSSES

Proforma: Thermal Storage\Stratified Storage Tank\User-Designated Inlets\Uniform Losses\Type4e.tmf

TRNSYS Model: Type 4

The thermal performance of a fluid-filled sensible energy storage tank, subject to thermal stratification, can be

modelled by assuming that the tank consists of N ($N \leq 15$) fully-mixed equal volume segments. The degree of stratification is determined by the value of N. If N is equal to 1, the storage tank is modelled as a fully-mixed tank and no stratification effects are possible. This instance of Type 4 models a stratified tank having user defined inlet positions. The node sizes in this instance need not be equal. Temperature deadband on heater thermostats are available. This instance further assumes that losses from each tank node are equal and does not compute losses to the gas flue of the auxiliary heater.

VARIABLE INLETS - NON-UNIFORM LOSSES

Proforma: Thermal Storage\Stratified Storage Tank\Variable Inlets\Non-uniform Losses\Type4d.tmf
TRNSYS Model: Type 4
The thermal performance of a fluid-filled sensible energy storage tank, subject to thermal stratification, can be modelled by assuming that the tank consists of N ($N \leq 15$) fully-mixed equal volume segments. The degree of stratification is determined by the value of N. If N is equal to 1, the storage tank is modelled as a fully-mixed tank and no stratification effects are possible. This instance of Type 4 models a stratified tank having variable inlet positions such that entering fluid may be added to the tank at a temperature as nearly equal to its own temperature as possible. The node sizes in this instance need not be equal. Temperature deadband on heater thermostats are available. This instance does not compute losses to the gas flue of the auxiliary heater but does allow the user to define losses on a per node basis. Thus the losses from each node need not be uniform.

VARIABLE INLETS - UNIFORM LOSSES

Proforma: Thermal Storage\Stratified Storage Tank\Variable Inlets\Uniform Losses\Type4c.tmf
TRNSYS Model: Type 4
The thermal performance of a fluid-filled sensible energy storage tank, subject to thermal stratification, can be modelled by assuming that the tank consists of N ($N \leq 15$) fully-mixed equal volume segments. The degree of stratification is determined by the value of N. If N is equal to 1, the storage tank is modelled as a fully-mixed tank and no stratification effects are possible. This instance of Type 4 models a stratified tank having variable inlet positions such that entering fluid may be added to the tank at a temperature as nearly equal to its own temperature as possible. The node sizes in this instance need not be equal. Temperature deadband on heater thermostats are available. This instance further assumes that losses from each tank node are equal and does not compute losses to the gas flue of the auxiliary heater.

3.4.12.5. Variable Volume Tank

VARIABLE VOLUME TANK

Proforma: Thermal Storage\Variable Volume Tank\Type39.tmf
TRNSYS Model: Type 39
This component models a fully-mixed tank with a constant cross-sectional area that contains a variable quantity of fluid. In its simplest form, a single flow enters from a hot source and a single flow stream exits to a load. Since the incoming and outgoing flows need not be equal, the level of fluid in the tank can vary. The level is allowed to vary between user specified high and low level limits. If the lower limit is reached, the load flow necessary to maintain this level is output rather than the desired load flow. If the volume of fluid exceeds the upper limit, then the excess flow necessary to keep the tank at the upper limit is set as an output. There are two modes for handling excess flow when the upper limit is reached. In mode 1, excess flow mixes with the contents of the tank to simulate a recirculation flow stream. In this case, the temperature of the excess flow stream is the temperature of the contents of the tank. In mode 2, the excess incoming fluid stream is diverted from the tank. The temperature of the diverted stream is equal to that of the incoming flow stream.

3.4.13. Utility

3.4.13.1. Calling External Programs

COMIS

Proforma: Utility\Calling External Programs\COMIS\Type157.tmf

TRNSYS Model: Type 157

The simulation code COMIS (COMVEN) has been adapted to be a separate type for TRNSYS to model air flow models. COMIS can be downloaded from <http://software.cstb.fr>
This component requires you to install COMIS and Type 157 to run.
Please refer to the manual that comes with Type 157 for more details.

CONTAM

Proforma: Utility\Calling External Programs\CONTAM\Type97.tmf

TRNSYS Model: Type 97

This model allows to use the CONTAM Multizone Air Flow Model with TRNSYS. Type97 reads a CONTAM multizone building description file, computes the air flow model using CONTAM, and provides CONTAM outputs. CONTAM building description files (*.air files) can be created using the CONTAMW graphical user interface (use Simulation/Create TRNSYS input file in CONTAMW).
Both CONTAM and CONTAMW are available for free download at <http://www.bfrl.nist.gov/IAQanalysis/>

EES - CALL EES EVERYTIME

Proforma: Utility\Calling External Programs\EES\Call EES EveryTime\Type66a.tmf

TRNSYS Model: Type 66

This Type may be used to call components written in the program Engineering Equation Solver (EES) from a TRNSYS simulation. For additional information about EES, please refer to the technical documentation or visit <http://www.fchart.com>. In this instance of the model, all inputs are sent to EES and EES is called at every iteration and at every time step.

EES - FIRST INPUT IS A CONTROL SIGNAL - HOLD LAST CALCULATED VALUES WHEN OFF

Proforma: Utility\Calling External Programs\EES\First Input is a Control Signal\Hold Last Calculated Values when OFF\Type66d.tmf

TRNSYS Model: Type 66

This Type may be used to call components written in the program Engineering Equation Solver (EES) from a TRNSYS simulation. For additional information about EES, please refer to the technical documentation or visit <http://www.fchart.com>. In this instance of the model, the first input to this model is treated as a control signal. When the control signal is set to zero, the EES model will not be called. When not called, the EES generated outputs will be held at their last calculated values in this instance.

EES - FIRST INPUT IS A CONTROL SIGNAL - SET OUTPUTS TO PREDEFINED VALUES WHEN OFF

Proforma: Utility\Calling External Programs\EES\First Input is a Control Signal\Set Outputs to Predefined Values when OFF\Type66c.tmf

TRNSYS Model: Type 66

This Type may be used to call components written in the program Engineering Equation Solver (EES) from a TRNSYS simulation. For additional information about EES, please refer to the technical documentation or visit <http://www.fchart.com>. In this instance of the model, the first input to this model is treated as a control signal. When the control signal is set to zero, the EES model will not be called. When not called, the EES generated outputs will be set to values predefined as parameters in this instance.

EES - FIRST INPUT IS A CONTROL SIGNAL - SET OUTPUTS TO ZERO WHEN OFF

Proforma: Utility\Calling External Programs\EES\First Input is a Control Signal\Set Outputs to Zero when OFF\Type66b.tmf

TRNSYS Model: Type 66

This Type may be used to call components written in the program Engineering Equation Solver (EES) from a TRNSYS simulation. For additional information about EES, please refer to the technical documentation or visit <http://www.fchart.com>. In this instance of the model, the first input to this model is treated as a control signal. When the control signal is set to zero, the EES model will not be called. When not called, the EES generated outputs will all be set to zero.

EXCEL

Proforma: Utility\Calling External Programs\Excel\Type62.tmf

TRNSYS Model: Type 62

This TRNSYS Type implements a link with Excel. The Fortran routine communicates with Excel through a Component Object Model (COM) interface for fast data transfer. TRNSYS sends the component's inputs to given cells in your excel worksheets. Those cells must be identified by defining an excel-name ("Inp1" ... "Inp10"). In Excel, names can be defined i.e. by using the shortcut "CTRL+F3". In the same way outputs must get names like "Out1" ... "Out10".

MATLAB

Proforma: Utility\Calling External Programs\Matlab\Type155.tmf

TRNSYS Model: Type 155

This TRNSYS Type implements a link with Matlab. The connection uses the Matlab engine, which is launched as a separate process. The Fortran routine communicates with the Matlab engine through a Component Object Model (COM) interface. Type 155 can have different calling modes (e.g. iterative component or real-time controller). You must have Matlab (6.5 or 7) installed to use this component and Matlab's "bin\win32" folder must be on windows search path

3.4.13.2. Data Readers

GENERIC DATA FILES - EXPERT MODE - FREE FORMAT

Proforma: Utility\Data Readers\Generic Data Files\Expert Mode\Free Format\Type9e.tmf

TRNSYS Model: Type 9

This component serves the purpose of reading data at regular time intervals from a data file, converting it to a desired system of units, and making it available to other TRNSYS components as time-varying forcing functions. This component is very general in nature and can read many different types of files. The data from line to line must be at constant time intervals.

Note that the use of Type 109 is recommended if Type 9 is used to read a weather file in combination with Type 16 (solar radiation processor). Type 109 performs the functions of both Type 9 and Type 16 in a more convenient way.

In expert mode, the user must select the appropriate operation mode (Parameter 1). If you do not know which mode to use, you should first check the other available proformas for Type 9. The operation modes allow to use files that start at the beginning of the year or at the beginning of the simulated period and that provide or not initial conditions in the input files. Please see the description of Parameter 1 and check the manuals for more details on operation modes.

GENERIC DATA FILES - EXPERT MODE - SPECIFIED FORMAT

Proforma: Utility\Data Readers\Generic Data Files\Expert Mode\Specified Format\Type9g.tmf

TRNSYS Model: Type 9

This component serves the purpose of reading data at regular time intervals from a data file, converting it to a desired system of units, and making it available to other TRNSYS components as time-varying forcing functions. This component is very general in nature and can read many different types of files. The data from line to line must be at constant time intervals.

Note that the use of Type 109 is recommended if Type 9 is used to read a weather file in combination with Type 16 (solar radiation processor). Type 109 performs the functions of both Type 9 and Type 16 in a more convenient way.

In expert mode, the user must select the appropriate operation mode (Parameter 1). If you do not know which mode to use, you should first check the other available proformas for Type 9. The operation modes allow to use files that start at the beginning of the year or at the beginning of the simulated period and that provide or not initial conditions in the input files. Please see the description of Parameter 1 and check the manuals for more details on operation modes.

GENERIC DATA FILES - FIRST LINE IS SIMULATION START - FREE FORMAT

Proforma: Utility\Data Readers\Generic Data Files\First Line is Simulation Start\Free Format\Type9a.tmf

TRNSYS Model: Type 9

This component serves the purpose of reading data at regular time intervals from a data file, converting it to a desired system of units, and making it available to other TRNSYS components as time-varying forcing functions. This component is very general in nature and can read many different types of files. The data from line to line must be at constant time intervals.

Note that the use of Type 109 is recommended if Type 9 is used to read a weather file in combination with Type 16 (solar radiation processor). Type 109 performs the functions of both Type 9 and Type 16 in a more convenient way. Check the manuals for more details on Type 9 operation modes.

GENERIC DATA FILES - FIRST LINE IS SIMULATION START - SPECIFIED FORMAT

Proforma: Utility\Data Readers\Generic Data Files\First Line is Simulation Start\Specified Format\Type9b.tmf

TRNSYS Model: Type 9

This component serves the purpose of reading data at regular time intervals from a data file, converting it to a desired system of units, and making it available to other TRNSYS components as time-varying forcing functions. This component is very general in nature and can read many different types of files. The data from line to line

must be at constant time intervals.
 Note that the use of Type 109 is recommended if Type 9 is used to read a weather file in combination with Type 16 (solar radiation processor). Type 109 performs the functions of both Type 9 and Type 16 in a more convenient way. Check the manuals for more details on Type 9 operation modes.

GENERIC DATA FILES - SKIP LINES TO START - FREE FORMAT

Proforma: Utility\Data Readers\Generic Data Files\Skip Lines to Start\Free Format\Type9c.tmf
TRNSYS Model: Type 9
<p>This component serves the purpose of reading data at regular time intervals from a data file, converting it to a desired system of units, and making it available to other TRNSYS components as time-varying forcing functions. This component is very general in nature and can read many different types of files. The data from line to line must be at constant time intervals.</p> <p>Note that the use of Type 109 is recommended if Type 9 is used to read a weather file in combination with Type 16 (solar radiation processor). Type 109 performs the functions of both Type 9 and Type 16 in a more convenient way. Check the manuals for more details on Type 9 operation modes.</p>

GENERIC DATA FILES - SKIP LINES TO START - SPECIFIED FORMAT

Proforma: Utility\Data Readers\Generic Data Files\Skip Lines to Start\Specified Format\Type9d.tmf
TRNSYS Model: Type 9
<p>This component serves the purpose of reading data at regular time intervals from a data file, converting it to a desired system of units, and making it available to other TRNSYS components as time-varying forcing functions. This component is very general in nature and can read many different types of files. The data from line to line must be at constant time intervals.</p> <p>Note that the use of Type 109 is recommended if Type 9 is used to read a weather file in combination with Type 16 (solar radiation processor). Type 109 performs the functions of both Type 9 and Type 16 in a more convenient way. Check the manuals for more details on Type 9 operation modes.</p>

STANDARD WEATHER FILES - ENERGYPLUS - SIMULATION START IS FIRST LINE

Proforma: Utility\Data Readers\Standard Weather Files\EnergyPlus\Simulation Start is first line\Type89e.tmf
TRNSYS Model: Type 89
<p>This component serves the purpose of reading data at regular time intervals from a logical unit number, converting it to a desired system of units, and making it available to other TRNSYS components as time-varying forcing functions.</p> <p>This component reads weather data files in the EnergyPlus / ESP-r format (.EPW). It assumes that the first line of the data file corresponds to the start time of the simulation.</p>

STANDARD WEATHER FILES - ENERGYPLUS - SKIP N LINES BEFORE STARTING

Proforma: Utility\Data Readers\Standard Weather Files\EnergyPlus\Skip N Lines before starting\Type89f.tmf
TRNSYS Model: Type 89
<p>This component serves the purpose of reading data at regular time intervals from a logical unit number, converting it to a desired system of units, and making it available to other TRNSYS components as time-varying forcing functions.</p> <p>This component reads weather data files in the EnergyPlus / ESP-r format (.EPW). It assumes that the file starts at the beginning of the year and skips the appropriate number of lines between the beginning of the year and the</p>

start time of the simulation.

STANDARD WEATHER FILES - IVEC - SIMULATION START IS FIRST LINE

Proforma: Utility\Data Readers\Standard Weather Files\IVEC\Simulation Start is first line\Type89g.tmf

TRNSYS Model: Type 89

This component serves the purpose of reading data at regular time intervals from a logical unit number, converting it to a desired system of units, and making it available to other TRNSYS components as time-varying forcing functions.

This component reads weather data files in the International Weather for Energy Calculations (IVEC) format (.IWC). It assumes that the first line of the data file corresponds to the start time of the simulation.

STANDARD WEATHER FILES - IVEC - SKIP N LINES BEFORE STARTING

Proforma: Utility\Data Readers\Standard Weather Files\IVEC\Skip N Lines before starting\Type89h.tmf

TRNSYS Model: Type 89

This component serves the purpose of reading data at regular time intervals from a logical unit number, converting it to a desired system of units, and making it available to other TRNSYS components as time-varying forcing functions.

This component reads weather data files in the International Weather for Energy Calculations (IVEC) format (.IWC). It assumes that the file starts at the beginning of the year and skips the appropriate number of lines between the beginning of the year and the start time of the simulation.

STANDARD WEATHER FILES - STANDARD TMY - SIMULATION START IS FIRST LINE

Proforma: Utility\Data Readers\Standard Weather Files\Standard Tmy\Simulation Start is first line\Type89i.tmf

TRNSYS Model: Type 89

This component serves the purpose of reading data at regular time intervals from a logical unit number, converting it to a desired system of units, and making it available to other TRNSYS components as time-varying forcing functions.

This component reads weather data files in the standard (as opposed to the TRNSYS modified) Typical Meteorological Year version 1 (TMY) format (.TMY). It assumes that the first line of the data file corresponds to the start time of the simulation.

STANDARD WEATHER FILES - STANDARD TMY - SKIP N LINES BEFORE STARTING

Proforma: Utility\Data Readers\Standard Weather Files\Standard Tmy\Skip N Lines before starting\Type89j.tmf

TRNSYS Model: Type 89

This component serves the purpose of reading data at regular time intervals from a logical unit number, converting it to a desired system of units, and making it available to other TRNSYS components as time-varying forcing functions.

This component reads weather data files in the standard (as opposed to the TRNSYS modified) Typical Meteorological Year version 1 (TMY) format (.TMY). It assumes that the file starts at the beginning of the year and skips the appropriate number of lines between the beginning of the year and the start time of the simulation.

STANDARD WEATHER FILES - TMY2 - SIMULATION START IS FIRST LINE

Proforma: Utility\Data Readers\Standard Weather Files\Tmy2\Simulation Start is first line\Type89b.tmf
TRNSYS Model: Type 89
<p>This component serves the purpose of reading data at regular time intervals from a logical unit number, converting it to a desired system of units, and making it available to other TRNSYS components as time-varying forcing functions.</p> <p>This component reads weather data files in the Typical Meteorological Year version 2 (TMY2) format (.TM2). It assumes that the first line of the data file corresponds to the start time of the simulation.</p>

STANDARD WEATHER FILES - TMY2 - SKIP N LINES BEFORE STARTING

Proforma: Utility\Data Readers\Standard Weather Files\Tmy2\Skip N Lines before starting\Type89d.tmf
TRNSYS Model: Type 89
<p>This component serves the purpose of reading data at regular time intervals from a logical unit number, converting it to a desired system of units, and making it available to other TRNSYS components as time-varying forcing functions.</p> <p>This component reads weather data files in the Typical Meteorological Year version 2 (TMY2) format (.TM2). It assumes that the file starts at the beginning of the year and skips the appropriate number of lines between the beginning of the year and the start time of the simulation.</p>

STANDARD WEATHER FILES - TRNSYS TMY - SIMULATION START IS FIRST LINE

Proforma: Utility\Data Readers\Standard Weather Files\Trnsys Tmy\Simulation Start is first line\Type89a.tmf
TRNSYS Model: Type 89
<p>This component serves the purpose of reading data at regular time intervals from a logical unit number, converting it to a desired system of units, and making it available to other TRNSYS components as time-varying forcing functions.</p> <p>This component reads weather data files in the TRNSYS modified Typical Meteorological Year version 1 (TRNTMY) format. It assumes that the first line of the data file corresponds to the start time of the simulation.</p>

STANDARD WEATHER FILES - TRNSYS TMY - SKIP N LINES BEFORE STARTING

Proforma: Utility\Data Readers\Standard Weather Files\Trnsys Tmy\Skip N Lines before starting\Type89c.tmf
TRNSYS Model: Type 89
<p>This component serves the purpose of reading data at regular time intervals from a logical unit number, converting it to a desired system of units, and making it available to other TRNSYS components as time-varying forcing functions.</p> <p>This component reads weather data files in the TRNSYS modified Typical Meteorological Year version 1 (TRNTMY) format. It assumes that the file starts at the beginning of the year and skips the appropriate number of lines between the beginning of the year and the start time of the simulation.</p>

3.4.13.3. Forcing Function Sequencers

UNIQUE DAYS AND HOLIDAYS

Proforma: Utility\Forcing Function Sequencers\Unique Days and Holidays\Type41d.tmf

TRNSYS Model: Type 41

This component is useful for organizing daily profiles generated by Type14 (Utility: Forcing Functions) into a sequence that forms an annual profile. Up to 20 different schedules may be considered for each day of a standard week. This version of the model allows the users to specify seven forcing functions, one for each day of the week. Additionally, the user is able to specify one non standard profile which may be used throughout the year for holidays or other intermittent occurrences.

UNIQUE DAYS OF THE WEEK

Proforma: Utility\Forcing Function Sequencers\Unique Days of the Week\Type41c.tmf

TRNSYS Model: Type 41

This component is useful for organizing daily profiles generated by Type14 (Utility: Forcing Functions) into a sequence that forms an annual profile. Up to 20 different schedules may be considered for each day of a standard week. This version of the model allows the users to specify seven forcing functions, one for each day of the week.

WEEKDAYS AND WEEKENDS

Proforma: Utility\Forcing Function Sequencers\Weekdays and Weekends\Type41a.tmf

TRNSYS Model: Type 41

This component is useful for organizing daily profiles generated by Type14 (Utility: Forcing Functions) into a sequence that forms an annual profile. Up to 20 different schedules may be considered for each day of a standard week. This version of the model allows the users to specify seven forcing functions, one for each day of the week.

WEEKDAYS WEEKENDS AND HOLIDAYS

Proforma: Utility\Forcing Function Sequencers\Weekdays Weekends and Holidays\Type41b.tmf

TRNSYS Model: Type 41

This component is useful for organizing daily profiles generated by Type14 (Utility: Forcing Functions) into a sequence that forms an annual profile. Up to 20 different schedules may be considered for each day of a standard week. This version of the model allows the users to specify seven forcing functions, one for each day of the week. Additionally, the user is able to specify one non standard profile which may be used throughout the year for holidays or other intermittent occurrences.

3.4.13.4. Forcing Functions

GENERAL

Proforma: Utility\Forcing Functions\General\Type14h.tmf

TRNSYS Model: Type 14

In a transient simulation, it is sometimes convenient to employ a time dependent forcing function which has a behavior characterized by a repeated pattern. The pattern of the forcing function is established by a set of discrete data points indicating the value of the function at various times throughout one cycle. Linear interpolation is provided in order to generate a continuous forcing function from the discrete data. The cycle will repeat every N

hours where N is the last value of time specified. While the code of Type14 is entirely general, this version of the component uses dimensionless units so that it too can be used in a very generic manner.

INTERNAL GAINS

Proforma: Utility\Forcing Functions\Internal Gains\Type14c.tmf
TRNSYS Model: Type 14
In a transient simulation, it is sometimes convenient to employ a time dependent forcing function which has a behavior characterized by a repeated pattern. The pattern of the forcing function is established by a set of discrete data points indicating the value of the function at various times throughout one cycle. Linear interpolation is provided in order to generate a continuous forcing function from the discrete data. The cycle will repeat every N hours where N is the last value of time specified. While the code of Type14 is entirely general, this version of the component uses units of kJ/hr so as to be more readily useful for creating internal heat gain forcing functions.

LIGHTING

Proforma: Utility\Forcing Functions\Lighting\Type14d.tmf
TRNSYS Model: Type 14
In a transient simulation, it is sometimes convenient to employ a time dependent forcing function which has a behavior characterized by a repeated pattern. The pattern of the forcing function is established by a set of discrete data points indicating the value of the function at various times throughout one cycle. Linear interpolation is provided in order to generate a continuous forcing function from the discrete data. The cycle will repeat every N hours where N is the last value of time specified. While the code of Type14 is entirely general, this version of the component uses units of kJ/hr so as to be more readily useful for creating lighting forcing functions.

OCCUPANCY

Proforma: Utility\Forcing Functions\Occupancy\Type14a.tmf
TRNSYS Model: Type 14
In a transient simulation, it is sometimes convenient to employ a time dependent forcing function which has a behavior characterized by a repeated pattern. The pattern of the forcing function is established by a set of discrete data points indicating the value of the function at various times throughout one cycle. Linear interpolation is provided in order to generate a continuous forcing function from the discrete data. The cycle will repeat every N hours where N is the last value of time specified. While the code of Type14 is entirely general, this version of the component uses units of "number of occupants" so as to be more readily useful for creating occupancy forcing functions.

RELATIVE HUMIDITY

Proforma: Utility\Forcing Functions\Relative Humidity\Type14f.tmf
TRNSYS Model: Type 14
In a transient simulation, it is sometimes convenient to employ a time dependent forcing function which has a behavior characterized by a repeated pattern. The pattern of the forcing function is established by a set of discrete data points indicating the value of the function at various times throughout one cycle. Linear interpolation is provided in order to generate a continuous forcing function from the discrete data. The cycle will repeat every N hours where N is the last value of time specified. While the code of Type14 is entirely general, this version of the component uses units of % (100 basis) so as to be more readily useful for creating relative humidity forcing functions.

TEMPERATURE**Proforma:** Utility\Forcing Functions\Temperature\Type14e.tmf**TRNSYS Model:** Type 14

In a transient simulation, it is sometimes convenient to employ a time dependent forcing function which has a behavior characterized by a repeated pattern. The pattern of the forcing function is established by a set of discrete data points indicating the value of the function at various times throughout one cycle. Linear interpolation is provided in order to generate a continuous forcing function from the discrete data. The cycle will repeat every N hours where N is the last value of time specified. While the code of Type14 is entirely general, this version of the component uses units of degrees C so as to be more readily useful for creating temperature forcing functions.

WATER DRAW**Proforma:** Utility\Forcing Functions\Water Draw\Type14b.tmf**TRNSYS Model:** Type 14

In a transient simulation, it is sometimes convenient to employ a time dependent forcing function which has a behavior characterized by a repeated pattern. The pattern of the forcing function is established by a set of discrete data points indicating the value of the function at various times throughout one cycle. Linear interpolation is provided in order to generate a continuous forcing function from the discrete data. The cycle will repeat every N hours where N is the last value of time specified. While the code of Type14 is entirely general, this version of the component uses units of kg/hr so as to be more readily useful for creating water draw forcing functions.

WIND SPEED**Proforma:** Utility\Forcing Functions\Wind Speed\Type14g.tmf**TRNSYS Model:** Type 14

In a transient simulation, it is sometimes convenient to employ a time dependent forcing function which has a behavior characterized by a repeated pattern. The pattern of the forcing function is established by a set of discrete data points indicating the value of the function at various times throughout one cycle. Linear interpolation is provided in order to generate a continuous forcing function from the discrete data. The cycle will repeat every N hours where N is the last value of time specified. While the code of Type14 is entirely general, this version of the component uses units of meters per second so as to be more readily useful for creating wind speed forcing functions.

3.4.13.5. Holiday Calculator**AMERICAN HOLIDAYS****Proforma:** Utility\Holiday Calculator\American Holidays\Type95a.tmf**TRNSYS Model:** Type 95

The TYPE 95 Holiday Calculator performs a number of "calendar computations" based on the starting date of a TRNSYS simulation and the elapsed time. These results may be useful when dealing with time-dependent load patterns or utility rate schedules. This component was originally developed for use with the TYPE 96 Rate Schedule Processor. The OUTPUTS of TYPE 95 include the year, month, date, and day of week, hour of day and an indication as to whether the current time step falls on a holiday or on a non holiday. TYPE 95 accounts for leap years and daylight savings time. In this version, Type95 computes the dates of the standard American holidays.

AMERICAN PLUS USER DEFINED HOLIDAYS

Proforma: Utility\Holiday Calculator\American plus user defined holidays\Type95b.tmf
TRNSYS Model: Type 95
The TYPE 95 Holiday Calculator performs a number of "calendar computations" based on the starting date of a TRNSYS simulation and the elapsed time. These results may be useful when dealing with time-dependent load patterns or utility rate schedules. This component was originally developed for use with the TYPE 96 Rate Schedule Processor. The OUTPUTS of TYPE 95 include the year, month, date, and day of week, hour of day and an indication as to whether the current time step falls on a holiday or on a non holiday. TYPE 95 accounts for leap years and daylight savings time. In this version, Type95 computes the dates of the standard American holidays but also allows for a series of user defined holidays as well.

USER DEFINED HOLIDAYS

Proforma: Utility\Holiday Calculator\User Defined Holidays\Type95c.tmf
TRNSYS Model: Type 95
The TYPE 95 Holiday Calculator performs a number of "calendar computations" based on the starting date of a TRNSYS simulation and the elapsed time. These results may be useful when dealing with time-dependent load patterns or utility rate schedules. This component was originally developed for use with the TYPE 96 Rate Schedule Processor. The OUTPUTS of TYPE 95 include the year, month, date, and day of week, hour of day and an indication as to whether the current time step falls on a holiday or on a non holiday. In this version of Type95, the user is asked to define the month and day of each holiday. TYPE 95 accounts for leap years and daylight savings time.

3.4.13.6. Input Value Recall**INPUT VALUE RECALL**

Proforma: Utility\Input Value Recall\Type93.tmf
TRNSYS Model: Type 93
The input value recal component remembers the values NI inputs for the preceeding NT timesteps. The values of NI and NT are set as parameters to the component. Such "input value recall" devices are useful in adding time delays to a system that is unrealistically sensitive to input changes or that suffers from control instability. By controlling based on values from a previous time step, systems will become much more robust. It is understood that in such situations, a small enough time step must be used so that the assumption of a delay in sensing the control signal is reasonable.

3.4.13.7. Integrators**PERIODIC INTEGRATOR**

Proforma: Utility\Integrators\Periodic Integrator\Type55.tmf
TRNSYS Model: Type 55
During a transient simulation, it is often desirable to know some basic statistics of an INPUT over a specified time range. This component calculates the count, mean, sample standard deviation, sum of squares, variance, minimum, time at which the minimum occurs, maximum, and time at which the maximum occurs of a series of

INPUTS over a range of time periods specified by the user. In addition, the component will calculate the integral of the INPUT with respect to time or alternatively, the sum of the INPUT over the specified time range.

QUANTITY INTEGRATOR

Proforma: Utility\Integrators\Quantity Integrator\Type24.tmf

TRNSYS Model: Type 24

This component integrates a series of quantities over a period of time. Each quantity integrator can have up to, but no more than 500 inputs. Type24 is able to reset periodically throughout the simulation either after a specified number of hours or after each month of the year. With the release of TRNSYS 16, Type24 was expanded so that the time between resets could be counted relative to the start time of the simulation or in absolute time. For example, with a 1 hour reset time, relative time resetting, and a simulation start time of 0.5, the integrator will reset at time 1.5, 2.5, 3.5, 4.5, etc. With a 1 hour reset time, absolute time resetting, and a simulation start time of 0.5, the Type24 integrator would reset at time 1.0, 2.0, 3.0, 4.0, etc. Thus the first integration period would not be a full hour.

3.4.13.8. Parameter replacement

PARAMETER REPLACEMENT

Proforma: Utility\Parameter replacement\Type70.tmf

TRNSYS Model: Type 70

Once, at the start of a simulation containing a Type70, TRNSYS will locate a specified file and collect the information contained within. This information is of two types; unit numbers and parameter values. Type 70 replaces the PARAMETERS specified in the deck with the values found in the file for each Unit number indicated. In this way, an external preprocessing program can generate the values of the PARAMETERS in question, and the user does not have to manually enter them into the TRNSYS deck.

As an example, say that the transfer function coefficients for a particular wall are generated with an external program (such as PREP). Normally, the user would have to preprocess the wall (obtain the coefficients) and then type them into the TRNSYS deck. By modifying PREP to produce the proper text based output file, and by using Type70, this transfer could become automatic.

3.4.13.9. Unit Conversion Routine

UNIT CONVERSION ROUTINE

Proforma: Utility\Unit Conversion Routine\Type57.tmf

TRNSYS Model: Type 57

To accommodate users accustomed to working with English units TYPE 57 unit conversion routine is provided. Users must describe the incoming variable type and units (temperature and C for example) and the desired output variable units (F for example) using tables provided at the end of the technical documentation of this component. The conversion routine checks the input to make sure it is of the correct variable type and units, performs the unit conversion, providing the new output type and units to all units depending on this output.

3.4.13.10. Utility Rate Schedule Processors

UTILITY RATE SCHEDULE PROCESSORS

Proforma: Utility\Utility Rate Schedule Processors\Type96.tmf

TRNSYS Model: Type 96

The TYPE 96 Utility Rate Schedule Processor calculates electric bills for grid-tied buildings. It may be used to determine savings in buildings employing electric parallel generation. This component accounts for both usage (\$/kWh) and demand (\$/kW) charges over the course of the simulation. TYPE 96 assumes that the area utility employs a "net metering" policy so that power generated on-site which exceeds the instantaneous load may be sold back to utility at the retail rate. Any parallel generation source may be used: photovoltaic arrays, wind turbines, or gas-fired microturbines, for example. Two TYPE 96 components may be employed in a simulation to compare utility bills with and without parallel generation.

3.4.14. Weather Data Reading and Processing

3.4.14.1. Standard Format

GERMAN TRY

Proforma: Weather Data Reading and Processing\Standard Format\German TRY\Type109-TRY.tmf

TRNSYS Model: Type 109

This component serves the main purpose of reading weather data at regular time intervals from a data file, converting it to a desired system of units and processing the solar radiation data to obtain tilted surface radiation and angle of incidence for an arbitrary number of surfaces.
In this mode, Type 109 reads a weather data file in the German TRY format

GERMAN VDI

Proforma: Weather Data Reading and Processing\Standard Format\German VDI\Type109-VDI.tmf

TRNSYS Model: Type 109

This component serves the main purpose of reading weather data at regular time intervals from a data file, converting it to a desired system of units and processing the solar radiation data to obtain tilted surface radiation and angle of incidence for an arbitrary number of surfaces.
In this mode, Type 109 reads a weather data file in a format specified by the German VDI 2078 standard.

JAPAN

Proforma: Weather Data Reading and Processing\Standard Format\Japan\Type109-AMeDAS.tmf

TRNSYS Model: Type 109

--- Special Info ---

This proforma is for treating 'Expanded AMeDAS Weather data' CD-ROM issued by AIJ in Japan. The CD-ROM contains 842 points hourly weather data.

The plugin converts 'Amedasty.wea' to Type109 format.

For use this component, the AMeDAS CD/DVD-ROM is necessary.

You can find information on <http://amedas.aae.kagoshima-u.ac.jp/index.html>.

Now, the data book is available in Japanese and English.

Usage:

- 1) Launch the plugin 'ExtAmedas.exe'.
- 2) Select the 'Amedasty.wea' file on CD-ROM.
- 3) Select a station where you want to calculate.
- 4) Click the OK button.

If you have questions about the plugin program and the proforma, please contact yamaguti@alpha-net.ne.jp

This component serves the main purpose of reading weather data at regular time intervals from a data file, converting it to a desired system of units and processing the solar radiation data to obtain tilted surface radiation and angle of incidence for an arbitrary number of surfaces.

In this mode, Type 109 reads a weather data file in the standard TMY2 format. The TMY2 format is used by the National Solar Radiation Data Base (USA) but TMY2 files can be generated from many programs, such as Meteororm.

Special Considerations

1. Up to 5 UNITS of TYPE 109 may be specified.

TMY2

Proforma: Weather Data Reading and Processing\Standard Format\TMY2\Type109-TMY2.tmf

TRNSYS Model: Type 109

This component serves the main purpose of reading weather data at regular time intervals from a data file, converting it to a desired system of units and processing the solar radiation data to obtain tilted surface radiation and angle of incidence for an arbitrary number of surfaces.

In this mode, Type 109 reads a weather data file in the standard TMY2 format. The TMY2 format is used by the National Solar Radiation Data Base (USA) but TMY2 files can be generated from many programs, such as Meteororm.

3.4.14.2. User Format

USER FORMAT

Proforma: Weather Data Reading and Processing\User Format\Type109-User.tmf

TRNSYS Model: Type 109

This component serves the main purpose of reading weather data at regular time intervals from a data file, converting it to a desired system of units and processing the solar radiation data to obtain tilted surface radiation and angle of incidence for an arbitrary number of surfaces.

In this mode, Type 109 reads a weather data file in Type 109's user format (see manual for details)

Special Considerations

1. Up to 5 UNITS of TYPE 109 may be specified.