TRNSYS 18

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 18. 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

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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:

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TRNSYS website: http://sel.me.wisc.edu/trnsys	

Notice

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Additional contributors who developed components that have been included in the Standard Library are listed in Volume 4.

Contributors to the building model (Type 56) and its interface (TRNBuild) are listed in Volume 5.

Contributors to the TRNSYS Simulation Studio are listed in Volume 2.

TABLE OF CONTENTS

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 Volume 4: Mathematical Reference, which gives the mathematical algorithms 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 is organized according to the user interface of each component ("proformas" in the Simulation Studio), while Volume 4 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 Volume 3. 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. **Ground Coupling**

   This category components for calculating the heat exchange between a building and the ground.

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 5) but also different single zone models of increasing complexity as well as some other components that are often integral to building simulations.

8. **Obsolete**

    Components that have been made obsolete in TRNSYS 18 have been moved here. These components have been 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**
   - 5-Stage Room Thermostat
   - Basic Aquastat
   - Basic Humidity Control
   - Delayed Inputs
   - Differential Controller w_ Hysteresis
   - Iterative Feedback Controller
   - Microprocessor Controller
   - PID Controller
   - Simple Thermostat
   - Tempering Valve Control

2. **Electrical**
   - Batteries
   - Busbar
   - Diesel Engine (DEGS)
   - MiniGrid Controller
   - Photovoltaic Panels
   - Power Conditioning
   - Regulators and Inverters
   - Wind Turbines

3. **Ground Coupling**
   - Slab on Grade

4. **HVAC**
   - Absorption Chiller (Hot-Water Fired, Single Effect)
   - Air Heater
   - Air-Cooled Chiller
   - Air-Source Heat Pump
   - Boiler
   - Conditioning Equipment
   - Cooling Coils
   - Cooling Towers
   - DX Coil
   - Fan Coil
   - Fluid Heater
   - Furnace
   - Heating Coil
   - Packaged Terminal Air Conditioner
   - Part Load Performance
   - Split System AC

- VAV Air Handlers
- Water-Cooled Chiller
- Water-Source Heat Pump

5. Hydrogen Systems

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

6. Hydronics

- Controlled Flow Mixer
- Duct
- Fan
- Flow Diverter
- Heat Exchangers
- Pipe
- Pumps
- Tee-Piece Flow Mixer
- Temperature Controlled Flow Diverter

7. Loads and Structures

- Infiltration
- Multi-Zone Building
- Multi-Zone Building with Internal Solver Parameters
- Overhang and Wingwall Shading
- Simple Natural Ventilation
- Single Zone Models
- Thermal Storage Wall

8. Obsolete

- 1D Interpolation
- Aquastat
- Attached Sunspace
- Auxiliary Cooling Unit
- Auxiliary Heaters
- Calling External Programs
- Cooling Coils
- Detailed Fluid Storage Tank
- Differential Controller w_ Hysteresis
- Economics

- Energy (Degree Day) Space Load
- Fans
- Furnace
- Histogram Plotter
- Input Value Recall
- Parallel Chillers
- Parameter Replacement
- Photovoltaic Panels
- Pitched Roof and Attic
- Pressure Relief Valve
- Pumps
- Stratified Storage Tank
- Thermodynamic Properties
- Utility Rate Schedule Processors
- W-Editor (CSTB)
- Window

9. Output
- Online Plotter
- Printegrator
- Printer
- Scope
- Simulation Summary
- TRNSYS Plugin for SketchUp Printer

10. Physical Phenomena
- Collector Array Shading
- Convection Coefficient Calculation
- Lumped Capacitance Model
- Radiation Processors
- Shading Masks
- Simple Ground Temperature
- Sky Temperature
- Thermodynamic Properties
- Weather Generators

11. Solar Thermal Collectors
- CPC Collector
- Evacuated Tube Collector
- Performance Map Collector
- PV-Thermal Collectors
- Quadratic Efficiency Collector

- Theoretical Flat-Plate Collector
- Thermosyphon Collector with Integral Storage

12. Thermal Storage

- Constant Volume Liquid Storage
- Plug-Flow Tank
- Rock Bed Storage
- Simple Electric Heated Liquid Storage
- Simple Gas Heated Liquid Storage
- Variable Volume Tank

13. Utility

- Calling External Programs
- Data Readers
- Differentiation
- EN 15251-2007 Floating Mean Temperature
- Forcing Function Sequencers
- Forcing Functions
- Holiday Calculator
- Integrators
- Interpolation
- Moving Average
- Simulation Control
- Time Values
- Unit Conversion Routine
- Utility Rates

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. 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 dead bands and set points. Dead bands that are greater than the temperature difference between the set points will cause controller convergence problems.

3.4.1.2. Basic Aquastat

COOLING MODE

Proforma: Controllers\Basic Aquastat\Cooling Mode\Type113.tmf
TRNSYS Model: Type 113
A simple aquastat is modeled to output on/off control functions that can be used to control a system that cools a fluid.

HEATING MODE

Proforma: Controllers\Basic Aquastat\Heating Mode\Type106.tmf
TRNSYS Model: Type 106
A simple aquastat is modeled to output on/off control functions that can be used to control a system that heats a fluid.

3.4.1.3. Basic Humidity Control

DEHUMIDISTAT

Proforma: Controllers\Basic Humidity Control\Dehumidistat\Type104.tmf
TRNSYS Model: Type 104
A simple dehumidistat is modeled to output on/off control functions that can be used to control a system that dehumidifies air.

HUMIDISTAT

Proforma: Controllers\ Basic Humidity Control\Dehumidistat\Type85.tmf
TRNSYS Model: Type 85
A simple humidistat is modeled to output on/off control functions that can be used to control a system that humidifies air.

3.4.1.4. Delayed Inputs

DELAYED INPUTS

Proforma: Controllers\Delayed Inputs\Type150.tmf
TRNSYS Model: Type 150
This component models a "sticky" controller where the outputs are set to the input values from a user-defined previous timestep. For example, the user could decide to have the outputs to another component be based on the zone temperatures from the previous hour or even from the previous day. The stickiness is set by the number of timesteps and not based on the number of hours.

3.4.1.5. Differential Controller w_ Hysteresis

FOR TEMPERATURES

Proforma: Controllers\Differential Controller w_ Hysteresis\for Temperatures\Type165.tmf
TRNSYS Model: Type 165
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 Th and Tl, compared with two dead band temperature differences DTh and DTl. The new value of the control function depends on the value of the input control function at the previous timestep. 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.

FOR TEMPERATURES – COMPLEX CONTROL STRATEGIES - SOLVER 0 (SUCCESSIVE SUBSTITUTION) CONTROL STRATEGY

Proforma: Controllers\Differential Controller w_ Hysteresis\for Temperatures\Complex Control Strategies\Solver 0 (Successive Substitution) Control Strategy\Type2b.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 Th and Tl, compared with two dead band temperature differences DTl and DTl. The new value of the control function depends on the value of the input control function at the previous time step. 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 uses unit descriptions of degC so that it is readily usable as a thermostatic differential controller.
This instance of the Type2 controller is intended for use with the standard TRNSYS SOLVER 0 (Successive Substitution)

GENERIC

Proforma: Controllers\Differential Controller w_ Hysteresis\generic\ Type165b.tmf

TRNSYS Model: Type 165

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 Th and Tl, compared with two dead band temperature differences DTh and DTl. The new value of the control function depends on the value of the input control function at the previous timestep.

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.

GENERIC - COMPLEX CONTROL STRATEGIES - SOLVER 0 (SUCCESSIVE SUBSTITUTION) CONTROL STRATEGY

Proforma: Controllers\Differential Controller w_ Hysteresis\generic\Complex Control Strategies\Solver 0 (Successive Substitution) Control Strategy\Type2d.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 Th and Tl, compared with two dead band temperature differences DTl and DTl. 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 the standard TRNSYS SOLVER 0 (Successive Substitution)

3.4.1.6.   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 (ySet). 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 = ySet-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.

3.4.1.7.   Microprocessor Controller

MICROPROCESSOR CONTROLLER

Proforma: Controllers\Microprocessor Controller\Type40.tmf
TRNSYS Model: Type 40

3.4.1.8.   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 (ySet). 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.

3.4.1.9.   Simple Thermostat

SIMPLE THERMOSTAT

Proforma: Controllers\Simple Thermostat\Type166.tmf

TRNSYS Model: Type 166
A simple room thermostat is modeled to output on/off control functions that can be used to control a system having a heating source and a cooling source.

3.4.1.10. Tempering Valve Control

COOLING MODE

Proforma: Controllers\Tempering Valve Control\Cooling Mode\Type116.tmf
TRNSYS Model: Type 116
This component calculates the fraction of fluid that should be sent to the source (one minus the fraction sent to the source is sent directly to the mixing valve) for a standard tempering valve. The controller calculates the amount of fluid that should be sent through the source and the amount of fluid bypassing the source that, when mixed together, provide the setpoint temperature.

HEATING MODE

Proforma: Controllers\Tempering Valve Control\Heating Mode\Type115.tmf
TRNSYS Model: Type 115
This component calculates the fraction of fluid that should be sent to the source (one minus the fraction sent to the source is sent directly to the mixing valve) for a standard tempering valve. The controller calculates the amount of fluid that should be sent through the source and the amount of fluid bypassing the source that, when mixed together, provide the setpoint temperature.

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 – PARAMETERS FROM EXTERNAL FILE

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).

WITH GASSING CURRENT EFFECTS – PARAMETERS FROM PROFORMA

Proforma: Electrical\Batteries\With Gassing Current Effects\Type185a.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

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).

SPECIFIC DEGS

Proforma: Electrical\Diesel Engine (DEGS)\Specific DEGS\Type120b.tmf

TRNSYS Model: Type 120

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 is used to predict the performance of a specific DEGS, provided a fuel consumption curve is supplied.

3.4.2.4. MiniGrid Controller

MINIGRID CONTROLLER

Proforma: Electrical\MiniGrid Controller\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. Hysteresis 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 (idling) powers for the fuel cell and electrolyzer are taken into consideration.

3.4.2.5. Photovoltaic Panels

ADVANCED MODEL – NO MPPT – NO INVERTER

Proforma: Electrical\Photovoltaic Panels\Advanced Model\no MPPT\no inverter\Type190a.tmf

TRNSYS Model: Type 190

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 190 may be used in simulations involving electrical storage batteries, direct load coupling, and utility grid connections. Depending on the MPPT mode parameter value this component can model either direct connect systems (in which case the user must provide the array operating voltage as an input) or an array with a maximum power point tracker. This model is also equipped with the ability to take additional parameters to specify an inverter coupled with the PV array itself. Inverter efficiency effects are thereby considered.

Notes: An external tool is provided to allow the user to determine the value of the five constants based on which power generation is computed. The tool is located in ..\TrnsysXX\Tools\PV_ref_params.exe. If the program is found to have expired a new version can be downloaded from:

http://www.fchart.com/ees/distributables.php

ADVANCED MODEL – NO MPPT – WITH INVERTER

Proforma: Electrical\Photovoltaic Panels\Advanced Model\no MPPT\with inverter\Type190b.tmf

TRNSYS Model: Type 190

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 190 may be used in simulations involving electrical storage batteries, direct load coupling, and utility grid connections. Depending on the MPPT mode parameter value this component can model either direct connect systems (in which case the user must provide the array operating voltage as an input) or an array with a maximum power point tracker. This model is also equipped with the ability to take additional parameters to specify an inverter coupled with the PV array itself. Inverter efficiency effects are thereby considered.

Notes: An external tool is provided to allow the user to determine the value of the five constants based on which power generation is computed. The tool is located in ..\TrnsysXX\Tools\PV_ref_params.exe. If the program is found to have expired a new version can be downloaded from:

http://www.fchart.com/ees/distributables.php

ADVANCED MODEL – WITH MPPT – NO INVERTER

Proforma: Electrical\Photovoltaic Panels\Advanced Model\with MPPT\no inverter\Type190c.tmf

TRNSYS Model: Type 190

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 190 may be used in simulations involving electrical storage batteries, direct load coupling, and utility grid connections. Depending on the MPPT mode parameter value this component can model either direct connect systems (in which case the user must provide the array operating voltage as an input) or an array with a maximum power point tracker. This model is also equipped with the ability to take additional parameters to specify an inverter coupled with the PV array itself. Inverter efficiency effects are thereby considered.

Notes: An external tool is provided to allow the user to determine the value of the five constants based on which power generation is computed. The tool is located in ..\TrnsysXX\Tools\PV_ref_params.exe. If the program is found to have expired a new version can be downloaded from:

http://www.fchart.com/ees/distributables.php

ADVANCED MODEL – WITH MPPT – WITH INVERTER

Proforma: Electrical\Photovoltaic Panels\Advanced Model\with MPPT\with inverter\Type190d.tmf

TRNSYS Model: Type 190

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 190 may be used in simulations involving electrical storage batteries, direct load coupling, and utility grid connections. Depending on the MPPT mode parameter value this component can model either direct connect systems (in which case the user must provide the array operating voltage as an input) or an array with a maximum power point tracker. This model is also equipped with the ability to take additional parameters to specify an inverter coupled with the PV array itself. Inverter efficiency effects are thereby considered.

Notes: An external tool is provided to allow the user to determine the value of the five constants based on which power generation is computed. The tool is located in ..\TrnsysXX\Tools\PV_ref_params.exe. If the program is found to have expired a new version can be downloaded from:

http://www.fchart.com/ees/distributables.php

BASIC MODEL – NO MPPT

Proforma: Electrical\Photovoltaic Panels\Baisc Model\no MPPT\ Type103a.tmf

TRNSYS Model: Type 103

This component is appropriate for modeling the electrical performance of mono and polycrystaline photovoltaic panels. It is not appropriate for modeling the electrical performance of thin film PV arrays. It may be used in one of two modes depending upon how the first parameter is set. When the MPPT mode parameter is set to 0, the PV array is assumed to be directly connected to a load voltage and/or to a battery. The operating voltage of the PV/load is an input to the PV model. When the MPPT mode parameter is set to 1 then the array is assumed to be connected to its load through a maximum power point tracker. In this case the load voltage is not needed as an input.

BASIC MODEL – WITH MPPT

Proforma: Electrical\Photovoltaic Panels\Baisc Model\with MPPT\ Type103b.tmf

TRNSYS Model: Type 103

This component is appropriate for modeling the electrical performance of mono and polycrystaline photovoltaic panels. It is not appropriate for modeling the electrical performance of thin film PV arrays. It may be used in one of two modes depending upon how the first parameter is set. When the MPPT mode parameter is set to 0, the PV array is assumed to be directly connected to a load voltage and/or to a battery. The operating voltage of the PV/load is an input to the PV model. When the MPPT mode parameter is set to 1 then the array is assumed to be connected to its load through a maximum power point tracker. In this case the load voltage is not needed as an input.

3.4.2.6. 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.

3.4.2.7. 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

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 1: Peak-power tracking collector, battery, monitoring of state of charge.

SYSTEM W_O BATTERY STORAGE

Proforma: Electrical\Regulators and Inverters\System w_o battery storage\Type48a.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 0: Peak-power tracking collector, no battery, power is feedback to a utility.

3.4.2.8. Wind Turbines

WIND TURBINES

Proforma: Electrical\Wind Turbines\Type90.tmf

TRNSYS Model: Type 90

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).

3.4.3. Ground Coupling

3.4.3.1. Slab on Grade

SLAB ON GRADE

Proforma: Ground Coupling\Slab on Grade\Type49.tmf

TRNSYS Model: Type 49

This component models the soil beneath a multi-zone Type 56 building in TRNSYS. The model takes the heat transfer into the building at the outside surface (QCOMO in TrnBuild) for each zone, calculates the fully 3-D soil temperature profile, and then outputs the average underfloor surface temperature for each zone. This underfloor surface temperature should be connected to the input outer surface temperature for each floor; where the floors are defined as boundary walls with INPUT temperatures. Note - the boundary wall floors should have the back side resistances set to a value of 0.0001 to signify direct contact with the back-side surface.

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.   Air Heater

AIR HEATER

Proforma: HVAC\Air Heater\Type117.tmf
TRNSYS Model: Type 117

This component represents an air heating device that can be controlled either externally, or set to automatically try and attain a setpoint temperature. The furnace is bound by a heating capacity and an efficiency. Thermal losses from the furnace are ignored in this type. The outlet state of the air is determined by an enthalpy based energy balance that takes pressure effects into account.

3.4.4.3.   Air-Cooled Chiller

AIR-COOLED CHILLER

Proforma: HVAC\Air-Cooled Chiller\Type118.tmf
TRNSYS Model: Type 118

Type118 models a vapor compression air-cooled chiller. It relies on catalog data provided as external text files to determine chiller performance. Example data files and information on data file format are provided.

3.4.4.4.   Air-Source Heat Pump

ELECTRIC AUXILIARY

Proforma: HVAC\Air-Source Heat Pump\Electric Auxiliary\Type119a.tmf
TRNSYS Model: Type 119

Type119 uses a manufacturer's catalog data approach to model an air source heat pump (air flows on both the condenser and evaporator sides of the device). The model includes mixing algorithms and damper settings so that the indoor air may be the result of two streams from different sources (recirculation and makeup air for example). In heating mode, the device is equipped with one of three auxiliary heater types: no auxiliary heat available, two element electric auxiliary heat, or gas fired auxiliary heat.

GAS AUXILIARY

Proforma: HVAC\Air-Source Heat Pump\Gas Auxiliary\Type119b.tmf
TRNSYS Model: Type 119

Type119 uses a manufacturer's catalog data approach to model an air source heat pump (air flows on both the condenser and evaporator sides of the device). The model includes mixing algorithms and damper settings so that the indoor air may be the result of two streams from different sources (recirculation and makeup air for example). In heating mode, the device is equipped with one of three auxiliary heater types: no auxiliary heat available, two element electric auxiliary heat, or gas fired auxiliary heat.

NO AUXILIARY

Proforma: HVAC\Air-Source Heat Pump\No Auxiliary\Type119c.tmf

TRNSYS Model: Type 119

Type119 uses a manufacturer's catalog data approach to model an air source heat pump (air flows on both the condenser and evaporator sides of the device). The model includes mixing algorithms and damper settings so that the indoor air may be the result of two streams from different sources (recirculation and makeup air for example). In heating mode, the device is equipped with one of three auxiliary heater types: no auxiliary heat available, two element electric auxiliary heat, or gas fired auxiliary heat.

3.4.4.5. Boiler

BOILER

Proforma: HVAC\Boiler\Type122.tmf

TRNSYS Model: Type 119

This component models a fluid boiler (auxiliary heater). This model will attempt to meet the user-specified outlet temperature but may be limited by capacity restraints. The available capacity is calculated by multiplying the rated capacity by the input control signal. The capacity refers to the heat input to the fluid and not the gross capacity of the device. In this model, the user enters the boiler efficiency which is then divided into the required fluid energy to calculate the required fuel input to the model. The user also provides the combustion efficiency which is used to calculate the boiler thermal losses. Overall efficiency is lower than the combustion efficiency due to boiler thermal losses and any cycling effects. The boiler is assumed to be off if the inlet flow rate is zero, the input control signal is zero, or if the inlet temperature is greater than or equal to the desired outlet temperature. If the desired outlet conditions cannot be met due to capacity limitations, the machine will run at its available capacity and the outlet state calculated.

This model is based on ASHRAE's definition of boiler efficiencies as published in 2000 ASHRAE Systems and Equipment Handbook.

3.4.4.6. 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.

3.4.4.7. 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.

SIMPLE – ALL DRY OR ALL WET

Proforma: HVAC\Cooling Coils\Simple\All Dry or All Wet\Type123.tmf

TRNSYS Model: Type 123

The simple cooling coil model provides a good estimation of the performance without the detailed geometric characteristics of the coil. The parameters of the model are only thermodynamic properties of the coil, which require no specific manufacturer's data. The simulation model is based on the ASHRAE Secondary Toolkit and modifications proposed by Chillar, et al. There are two versions of the simple cooling coil model. This version assumes that the coil is always either totally dry or wet.

SIMPLE – PARTIALLY WET CALCULATIONS

Proforma: HVAC\Cooling Coils\Simple\Partially Wet Calculations\Type124.tmf

TRNSYS Model: Type 124

The simple cooling coil model provides a good estimation of the performance without the detailed geometric characteristics of the coil. The parameters of the model are only thermodynamic properties of the coil, which require no specific manufacturer's data. The simulation model is based on the ASHRAE Secondary Toolkit and modifications proposed by Chillar, et al. There are two versions of the simple cooling coil model. This version will iterate to determine the performance if the coil is partially wet. Because of the iterations, this version is slower than Type 123 which assumes the coil is either completely dry or wet

3.4.4.8. Cooling Towers

DETAILED – EXTERNAL CONTROLS - EXTERNAL PERFORMANCE FILE

Proforma: HVAC\Cooling Towers\Detailed\External Controls\External Performance File\Type162a.tmf

TRNSYS Model: Type 162

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.

This component also has two control modes. In this instance (control mode 0) the model takes the tower fan

speed as an input.

DETAILED – EXTERNAL CONTROLS - USER-SUPPLIED COEFFICIENTS

Proforma: HVAC\Cooling Towers\Detailed\External Controls\User-Supplied Coefficients\Type162b.tmf

TRNSYS Model: Type 162

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 calculation modes for this model. In this instance calculation 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.

This component also has two control modes. In this instance (control mode 0) the model takes the tower fan speed as an input.

DETAILED – INTERNAL CONTROLS - EXTERNAL PERFORMANCE FILE

Proforma: HVAC\Cooling Towers\Detailed\Internal Controls\External Performance File\Type162c.tmf

TRNSYS Model: Type 162

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.

This component also has two control modes. In this instance (control mode 1) the model computes the tower fan speed required to best achieve a user specified tower water outlet temperature. All of the tower fans are assumed to run at the same speed.

DETAILED – INTERNAL CONTROLS - USER-SUPPLIED COEFFICIENTS

Proforma: HVAC\Cooling Towers\Detailed\Internal Controls\User-Supplied Coefficients\Type162d.tmf

TRNSYS Model: Type 162

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 calculation modes for this model. In this instance calculation 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.

This component also has two control modes. In this instance (control mode 1) the model computes the tower fan speed required to best achieve a user specified tower water outlet temperature. All of the tower fans are assumed to run at the same speed.

SIMPLE – SINGLE SPEED – CONTROL SIGNAL

Proforma: HVAC\Cooling Towers\Simple\Single Speed\Control Signal\Type126.tmf

TRNSYS Model: Type 126

Type 126 estimates the performance of a cooling tower without any detailed parameters of the tower configuration. Instead it uses the design inlet and outlet conditions to calculate an overall heat transfer coefficient (UA) for the tower and then uses that UA value to estimate performance at other inlet conditions. This version calculates the performance of a single speed cooling tower that provides cooling to the fluid stream with the fan on and fan off (natural convection). The control for this version is a fan and fluid control signal where the model calculates the outlet conditions that would be achieved with the inlet conditions and control signals.

SIMPLE – SINGLE SPEED – SETPOINT

Proforma: HVAC\Cooling Towers\Simple\Single Speed\Setpoint\Type161.tmf

TRNSYS Model: Type 161

Type 161 estimates the performance of a cooling tower without any detailed parameters of the tower configuration. Instead it uses the design inlet and outlet conditions to calculate an overall heat transfer coefficient (UA) for the tower and then uses that UA value to estimate performance at other inlet conditions. This version calculates the performance of a single speed cooling tower that provides cooling to the fluid stream with the fan on and fan off (natural convection). In this version of the cooling tower, the desired temperature of the fluid leaving the tower is an input. The model then determines which speed (off, natural convection, or fan operating) creates a temperature colder than the setpoint. If the capacity needed to cool the fluid down to the setpoint exceeds the capacity of the tower at the inlet conditions, the model calculates the leaving fluid temperature with the fan on.

SIMPLE – TWO-SPEED – CONTROL SIGNAL

Proforma: HVAC\Cooling Towers\Simple\Two-Speed\Control Signal\Type128.tmf

TRNSYS Model: Type 128

Type 128 estimates the performance of a cooling tower without any detailed parameters of the tower configuration. Instead it uses the design inlet and outlet conditions to calculate an overall heat transfer coefficient (UA) for the tower and then uses that UA value to estimate performance at other inlet conditions. This version calculates the performance of a two speed cooling tower that provides cooling to the fluid stream with the fan at high speed, at low speed, and off (natural convection). The control for this version is a fan and fluid control signal where the model calculates the outlet conditions that would be achieved with the inlet conditions and control signals.

SIMPLE – TWO-SPEED – SETPOINT

Proforma: HVAC\Cooling Towers\Simple\Two-Speed\Setpoint\Type129.tmf

TRNSYS Model: Type 129

Type 129 estimates the performance of a cooling tower without any detailed parameters of the tower configuration. Instead it uses the design inlet and outlet conditions to calculate an overall heat transfer coefficient (UA) for the tower and then uses that UA value to estimate performance at other inlet conditions. This version calculates the performance of a two speed cooling tower that provides cooling to the fluid stream with the fan at high speed, at low speed, and off (natural convection). In this version of the cooling tower, the desired temperature of the fluid leaving the tower is an input. The model then determines which speed (off, natural convection, low speed fan or high speed fan) creates a temperature colder than the setpoint. If the capacity needed to cool the fluid down to the setpoint exceeds the capacity of the tower at the inlet conditions, the model calculates the leaving fluid temperature with the high speed fan on.

3.4.4.9. DX Coil

DX COIL

Proforma: HVAC\DX Coil\Type136.tmf

TRNSYS Model: Type 136

Type 136 uses a manufacturer's catalog data approach to model an air to air heat pump section that might appear in an air handler. It does not include algorithms to mix return and fresh air, it does not include any auxiliary heating, and it does not include the ability to define a domestic/service water heating desuperheater. Because of the lack of these features, Type 136 can be used to model a DX Coil – Condenser component of an air handler.

3.4.4.10. Fan Coil

FAN COIL

Proforma: HVAC\Fan Coil\Type137.tmf

TRNSYS Model: Type 137

This component models a fan coil where the air is heated or cooled as it passes across coils containing hot and cold liquid flow streams. This model relies on user-provided external data files which contain the performance of the coils as a function of the entering air and fluid conditions. Refer to the sample data files which accompany this model for the format of these external files.

3.4.4.11. Fluid Heater

FAN COIL

Proforma: HVAC\Fluid Heater\Type138.tmf

TRNSYS Model: Type 138

An auxiliary heater is modeled to elevate the temperature of a flow stream using either internal control, external control or a combination of both types of control. The heater is designed to add heat to the flow stream at a user-designated rate (Qmax) whenever the external control input is equal to one and the heater outlet temperature is less than a user-specified maximum (Tset). By specifying a constant value of the control function of one and specifying a sufficiently large value of Qmax, this routine will perform like a domestic hot water auxiliary with internal control to maintain an outlet temperature of Tset. By providing a control function of zero or one from a thermostat or controller, this routine will perform like a heater adding heat at a rate of Qmax but not exceeding an

outlet temperature of Tset. In this application, a constant outlet temperature is not sought and Tset may be thought of as an arbitrary safety limit.

3.4.4.12. Furnace

FAN COIL

Proforma: HVAC\Furnace\Type139.tmf

TRNSYS Model: Type 139

This component represents an air heating device that can be controlled either externally, or set to automatically try and attain a setpoint 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. This model includes a blower that can control the flow of air through the device.

3.4.4.13. Heating Coil

CONSTANT UA

Proforma: HVAC\Heating Coil\Constant UA\Type140.tmf

TRNSYS Model: Type 140

The simple heating coil model provides a good estimation of the performance without the detailed geometric characteristics of the coil. The parameters of the model are only thermodynamic properties of the coil, which require no specific manufacturer's data. The simulation model is based on the ASHRAE Secondary Toolkit. There are two versions of the simple heating coil model. This version assumes that the heat transfer coefficient (UA) for the coil is constant regardless of the inlet conditions

VARYING UA

Proforma: HVAC\Heating Coil\Varying UA\Type141.tmf

TRNSYS Model: Type 141

The simple heating coil model provides a good estimation of the performance without the detailed geometric characteristics of the coil. The parameters of the model are only thermodynamic properties of the coil, which require no specific manufacturer's data. The simulation model is based on the ASHRAE Secondary Toolkit. There are two versions of the simple heating coil model. The version varies the heat transfer coefficient (UA) for the coil based on the inlet conditions using a technique by Wetter.

3.4.4.14. Packaged Terminal Air Conditioner

PACKAGED TERMINAL AIR CONDITIONER

Proforma: HVAC\Packaged Terminal Air Conditioner\Type144.tmf

TRNSYS Model: Type 144

This component models an air conditioner for residential or commercial applications. The model requires an external file of performance data that contains the total capacity, sensible capacity and power as a function of the

outdoor dry bulb temperature, the indoor dry bulb temperature, the indoor wet bulb temperature, and the evaporator flow rate.

3.4.4.15. Part Load Performance

LINEAR WITH LOAD

Proforma: HVAC\Part Load Performance\Linear with Load\Type43b.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 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.

3.4.4.16. Split System AC

SPLIT SYSTEM AC

Proforma: HVAC\Split System AC\Type144.tmf

TRNSYS Model: Type 144

This component models an air conditioner for residential or commercial applications. The model requires an external file of performance data that contains the total capacity, sensible capacity and power as a function of the outdoor dry bulb temperature, the indoor dry bulb temperature, the indoor wet bulb temperature, and the evaporator flow rate.

3.4.4.17. VAV Air Handlers

VAV

Proforma: HVAC\VAV Air Handlers\VAV\Type151.tmf

TRNSYS Model: Type 151

The subroutine models a VAV air handler for TRNSYS. The air handler contains a fan, heating coil, cooling coil and optional economizer and preheat coil. The model is intended to be connected to building models that can calculate sensible energy-rate-control loads (Type 56 etc.). The user should not specify the energy rate control dehumidification system, but rather should connect the moisture removal rate from the model as a negative moisture gain into the building model.

VAV WITH PFP BOXES

Proforma: HVAC\VAV Air Handlers\VAV with PFP Boxes\Type152.tmf

TRNSYS Model: Type 152

The subroutine models a VAV air handler with parallel powered (PFP) fan boxes for TRNSYS. The air handler contains a fan, heating coil, cooling coil and optional economizer and preheat coil. The model is intended to be connected to building models that can calculate sensible energy-rate-control loads (Type 56 etc.). The user should not specify the energy rate control dehumidification system, but rather should connect the moisture removal rate from the model as a negative moisture gain into the building model.

3.4.4.18. Water-Cooled Chiller

WATER-COOLED CHILLER

Proforma: HVAC\Water-Cooled Chiller\Type142.tmf

TRNSYS Model: Type 142

Type 142 models a vapor compression style water-cooled chiller. It relies on catalog data provided as an external text files to determine chiller performance. Example data files and information on data file format are provided.

3.4.4.19. Water-Source Heat Pump

WATER-SOURCE HEAT PUMP

Proforma: HVAC\Water-Source Heat Pump\Type143.tmf

TRNSYS Model: Type 143

This component models a single-stage liquid source heat pump. The heat pump conditions a moist air stream by rejecting energy to (cooling mode) or absorbing energy from (heating mode) a liquid stream. This heat pump model was intended for a residential ground source heat pump application, but may be used in any liquid source application. This model is based on user-supplied data files containing catalog data for the capacity (both total and sensible in cooling mode), and power, based on the entering water temperature to the heat pump, the entering water flow rate and the air flow rate. Other curve fits are used to modify the capacities and power based on off-design indoor air temperatures.

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 modeled 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/H2-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/H2-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 (idling) 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 temperature 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 - A*IR*-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 - A*IR*-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 - *A*ɪʀ-*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. Controlled 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.

3.4.6.2. Duct

DUCT

Proforma: Hydronics\Duct\Type145.tmf

TRNSYS Model: Type 145

This component models the thermal behavior of air flow in a duct using variable size segments of air. 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 and humidity is that of the incoming air. 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. This model ignores friction effects, air leakage and condensation energy. If the conditions of any segment would lead to condensation, the humidity level of that segment is set to the saturated humidity properties. 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.

3.4.6.3. Fan

CONSTANT SPEED

Proforma: Hydronics\Fan\Constant Speed\Type146.tmf

TRNSYS Model: Type 146

Type 146 models a fan that is able to spin at a single speed and thereby maintain a constant volumetric flow rate of air. As with most pumps and fans in TRNSYS, Type 146 takes mass flow rate as an input but ignores the value except in order to perform mass balance checks. Type 146 sets the downstream flow rate based on its rated flow rate parameter and the current value of its control signal input.

VARIABLE SPEED

Proforma: Hydronics\Fan\Variable Speed\Type147.tmf

TRNSYS Model: Type 147

Type 147 models a fan that is able to turn at any speed between 0 (full stop) and its rated speed. While the volumetric 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, Type 147 takes mass flow rate as an input but ignores the value except to perform mass balance checks. Type 147 sets the downstream flow rate based on its rated flow rate parameters and the current value of its control signal inputs.

3.4.6.4. Flow Diverter

MOIST AIR

Proforma: Hydronics\Flow Diverter\Moist Air\Type148a.tmf

TRNSYS Model: Type 148

This instance of the Type148 model uses mode 2 to model a flow diverter in which a single inlet air stream is split according to a user specified valve setting into two outlet streams.

OTHER FLUIDS

Proforma: Hydronics\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.

3.4.6.5. Heat Exchanger

CONSTANT EFFECTIVENESS

Proforma: Hydronics\Heat Exchangers\Constant Effectiveness\Type91.tmf

TRNSYS Model: Type 91

A zero capacitance sensible heat exchanger is modeled 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.

COUNTER FLOW

Proforma: Hydronics\Heat Exchangers\Counter Flow\Type5b.tmf

TRNSYS Model: Type 5

A zero capacitance sensible heat exchanger is modeled 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.

CROSS FLOW - BOTH FLUIDS MIXED

Proforma: Hydronics\Heat Exchangers\Cross Flow\Both Fluids Mixed\Type5f.tmf

TRNSYS Model: Type 5

A zero capacitance sensible heat exchanger is modeled 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.

CROSS FLOW - BOTH FLUIDS UNMIXED

Proforma: Hydronics\Heat Exchangers\Cross Flow\Both Fluids Unmixed\Type5e.tmf

TRNSYS Model: Type 5

A zero capacitance sensible heat exchanger is modeled 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.

CROSS FLOW - COLD SIDE MIXED

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

TRNSYS Model: Type 5

A zero capacitance sensible heat exchanger is modeled 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.

CROSS FLOW - HOT SIDE MIXED

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

TRNSYS Model: Type 5

A zero capacitance sensible heat exchanger is modeled 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.

PARALLEL FLOW

Proforma: Hydronics\Heat Exchangers\Parallel Flow\Type5a.tmf

TRNSYS Model: Type 5

A zero capacitance sensible heat exchanger is modeled 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.

SHELL AND TUBE

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

TRNSYS Model: Type 5

A zero capacitance sensible heat exchanger is modeled 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.

USER-PROVIDED EFFECTIVENESS

Proforma: Hydronics\Heat Exchangers\User-Provided Effectiveness\Type91b.tmf

TRNSYS Model: Type 91

A zero capacitance sensible heat exchanger is modeled 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 version, the effectiveness is constant over the timestep as the effectiveness is provided to the model as an input and not a parameter.

3.4.6.6.   Pipe

PIPE

Proforma: Hydronics\Pipe\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.

3.4.6.7.   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.

VARIABLE SPEED

Proforma: Hydronics\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.

3.4.6.8.   Tee-Piece Flow Mixer

MOIST AIR

Proforma: Hydronics\Tee-Piece Flow Mixer\Moist Air\Type148b.tmf
TRNSYS Model: Type 148
This instance of the Type148 model uses mode 1 to model a flow mixer in which two inlet air streams are combined into a single outlet air stream.

Proforma: Hydronics\Tee-Piece Flow Mixer\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.

3.4.6.9.   Temperature Controlled Flow Diverter

MOIST AIR

Proforma: Hydronics\Temperature Controlled Flow Diverter\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 Th < Ti. In mode 10, the entire flow stream is sent through outlet 2 under these circumstances.

OTHER FLUIDS

Proforma: Hydronics\ Temperature Controlled Flow Diverter \Other Fluids\Type11b.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 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 Th < Ti. In mode 5, the entire flow stream is sent through outlet 2 under these circumstances.

3.4.7.   Loads and Structures

3.4.7.1.   Infiltration

NIST SIMPLIFIED METHOD

Proforma: Loads and Structures\Infiltration\NIST Simplified Method\Type149.tmf

TRNSYS Model: Type 149

This component models the infiltration into a building based on the article "Improving Infiltration in Energy Modeling" by Ng, Persily and Emmerich in the July 2104 issue of the ASHRAE Journal.

SHERMAN GRIMSRUD - HUMIDITY RATIO INPUTS

Proforma: Loads and Structures\Infiltration\ Sherman Grimsrud \Humidity Ratio Inputs\\Type75a.tmf

TRNSYS Model: Type 75

This model calculates infiltration based on the Sherman Grimsrud equation in ASHRAE Fundamentals 1997 Chapter 25 equation 46. The equation is semi-empirical, relying on the user to specify not only building data such as volume, equivalent leakage area, indoor and outdoor conditions but also a local shielding class that describes the building's nearby surroundings. The Sherman Grimsrud model is ostensibly for a single zone building. Equivalent leakage area is typically obtained from blower door testing.

The model calculates infiltration air changes as well as volumetric flows. In this instance of Type75, the model reads the indoor and outdoor humidity ratio inputs and ignores the relative humidity inputs.

SHERMAN GRIMSRUD - RH INPUTS

Proforma: Loads and Structures\Infiltration\ Sherman Grimsrud \RH Inputs\ Type75b.tmf

TRNSYS Model: Type 75

This model calculates infiltration based on the Sherman Grimsrud equation in ASHRAE Fundamentals 1997 Chapter 25 equation 46. The equation is semi-empirical, relying on the user to specify not only building data such as volume, equivalent leakage area, indoor and outdoor conditions but also a local shielding class that describes the building's nearby surroundings. The Sherman Grimsrud model is ostensibly for a single zone building. Equivalent leakage area is typically obtained from blower door testing.

The model calculates infiltration air changes as well as volumetric flows. In this instance of Type75, the model reads the indoor and outdoor relative humidity inputs and ignores the humidity ratio inputs.

3.4.7.2. Multi-Zone Building

MULTI-ZONE BUILDING

Proforma: Loads and Structures\Multi-Zone Building\ Type56.tmf

TRNSYS Model: Type 56

This component models the thermal behavior of a building having multiple thermal zones. The building description is passed to the model by the building description file (*.b18,*.b17, *.bui). This file can be generated the preprocessor program called TRNBuild.

For detailed information see chapter 05-MultizoneBuilding of the documentation.

3.4.7.3. Multi-Zone Building with Internal Solver Parameters

MULTI-ZONE BUILDING WITH INTERNAL SOLVER PARAMETERS

Proforma: Loads and Structures\Multi-Zone Building with Internal Solver Parameters\Type56b.tmf

TRNSYS Model: Type 56

This component models the thermal behavior of a building having multiple thermal zones. The building description is passed to the model by the building description file (*.b18,*.b17, *.bui). This file can be generated the preprocessor program called TRNBuild.

For detailed information see chapter 05-MultizoneBuilding of the documentation.

3.4.7.4.   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. Therefore, care should be taken in choosing an appropriate mode of Type 15 (or Type 16) for use with this component.

3.4.7.5.   Simple Natural Ventilation

SIMPLE NATURAL VENTILATION

Proforma: Loads and Structures\Simple Natural Ventilation\Type168.tmf
TRNSYS Model: Type 168

3.4.7.6.   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 04 (Mathematical Reference) for a description of Type 19.

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.

3.4.7.7.   *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

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 1), the total solar radiation and glazing transmittance are inputs as is the mass flow rate of air in the gap.

FLOWRATE, TRANSMITTANCE CALCULATED INTERNALLY

Proforma: Loads and Structures\Thermal Storage Wall\Flowrate, Transmittance Calculated Internally\Type36d.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 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.

3.4.8.   Obsolete

Components in the Obsolete folder are from older versions of TRNSYS and are kept for backwards compatibility reasons. The use of these components is not recommended and they will be removed in future versions of the software.

3.4.9.   Output

3.4.9.1.   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.

3.4.9.2.   Printegrator

FORMATTED - USER- DEFINED AND AUTOMATIC MONTHLY PERIODS

Proforma: Output\Printegrator\Formatted\User-Defined and Automatic Monthly Periods\Type46f.tmf

TRNSYS Model: Type 46

The component is used to print the integrated values of the connected inputs to a user-specified data file. The file is written in such a way as to be easily imported into Microsoft Excel. In this version of the combined printer / integrator, the user specifies two output files. One output file will contain integrated results over a user-designated period. The other will contain automatically contain monthly integrated values of the same inputs.

FORMATTED - USER-DEFINED PERIODS

Proforma: Output\Printegrator\Formatted\User-Defined Period\Type46e.tmf

TRNSYS Model: Type 46

The component is used to print the integrated values of the connected inputs to a user-specified data file. The file is written in such a way as to be easily imported into Microsoft Excel.

FORMATTED

Proforma: Output\Printegrator\Formatted\Type46d.tmf

TRNSYS Model: Type 46

The component is used to print the integrated values of the connected inputs to a user-specified data file. The file is written in such a way as to be easily imported into Microsoft Excel.

UNFORMATTED - USER- DEFINED AND AUTOMATIC MONTHLY PERIODS

Proforma: Output\Printegrator\Unformatted\User-Defined and Automatic Monthly Periods\Type46b.tmf

TRNSYS Model: Type 46

The component is used to print the integrated values of the connected inputs to a user-specified data file. The file is written in such a way as to be easily imported into Microsoft Excel. In this version of the combined printer / integrator, the user specifies two output files. One output file will contain integrated results over a user-designated period. The other will contain automatically contain monthly integrated values of the same inputs.

UNFORMATTED - USER-DEFINED PERIODS

Proforma: Output\Printegrator\Unformatted\User-Defined Period\Type46a.tmf

TRNSYS Model: Type 46

The component is used to print the integrated values of the connected inputs to a user-specified data file. The file is written in such a way as to be easily imported into Microsoft Excel.

3.4.9.3. Printer

FORMATTED - NO UNITS

Proforma: Output\Printer\Formatted\No Units\Type25f.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.

FORMATTED - TRNSYS-SUPPLIED UNITS

Proforma: Output\Printer\Formatted\TRNSYS-Supplied Units\Type25d.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.

FORMATTED - USER-SUPPLIED UNITS

Proforma: Output\Printer\Formatted\User-Supplied Units\Type25e.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.

UNFORMATTED – EES LOOKUP TABLES

Proforma: Output\Printer\Unformatted\EES lookup tables\Type25h.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.

This specific printer creates a text file that can be read directly in EES as a lookup table. It automatically create the header information required for EES to understand how many columns are in the file and their units.

UNFORMATTED – NO UNITS

Proforma: Output\Printer\No Units\Unformatted\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.

UNFORMATTED – TRNSYS-SUPPLIED UNITS

Proforma: Output\Printer\Unformatted\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.

UNFORMATTED – USER-SUPPLIED UNITS

Proforma: Output\Printer\Unformatted\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.

3.4.9.4. Scope

SCOPE

Proforma: Output\Scope\Scope.tmf

TRNSYS Model: Type 76

This component will update its icon inside a Simulation Studio project while the simulation is running, depending on its input values.

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.

3.4.9.6.   TRNSYS Plugin for SketchUp Printer

TRNSYS PLUGIN FOR SKETCHUP PRINTER

Proforma: Output\TRNSYS Plugin for SketchUp Printer\Type125.tmf

TRNSYS Model: Type 125

The Type 125 is a version of the eso Printer that is required to visualize results in the TRNSYS Plugin for Google SketchUp.

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 modeled 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 modeled 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. Lumped Capacitance Model

LUMPED CAPACITANCE MODEL

Proforma: Physical Phenomena\Lumped Capacitance Model\Type59.tmf
TRNSYS Model: Type 59
Type 59 represents the dynamic thermal behavior of a body using the lumped capacitance model (in other words, a first order differential equation)

3.4.10.4. 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.

HORIZ DIFFUSE, DIRECT NORMAL KNOWN (MODE=6)

Proforma: Physical Phenomena\Radiation Processors\ Horiz Diffuse, Direct Normal Known (Mode=6)\Type16k.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 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.

3.4.10.5. Shading Masks

SHADING MASKS - SHADING ON OPENING AND HORIZONTAL

Proforma: Physical Phenomena\Shading Masks\Shading on opening and horizontal\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 components 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 - SINGLE MASK FOR ALL OPENINGS

Proforma: Physical Phenomena\Shading Masks\Single mask for all openings\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 components 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.

3.4.10.6. *Simple Ground Temperature Model*

SIMPLE GROUND TEMPERATURE MODEL

Proforma: Physical Phenomena\Simple Ground Temperature Model\Type77.tmf

TRNSYS Model: Type 77

Refer to the document: " .\Tess Models\Documentation\Utility Library\Type501.pdf " for a complete technical description of this component.
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).

3.4.10.7. *Sky Temperature*

CALCULATE CLOUDINESS FACTOR

Proforma: Physical Phenomena\Sky Temperature\calculate cloudiness factor\Type69b.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 is calculated based on user provided dry bulb and dew point temperatures.

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.

3.4.10.8. Thermodynamic Properties

PSYCHROMETRICS - DRY BULB AND DEW POINT KNOWN

Proforma: Physical Phenomena\Thermodynamic Properties\Psychrometrics\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\Psychrometrics\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\Psychrometrics\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\Psychrometrics\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\Psychrometrics\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 – ENTHALPY AND RELATIVE HUMIDITY KNOWN

Proforma: Physical Phenomena\Thermodynamic Properties\Psychrometrics\Enthalpy and Relative Humidity Known\Type33h.tmf

TRNSYS Model: Type 33

This component takes as input the relative humidity 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 - HUMIDITY RATIO AND ENTHALPY KNOWN

Proforma: Physical Phenomena\Thermodynamic Properties\Psychrometrics\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.

PSYCHROMETRICS - HUMIDITY RATIO AND ENTHALPY KNOWN

Proforma: Physical Phenomena\Thermodynamic Properties\Psychrometrics\Humidity ratio and Enthalpy Known\Type33g (reset w).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.

PSYCHROMETRICS - HUMIDITY RATIO AND RELATIVE HUMIDITY KNOWN

Proforma: Physical Phenomena\Thermodynamic Properties\Psychrometrics\Humidity Ratio and Relative Humidity Known\Type33i.tmf

TRNSYS Model: Type 33

This component takes as input the humidity ratio 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 – RELATIVE HUMIDITY AND DEWPOINT TEMPERATURE KNOWN

Proforma: Physical Phenomena\Thermodynamic Properties\Psychrometrics\Relative Humidity and Dewpoint Temperature Known\Type33j.tmf

TRNSYS Model: Type 33

This component takes as input the relative humidity and dewpoint 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.

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).

3.4.10.9. 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 wind speed. 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 wind speed. 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 (theta,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 hbar 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 flow stream 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 plat, 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

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, a second order quadratic function is used to compute the incidence angle modifier. The coefficients of the function are supplied by an ASHRAE test.

BIAXIAL INCIDENCE ANGLE MODIFIERS

Proforma: Solar Thermal Collectors\Performance Map Collector\Biaxial Incidence Angle Modifiers\Type72e.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 instance of Type72, the incidence angle modifiers are read from an external data file as a function of the transverse and of the longitudinal incidence angle.

COVER AND ABSORBER PROPERTIES

Proforma: Solar Thermal Collectors\Performance Map Collector\Cover and Absorber Properties\Type72d.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 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.

MODIFERS=F(INCIDENCE ANGLE)

Proforma: Solar Thermal Collectors\Performance Map Collector\Modifers=f(Incidence Angle)\Type72c.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 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. PV-Thermal Collectors

CONCENTRATING COLLECTORS - CONSTANT LOSSES - CELL OPERATING V IS INPUT

Proforma: Solar Thermal Collectors\PV-Thermal Collectors\Concentrating Collectors\Constant Losses\Cell Operating V is input\Type50g.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 7.

CONCENTRATING COLLECTORS - CONSTANT LOSSES - NO CELL OPERATING VOLTAGE

Proforma: Solar Thermal Collectors\PV-Thermal Collectors\Concentrating Collectors\Constant Losses\No cell operating voltage\Type50e.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 5.

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

Proforma: Solar Thermal Collectors\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.

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

Proforma: Solar Thermal Collectros\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.

FLAT PLATE COLLECTORS - ANGULAR DEPENDENCE OF TRANSMITANCE

Proforma: Solar Thermal Collectros\PV-Thermal Collectors\Flat Plate Collectors\Angular dependence of Transmitance\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.

FLAT PLATE COLLECTORS - CONSTANT LOSSES

Proforma: Solar Thermal Collectors\PV-Thermal Collectors\Flat Plate Collectors\Constant Losses\Type50a.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 1: constant loss coefficient (UL) and transmission coefficient (to).

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

Proforma: Solar Thermal Collectors\PV-Thermal Collectors\Flat Plate Collectors\Loss=f(T,WS,G) and t=f(angle)\Type50d.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 4.

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

Proforma: Solar Thermal Collectors\PV-Thermal Collectors\Flat Plate Collectors\Losses=f(Temp, wind, geometry)\Type50b.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 2: the thermal loss coefficient of the collector is calculated as a function of the operating temperatures, windspeed and collector construction details.

3.4.11.5. 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\Modifers=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.

3.4.11.6. 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.

3.4.11.7. 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. Constant Volume Liquid Storage

VERTICAL TANK – NO HX

Proforma: Thermal Storage\Constant Volume Liquid Storage\Vertical Tank\No HX\Type158.tmf

TRNSYS Model: Type 158

This subroutine models a fluid-filled, constant volume storage tank with a vertical configuration. The fluid in the storage tank interacts with the environment (through thermal losses from the top, bottom and edges) and with up to two flow streams that pass into and out of the storage tank. The tank is divided into isothermal temperature nodes (to model stratification observed in storage tanks) where the user controls the degree of stratification through the specification of the number of "nodes". Each constant-volume node is assumed to be isothermal and interacts thermally with the nodes above and below through several mechanisms: fluid conduction between nodes and through fluid movement (either forced movement from inlet flow streams or natural destratification mixing due to temperature inversions in the tank). Auxiliary heat may be provided to the tank through the use of inputs to the model.

VERTICAL TANK – WITH HX

Proforma: Thermal Storage\Constant Volume Liquid Storage\Vertical Tank\With HX\Type156.tmf

TRNSYS Model: Type 156

This subroutine models a fluid-filled, constant volume storage tank with an immersed coiled-tube heat exchanger. This component models a cylindrical tank with a vertical configuration. The fluid in the storage tank interacts with the fluid in the heat exchanger (through heat transfer with the immersed heat exchanger), with the environment (through thermal losses from the top, bottom and edges) and with up to two flow streams that pass into and out of the storage tank. The tank is divided into isothermal temperature nodes (to model stratification observed in storage tanks) where the user controls the degree of stratification through the specification of the number of "nodes". Each constant-volume node is assumed to be isothermal and interacts thermally with the nodes above and below through several mechanisms: fluid conduction between nodes and through fluid movement (either forced movement from inlet flow streams or natural destratification mixing due to temperature inversions in the tank). Auxiliary heat may be provided to the tank through the use of inputs to the model.

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. Simple Electric Heated Liquid Storage

SIMPLE ELECTRIC HEATED LIQUID STORAGE

Proforma: Thermal Storage\Simple Electric Heated Liquid Storage\Type154.tmf

TRNSYS Model: Type 154

This Type models a standard residential dual-element electric water heater. The model represents the storage volume as a series of cylindrical, isothermal nodes in order to model the stratification observed in storage tanks. Each constant-volume node interacts thermally with the nodes above and below through fluid conduction, forced fluid movement (from inlet flow), and natural fluid mixing (destratification of temperature inversions in the tank). The fluid in the tank interacts with the environment through thermal losses from the top, bottom, and edges. There are two integrated auxiliary heaters for the tank, both of which are controlled through integrated thermostats.

3.4.12.5. Simple Gas Heated Liquid Storage

SIMPLE GAS HEATED LIQUID STORAGE

Proforma: Thermal Storage\Simple Gas Heated Liquid Storage\Type153.tmf

TRNSYS Model: Type 153

This Type models a standard residential gas water heater. The model represents the storage volume as a series of cylindrical, isothermal nodes, in order to model the stratification observed in storage tanks. Each constant-volume node interacts thermally with the nodes above and below through fluid conduction, forced fluid movement (from inlet flow), and natural fluid mixing (destratification of temperature inversions in the tank). The fluid in the tank interacts with the environment through thermal losses from the top, bottom, and edges. There is an integrated auxiliary heater at the bottom of the tank, which is controlled through an integrated thermostat.

3.4.12.6. *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*

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.

ESP-R

Proforma: Utility\Calling External Programs\ESP-r\Type130.tmf

TRNSYS Model: Type 130

Type130 is a data exchanger type. It is to be used in a co-simulation with the building performance energy modeling software ESP-r.

It works as a multi hydraulic and/or air connection. It receives air and fluid states (temperatures, flow rates), transmits them to a TRNSYS simulation and then sends them back to the external program. Outputs of Type130 represent data coming from ESP-r whereas inputs are data sent to ESP-r.

Other information can also be exchanged like zones data (temperature, humidity) from buildings implemented in ESP-r and casual gains from TRNSYS systems components (environement losses,...)

The "Mode"parameter allows the user to choose between using Type 130 normally and exchange data with ESP-r (Mode = 0) or also to use the "test" version of the type (Mode = 1). The test version is meant to be used to test and debug a Trnsys simulation before adding Esp-r and performing a real co-simulation. It sends constant values for a maximum of 2 zones, 2 HCCs and 2 ACCs ports.

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".

MATHIS

Proforma: Utility\Calling External Programs\Mathis\Type159.tmf

TRNSYS Model: Type 159

The simulation code MATHIS is available as a separate type for TRNSYS. It allows modelling the air flow network of a building.

A new project can be created using the "File/New project/Coupled MATHIS project" feature in Simulation Studio.

To edit the air flow network, right click the type 159 and select "Edit air flow network".

DEMO version comes with the default Trnsys installer. If you wish to get a full commercial version, please contact your distributor or go to http://software.cstb.fr

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 later) installed to use this component and Matlab's "bin\win32" folder must be on windows search path. Please note that this TRNSYS component must be recompiled specific to a particular version of Matlab.

PYTHON

Proforma: Utility\Calling External Programs\Python\Type163.tmf

TRNSYS Model: Type 163

This component will simply execute a python script at each iteration. The component writes a file containing the parameters and inputs that the python script will read and then reads a file with the output values that the python script has written.

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.

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.

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

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.

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

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.

3.4.13.3. Differentiation

CONSTANT MATRIX

Proforma: Utility\Differentiation\Constant Matrix\Type78a.tmf

TRNSYS Model: Type 78

Computes x for

$x\_dot = A*x + B*U$

where U is a vector composed of the list of the component's inputs. A and B are constant matrices read from an external file.

The component solves the above differential equation :

$x = - A^{(-1)} * BU$

It uses TRNSYS' internal DIFFERENTIAL_EQUATION() kernal function to do so.

VARIABLE MATRIX

Proforma: Utility\Differentiation\Variable Matrix\Type78b.tmf

TRNSYS Model: Type 78

Computes x for

$x\_dot = A*x + B*U$

where U is a vector composed of the list of the component's inputs. A and B are constant matrices read from an external file.

The component solves the above differential equation using TRNSYS' internal DIFFERENTIAL_EQUATION() kernel function.

The external data files must contain Size(U) x Size(X) values, e.g., for a 2x2 matrix :

63.66   0.01

0.00   0.01

Optionaly, the user can apply variable (dynamic) factors (inputs) to additional matrices; all matrices will be added up before the algorithm is applied. The additional matrices are specified in the same external file as the matrix to which they are added, preceeded by a name.

For example, if "Number of dynamic factors" is set to 1, the above example data file for matrix A should be extended to:

63.66   0.01

0.00   0.01

VAR 1

10 10

0 0

(where "VAR 1" is a comment naming the variable matrix). The data file for matrix B should be extended similarly (the number of A and B matrices must be the same). The first factor is applied to the first variable matrix, the second factor to the second variable matrix, etc. The number of matrices is not limited.

DIFFERENTIATION

Proforma: Utility\Differentiation\Type83.tmf

TRNSYS Model: Type 83

Type 83 calculates the derivative of a signal, based on the value during the previous time step.

Type 83 can integrate up to 100 variables and there is no specific limit on the number of Type 83 units that can be used in a simulation.

3.4.13.4. EN 15251-2007 Floating Mean Temperature

EN 15251-2007 FLOATING MEAN TEMPERATURE

Proforma: Utility\EN 15251-2007 Floating Mean Temperature\Type127.tmf

TRNSYS Model: Type 127

3.4.13.5. 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 user 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 user 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 user 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 user 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.

3.4.13.6. 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.

3.4.13.7. 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.

3.4.13.8. 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.

3.4.13.9. *Interpolation*

1 INDEPENDENT VARIABLE

Proforma: Utility\Interpolation\1 Independent Variable\Type42c.tmf

TRNSYS Model: Type 42

This component models is the same as the Type42 mentioned in the HVAC library. Fundamentally, this component passes between 1 and 3 independent variable values into a routine that interpolates between those values and returns between 1 and 5 dependent variable values. While the component can be used to model HVAC equipment, it can equally well be used for other purposes in which multidimensional interpolation is needed.

In this version of Type42 there is one independent variable and up to 5 dependent values.

2 INDEPENDENT VARIABLE

Proforma: Utility\Interpolation\2 Independent Variable\Type42b.tmf

TRNSYS Model: Type 42

This component models is the same as the Type42 mentioned in the HVAC library. Fundamentally, this component passes between 1 and 3 independent variable values into a routine that interpolates between those values and returns between 1 and 5 dependent variable values. While the component can be used to model HVAC equipment, it can equally well be used for other purposes in which multidimensional interpolation is needed.

In this version of Type42 there are two independent variables and up to 5 dependent values.

3 INDEPENDENT VARIABLE

Proforma: Utility\Interpolation\3 Independent Variable\Type42a.tmf

TRNSYS Model: Type 42

This component models is the same as the Type42 mentioned in the HVAC library. Fundamentally, this component passes between 1 and 3 independent variable values into a routine that interpolates between those values and returns between 1 and 5 dependent variable values. While the component can be used to model HVAC equipment, it can equally well be used for other purposes in which multidimensional interpolation is needed.

In this version of Type42 there are three independent variables and up to 5 dependent values.

3.4.13.10. Moving Average

MOVING AVERAGE

Proforma: Utility\Moving Average\Type84.tmf

TRNSYS Model: Type 84

Type 84 calculates the moving average of a signal, during the previous N time steps.

Type 84 can calculate the moving average of up to 100 variables and there is no specific limit on the number of Type 84 units that can be used in a simulation.

3.4.13.11. Simulation Control

PACEMAKER

Proforma: Utility\Simulation Control\Pacemaker.tmf

TRNSYS Model: Type 82

This type slows down a TRNSYS simulation to make it run in 'real' time (one hour takes one hour to run). Alternatively, a constant delay per time step can be given as an input. The idea of the Type is that you might want the Scope type or the online plotter to display more slowly so that the user can catch an error condition better.

3.4.13.12. Time Values

TIME VALUES

Proforma: Utility\Time Values\Type21.tmf

TRNSYS Model: Type 21

This component returns different time values at the current time step, such as: current year of simulation, current month of simulation, current day of the simulation, month of the year (1 - 12), day of the year (1 - 365), day of the month (1 - 28/30/31), day of the week (1 - 7), hour of the year (0 - 8760), hour of the month (0 - 744), hour of the week (0 - 168), hour of the day (0 - 24), Type 21 may give these values relative to the initial time or in an absolute value from hour = 0.

3.4.13.13. 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.

3.4.13.14. 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

Proforma: Weather Data Reading and Processing\Standard Format\Energy+ Weather Files (EPW)\Type15-3.tmf
TRNSYS Model: Type 15
This component serves the purpose of reading data at regular time intervals from an external weather data file, interpolating the data (including solar radiation for tilted surfaces) at time steps of less than one hour, and making it available to other TRNSYS components. The model also calculates several useful terms including the mains water temperature, the effective sky temperature, and the heating and cooling season forcing functions. This version of Type15 reads data in the EnergyPlus Weather File format (EPW).

Proforma: Weather Data Reading and Processing\Standard Format\German TRY 2004\Type15-7.tmf
TRNSYS Model: Type 15
This component serves the purpose of reading data at regular time intervals from an external weather data file, interpolating the data (including solar radiation for tilted surfaces) at time steps of less than one hour, and making it available to other TRNSYS components. The model also calculates several useful terms including the mains water temperature, the effective sky temperature, and the heating and cooling season forcing functions. This version of Type15 reads data in the German TRY 2004 format.

Proforma: Weather Data Reading and Processing\Standard Format\German TRY 2010\Type15-7.tmf
TRNSYS Model: Type 15
This component serves the purpose of reading data at regular time intervals from an external weather data file,

interpolating the data (including solar radiation for tilted surfaces) at time steps of less than one hour, and making it available to other TRNSYS components. The model also calculates several useful terms including the mains water temperature, the effective sky temperature, and the heating and cooling season forcing functions.

This version of Type15 reads data in the German TRY 2010 format.

INTERNATIONAL WEATHER FOR ENERGY CALCULATIONS (IWEC)

Proforma: Weather Data Reading and Processing\Standard Format\International Weather for Energy Calculations (IWEC)\Type15-4.tmf

TRNSYS Model: Type 15

This component serves the purpose of reading data at regular time intervals from an external weather data file, interpolating the data (including solar radiation for tilted surfaces) at time steps of less than one hour, and making it available to other TRNSYS components. The model also calculates several useful terms including the mains water temperature, the effective sky temperature, and the heating and cooling season forcing functions.

This version of Type15 reads data in the International Weather for Energy Calculations (IWEC) format.

JAPAN

Proforma: Weather Data Reading and Processing\Standard Format\Japan\Type99-AMeDAS.tmf

TRNSYS Model: Type 99

--- 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) Lunch 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
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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 Meteonorm.
Special Considerations
1. Up to 5 UNITS of TYPE 109 may be specified.

METEONORM FILES (TM2)

Proforma: Weather Data Reading and Processing\Standard Format\Meteonorm\Type15-6.tmf

TRNSYS Model: Type 15

This component serves the purpose of reading data at regular time intervals from an external weather data file, interpolating the data (including solar radiation for tilted surfaces) at time steps of less than one hour, and making it available to other TRNSYS components. The model also calculates several useful terms including the mains

water temperature, the effective sky temperature, and the heating and cooling season forcing functions.

This version of Type15 reads data in the format generated by Meteonorm, which is identical to the Typical Meteorological Year (version 2) standard form.

TMY2: TYPE15-2

Proforma: Weather Data Reading and Processing\Standard Format\Meteonorm\Type15-2.tmf

TRNSYS Model: Type 15

This component serves the purpose of reading data at regular time intervals from an external weather data file, interpolating the data (including solar radiation for tilted surfaces) at time steps of less than one hour, and making it available to other TRNSYS components. The model also calculates several useful terms including the mains water temperature, the effective sky temperature, and the heating and cooling season forcing functions.

This version of Type15 reads data in the Typical Meteorological Year (version 2) standard form.

TMY3

Proforma: Weather Data Reading and Processing\Standard Format\Meteonorm\Type15-TMY3.tmf

TRNSYS Model: Type 15

This component serves the purpose of reading data at regular time intervals from an external weather data file, interpolating the data (including solar radiation for tilted surfaces) at time steps of less than one hour, and making it available to other TRNSYS components. The model also calculates several useful terms including the mains water temperature, the effective sky temperature, and the heating and cooling season forcing functions.

This version of Type15 reads data in the Typical Meteorological Year (version 3) standard form.

TMY

Proforma: Weather Data Reading and Processing\Standard Format\Meteonorm\Type15-1.tmf

TRNSYS Model: Type 15

This component serves the purpose of reading data at regular time intervals from an external weather data file, interpolating the data (including solar radiation for tilted surfaces) at time steps of less than one hour, and making it available to other TRNSYS components. The model also calculates several useful terms including the mains water temperature, the effective sky temperature, and the heating and cooling season forcing functions.

This version of Type15 reads data in the Typical Meteorological Year (version 1) standard form.

3.4.14.2.   User Format

USER FORMAT

Proforma: Weather Data Reading and Processing\User Format\Type99.tmf

TRNSYS Model: Type 99

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 99 reads a weather data file in Type 99's user format (see Volume 04 Mathematical Reference manual for details)

Special Considerations: up to 5 instances of TYPE 99 may be specified in a given simulation.