TESS Component Library

General Descriptions

THE APPLICATIONS COMPONENT LIBRARY (GENERAL DESCRIPTIONS)

TYPE 514: THERMOSTAT CONTROLS *(new in version 2.0)*

The Thermostat Controls utility program (ThermoSched.exe) and Type514 are used in conjunction with one another to define a set point schedule that stays the same regardless of the day of the week. A set point schedule consists of a heating set point and setback temperatures, a cooling set point and setup temperatures, and the hours during which they apply. While this documentation has been written using temperature set points as an example, it should be noted that there is nothing inherent about the ThermoSched program that forces it to be used only for temperatures. It should also be noted that the difference between Type520 and Type514 is that Type520 allows for differing schedules during weekdays, on Saturdays and on Sundays while Type514 applies the same schedule regardless of the day of the week.

TYPE 515: HEATING AND COOLING SEASON SCHEDULER *(new in version 2.0)*

The Heating and Cooling Season Scheduler utility program (SeasonsScheduler.exe) and Type515 are used in conjunction with one another to input a heating/cooling season schedule. A heating/cooling schedule denotes which portions of the year when heating or cooling (or both) equipment may be utilized.

TYPE 516: MULTIPLE DAY SCHEDULER

The Multiple Schedules utility program (MultSched.exe) and TRNSYS Type516 are used in conjunction with one another to input schedules with a Weekday, Saturday, and Sunday basis. It should be noted that while temperature notation is used throughout this documentation, there is no inherent reason why Type516 cannot be used to schedule any type of data desired by the user. Type516 differs from Type517 only in that it allows for different schedules to be set for weekdays, Saturdays and Sundays. Type517 applies the same schedule regardless of the day of the week.

TYPE 517: SINGLE DAY SCHEDULER

The Daily Schedule utility program (Sched.exe) and TRNSYS Type517 are used in conjunction with one another to input a 24-hour schedule. The same schedule is repeated for every day of the simulation. It should be noted that while temperature notation is used throughout this documentation, there is no inherent reason why Type517 cannot be used to schedule any type of data desired by the user. Type517 differs from Type516 only in that it does not allows for different schedules to be set for weekdays, Saturdays and Sundays. Type517 applies the same schedule regardless of the day of the week.

TYPE 518: MONTHLY SCHEDULER *(new in version 2.0)*

The Monthly Values utility program (MonthSched.exe) is used in conjunction with TRNSYS Type518 to input schedules that change on a monthly basis.

TYPE 519: HOLIDAY SCHEDULER *(new in version 2.0)*

The Holiday Scheduler utility program (Scheduler.exe) and TRNSYS Type519 are used in conjunction with one another to input and read a holiday schedule. A holiday schedule denotes which days of the year are holidays. This type of schedule is very useful when trying the match the actual operation of a building or calibrate a simulation to measured data or when switching between “occupied” and “unoccupied” building schedules.

TYPE 520: MULTIPLE THERMOSTAT CONTROLS *(new in version 2.0)*

The Multiple Thermostat Controls utility program (MultThermoSched.exe) and Type520 are used in conjunction with one another to define a set point schedule that changes based on a weekday, Saturday, and Sunday basis. A set point schedule consists of a heating set point and setback temperatures, a cooling set point and setup temperatures, and the hours during which they apply. While this documentation has been written using temperature set points as an example, it should be noted that there is nothing inherent about that MultThermoSched program that forces it to be used only for temperatures. It should also be noted that the difference between Type520 and Type514 is that Type520 allows for differing schedules during weekdays, on Saturdays and on Sundays while Type514 applies the same schedule regardless of the day of the week.

THE CONTROLS COMPONENT LIBRARY (GENERAL DESCRIPTIONS)

TYPE 502: THREE STAGE AQUASTAT IN HEATING

A three stage aquastat is modeled to output three ON/OFF control functions that can be used to control a fluid cooling system having up to a three stage heating source.

TYPE 503: THREE STAGE AQUASTAT IN COOLING

A three stage aquastat is modeled to output three ON/OFF control functions that can be used to control a fluid cooling system having up to a three stage cooling source.

TYPE 645: FIVE STAGE ROOM THERMOSTAT

This ON/OFF differential device models a five stage room thermostat which outputs five control signals that can be used to control an HVAC system having a three stage heating source and a two stage cooling source. The controller contains hysteresis effects and is equipped with a parameter that allows the user to set the number of controller oscillations permitted within a single time step before the output values "stick." Type645 was made standard TRNSYS component Type108 with the release of TRNSYS v. 16.

TYPE 658: HUMIDISTAT

This ON/OFF differential device is most often used to control the operation of a humidifier based on the temperatures and relative humidities of the zone and inlet air ventilation stream. The humidistat generates a control function which can have a value of 1 or 0. The value of the control signal is set as a function of the difference between a set point relative humidity and the relative humidity of the zone air, compared with two dead band relative humidity differences. The new value of the control function also depends upon 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.

TYPE 661: DELAYED OUTPUT DEVICE

This component models a "sticky" controller where the outputs are set to the input values from a user-defined previous time step. 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.

TYPE 669: PROPORTIONAL CONTROLLER

This component returns a control signal between 0 and 1 that is related to the current value of an input as compared to a user defined minimum and maximum value.

TYPE 671: N-STAGE DIFFERENTIAL CONTROLLER IN HEATING

An N-stage differential controller is modeled to output N ON/OFF control functions that can be used to control a heating system having a N-stage heat source.

The controller commands a first stage control signal at low input values, a second stage control signal at lower input values, a third stage control signal at even lower input values etc. through the n^{th} defined level.

The user has the option to enable or disable the output control functions for levels lower than the critical control function. For example if the model decides that the third stage signal should be ON, the user has the option of then deciding whether stage 1 and stage 2 should be ON or OFF.

TYPE 672: N-STAGE DIFFERENTIAL CONTROLLER IN COOLING

An N-stage differential controller is modeled to output N ON/OFF control functions that can be used to control a cooling system having a N-stage cooling source.

The controller commands a first stage control signal at high input values, a second stage control signal at higher input values, a third stage control signal at even higher input values etc. through the n^{th} defined level.

The user has the option to enable or disable the output control functions for levels lower than the critical control function. For example if the model decides that the third stage signal should be ON, the user has the option of then deciding whether stage 1 and stage 2 should be ON or OFF.

TYPE 698: FIVE STAGE ROOM THERMOSTAT EVALUATING N TEMPERATURES *(new in version 2.0)*

This ON/OFF differential device models a five stage room thermostat which outputs five control signals that can be used to control an HVAC system having a three stage heating source and a two stage cooling source. This version of the model is designed to allow the user to specify multiple temperatures to watch with the same set of set points. The controller contains hysteresis effects and is equipped with a parameter that allows the user to set the number of controller oscillations permitted within a single time step before the output values "stick."

THE GEOTHERMAL HEAT PUMP COMPONENT LIBRARY (GENERAL DESCRIPTIONS)

Type501: GROUND TEMPERATURE PROFILE

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).

Type504: WATER SOURCE HEAT PUMP

This component models a single-stage liquid source heat pump with an optional desuperheater for hot water heating. 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.

The heat pump has a desuperheater attached to a secondary fluid stream. In cooling mode, the desuperheater relieves the liquid stream of some of the burden of rejecting energy. However, in heating mode, the desuperheater requires the liquid stream to absorb more energy than is just required for space heating.

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. Type504 takes either air relative humidity or absolute humidity ratio as an input. It is identical to Type505 in the TESS HVAC Equipment Library. Formerly, Type504 took air humidity ratio as an input while Type505 took air relative humidity.

Type556: DETAILED BURIED PIPE

This model is based on work done by John Giardina at the Solar Energy Lab at the University of Wisconsin. This subroutine models a horizontal ground coupled heat exchanger or, more simply, a horizontal pipe buried in the earth. The model is based on an earlier work by V.C. Mei of Oak Ridge National Laboratory.

This model accounts for ground seasonal temperature variations and backfilling of the trench containing the pipe. The fluid convection, the pipe wall, and the backfilled material are all represented as a net resistance. The inner soil nodes, those in contact with the backfill are also modeled without capacitance. The rest of the nodes within the soil are modeled as capacitors connected by resistors in both the radial and circumferential directions.

Type557: VERTICAL U TUBE OR TUBE IN TUBE GROUND HEAT EXCHANGER

This subroutine models a vertical ground heat exchanger that interacts thermally with the ground. This ground heat exchanger model is most commonly used in ground source heat pump applications. This subroutine models identical vertical U-tube ground heat exchangers or identical vertical tube in tube heat exchangers. A heat carrier fluid is circulated through the ground heat exchangers and either rejects heat to, or absorbs heat from the ground depending on the temperatures of the heat carrier fluid and the ground.

In typical U-tube or tube in tube ground heat exchanger applications, a vertical borehole is drilled into the ground. A u-tube or tube in tube heat exchanger is then pushed into the borehole. The top of the ground heat exchanger is typically several feet below the surface of the ground. Finally, the borehole is filled with a fill material; either virgin soil or a grout of some type.

The model assumes that the boreholes are placed uniformly within a cylindrical storage volume of ground. There is convective heat transfer within the pipes and conductive heat transfer to the storage volume. The temperature of the surrounding ground is calculated from three parts; a global temperature, a local solution, and a steady-flux solution. The global and local problems are solved with the use of an explicit finite-difference method. The steady-flux solution is obtained analytically. The resulting temperature is then calculated using superposition methods.
This subroutine was written by the Department of Mathematical Physics at the University of Lund, Sweden, and is considered to be the state-of-the-art in dynamic simulation of ground heat exchangers. Further information about this model

may be found in: Hellstrom, Goran, “Duct Ground Heat Storage Model, Manual for Computer Code,” Department of Mathematical Physics, University of Lund, Sweden.

THE GREEN BUILDING COMPONENT LIBRARY (GENERAL DESCRIPTIONS)

Type 56 Window Library ***(new in version 2.0)***

Historically, five generic windows have been included with the multizone building model (Type56) in the TRNSYS package. Users can create new windows for use with Type 56 by running a freely downloadable software product called "Window," written by Lawrence Berkeley National Labs. The Green Building Library includes an expanded library of windows that were created using version 5.2 of the LBNL Window software package. The windows come from four sources; ASHRAE Standard 90.1.99 Table A17, ASHRAE Standard 90.1-99 code minimum windows for various wall coverages and for a particular climate zone (defined in terms of heating and cooling degree days). A window that matches the window defined in ASHRAE Standard 140 and in the BESTEST Standard, and a set of windows that are used in the Building America program. In all, over 100 new windows are available for use with Type56.

Type 551: PHOTOVOLTAIC ARRAY SHADING ***(new in version 2.0)***

It is known that even partial shading of photovoltaics (PV) can have a dramatic effect upon array performance. However, the relationship between the shaded area of a photovoltaic array and the drop in electrical performance due to that shaded area is not only highly non-linear but depends upon the placement of the array with regards to surrounding objects and upon the array's inter and intra modular electrical connections. In order to accurately perform a shading analysis of a photovoltaic array, information about the specific order in which modules are connected in series in parallel, as well as some method for determining time dependent shadow patterns on the array are needed. Only in very rare circumstances would a user have access to such information. As an alternative, component Type551 has been developed as a simplified method for bracketing the effect of shading. Users are asked to select between two general array configurations: generally horizontal rows or generally vertical rows. The first configuration would be appropriate for a series of ballasted roof pan photovoltaics on a flat or sloped roof. The second would be appropriate in a high rise building in which PV is used as a window shading device.

The Type assumes that the array is divided into a user specified number of equal length rows and that all rows in the array are identically sloped. Based on configuration parameters and current input values, the component outputs two different estimates of radiation incident on the array rows. In the more conservative of the two estimates, a row that is partially shaded from beam radiation is assumed to "see" only diffuse radiation. In the less conservative estimate, the fraction of the array exposed to beam radiation is computed and the entire array is assumed to be exposed evenly to that reduced amount.

Type 560: FIN-TUBE PV/T SOLAR COLLECTOR ***(new in version 2.0)***

This component models an un-glazed solar collector that has the dual purpose of creating power from embedded photovoltaic (PV) cells and providing heat to a fluid stream passing through tubes bonded to an absorber plate located beneath the PV cells. The waste heat rejected to the fluid stream cools the PV cells allowing higher power conversion efficiencies and can be used to provide a source of heat for various low-grade temperature applications such as space and water heating.

This model relies on linear factors relating the efficiency of the PV cells to the cell temperature and to incident solar radiation. The cells are assumed to be operating at their maximum power point condition.

The thermal model of this collector relies on algorithms presented in Chapter 6 of "Solar Engineering of Thermal Processes" by J.A. Duffie and W.A. Beckman.

Type 562: SIMPLE GLAZED OR UNGLAZED PHOTOVOLTAIC PANEL ***(new in version 2.0)***

Type562 models either a glazed or unglazed photovoltaic array, basing its performance calculation on a user provided overall array efficiency. Efficiency may be constant, variable, provided as a function of cell temperature and incident radiation in an external file or provided for reference conditions along with coefficients that describe the effect of cell temperature and incident radiation changes. This model is appropriate for PV arrays that are connected to a load through a maximum power point tracking device since the efficiency of the Type562 PV is not dependent upon load voltage.

Type 563: UNGLAZED FIN-TUBE PV/T SOLAR COLLECTOR ***(new in version 2.0)***

This component is intended to model an un-glazed solar collector that has the dual purpose of creating power from embedded photovoltaic (PV) cells and providing heat to a fluid stream passing through tubes bonded to an absorber plate located beneath the PV cells. This model relies on linear factors relating the efficiency of the PV cells to the cell temperature and to the incident solar radiation. The cells are assumed to be operating at their maximum power point condition.

The thermal model of this collector relies on algorithms presented in Chapter 6 of "Solar Engineering of Thermal Processes" by J.A. Duffie and W.A. Beckman.

This version of the PV/T collector may be connected to the multi-zone building model in TRNSYS so that the impact of the collector on the building heating and cooling loads can be evaluated.

Type 566: BUILDING-INTEGRATED PHOTOVOLTAIC SYSTEM (INTERFACES WITH ZONE AIR TEMPERATURE) ***(new in version 2.0)***

This component is intended to model a glazed solar collector that has the dual purpose of creating power from embedded photovoltaic (PV) cells and providing heat to an air stream passing beneath the absorbing PV surface. This model is intended to operate with simple building models that can provide the temperature of the zone air on the back-side of the collector and possibly provide an estimate of the radiant temperature for back-side radiation calculations (the room air temperature may be used as a suitable estimate of the radiant temperature if surface temperatures are not available).

The model allows for the user to choose between two methods of handling the off-normal solar radiation effects. The model also allows the user three options on specifying how the cell temperature and the incident solar radiation affect the PV efficiency. The cells are assumed to be operating at their maximum power point condition, implying that the voltage and current are not calculated by the model.

The thermal model of this collector relies on algorithms supplied in "Solar Engineering of Thermal Processes" by J.A. Duffie and W.A. Beckman.

Type 567: BUILDING-INTEGRATED PHOTOVOLTAIC SYSTEM (INTERFACES WITH TYPE56) ***(new in version 2.0)***

This component is intended to model a glazed solar collector that has the dual purpose of creating power from embedded photovoltaic (PV) cells and providing heat to an air stream passing beneath the absorbing PV surface. This model is intended to operate with detailed building models that can provide the temperature of the back surface of the collector (zone air/collector back interface) given the mean surface temperature of the lower flow channel. The Type 56 multi-zone building model in TRNSYS in one of these detailed zone models. Instructions for connecting this model to a Type 56 building can be found in this model's technical documentation.

The model allows for the user to choose between two methods of handling the off-normal solar radiation effects. The model also allows the user three options on specifying how the cell temperature and the incident solar radiation affect the PV efficiency. The cells are assumed to be operating at their maximum power point condition, implying that the voltage and current are not calculated by the model.

The thermal model of this collector relies on algorithms supplied in "Solar Engineering of Thermal Processes" by J.A. Duffie and W.A. Beckman.

Type 568: UN-GLAZED BUILDING-INTEGRATED PHOTOVOLTAIC SYSTEM (INTERFACES WITH TYPE56) ***(new in version 2.0)***

This component is intended to model an un-glazed solar collector that has the dual purpose of creating power from embedded photovoltaic (PV) cells and providing heat to an air stream passing beneath the absorbing PV surface. The waste heat rejected to the air stream is useful for two reasons; 1) it cools the PV cells allowing higher power conversion efficiencies and 2) it provides a source of heat for many possible low-grade temperature applications including heating of room air. This model is intended to operate with detailed building models that can provide the temperature of the back surface of the collector (zone air/collector back interface) given the mean surface temperature of the lower flow channel. The Type 56 multi-zone building model in TRNSYS in one of these detailed zone models. Instructions for connecting this model to a Type 56 building can be found later in this document.

The model allows the user three options on specifying how the cell temperature, and the incident solar radiation affect the PV efficiency. The cells are assumed to be operating at their maximum power point condition; implying that the voltage and current are not calculated by the model.

The thermal model of this collector relies on algorithms supplied in “Solar Engineering of Thermal Processes” by J.A. Duffie and W.A. Beckman.

Type 569: UN-GLAZED BUILDING-INTEGRATED PHOTOVOLTAIC SYSTEM (INTERFACES WITH ZONE AIR TEMPERATURE) *(new in version 2.0)*

This component is intended to model an un-glazed solar collector that has the dual purpose of creating power from embedded photovoltaic (PV) cells and providing heat to an air stream passing beneath the absorbing PV surface. This model is intended to operate with simple building models that can provide the temperature of the zone air on the back-side of the collector and possibly provide an estimate of the radiant temperature for back-side radiation calculations (the room air temperature may be used as a suitable estimate of the radiant temperature if surface temperatures are not available).

The model allows the user three options on specifying how the cell temperature, and the incident solar radiation affect the PV efficiency. The cells are assumed to be operating at their maximum power point condition, which implies that the voltage and current are not calculated by the model.

The thermal model of this collector relies on algorithms supplied in “Solar Engineering of Thermal Processes” by J.A. Duffie and W.A. Beckman.

Type 687: NATIONAL FENESTRATION RATING COUNCIL (NFRC) WINDOW *(new in version 2.0)*

The Type687 model calculates the amount of solar energy and illumination transmitted through a window given only the basic information available on the National Fenestration Rating Council label of any window commercially available in the United States. It takes, as input data the window’s solar heat gain coefficient, overall u value and visible light transmittance.

Type 726: PROPORTIONAL LIGHTING CONTROLLER *(new in version 2.0)*

This component returns a control signal between a user defined minimum value and 1 that is related to the value of an input signal at the current time step and compared to user defined minimum and maximum values. The component can be used to simulate an ON/OFF controller by setting the minimum and maximum set point values equal to one another. The controller differs from other proportional controllers in that it generates its maximum signal at the lower set point and its minimum signal at its upper set point. In this regard, the output is inverted from that of a typical controller.

Type 727: CONTINUALLY STEPPED LIGHT FIXTURES *(new in version 2.0)*

This component is intended to model one of many control strategies for reduced energy usage lighting. It takes two control signals and is only ON if both control signals are ON. One of the two control signals is digital, the other an analog value between 0 and 1. The light supplied by the fixture (and its corresponding heat gain) are stepped linearly with the value of the analog control signal. In a typical application, the digital control signals might be connected to the occupancy of the a room, while the analog signal is connected to a daylight level sensor. The model also features an automatic delayed shut off as would be appropriate to model lighting connected to a motion sensor. When the digital control signal drops to zero, the lights stay on (and continue to draw power and create a heat gain in the space) for a user settable amount of time.

Type 728: MULTIPLE POWER LEVEL LIGHTS *(new in version 2.0)*

This component is intended to model one of many control strategies for reduced energy usage lighting. It takes two control signals and is only ON if both control signals are ON. In a typical application, one of the control signals might be connected to the occupancy of the a room, while the other is connected to a daylight level sensor. The model also features an automatic delayed shut off as would be appropriate to model lighting connected to a motion sensor. When one of the two control signals drops to zero, the lights stay on (and continue to draw power and create a heat gain in the space) for a user settable amount of time. Finally, users may specify the number of power levels at which the lighting may be operated. Both power draw and heat gain are correspondingly stepped back.

THE GROUND COUPLING COMPONENT LIBRARY (GENERAL DESCRIPTIONS)

Type501: GROUND TEMPERATURE PROFILE

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).

Type653: SIMPLE FLOOR HEATING SYSTEM

This component models a simple radiant slab (floor heating or cooling) system that operates under the assumption that the slab can be treated as a single lump of isothermal mass and that the fluid to slab energy transfer can be modeled using a heat exchanger effectiveness approach.

Type701: BASEMENT CONDUCTION (INTERFACES WITH TYPE56) *(new in version 2.0)*

This routine models the heat transfer from a basement (typically four walls and a floor, all made of concrete) to the soil surrounding the five surfaces of the basement. The heat transfer is assumed to be conductive only and moisture effects are not accounted for in the model. The model relies on a 3-dimensional finite difference model of the soil and solves the resulting inter-dependent differential equations using a simple iterative method. The user enters the temperature of the zone air / slab interface for each of the five surfaces as well as the U value of each surface. The user is also asked to enter the soil properties, soil grid geometry, and the conditions outside of the basement (near-field). The initial soil conditions may be calculated from the Kasuda correlation [1] or read from a user-supplied data file. The surface conditions for the near-field and far-field soil may be calculated in one of three ways; 1) from the Kasuda correlation, 2) from an energy balance on the surface plane, 3) provided as an input to the model. The near-field soil temperatures are affected by the heat transfer from the basement. The far-field soil temperatures are only affected by the surface conditions (time of year) and depth. The model in return calculates the slab/ground interface temperature for each surface, which are passed back to the building model as an input.

This basement model is intended to be used in conjunction with Type56. If you wish to use this model in conjunction with a simplified building model, you should use Type702 instead.

Type702: BASEMENT CONDUCTION (INTERFACES WITH ZONE AIR TEMPERATURE) *(new in version 2.0)*

This routine models the heat transfer from a basement (typically four walls and a floor, all made of concrete) to the soil surrounding the five surfaces of the basement. The heat transfer is assumed to be conductive only and moisture effects are not accounted for in the model. The model relies on a 3-dimensional finite difference model of the soil and solves the resulting inter-dependent differential equations using a simple iterative method. The user enters the temperature of the zone air, the thermal properties of the basement wall material, the soil properties and grid geometry, and the ambient conditions in the soil outside of the basement (near-field). The initial soil conditions may be calculated from the Kasuda correlation [1] or read from a user-supplied data file. The surface conditions for the near-field and far-field soil may be calculated in one of three ways; 1) from the Kasuda correlation, 2) from an energy balance on the surface plane, 3) provided as an input to the model. The near-field soil temperatures are affected by the heat transfer from the basement. The far-field soil temperatures are only affected by the surface conditions (time of year) and depth.

This basement model is intended to be used in conjunction with simplified building models. If you wish to use this model in conjunction with Type56, you should use Type701 instead. More information on this distinction is provided in section 1 below.

Type703: SLAB ON GRADE (INTERFACES WITH TYPE56) *(new in version 2.0)*

This routine models the energy transfer from a horizontal surface (commonly a concrete slab) to the soil beneath the surface. The energy transfer is assumed to be conductive only and moisture effects are not accounted for in the model. The model relies on a 3-dimensional finite difference model of the soil and solves the resulting inter-dependent differential equations using a simple iterative method. The user enters the temperature of the zone side surface of the slab, the slab U value, the soil properties and grid geometry, and the conditions outside of the slab (near-field). The initial soil conditions may be calculated from the Kasuda correlation [1] or read from a user-supplied data file. The surface conditions for the near-field and far-field soil may be calculated in one of three ways; 1) from the Kasuda correlation, 2) from an energy balance on the surface plane,

3) provided as an input to the model. The near-field soil temperatures are affected by the heat transfer from the slab. The far-field soil temperatures are only affected by the surface conditions (time of year) and depth. The model in return calculates the slab/ground interface temperature, which is passed back to the building model as an input.

This slab model is intended to be used in conjunction with Type56. If you wish to use this slab model in conjunction with a simplified building model, you should use Type704 instead.

Type704: SLAB ON GRADE (INTERFACES WITH ZONE AIR TEMPERATURE) ***(new in version 2.0)***

This routine models the heat transfer from a horizontal surface (slab) to the soil beneath the surface. The heat transfer is assumed to be conductive only and moisture effects are not accounted for in the model. The model relies on a 3-dimensional finite difference model of the soil and solves the resulting inter-dependent differential equations using a simple iterative method. The user enters the temperature of the zone air above the slab, the thermal properties of the slab, the soil properties and grid geometry, and the ambient conditions outside of the slab (near field). The initial soil conditions may be calculated from the Kasuda correlation [1] or read from a user-supplied data file. The surface conditions for the near-field and far-field soil may be calculated in one of three ways; 1) from the Kasuda correlation, 2) from an energy balance on the surface plane, 3) provided as an input to the model. The near-field soil temperatures are affected by the heat transfer from the slab. The far-field soil temperatures are only affected by the surface conditions (time of year) and depth.

This radiant slab model is intended to be used with simple building models that calculate the zone air temperature and not with detailed building models that are capable of calculating inner surface temperatures based on provided outer surface temperatures (such as the standard TRNSYS Type 56 model). If you wish to use this radiant slab model in conjunction with Type56, please refer to the companion model, Type703.

Type705: RADIANT SLAB WITH EMBEDDED PIPES (INTERFACES WITH TYPE56) ***(new in version 2.0)***

This component is intended to model a radiant floor-heating slab, embedded in soil, and containing a number of fluid filled pipes. The heat transfer within the slab and surrounding soil is assumed to be conductive only and moisture effects are not accounted for in the model. The model relies on a three-dimensional finite difference method, solving the resulting inter-dependent differential equations using an iterative approach. The user may define any number of pipes within the slab and surrounding soil through a separate data file containing information about the path that the pipes follow through the slab/soil for each pipe. The slab is assumed to be embedded in the soil and the user may define bottom and/or perimeter insulation that extends below the slab if desired. Default numbers of maximum slab nodes, maximum pipe nodes and maximum number of pipes are set, but may be increased by modification of the Fortran code.

This version of the radiant slab model is designed to be used in conjunction with the Type56 building model. If you wish to use the same model in conjunction with a different building model (one that computes a zone air temperature but does not calculate interior surface temperatures), you should use Type706 instead.

Type706: RADIANT SLAB WITH EMBEDDED PIPES (INTERFACES WITH ZONE AIR TEMPERATURE) ***(new in version 2.0)***

This component is intended to model a radiant floor-heating slab, embedded in soil, and containing a number of fluid filled pipes. The heat transfer within the slab and surrounding soil is assumed to be conductive only and moisture effects are not accounted for in the model. The model relies on a three-dimensional finite difference method, solving the resulting inter-dependent differential equations using an iterative approach. The user may define any number of pipes within the slab and surrounding soil through a separate data file containing information about the path that the pipes follow through the slab/soil for each pipe. The slab is assumed to be embedded in the soil and the user may define bottom and/or perimeter insulation that extends below the slab if desired. The slab may also be exposed to incident radiation whether from interior lights or from the sun. Default numbers of maximum slab nodes, maximum pipe nodes and maximum number of pipes are set, but may be increased by modification of the Fortran code.

If you wish to use this radiant slab model in conjunction with Type56, you should use Type705 instead. This version (Type706) is designed to be used with building models that do not contain the notion of a boundary wall and compute interior surface temperatures.

Type707: BURIED VERTICALLY CYLINDRICAL STORAGE TANK WRAPPER ***(new in version 2.0)***

This component can be used in conjunction with most thermal storage tank models to calculate the energy exchange through the bottom, top, and sides of a vertically cylindrical tank that is entirely buried beneath the ground surface. As inputs, the model takes the U values of the tank top, bottom, and each thermal node section as well as the temperature of each tank node. The user is also asked to define a 3 dimensional radial soil node structure. In return, Type707 computes the temperature of each tank node / soil node boundary, passing those temperatures back to the tank model for its own loss calculations.

Type711: BURIED PIPE WRAPPER *(new in version 2.0)*

This component can be used in conjunction with most pipe models to calculate the energy exchange through the sides of a horizontally oriented pipe that is entirely buried beneath the ground surface. As inputs, the model takes the U values of the pipe as well as the temperature of each axial pipe node. The user is also asked to define a 3 dimensional radial soil node structure. In return, Type701 computes the temperature of each pipe node / soil node boundary, passing those temperatures back to the pipe model for it's own loss calculations.

Type712: RADIANT SLAB WITH EMBEDDED PIPES AND NO GROUND STORAGE EFFECTS (INTERFACES WITH TYPE 56) *(new in version 2.0)*

This component is intended to model a radiant floor-heating slab, embedded in soil, and containing a number of fluid filled pipes. The heat transfer within the slab is assumed to be conductive only and moisture effects are not accounted for in the model. The model relies on a three-dimensional finite difference method, solving the resulting inter-dependent differential equations using an iterative approach. The user may define any number of pipes within the slab through An external data file containing information about the path that the pipes follow through the slab for each pipe. The slab is assumed to be embedded in the soil and the user may define bottom and/or perimeter insulation that extends below the slab if desired. Default numbers of maximum slab nodes, maximum pipe nodes and maximum number of pipes are set, but may be increased by modification of the Fortran code. This model differs from Type705 in that it does not extend the 3D grid into the soil that surrounds the slab. Instead, the zone temperature communicates (through the slab) with a ground surface temperature generated by the Kasuda [1] correlation.

This version of the radiant slab model is designed to be used in conjunction with the Type56 building model. If you wish to use the same model in conjunction with a different building model (one that computes a zone air temperature but does not calculate interior surface temperatures), you should use Type713 instead.

Type 713: RADIANT SLAB WITH EMBEDDED PIPES AND NO GROUND STORAGE EFFECTS (INTERFACES WITH ZONE AIR TEMPERATURE) *(new in version 2.0)*

This component is intended to model a radiant floor-heating slab, embedded in soil, and containing a number of fluid filled pipes. The heat transfer within the slab is assumed to be conductive only and moisture effects are not accounted for in the model. The model relies on a three-dimensional finite difference method, solving the resulting inter-dependent differential equations using an iterative approach. The user may define any number of pipes within the slab through An external data file containing information about the path that the pipes follow through the slab for each pipe. The slab is assumed to be embedded in soil and the user may define bottom and/or perimeter insulation that extends below the slab if desired. The slab may also be exposed to incident radiation whether from interior lights or from the sun. Default numbers of maximum slab nodes, maximum pipe nodes and maximum number of pipes are set, but may be increased by modification of the Fortran code. This model differs from Type706 in that it does not extend the 3D finite element grid into the soil that surrounds the slab. Instead, the zone temperature communicates (through the slab) with a ground surface temperature generated by the Kasuda [1] correlation.

If you wish to use this radiant slab model in conjunction with Type56, you should use Type712 instead. This version (Type713) is designed to be used with building models that do not contain the notion of a boundary wall and compute interior surface temperatures.

Type714: ASHRAE METHOD FOR CALCULATING SLAB HEAT TRANSFER *(new in version 2.0)*

In 2001 ASHRAE Fundamentals Chapter 31, the American Society of Heating and Refrigeration Engineers proposes a simplified method for calculating the energy transfer through a rectangular slab on grade with various insulation schemes (back insulation, side insulation, no insulation, etc.). The same chapter extends the simplified method to calculating energy transfer through basements. This Type should be used for slabs while Type715 is available for calculating energy transfer through basements.

Type715: ASHRAE METHOD FOR CALCULATING BASEMENT HEAT TRANSFER ***(new in version 2.0)***

In 2001 ASHRAE Fundamentals Chapter 31, the American Society of Heating and Refrigeration Engineers proposes a simplified method for calculating the energy transfer through a rectangular aspect ratio basement with various insulation schemes (back insulation, side insulation, no insulation, etc.). The same chapter also presents the simplified method as it applies to calculating energy transfer through slabs. This Type should be used for basements while Type714 is available for calculating energy transfer through slabs. Because of the methodology used, this model is not appropriate for use with Type56 but can be used with simplified building models such as standard TRNSYS Type12, or 88, or the TESS simplified multizone building model (Type660).

THE HVAC COMPONENT LIBRARY (GENERAL DESCRIPTIONS)

TYPE 505: WATER SOURCE HEAT PUMP

This component models a single-stage liquid source heat pump with an optional desuperheater for hot water heating. 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.

The heat pump has a desuperheater attached to a secondary fluid stream. In cooling mode, the desuperheater relieves the liquid stream of some of the burden of rejecting energy. However, in heating mode, the desuperheater requires the liquid stream to absorb more energy than is just required for space
heating.

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. Type505 takes either air relative humidity or absolute humidity ratio as an input. It is identical to Type504 in the TESS Ground Source Heat Pump Library. Formerly, Type505 took air relative humidity while Type504 took air humidity ratio as an input.

TYPE 506: DIRECT EVAPORATIVE COOLER (SWAMP COOLER) *(new in version 2.0)*

Type506 models an evaporative cooling device for which the user supplies the inlet air conditions and the saturation efficiency and the model calculates the outlet air conditions. The cooling process is assumed to be a constant wet bulb temperature process meaning that air enters and exits at the same wet bulb temperature. The device is not equipped with controls that monitor the conditions of the outlet air. When the device is ON (based on a user supplied control signal value), Type506 cools the air as much as it can given the entering conditions and the device efficiency. If a controlled evaporative cooling device is more appropriate to the user's circumstances, Type507 may be used. Type507 models a similar direct evaporative cooling device but takes a target air outlet relative humidity.

TYPE 507: CONTROLLED DIRECT EVAPORATIVE COOLING DEVICE (FOGGING DEVICE) *(new in version 2.0)*

Type507 models an evaporative cooling device for which the user supplies the inlet air conditions and a target air outlet relative humidity. The outlet air dry bulb temperature is modulated given to achieve the desired outlet relative humidity. The cooling process is assumed to be a constant wet bulb temperature process meaning that air enters and exits at the same wet bulb temperature.

TYPE 508: COOLING COIL WITH VARIOUS CONTROL MODES *(new in version 2.0)*

Type508 models a cooling coil using one of four control modes. The cooling coil is modeled using a bypass approach in which the user specifies a fraction of the air stream that bypasses the coil. The remainder of the air stream is assumed to exit the coil at the average temperature of the fluid in the coil and at saturated conditions. The two air streams are remixed after the coil. In its unrestrained (uncontrolled) mode of operation, the coil cools and dehumidifies the air stream as much as possible given the inlet conditions of both the air and the fluid streams. The model is alternatively able to internally bypass fluid around the coil so as to maintain the outlet air dry bulb temperature above a user specified minimum, to maintain the air outlet absolute humidity ratio above a user specified minimum or to maintain the fluid outlet temperature below some user specified maximum.

TYPE 510: CLOSED CIRCUIT COOLING TOWER *(new in version 2.0)*

Type510 models a closed circuit cooling tower; a device used to cool a liquid stream by evaporating water from the outside of coils containing the working fluid. The working fluid is completely isolated from the air and water in this type of system. Closed circuit cooling towers are often referred to as indirect cooling towers or indirect evaporators.

TYPE 641: SIMPLE ADIABADIC HUMIDIFER

This model represents a simple adiabatic humidifier whose outlet air state is determined by an energy balance. Thermal losses from the humidifier are neglected. The model allows for the humidifier not to respond immediately to the control signal but to reach its steady state moisture gain rate exponentially. Furthermore, the model allows the user to determine whether condensate leaves the humidifier at the temperature at which it enters, at the temperature of the air exiting the humidifier or at any point in between.

TYPE 643: SIMPLE FURNACE / AIR HEATER

Much like Type6 does for fluids, Type643 represents an air heating device that can be controlled either externally, or set to automatically try and attain a set point temperature. The furnace is bound by a heating capacity and an efficiency. Thermal losses from the furnace are based on the average air temperature. The outlet state of the air is determined by an enthalpy based energy balance that takes pressure effects into account.

TYPE 650: HEAT EXCHANGER WITH HOT-SIDE BYPASS TO KEEP COLD-SIDE OUTLET BELOW ITS SETPOINT

Type650 models a constant effectiveness / C_{min} heat exchanger that is able to automatically bypass hot-side fluid around the heat exchanger in order to maintain the cold-side outlet temperature below a user specified, time dependent set point. The bypass may be enabled or disabled at any point during the simulation if desired.

TYPE 651: RESIDENTIAL COOLING COIL (AIR CONDITIONER)

Type651 models a residential cooling coil, more commonly known as a residential air conditioner. It relies on catalog data provided as external text files to determine coil performance. Example data files and information on data file format are provided. This component is functionally identical to Type756 except that Type756 takes a different data file format.

TYPE 652: HEAT EXCHANGER WITH HOT-SIDE BYPASS TO KEEP COLD-SIDE OUTLET ABOVE ITS SETPOINT

Type652 models a constant effectiveness / C_{min} heat exchanger that is able to automatically bypass hot-side fluid around the heat exchanger in order to maintain the cold-side outlet temperature above a user specified, time dependent set point. The bypass may be enabled or disabled at any point during the simulation if desired.

TYPE 655: AIR COOLED CHILLER

Type655 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.

TYPE 657: HEAT EXCHANGER WITH COLD-SIDE BYPASS TO KEEP HOT-SIDE OUTLET BELOW ITS SETPOINT

Type657 models a constant effectiveness / C_{min} heat exchanger that is able to automatically bypass cold-side fluid around the heat exchanger in order to maintain the hot-side outlet temperature below a user specified, time dependent set point. The bypass may be enabled or disabled at any point during the simulation if desired.

TYPE 659: AUXILIARY FLUID HEATER WITH PROPORTIONAL CONTROL (PROPORTIONAL BOILER)

Type659 models an external, proportionally controlled fluid heater. External proportional control (an input signal between 0 and 1) is in effect as long as a fluid set point temperature is not exceeded. If the set point is exceeded, the proportional control is internally modified to limit the fluid outlet temperature to the set point as with Type6.

TYPE 663: ELECTRIC UNIT HEATER WITH VARIABLE SPEED FAN AND PROPORTIONAL CONTROL

Type663 models an electric unit heater whose fan speed and heating power are proportionally and externally controlled. Proportional control indicates that both fan speed and heating power can vary between 0 and their rated values. External control indicates that the fraction of rated capacity or speed is specified as a time dependent value by the user and is provided to the model as an input. The heater is designed not to exceed a user specified set point temperature. If at any point in the simulation the heater capacity and control signal would result in an outlet temperature higher than the set point, the external control signal value will be overridden. Fan power is specified as a polynomial relating normalized mass flow rate to normalized fan power. The user may control the extent to which the fan power results in a temperature rise in the air stream.

TYPE 664: ELECTRIC UNIT HEATER WITH VARIABLE SPEED FAN, PROPORTIONAL CONTROL, AND DAMPER CONTROL

Type664 models an electric unit heater whose fan speed, heating power, and fraction of outdoor air are proportionally and externally controlled. Proportional control indicates that these three variables can have any value between 0 and their rated values. External control indicates that the fraction of rated capacity, speed, or outdoor air is specified as a time dependent value by the user and is provided to the model as an input. The heater is designed not to exceed a user specified set point temperature. If at any point in the simulation the heater capacity and control signal would result in an outlet temperature higher than the set point, the external control signal value will be overridden. Fan power is specified as a polynomial relating normalized mass flow rate to normalized fan power. The user may also control the extent to which the fan power results in a temperature rise in the air stream.

TYPE 665: AIR SOURCE HEAT PUMP (SPLIT SYSTEM HEAT PUMP)

Type665 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. The model is also equipped with a capacity multiplier parameter so that the heat pump may be quickly resized without having to resort to finding new data files.

TYPE 666: WATER COOLED CHILLER

Type666 models a vapor compression style water 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.

TYPE 667: AIR TO AIR HEAT RECOVERY DEVICE

Type667 uses a "constant effectiveness – minimum capacitance" approach to model an air to air heat recovery device in which two air streams are passed near each other so that both energy and possibly moisture may be transferred between the streams. Because of the "constant effectiveness – minimum capacitance" methodology, the model may be used to model a device with any configuration of air streams (parallel flow, cross flow, counter flow, etc.) and may be used to model the sensible and latent aspects of an air to air heat exchanger, an enthalpy wheel, a hygroscopic heat exchanger or a permeable walled flat plate recuperator, among other devices.

TYPE 668: WATER – WATER HEAT PUMP

This component models a single-stage heat pump. The heat pump conditions a one liquid stream by rejecting energy to (cooling mode) or absorbing energy from (heating mode) a second. This model is based on user-supplied data files containing catalog data for the capacity and power draw, based on the entering load and source temperatures. Type668 operates in temperature level control much like an actual heat pump would; when the user defined control signal indicates that the unit should be ON in either heating or cooling mode, it operates at its capacity level until the control signal values changes.

TYPE 670: AIR HEATING COIL (KEEPS THE OUTLET AIR TEMPERATURE BELOW A USER-SPECIFIED SETPOINT)

Type670 simulates an air heating coil with an internally controlled bypass damper that acts to maintain the outlet air temperature above the inlet air temperature and below a user-specified set point temperature.

TYPE 673: TWO PIPE CONSOLE UNIT IN ENERGY RATE CONTROL

Type673 models a piece of HVAC equipment commonly known as a two pipe console unit. Such devices pass air across a tube bank that contains either hot or cold fluid. Depending upon the temperature of the air and the fluid, the air will exit either hotter or colder than it entered. Type673 models a two pipe console unit in energy rate control mode, meaning that sensible and latent loads are inputs to the model. Type673 includes a "number of identical units" parameter that allows for easy scaling of the system to meet the building load.

TYPE 676: DOUBLE-EFFECT STEAM-FIRED ABSORPTION CHILLER

Type676 uses a normalized catalog data lookup approach to model a double-effect steam-fired absorption chiller. "Steam-Fired" indicates that the energy supplied to the machine's generator comes from a steam source. Because the data files are normalized, the user may model any size chiller using a given set of data files. Example files are provided.

TYPE 677: DOUBLE-EFFECT HOT WATER-FIRED ABSORPTION CHILLER

Type677 uses a normalized catalog data lookup approach to model a double-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.

TYPE 678: DOUBLE-EFFECT DIRECT-FIRED ABSORPTION CHILLER

Type678 uses a normalized catalog data lookup approach to model a double-effect direct fired absorption chiller. "Direct Fired" indicates that the energy that must be supplied to the machine's generator comes from a burner (natural gas or other combustible fuel) built into the machine. Because the data files are normalized, the user may model any size chiller using a given set of data files. Example files are provided.

TYPE 679: SINGLE-EFFECT STEAM-FIRED ABSORPTION CHILLER

Type679 uses a normalized catalog data lookup approach to model a single-effect steam-fired absorption chiller. "Steam-Fired" indicates that the energy supplied to the machine's generator comes from a steam source. Because the data files are normalized, the user may model any size chiller using a given set of data files. Example files are provided.

TYPE 680: SINGLE-EFFECT HOT WATER-FIRED ABSORPTION CHILLER

Type680 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. Type680 was made a standard TRNSYS Component (Type107) with the release of TRNSYS 16.

TYPE 681: SINGLE-EFFECT DIRECT-FIRED ABSORPTION CHILLER

Type681 uses a normalized catalog data lookup approach to model a single-effect direct fired absorption chiller. "Direct Fired" indicates that the energy that must be supplied to the machine's generator comes from a series of burners built into the device. Because the data files are normalized, the user may model any size chiller using a given set of data files. Example files are provided.

TYPE 683: ROTARY DESICCANT DEHUMIDIFIER *(new in version 2.0)*

This component models a rotary desiccant dehumidifier containing nominal silica gel whose performance is based on equations for F1-F2 potentials developed by Jurinak. The model determines the regeneration temperature at ambient humidity ratio which will dehumidify process air to the a user specified humidity ratio. The process stream and regeneration stream outlet conditions are determined as well.

TYPE 684: AIR SIDE ECONOMIZER *(new in version 2.0)*

Type684 models an air side economizer that internally determines an appropriate mixture of outside and return air that will result in air delivered to the zone at the same temperature, enthalpy, or humidity ratio as air that would be delivered by a cooling coil.

TYPE 688: DEHUMIDIFIER *(new in version 2.0)*

Type688 models a stand-alone "all in one" dehumidifier in which the air stream is in contact with the evaporator section (cools and dehumidifies the air), and with the condenser section (reheats the air) of the refrigerant loop. The user can control the amount of heat that is added to the flow stream by setting an input value; a value of zero signifies that no air reheating is done and that all the compressor and evaporator energy is rejected to the surroundings. A value of one signifies that all the compressor and evaporator energy is added back into the air stream flowing across the coils. The model relies on a data file containing performance data at various entering air conditions. The power reported in this data file should contain only the compressor power as the fan power is handled separately.

TYPE 689: HEAT PIPE ***(new in version 2.0)***

Type689 models a passive device called a heat pipe, which transfers energy from one fluid stream to another - often times the same fluid stream but with a heating or cooling device inserted between the two heat exchangers of the heat pipe. Heat pipes are commonly used in dehumidification applications where warm humid air is cooled to near its dew point using the heat pipe, then is further cooled and dehumidified in a dehumidifier, then is passed back across the other end of the heat pipe where it is reheated using the heat removed from the first cooling in the heat pipe.

TYPE 692: PERFORMANCE MAP FLUID COOLER ***(new in version 2.0)***

Type692 models a simple fluid cooling device. The model relies on an external, user-supplied data file that contains device capacity and COP as a function of the inlet fluid temperature and a sink temperature.

TYPE 696: AIR STREAM CONDITIONING DEVICE ***(new in version 2.0)***

Type696 models a simple air conditioning device that adds or removes sensible and latent energy from an air stream to meet user-specified set point conditions of temperature and / or humidity. In this device the sensible condition controls the latent decisions. In other words the device cannot heat and dehumidify or cool and humidify the air stream. It can, however, heat and humidify or cool and dehumidify. To use the component effectively as a dehumidifying coil, set the set point temperature in cooling to the inlet air temperature and the humidity set point to desired level, then set the IREHEAT parameter value to 1 so that the air is returned (through reheat after dehumidification) to its inlet condition or set IREHEAT to 0 allow for a free-floating outlet temperature. To operate this component as a temperature controlled device only, choose the RH input mode and set the RH set point to 100% in cooling and to 0% in heating.

TYPE 697: PERFORMANCE MAP COOLING COIL ***(new in version 2.0)***

Type697 models a simple air cooling device that removes energy from an air stream according to performance data found in a combination of three external data files and based upon the flow rates and inlet conditions of the air stream and a liquid stream. Normally a water stream is used but if the external data is available for other liquids, that data can be used equally well.

TYPE 699: HEAT EXCHANGER WITH COLD-SIDE BYPASS TO KEEP HOT-SIDE OUTLET ABOVE ITS SETPOINT ***(new in version 2.0)***

Type699 models a constant effectiveness / C_{min} heat exchanger that is able to automatically bypass hot-side fluid around the heat exchanger in order to maintain the cold-side outlet temperature above a user specified, time dependent set point. The bypass may be enabled or disabled at any point during the simulation if desired.

TYPE 700: SIMPLE BOILER WITH EFFICIENCY INPUTS ***(new in version 2.0)***

Type700 models a simple steam boiler. According to ASHRAE, a boiler is defined by its overall efficiency (output/input) and by its combustion efficiency ((input energy-stack energy)/input energy). In this model, the boiler efficiency and the combustion efficiency are supplied as inputs to the model. A version of this component also exists (Type751) in which boiler and combustion efficiency are read as a function of entering liquid temperature and device part load ratio from an external data file. This component (Type700) assumes that device efficiency is not a function of inlet conditions.

TYPE 751: SIMPLE BOILER WITH EFFICIENCY FROM DATA FILE ***(new in version 2.0)***

Type751 models a simple steam boiler. According to ASHRAE, a boiler is defined by its overall efficiency (output/input) and by its combustion efficiency ((input energy-stack energy)/input energy). In this model, the boiler efficiency and the combustion efficiency are read from an external data file in which they are provided as a function of entering liquid temperature and device part load ratio. A version of this component exists (Type700) in which the combustion and boiler efficiency values are specified as inputs to the model instead of in an external data file.

TYPE 752: SIMPLE COOLING COIL ***(new in version 2.0)***

Type752 models a cooling coil using a bypass fraction approach. A user-defined fraction of the inlet air stream is assumed to reach the average temperature of the liquid filled coils of the device while the remaining fraction is assumed to completely bypass the effects of the coil. The two air streams then mix back together and the outlet conditions are calculated. The

Type752 cooling coil differs from other cooling coil models in that it does not treat the liquid side of the system at all. It is assumed that the coil is not constrained by the liquid side or in other words, that the liquid side can absorb as much energy from the air side as needed. Type752 can be used in three different control modes; in one control mode, the outlet dry bulb temperature of the air stream is maintained at a desired level. In another control mode the air outlet humidity (whether relative humidity or absolute humidity ratio) is maintained at a desired level. In the third control strategy both temperature and humidity are maintained at desired levels. This cooling coil model is not designed to be used in a free float mode because nothing is known about the conditions of liquid entering the device. The model reports the amount of energy removed from the air stream and (if both temperature and humidity are controlled) the amount of reheat energy required to bring the temperature back up to the desired level after meeting the humidity requirement.

TYPE 753: HEATING COIL WITH VARIOUS CONTROL MODES *(new in version 2.0)*

Type753 models a heating coil using one of three control modes. The heating coil is modeled using a bypass approach in which the user specifies a fraction of the air stream that bypasses the coil. The remainder of the air stream is assumed to exit the coil at the average temperature of the fluid in the coil. The air stream passing through the coil is then remixed with the air stream that bypassed the coil. In its unrestrained (uncontrolled) mode of operation, the coil heats the air stream as much as possible given the inlet conditions of both the air and the fluid streams. The model is alternatively able to internally bypass air around the coil so as to maintain the outlet air dry bulb temperature above a user specified minimum, or to maintain the fluid outlet temperature above a user specified minimum.

TYPE 754: HEATER / HUMIDIFIER *(new in version 2.0)*

Type754 models a device that can heat and / or humidify an air stream. Depending upon the device control mode, the outlet air stream dry bulb temperature, dry bulb temperature and relative humidity, dry bulb temperature and humidity ratio, or humidity ratio only will be maintained by the device. Type754 is not capacity limited but reports the sensible and latent energy required to meet the requested outlet condition based on the air inlet conditions.

TYPE 756: RESIDENTIAL COOLING COIL (AIR CONDITIONER) WITH UNIFIED DATA FORMAT *(new in version 2.0)*

Type756 models a residential cooling coil, more commonly known as a residential air conditioner. It relies on catalog data provided in an external text file to determine coil performance. An example data file and information on data file format are provided. This component is functionally identical to the Type651 residential cooling coil except that Type651 requires a different data file format. Depending upon the source of data, this component or Type651 may be the more appropriate version.

TYPE 757: INDIRECT EVAPORATIVE COOLER *(new in version 2.0)*

Type757 models an evaporative cooling device for which the user supplies the inlet air conditions of a primary and secondary air stream and the device effectiveness as a function of primary stream inlet air dry bulb temperature and secondary stream inlet air wet bulb temperature. The model calculates outlet air conditions and assumes that the secondary air stream process is a constant wet bulb temperature process meaning that air enters and exits at the same wet bulb temperature. The device is not equipped with controls that monitor the conditions of the outlet air. When the device is ON (based on a user supplied control signal value), Type757 cools the primary air stream as much as it can given the entering conditions and the device effectiveness.

TYPE 760: AIR TO AIR SENSIBLE HEAT EXCHANGER (HEAT WHEEL) *(new in version 2.0)*

Type760 uses an effectiveness – minimum capacitance approach to model an air to air heat exchanger that transfers only sensible energy. If moisture transfer as well as sensible energy transfer between the exhaust and fresh air streams is important, Type667 (an air to air heat recovery device) uses similar principals to this model but also accounts for moisture transfer between the air streams. Type760 includes five different control modes. In the first of these control modes, the outlet temperatures of the two air streams are completely uncontrolled. In the other four operation modes, the temperature of either the fresh or exhaust air streams is maintained either above or below a user defined set point.

THE HYDRONICS COMPONENT LIBRARY (GENERAL DESCRIPTIONS)

TYPE 642: SINGLE SPEED FAN

Type642, donated at Type112 to the standard TRNSYS Library with the release of v. 16, models a fan that is able to spin at a single speed and thereby maintain a constant mass flow rate of air. As with most pumps and fans in TRNSYS, Type642 takes mass flow rate as an input but ignores the value except in order to perform mass balance checks. Type642 sets the downstream flow rate based on its rated flow rate parameter and the current value of its control signal input.

TYPE 644: TWO SPEED FAN/BLOWER

Type644 models a fan that is able to spin at one of two speeds, thereby maintaining one of two constant mass flow rates of air. As with most pumps and fans in TRNSYS, Type644 takes mass flow rate as an input but ignores the value except in order to perform mass balance checks. Type644 sets the downstream flow rate based on its rated flow rate parameters and the current value of its control signal inputs.

TYPE 646: AIR SUPPLY PLENUM WITH UP TO 100 PORTS

Type646 models a supply air plenum. One inlet flow of air is split up into as many as 100 individual streams whose mass flow rates are user specified fractions of the inlet air flow rate. The limit of 100 inlet flows can be modified in the Fortran source code.

TYPE 647: FLOW DIVERTER WITH UP TO 100 PORTS

Type647 models a diverting valve that splits a liquid inlet mass flow into fractional outlet mass flows. One inlet flow may be split into as many as 100 individual streams. The limit of 100 inlet flows can be modified in the Fortran source code.

TYPE 648: AIR RETURN PLENUM WITH UP TO 100 PORTS

Type648 models a return air plenum. Up to 100 individual flows of air are mixed together to determine the properties of the air exiting the plenum. The limit of 100 inlet flows can be modified in the Fortran source code.

TYPE 649: FLOW MIXER WITH UP TO 100 PORTS

Type649 models a mixing valve that combines up to 100 individual liquid streams into a single outlet mass flows. The limit of 100 inlet flows can be modified in the Fortran source code.

TYPE 654: CONSTANT SPEED PUMP

Type654, donated at Type114 to the standard TRNSYS Library with the release of v. 16, 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, Type654 takes mass flow rate as an input but ignores the value except in order to perform mass balance checks. Type654 sets the downstream flow rate based on its rated flow rate parameter and the current value of its control signal input.

TYPE 656: VARIABLE SPEED PUMP

Type656, donated to the standard TRNSYS Library with the release of TRNSYS v. 16, 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, Type656 takes mass flow rate as an input but ignores the value except in order to perform mass balance checks. Type656 sets the downstream flow rate based on its rated flow rate parameter and the current value of its control signal input.

TYPE 662: VARIABLE SPEED FAN/BLOWER

Type662, donated as Type111 to the standard TRNSYS Library with the release of v. 16, models a fan that is able to turn at any speed between 0 (full stop) and its rated speed. While the mass flow rate of air moved by the fan is linearly related to the control signal, the power drawn by the fan at a given flow rate can be any polynomial expression of the control signal. As with most pumps and fans in TRNSYS, Type662 takes mass flow rate as an input but ignores the value except in order to perform mass balance checks. Type662 sets the downstream flow rate based on its rated flow rate parameters and the current value of its control signal inputs.

TYPE 695: VARIABLE SPEED PUMP, CONTROL SIGNAL INPUT, POWER CALCULATED FROM HEAD AND DESIRED FLOW RATE *(new in version 2.0)*

Type695 models a pump that sets its outlet mass flow rate equal to a user specified maximum mass flow rate multiplied by a control signal that can vary between a value of 0 and 1. By insuring that the control signal only ever has a value of 0 or 1 (never anything in between) Type695 can equally well be used to model a constant speed pump. Like most pumps and fans in TRNSYS, Type695 ignores the inlet mass flow rate of liquid and sets the downstream flow. The pump's power draw is calculated based upon a user specified polynomial. Pump starting and stopping characteristics are not modeled.

TYPE 709: PIPE (U VALUE CALCULATED FROM PHYSICAL CHARACTERISTICS) *(new in version 2.0)*

Very much like standard TRNSYS Type31, 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 multiplied by the simulation time step. 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 so-called "plug-flow" model does not consider mixing or conduction between adjacent elements. A maximum of 25 segments are allowed in the pipe. When the maximum is reached, the two adjacent segments with the closest temperatures are combined to make a single segment. Where Type709 differs from Type31 is that instead of asking the user to provide an overall UA value for the pipe and its insulation, the user is here asked to provide the physical characteristics of the pipe material, fluid and insulation material.

It should also be noted that the documentation for Type709 is taken largely verbatim from the documentation of Type31.

TYPE 740: CONSTANT SPEED PUMP, CONTROL SIGNAL INPUT, POWER CALCULATED FROM PRESSURE DROP AND PUMP EFFICIENCY *(new in version 2.0)*

Type740 models a single (constant) speed pump that is able to maintain a constant fluid outlet mass flow rate. The pump's power draw is calculated from pressure rise, motor efficiency and fluid characteristics. Pump starting and stopping characteristics are not modeled. As with most pumps and fans in TRNSYS, Type740 takes mass flow rate as an input but ignores the value except in order to perform mass balance checks. Type740 sets the downstream flow rate based on its rated flow rate parameter and the current value of its control signal input.

TYPE 741: VARIABLE SPEED PUMP, CONTROL SIGNAL INPUT, POWER CALCULATED FROM PRESSURE RISE AND PUMP EFFICIENCY *(new in version 2.0)*

Type741 models a variable speed pump that is able to produce any mass flow rate between zero and its rated flow rate. The pump's power draw is calculated from pressure rise, motor efficiency and fluid characteristics. Pump starting and stopping characteristics are not modeled. As with most pumps and fans in TRNSYS, Type741 takes mass flow rate as an input but ignores the value except in order to perform mass balance checks. Type741 sets the downstream flow rate based on its rated flow rate parameter and the current value of its control signal input.

TYPE 742: VARIABLE OR CONSTANT SPEED PUMP, MASS FLOW RATE INPUT, POWER CALCULATED FROM PRESSURE RISE AND PUMP EFFICIENCY *(new in version 2.0)*

Type742 models a pump that sets its fluid outlet mass flow rate equal to the user specified inlet mass flow rate. Because mass flow rate is an input (as opposed to a parameter), Type742 can equally well be used to model a constant or a variable speed pump. Unlike most pumps and fans in TRNSYS, Type742 passes the inlet mass flow rate through to its output. Type742 sets the downstream flow but does not take either a maximum allowable flow rate or a control signal. The pump's power draw is calculated from pressure rise, motor efficiency, fluid flow rate and fluid characteristics. Pump starting and stopping characteristics are not modeled.

TYPE 743: VARIABLE OR CONSTANT SPEED PUMP, MASS FLOW RATE INPUT, POWER CALCULATED FROM POWER CURVE POLYNOMIAL *(new in version 2.0)*

Type743 models a pump that sets its outlet mass flow rate equal to a user specified inlet mass flow rate. Because mass flow rate is an input (as opposed to a parameter), Type743 can equally well be used to model a constant or a variable speed pump. Unlike most pumps and fans in TRNSYS, Type743 passes the inlet mass flow rate of fluid through to its output. Type743 sets the downstream flow but does not take a control signal. The pump's power draw is calculated based upon a user specified polynomial. Pump starting and stopping characteristics are not modeled.

TYPE 744: VARIABLE OR CONSTANT SPEED FAN, MASS FLOW RATE INPUT, POWER CALCULATED FROM POWER CURVE POLYNOMIAL *(new in version 2.0)*

Type744 models a fan that sets its outlet mass flow rate equal to a user specified inlet mass flow rate. Because mass flow rate is an input (as opposed to a parameter), Type744 can equally well be used to model a constant or a variable speed fan. Unlike most pumps and fans in TRNSYS, Type744 passes the inlet mass flow rate of air through to its output. Type744 sets the downstream flow but does not take a control signal. The fan's power draw is calculated based upon a user specified polynomial. Fan starting and stopping characteristics are not modeled.

TYPE 745: VARIABLE SPEED PUMP, MASS FLOW RATE CALCULATED FROM AVAILABLE POWER, POWER DRAWN CALCULATED FROM MOTOR EFFICIENCY AND PRESSURE RISE *(new in version 2.0)*

Type745 models a pump that sets its outlet mass flow rate based upon user specified available power. It calculates the power drawn by the pump based on motor efficiency and pump pressure rise. Like most pumps and fans in TRNSYS, Type745 takes the inlet mass flow rate of fluid as an input but does not necessarily pass the value through to its output. Type745 sets the downstream flow. Because of the power input, this pump model is particularly useful for direct drive applications in which a pump is directly connected to an intermittent power source.

TYPE 746: VARIABLE SPEED PUMP, MASS FLOW RATE CALCULATED FROM AVAILABLE POWER, POWER DRAWN CALCULATED FROM POWER CURVE *(new in version 2.0)*

Type746 models a pump that sets its outlet mass flow rate based upon user specified available power. It then calculates the power drawn by the pump using a power curve. Like most pumps and fans in TRNSYS, Type746 takes the inlet mass flow rate of fluid as an input but does not necessarily pass the value through to its output. Type746 sets the downstream flow. Because of the power input, this pump model is particularly useful for direct drive applications in which a pump is directly connected to an intermittent power source.

TYPE 747: CONSTANT SPEED PUMP, MASS FLOW RATE CALCULATED FROM MATCHING SYSTEM CURVE AND HEAD CURVE *(new in version 2.0)*

Type747 models a pump whose outlet mass flow rate is based upon a user supplied ON/OFF signal and the intersection point between a user specified system head curve (polynomial) and a user specified pump head curve (external data file). Like most pumps and fans in TRNSYS, Type747 takes the inlet mass flow rate of fluid as an input but does not necessarily pass the value through to its output. Type747 sets the downstream flow based solely upon the pump / system curve intersection point.

TYPE 748: VARIABLE SPEED PUMP, DESIRED MASS FLOW RATE INPUT, MATCH SYSTEM CURVE AND HEAD CURVE *(new in version 2.0)*

Type748 models a pump whose outlet mass flow rate is based upon a user supplied ON/OFF signal, a user specified desired mass flow rate and the intersection point between a user specified system head curve (polynomial) and a series of user specified pump head curve for various pump speeds (external data file). Like most pumps and fans in TRNSYS, Type748 takes the inlet mass flow rate of fluid as an input but does not necessarily pass the value through to its output. Type748 sets the downstream flow based solely upon the pump / system curve intersection point.

TYPE 749: VARIABLE SPEED PUMP, POWER INPUT, MATCH SYSTEM CURVE AND HEAD CURVE *(new in version 2.0)*

Type749 models a pump whose outlet mass flow rate is based upon a user specified amount of available power and the intersection point between a user specified system head curve (polynomial) and a series of user specified pump head curve for various pump speeds (external data file). Like most pumps and fans in TRNSYS, Type749 takes the inlet mass flow rate of fluid as an input but does not necessarily pass the value through to its output. Type749 sets the downstream flow based solely upon the pump / system curve intersection point.

TYPE 750: VARIABLE SPEED PUMP, FRACTION OF RATED SPEED INPUT, MATCH SYSTEM CURVE AND HEAD CURVE *(new in version 2.0)*

Type750 models a variable speed pump whose flow rate is calculated based on the intersection of the pump curve and the system curve. The user must specify coefficients of the system curve polynomial (head pressure versus flow rate) and must provide an external data file containing the pump curve (head versus flow rate) at several values of the rotational speed. Type750 will attempt to find a flow rate that provides the same system head and pump head given the provided fraction of rated rotational speed. Like most pumps and fans in TRNSYS, Type750 takes the inlet mass flow rate of fluid as an input but does not necessarily pass the value through to its output. Type750 sets the downstream flow based solely upon the pump / system curve intersection point.

THE LOADS AND STRUCTURES COMPONENT LIBRARY (GENERAL DESCRIPTIONS)

Library of Building Templates ***(new in version 2.0)***

This set of buildings is based on research carried out at the Pacific Northwest Laboratory (PNL). The United States office building stock was categorized using a statistically valid sample of the nation's office building sector known as the Commercial Building Energy Consumption Survey (CBECS) [EIA 1986, 1989]. The categories were developed using a statistical technique known as cluster analysis based on attributes such as size, age and location. Twenty buildings representing the existing building stock as of 1979 were described by Briggs et al (1987) and five buildings representing expected construction between 1980 and 1995 were described by Crawley et al (1992). The resulting twenty five buildings were entered into TRNBuild and include template TRNSYS Studio projects including schedules for occupancy, lighting, equipment, heating and cooling set points.

Type660: MULTI ZONE LUMPED CAPACITANCE BUILDING

This subroutine models the temperature and humidity level of a simple building zone subject to infiltration effects, ventilation effects, skin losses, internal heat and mass gains, and conductive and convective exchanges with adjacent zones. The model uses two differential equations to solve for the heat and mass balances at each time step. This model is unique in that the user may operate the building in one of two unique control modes. In the first mode, the user controls the temperature and humidity of the zone externally through the control of the ventilation flow stream. This method of control is termed temperature level control and requires that the user typically set the available heating, cooling, humidifying and dehumidifying capacities to zero.

In the second mode, the temperature and humidity are ideally controlled inside the model to maintain user specified set points. The model then outputs the energies that were required to maintain these set points. This method of control is often termed energy rate control. See the discussion on energy rate control in the main TRNSYS manual for more details about this topic.

Type682: LOAD IMPOSED ON A LIQUID STREAM

Often in simulating an HVAC system, the heating and cooling loads on the building have already been determined, either by measurement or through the use of another simulation program and yet the simulation task at hand is to simulate the effect of these loads upon the system. This component allows for there to be an interaction between such precalculated loads and the HVAC system by imposing the load upon a liquid flowing through a pipe.

Type686: SYNTHETIC BUILDING LOADS GENERATOR ***(new in version 2.0)***

This component will generate hourly heating and cooling loads for a synthetic building based on user-defined peak heating and cooling loads and modifying sine-wave functions used to account for seasonal variations, time-of-day variations and weekday/weekend differences. The user may also have the model generate some random noise on both an hourly basis and a daily basis to more realistically model real building loads. This component is an excellent first choice for simulations requiring heating and cooling loads for commercial, industrial, and residential buildings. The model represents a quick method of providing realistic loads without the time-intensive modeling required of a real building.

Type687: NATIONAL FENESTRATION RATING COUNCIL (NFRC) WINDOW ***(new in version 2.0)***

The Type687 model calculates the amount of solar energy and illumination transmitted through a window given only the basic information available on the National Fenestration Rating Council label of any window commercially available in the United States.

Type690: ENERGY RATE LOADS CONVERSION ***(new in version 2.0)***

This component models a single node lumped capacitance using a differential equation. It then takes inputs of heating load, sensible and latent cooling load (which may have been generated by some other simulation program such as DOE-2) and, using knowledge of the lump capacitance, turns those loads into a modulating temperature. The component also has inputs for the conditions of ventilation streams, which may be conditioned to control the modulating temperature. Type690 is quite a useful component for those seeking to model new HVAC systems for buildings whose heating and cooling loads have already been simulated by other parties, perhaps not using TRNSYS.

Type693: LOAD IMPOSED ON AN AIR STREAM ***(new in version 2.0)***

Often in simulating an HVAC system, the heating and cooling loads on the building have already been determined, either by measurement or through the use of another simulation program. This component allows for there to be an interaction between such precalculated loads and the HVAC system by imposing them upon air flowing through a duct.

Type759: LUMPED CAPACITANCE MULTIZONE BUILDING WITH NO CONTROLS ***(new in version 2.0)***

This subroutine models the temperature and humidity level of a simple building zone subject to infiltration effects, ventilation effects, skin losses, internal heat and mass gains, and conductive and convective exchanges with adjacent zones. The model uses two differential equations to solve for the heat and mass balances at each time step. The zone temperature and humidity are controlled externally through the conditioning of a ventilation flow stream.

THE OPTIMIZATION COMPONENT LIBRARY (GENERAL DESCRIPTION)

Type758: TRNOPT Printer

TRNOPT and the Type758 TRNOPT Printer were written in order to couple the TRNSYS simulation software package with the GENOPT optimization algorithms produced by Lawrence Berkeley National Laboratory (LBNL). GENOPT is a generic optimization algorithm developed by LBNL to interface with black-box simulation programs like TRNSYS. TRNOPT acts as an interface between TRNSYS and the GENOPT Optimizer and streamlines the optimization process. With TRNOPT, the entire process of optimizing the results from a TRNSYS simulation reduces to choosing the TRNSYS input file, choosing the variables which will be varied to optimize the results, and choosing the simulation result to be optimized.

TRNOPT requires that the user register and download the GENOPT optimization engine from Lawrence Berkeley National Laboratory; instructions for doing so are contained in the Technical Description of this component.

THE SOLAR COMPONENT LIBRARY (GENERAL DESCRIPTIONS)

TYPE 536: LINEAR PARABOLIC CONCENTRATING SOLAR COLLECTOR

Type536 models a type of solar collector called a linear parabolic concentrator that is commonly used in high temperature applications. In the simplest form of a linear parabolic concentrator, fluid passes through a long evacuated tube that runs along an east-west axis and is horizontal to the plane of the ground or which runs on a north-south axis and is in a plane tilted with respect to the ground. The Type536 parabolic concentrator is modeled based on theoretical equations developed in Solar Engineering of Thermal Processes.

TYPE 537: FLAT PLATE SOLAR COLLECTOR WITH A VARIABLE SPEED PUMP TO MAINTAIN A DESIRED OUTLET TEMPERATURE

Type537 models a standard flat plate, quadratic efficiency solar collector based on theoretical equations developed in Solar Engineering of Thermal Processes. The flat plate collector is assumed to incorporate a variable speed pump and a control system that adjusts the flow rate of fluid through the collector to maintain a user desired outlet temperature. The model is equipped with minimum and maximum flow rates for the pump; if the calculated values of these parameters are exceeded, the temperature of fluid exiting the collector will not be equal to the user requested temperature.

TYPE 538: EVACUATED TUBE SOLAR COLLECTOR

This component models an evacuated tube solar collector with either a variable speed pump to keep the outlet temperature at a user-defined value or a constant speed pump with a variable outlet temperature.

TYPE 539: FLAT PLATE COLLECTOR WITH CAPACITANCE, VS PUMP AND EFF = $f(T_{IN})$

This component models a flat plate solar collector which considers capacitance effects and includes an option for a variable speed pump to keep the outlet temperature at a user-defined value if possible. The collector performance equation is based on the difference between inlet fluid temperature and ambient temperature.

TYPE 540: FLAT PLATE COLLECTOR WITH CAPACITANCE, VS PUMP AND EFF = $f(T_{AVE})$

This component models a flat plate solar collector which considers capacitance effects and includes an option for a variable speed pump to keep the outlet temperature at a user-defined value if possible. The collector performance equation is based on the difference between average collector plate temperature and ambient temperature.

TYPE 541: FLAT PLATE INTEGRAL COLLECTOR STORAGE (ICS) SYSTEM

This subroutine models an integral collector storage (ICS) domestic hot water system with or without an immersed load-side heat exchanger. In this model, the ICS system is basically a liquid-filled rectangular "box" with a solar collector located directly above it. The fluid in the box is in contact with the collector's absorbing surface and heat is transferred to the fluid in the box and then to the fluid in the immersed heat exchanger (if present) when solar radiation is incident upon the collecting surface.

TYPE 543: SINGLE COVER TOP LOSS MODEL

Type543 performs a combined radiation and convection energy balance on a plate of known temperature that is separated from an ambient temperature (for convection calculations) and an effective sky temperature (for radiation calculations) by a single sheet of cover material. The model iterates to balance energy and to converge upon a cover temperature. Wind effects on the outer cover surface are modeled. This model can be used to calculate a time dependent top loss coefficient for solar collector models that take top loss coefficients as an input (as is the case with the TESS Integral Collector Storage (ICS) models). The energy balance methodology of this component was developed at the National Renewable Energy Laboratory.

TYPE 544: DOUBLE COVER TOP LOSS MODEL

Type544 performs a combined radiation and convection energy balance on a plate of known temperature that is separated from an ambient temperature (for convection calculations) and an effective sky temperature (for radiation calculations) by two sheets of cover material. The model iterates to balance energy and to converge upon a temperature for each of the two covers. Wind effects on the outer cover surface are modeled. This model can be used to calculate a time dependent top loss coefficient for solar collector models that take top loss coefficients as an input (as is the case with the TESS Integral Collector Storage (ICS) models). The energy balance methodology of this component was developed at the National Renewable Energy Laboratory.

TYPE 550: TUBULAR INTEGRAL COLLECTOR STORAGE (ICS) SYSTEM *(new in version 2.0)*

This component is intended to model an integral collector storage system; a solar collector design where the collector and storage sections of a typical solar domestic hot water system are combined into one unit. The model is intended to be applied to ICS systems that store fluid in several tubes that are connected in series and placed within a collector enclosure.

TYPE 553: UNGLAZED FLAT PLATE COLLECTOR (EFFICIENCY COEFFICIENT METHOD) *(new in version 2.0)*

This component models an unglazed flat plate solar collector where the collector efficiency coefficients are known. This model relies on algorithms supplied by the solar collector text: Solar Engineering of Thermal Processes by Duffie and Beckman.

TYPE 559: THEORETICAL UNGLAZED FLAT PLATE COLLECTOR *(new in version 2.0)*

This component models an unglazed flat plate solar collector where the collector efficiency coefficients are calculated from theoretical models. This model relies on algorithms supplied by the solar collector text: Solar Engineering of Thermal Processes by Duffie and Beckman.

TYPE 561: UNGLAZED AIR HEATING COLLECTOR *(new in version 2.0)*

This component is intended to model an un-glazed solar collector that passes air behind the absorbing plate. Moist air calculations are not included in the model. The thermal model of this collector relies on algorithms supplied by the classic Solar Engineering of Thermal Processes textbook by Duffie and Beckman.

TYPE 564: THEORETICAL FIN / TUBE SOLAR COLLECTOR (POOL HEATER) *(new in version 2.0)*

This component models a tube-fin solar collector based on algorithms presented by Duffie and Beckman in chapter 6 of their book Solar Engineering of Thermal Processes.

TYPE 565: THEORETICAL SERPENTINE TUBE SOLAR COLLECTOR *(new in version 2.0)*

This component models a serpentine tube-fin solar collector based on algorithms presented by Duffie and Beckman in chapter 6 of their book Solar Engineering of Thermal Processes.

THE STORAGE COMPONENT LIBRARY (GENERAL DESCRIPTIONS)

TYPE 502: THREE STAGE AQUASTAT IN HEATING

A three stage aquastat is modeled to output three ON/OFF control functions that can be used to control a fluid cooling system having up to a three stage heating source.

TYPE 503: THREE STAGE AQUASTAT IN COOLING

A three stage aquastat is modeled to output three ON/OFF control functions that can be used to control a fluid cooling system having up to a three stage cooling source.

TYPE 531: RECTANGULAR STORAGE TANK WITH OPTIONAL IMMERSED HEAT EXCHANGERS *(new in version 2.0)*

This subroutine models a rectangular cross section fluid-filled, constant volume storage tank with immersed heat exchangers as shown in Figure 1 below. The fluid in the storage tank interacts with the fluid in the heat exchangers (through heat transfer with the immersed heat exchangers), 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). The user has the ability to specify one of four different immersed heat exchanger types (or no HX if desired); horizontal tube bank, vertical tube bank, serpentine tube, or coiled tube. Auxiliary heat may be provided to each isothermal node individually; through the use if INPUTs to the model. The model also considers temperature-dependent fluid properties for either pure water, an ethylene glycol and water solution, or a propylene glycol and water solution for both the tank and heat exchanger fluids.

TYPE 532: SPHERICAL STORAGE TANK WITH OPTIONAL IMMERSED HEAT EXCHANGERS *(new in version 2.0)*

This subroutine models a spherical fluid-filled, constant volume storage tank with immersed heat exchangers as shown in Figure 1 below. The fluid in the storage tank interacts with the fluid in the heat exchangers (through heat transfer with the immersed heat exchangers), 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). The user has the ability to specify one of four different immersed heat exchanger types (or no HX if desired); horizontal tube bank, vertical tube bank, serpentine tube, or coiled tube. Auxiliary heat may be provided to each isothermal node individually; through the use if INPUTs to the model. The model also considers temperature-dependent fluid properties for either pure water, an ethylene glycol and water solution, or a propylene glycol and water solution for both the tank and heat exchanger fluids.

TYPE 533: HORIZONTALLY CYLINDRICAL STORAGE TANK WITH OPTIONAL IMMERSED HEAT EXCHANGERS *(new in version 2.0)*

This subroutine models a fluid-filled, constant volume storage tank with immersed heat exchangers. This component models a cylindrical tank with a horizontal configuration as shown in Figure 1 below. The fluid in the storage tank interacts with the fluid in the heat exchangers (through heat transfer with the immersed heat exchangers), with the environment (through thermal losses from the left end, right end 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). The user has the ability to specify one of four different immersed heat exchanger types (or no HX if desired); horizontal tube bank, vertical tube bank, serpentine tube, or coiled tube. Auxiliary heat may be provided to each isothermal node individually; through the use if INPUTs to the model. The model also considers temperature-dependent fluid properties for either pure water, an ethylene glycol and water solution, or a propylene glycol and water solution for both the tank and heat exchanger fluids.

TYPE 534: VERTICALLY CYLINDRICAL STORAGE TANK WITH OPTIONAL IMMERSED HEAT EXCHANGERS *(new in version 2.0)*

This subroutine models a fluid-filled, constant volume storage tank with immersed heat exchangers. This component models a cylindrical tank with a vertical configuration as shown in Figure 1 below. The fluid in the storage tank interacts with the fluid in the heat exchangers (through heat transfer with the immersed heat exchangers), 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). The user has the ability to specify one of four different immersed heat exchanger types (or no HX if desired); horizontal tube bank, vertical tube bank, serpentine tube, or coiled tube. Auxiliary heat may be provided to each isothermal node individually; through the use if INPUTs to the model. The model also considers temperature-dependent fluid properties for either pure water, an ethylene glycol and water solution, or a propylene glycol and water solution for both the tank and heat exchanger fluids.

THE UTILITY COMPONENT LIBRARY (GENERAL DESCRIPTIONS)

TYPE 501: GROUND TEMPERATURE PROFILE

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).

TYPE 571: INFILTRATION TO A CONDITIONED ZONE

ASHRAE long recommended the use of a semi empirical model for the calculation of infiltration to a conditioned zone. The so called K1, K2, K3 method is considered to be less rigorous than the calculation of infiltration based upon dynamic wind pressure, buoyancy forces and envelope characteristics. However, the more rigorous model requires extensive knowledge of parameters whose values are difficult to measure without a blower door test and the K1, K2, K3 model remains an accurate method for obtaining quick computation of infiltration.

TYPE 572: EQUIPMENT FOULING

This component can be used to degrade and reset the performance of other components over the course of a simulation. For example, as a solar thermal collector sits on a roof, dust and pollen accumulate on its glass cover, degrading its performance until it rains or until it is washed. The component calculates a “fouling factor” for equipment as a function of time. Cleanings can be scheduled, at which time the fouling percentage is set back to zero The model also allows for the equipment to self-clean at a user specified rate with the input of a control signal.

TYPE 573: OUTPUT DEVICE FOR AVERAGE DAY OF EACH MONTH

This component creates the hourly profile for the average day of each simulated month and for two alternatives (inputs). The profiles are stored in a user defined output file, which is perhaps best viewed as a 2-D Area Chart in TRNSPREAD (the TRNSYS spreadsheet program) or Microsoft Excel.

TYPE 574: ASHRAE OCCUPANCY LOADS

The ASHRAE Handbook of Fundamentals lists typical latent and sensible loads for occupancy based on the activity level of the occupants. This component takes, as parameters, the number of different people types and their associated activity level, and as inputs the number of people at each of these activity levels. The outputs from this component are the latent and sensible loads for the building (totals and per activity).

TYPE 575: SKY TEMPERATURE

This subroutine calculates an effective sky temperature based on the dew point temperature, the station pressure, the fraction of opaque cloud cover, and the emissivity of the clouds. The correlation is based on equations developed in “Characteristics of Infrared Sky Radiation in the U.S.A.” (Berdahl, 1984). Such calculated sky temperatures are most commonly used in the calculation of radiation losses from structures and solar collectors.

TYPE 576: TWO DIMENSIONAL BIN SORTER

This component calculates the number of hours during the simulation in which the two inputs fall within user-specified bins. The user must provide the number of bins for each of the inputs and the minimum and maximum values for the bins. The model will then sort the inputs into these bins; producing a 2-D grid upon completion. The outputs from this model are written to a user-specified file.

TYPE 577: RANDOM NUMBER GENERATOR DRAWN FROM UNIFORM DISTRIBUTION

This model generates a random number drawn from a uniform distribution based on user-supplied values of an initial seed, minimum and maximum function values.

TYPE 578: RANDOM NUMBER GENERATOR DRAWN FROM NORMAL DISTRIBUTION

This model generates a random number drawn from a normal distribution based on user-supplied values of an initial seed, mean and standard deviation.

TYPE 579: NESTED FORCING FUNCTION

The nested forcing function eliminates the multiple TYPE 14 forcing functions and numerous equations needed to set the schedule for an input that changes throughout the year. This forcing function allows the user to "tier" the forcing functions such that the schedule of the tertiary function depends on the value of the secondary and primary forcing functions.

TYPE 580: PARAMETRIC TABLE OUTPUT PRINTER

The parametric table output printer prints specified results at the very end of a simulation to an assigned data file. Information can be *appended* instead of simply written to the output file such that the results from a parametric table analysis can be quickly viewed and compared. A time and date stamp is also appended to each set of results so that the user knows exactly when and from which input file the results were generated.

TYPE 581: MULTI DIMENSIONAL DATA INTERPOLATION ***(new in version 2.0)***

A generalized adaptation of Type42, this component can be used to model the performance of generic equipment or as a device to interpolate data in up to a four dimensions.

TYPE 582: LIFE CYCLE COST ANALYSIS ***(new in version 2.0)***

One of the most common measures of engineering economics is the life cycle cost of a system and one method of calculating the life cycle cost is referred to as the P1 P2 method. The idea of the method is that the life cycle cost of a purchase option or alternative is calculated based on two economic indicators. The first (P1) is the ratio of the life cycle fuel cost to the first year fuel cost. A low value of P1 indicates that immediate fuel costs are high and that consequently, potential immediate fuel savings are important. The second indicator (P2) is the ratio of life cycle expenditures incurred as a result of the investment to the investment amount. A high value of P2 indicates that the investment has a low first cost but higher costs over the life of the equipment. This component operates in one of two modes. It can either calculate P1 and P2 based on a set of simple economic indicators, or it can accept values of P1 and P2 directly. In both modes, the component calculates the life cycle cost for up to ten system alternatives. More alternatives may be added by modifying a single parameter in the Fortran code and recompiling. The model then compares each alternative to a user designated comparison system.

TYPE 584: OUT OF SET POINT WATCHER ***(new in version 2.0)***

When operating in temperature level control, it is a fairly common occurrence for the temperature of a zone to exceed the cooling set point temperature or to be below the heating set point temperature. Type584 watches temperature conditions, records and (if desired) prints information on the time, duration and extent to which the set points were exceeded. While most often, this component is used in building applications, there is nothing inherent to it about buildings. Type584 may equally well be used in other situations in which a watched variable (mass flow rate, relative humidity, power, etc.) is intended to be maintained within an allowable range but may at times exceed that range.

Library Name	Standard Price	Educational Price
Geothermal Heat Pump Component Library	350 €	175 €
Utility Component Library	350 €	175 €
HVAC Equipment Component Library	500 €	250 €
Applications Component Library	200 €	100 €
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Controls Component Library	100 €	50 €
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Hydronics Component Library	200 €	100 €
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The following discounts apply to purchases of multiple libraries.

Library Name	Standard Price Discount	Educational Price Discount
Purchase of 2 – 4 Component Libraries	-10 %	-10 %
Purchase of 5 – 7 Component Libraries	-20 %	-20 %
Purchase of 8 – 9 Component Libraries	-30 %	-30 %
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Customers upgrading any combination of Libraries from of the Software v. 1.x to the Software v. 2.x will **receive a credit of the amount that they paid** toward the purchase of the Software v. 1.x toward their purchase of the Software v. 2.x.