TESS COMPONENT LIBRARIES

General Descriptions

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THE APPLICATIONS COMPONENT LIBRARY

TYPE 514: THERMOSTAT CONTROLS

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

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 517_NORMALIZED: SINGLE DAY SCHEDULER

The Normalized Daily Schedule utility program (Sched_Normalized.exe) and TRNSYS Type517_Normalized are used in conjunction with one another to input a 24-hour schedule that can be normalized by the click a button.

TYPE 518: MONTHLY SCHEDULER

The Monthly Values utility program (MonthSched.exe) is used in conjunction with TRNSYS Type518 to input schedules that change on a monthly basis. This component sets a monthly forcing function schedule. The user may have the value be constant for the month, or be linearly interpolated from mid-point to another.

TYPE 519: HOLIDAY SCHEDULER

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

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

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 698: 5-STAGE MULTIZONE 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. This version of the model is designed to allow the user to specify multiple temperatures for multiple zones 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."

TYPE 911: DIFFERENTIAL CONTROLLER WITH LOCKOUTS

This component operates like the standard Type 2 differential controller in TRNSYS but allows the user to specify the minimum "On" time and the minimum reset time. For example, the controller could be set such that once the pump comes on it must stay on for 15-minutes and once it turns off it must stay off for an hour.

TYPE 953: TEMPERING VALVE CONTROLLER

This component simulates both a tempering valve controller for domestic hot water applications and a three-way valve controller for supply/return systems. In the domestic hot water application, this component sets the fraction of mains water that bypasses the storage tank and mixes with the water from the storage tank to maintain the delivery temperature below a user-specified maximum delivery temperature (scald set point). In a supply/return application, this component calculates the fraction of return fluid that must be sent to the heat supply in order to maintain the mixed supply temperature at the user-specified set point.

TYPE 970: N-STAGE DIFFERENTIAL CONTROLLER – MULTIPLE SETPOINTS & DEADBANDS - 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 nth defined level. The user must specify the setpoints and deadbands for each stage. The controller may limit the turning on and off of the stages based on elapsed time for the previous stage.

TYPE 971: N-STAGE DIFFERENTIAL CONTROLLER – MULTIPLE SETPOINTS & DEADBANDS - 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 nth defined level. The user must specify the setpoints and deadbands for each stage. The controller may limit the turning on and off of the stages based on elapsed time for the previous stage.

TYPE 973: N-STAGE DIFFERENTIAL CONTROLLER – SINGLE SETPOINT- MULTIPLE DEADBANDS - TIME DELAY

An N-stage differential controller is modeled to output N ON/OFF control functions that can be used to control a heating or cooling system having a N-stage source. The model turns on the first stage when the temperature falls below (rises above) the setpoint minus (plus) one-half of the deadband temperature difference and remains on until the temperature rises above (falls below) the setpoint plus (minus) one half of the deadband temperature difference. The controller will turn on the second, and subsequent stages, after a user-specified period of time has elapsed and the temperature has not yet reached the turn off temperature (setpoint plus (minus) one half of the deadband temperature difference). Once the turn off temperature has been reached, stages will be turned off one at a time after the user specified delay time has been passed.

TYPE 974: N-STAGE DIFFERENTIAL CONTROLLER – SINGLE SETPOINT WITH TIME DELAY

This subroutine models a n-stage thermostat which outputs n on/off control functions that can be used to control a system having n levels of alternatives. Although temperature notation is used, this controller can be based on any consistent set of input variable types. This model will stage on and off the various levels based on elapsed time in an attempt to keep the "watched" temperature at the setpoint.

TYPE 980: ON/OFF TIME CALCULATOR

This component watches a control signal and calculates the current "on" and "off" times of the signal. After convergence, if the input control signal is greater than 0.5 then the "on time" output control signal is incremented by the timestep and the "off- time" signal is set to zero. If the input control signal is zero, the "on time" control signal is set to zero and the "off time" control signal is incremented by the timestep.

TYPE 1233: RUN TIME CONTROLLER

The on/off controller generates a control function which can have a value of 1 (on) or 0 (off). That will turn "on" when a temperatures falls below a user-specified setpoint temperature and stay on until the run-time period has been elapsed or until the temperature rises above the safety-limit temperature. The value of the control signal is chosen as a function of the temperature input and the temperature setpoint input. For safety considerations, a high/low limit cut-out is included with this controller. Regardless of the current conditions, the control function will be set to zero if the high limit condition is exceeded in heating mode or if the low limit condition has been tripped in cooling mode. We've also added a minimum run-time period and a minimum reset time period to better replicate controllers found in many HVAC and solar applications. We've also added a lockout input that sets the output control function to zero whenever this lockout signal is greater than 0.5. This feature can be used to disable the controller during certain times of the day, certain times of year, or during periods where a given criteria is met.

TYPE 1250: OUTSIDE AIR RESET CONTROL

This component creates two outputs; a temperature dependent setpoint and an on/off signal. The user provides the mode (heating or cooling) and two pairs of ambient/setpoint combinations. There are multiple (N) setpoint conditions available to control with this model.

TYPE 1502: N-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 a single or multiple stage heating source(s).

TYPE 1502_RH: N-STAGE HUMIDIFICATION

This component has simply been modified from the nominal Type 1502 heating aquastat to control a system having a single or multiple stage humidification.

TYPE 1503: N-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 a single or multiple stage cooling source(s).

TYPE 1503_RH: SINGLE STAGE DEHUMIDIFICATION

This component has simply been modified from the nominal Type 1503 cooling aquastat to control a system having a single or multiple stage dehumidification.

TYPE 1669: 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. This component was modified from Type669 in the previous version to now include maximum change rate.

THE ELECTRICAL COMPONENT LIBRARY

TYPE 551: PHOTOVOLTAIC ARRAY SHADING

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

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

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

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)

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)

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)

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)

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 726: PROPORTIONAL LIGHTING CONTROLLER

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

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 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

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 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.

TYPE 1236: EQUIPMENT OUTAGE

This component models a piece of equipment (utility grid, air conditioner, etc.) that becomes unavailable at planned and/or random intervals throughout a simulation. As parameters, it takes the number of random outages in a given year, the minimum and the maximum allowable outage length, a random number seed, the number of planned outages, and the start time and duration of each planned outage.

THE GROUND COUPLING COMPONENT LIBRARY

TYPE 653: 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.

TYPE 714: ASHRAE METHOD FOR CALCULATING SLAB HEAT TRANSFER

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.

TYPE 715: ASHRAE METHOD FOR CALCULATING BASEMENT HEAT TRANSFER

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).

TYPE 957: VERTICAL RECTANGULAR STORAGE TANK WRAPPER UNDER INSULATED SURFACE

This subroutine models the heat transfer to the soil for a buried, rectangular storage tank.

TYPE 993: RADIANT SLAB ON GRADE

This component models a series of fluid-filled, parallel, horizontal pipes buried in a radiant floor slab.

TYPE 1244: MULTIZONE BASEMENT MODEL (INTERFACES WITH TYPE56)

This routine models the heat transfer from a horizontal or vertical surfaces (typically, but not limited to a basement) to the surrounding soil. 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 model takes the heat transfer into/out of the building at the outside surface (QCOMO in TRNBUILD) for each zone, calculates the fully 3-D soil temperature profile, and then outputs the average underfloor surface temperature for each zone. Also provided, the Ground Temperature Viewer can display the soil node temperatures of the output file. 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 Type702 instead.

TYPE 1255: SLAB ON GRADE – MONOLITHIC POUR (INTERFACES WITH SIMPLE BUILDING)

This component models a multi-zone slab on grade situation where the slab is a "monolithic pour" slab without footings.   This model is intended to work with building models that can provide the zone temperature, convection coefficient, incident solar radiation on the surface, and effective long-wave temperature to the ground coupling model.

TYPE 1256: SLAB AND BASEMENT MODEL (INTERFACES WITH SIMPLE BUILDING

This subroutine models the heat transfer from a multi-zone building/slab/basement/crawlspace conditions (non-Type 56) that communicates thermally with the ground. The user must have created an external data file which maps the three dimensional air, soil, floor, wall, insulation, and footer materials. This subroutine is not intended for use with the Type 56 multi-zone building model in TRNSYS. This model is intended to work with building/zone models that can provide the energy balance terms for each surface (air temperature, long-wave radiation exchange temperature, incident radiation (lights, solar etc.)).

THE GEOTHERMAL HEAT PUMP COMPONENT LIBRARY

TYPE 557: 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.

TYPE 919: NORMALIZED WATER SOURCE HEAT PUMP

This component is intended to model a water source (geothermal) heat pump for which the heating and cooling performance can be read from a file of catalog performance data. It is assumed that the catalog data accounts for the additional heat input by the fan; both in the power reported and the impact and the net capacity. This version of the heat pump model takes normalized capacity and power as parameters.

TYPE 927: NORMALIZED WATER-TO-WATER HEAT PUMP

This component models a single-stage water-to-water heat pump. The heat pump conditions a liquid stream by rejecting energy to (cooling mode) or absorbing energy from (heating mode) a second liquid stream. This model is based on user-supplied data files containing catalog data for the normalized capacity and power draw, based on the entering load and source temperatures and the normalized source and load flow rates. Type927 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 951: BURIED TWIN-PIPE

This component models the two-pipes-in-a-sheath piping system common to the geothermal heat pump and district heating industries (EcoflexTM). In this model, two pipes are encapsulated by an insulating material and then surrounded by a cylindrical sheath. The model allows the user to specify whether the pipes are flowing in the same direction or opposite directions. Pipe-to-pipe interaction is considered. The cylindrical sheath (outer pipe) is surrounded by a fully 3-D radial conduction model of the ground that includes the impact of energy storage in the ground.

TYPE 952: BURIED SINGLE PIPE

This subroutine models a pipe buried beneath the ground surface. The buried pipe is surrounded by a 3-dimensional finite difference conduction network in order to calculate the heat build-up in the soil.

TYPE 997: MULTI-LEVEL HORIZONTAL GROUND HEAT EXCHANGER

This component models the heat transfer to/from the ground from a series of horizontal pipes buried in the earth. The pipes may be configured in any conceivable flow configuration including all in parallel, serpentine, double-serpentine, intertwined quadruple serpentine, etc. Insulation may be placed on the soil surface and also down the edges of the pipe system. Pipe-to-pipe interaction is considered. The pipes are surrounded by a fully 3-D rectangular conduction model of the ground that includes the impact of energy storage in the ground.

TYPE 1221: NORMALIZED 2-STAGE WATER-TO-WATER HEAT PUMP

This component models a two-stage water-to-water heat pump. The heat pump conditions a liquid stream by rejecting energy to (cooling mode) or absorbing energy from (heating mode) a second liquid stream. This model is based on user-supplied data files containing catalog data for the normalized capacity and power draw, based on the entering load and source temperatures and the normalized source and load flow rates. Type221 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 506: DIRECT EVAPORATIVE COOLER (SWAMP COOLER)

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)

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

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

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 511: DRY FLUID COOLER

This component models a dry fluid cooler; a device used to cool a liquid stream by blowing cool air across the coils. The user provides the performance at design conditions (easily found on the internet) and the model calculates the off-design performance.

TYPE 512: SENSIBLE HEAT EXCHANGER WITH HOT-SIDE MODULATION

Type512 models a constant effectiveness (minimum capacitance rate) heat exchanger that is able to control hot side fluid flow rate into the heat exchanger in order to maintain the cold-side outlet temperature above a user specified, time dependent set point. This component is designed to be used with a variable speed pump that is upstream from the heat exchanger.

TYPE 600: TWO-PIPE FAN COIL

This component models a 2-pipe fan coil model; delivering heating and cooling to an air stream from a source liquid stream. This component is used with a mass flow rate whereas the Type928 is used with a volumetric flow rate.

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

Type650 models a constant effectiveness / Cmin 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 / Cmin 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 / Cmin 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 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 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 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 684: AIR SIDE ECONOMIZER

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

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

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

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

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

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

Type699 models a constant effectiveness / Cmin 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

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 minimum turn-down ratio has been added for the latest version of 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 716: ROTARY DESICCANT DEHUMIDIFIER

This component models a rotary desiccant dehumidifier containing nominal silica gel whose performance is based on equations for F1-F2 potentials developed by Jurinak and Howe at the

University of Wisconsin. The model determines the regeneration temperature at ambient humidity ratio which will dehumidify process air to the user specified humidity ratio. The process stream and regeneration stream outlet conditions are determined as well.

TYPE 751: SIMPLE BOILER WITH EFFICIENCY FROM DATA FILE

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

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

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

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 757: INDIRECT EVAPORATIVE COOLER

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)

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.

TYPE 761: SENSIBLE HEAT EXCHANGER – TEMPERATURE DELTA

Type761 models a heat exchanger that is able to control cold side fluid flow rate into the heat exchanger in order to maintain the user-defined temperature difference of the cold side. This component is designed to be used with a variable speed pump that is upstream from the heat exchanger.

TYPE 909: HOT-WATER FIRED ABSORPTION CHILLER

Type909 is an absorption chiller component that relies on user-provided performance data files containing normalized capacity and COP ratios as a function of three temperatures: hot water inlet temperature, cooling water inlet temperature, and chilled water inlet temperature.

TYPE 917: AIR-TO-WATER HEAT PUMP

This component models a single-stage air source heat pump. The heat pump conditions a water stream by rejecting energy to (cooling mode) or absorbing energy from (heating mode) the air stream. 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. The air humidity effects are neglected in this model whereas in the Type941 air-to-water heat pump, the air humidity effects are included.

TYPE 918: DOUBLE MODE DEHUMIDIFIER

Type918 models a double-mode dehumidifier where the waste heat is either dumped back into the air stream or into a wastewater stream. The model relies on an external data file containing performance data at various entering air conditions.

TYPE 919: NORMALIZED 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 normalized capacity (both total and sensible in cooling mode), and normalized 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.

TYPE 921: AIR CONDITIONER (NORMALIZED)

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

TYPE 922: TW0-SPEED AIR-SOURCE HEAT PUMP (NORMALIZED)

Type922 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 utilizes normalized off-performance data so that the heat pump may be quickly resized without having to resort to finding new data files.

TYPE 923: TW0-SPEED AIR CONDITIONER (NORMALIZED)

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

TYPE 927: NORMALIZED WATER-TO-WATER HEAT PUMP

This component models a single-stage water-to-water heat pump. The heat pump conditions a liquid stream by rejecting energy to (cooling mode) or absorbing energy from (heating mode) a second liquid stream. This model is based on user-supplied data files containing catalog data for the normalized capacity and power draw, based on the entering load and source temperatures and the normalized source and load flow rates. Type927 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 928: TWO-PIPE FAN COIL (VOLUMETRIC FAN MODE)

This component models a 2-pipe fan coil model delivering heating and cooling to an air stream from a source liquid stream. This component uses a volumetric flow rate whereas the Type600 uses a volumetric flow rate.

TYPE 929: GAS HEATING COIL

Type929 represents an air heating device that can be controlled either externally, or set to automatically try and attain a set point temperature, much like Type6 does for fluids,. The heating coil is bound by a heating capacity and efficiency. The outlet state of the air is determined by an enthalpy based energy balance that takes pressure effects into account.

TYPE 930: ELECTRIC HEATING COIL

Type930 is similar to the previous gas heating coil, Type929, and it is also very similar to the simple heating device, Type6, in the TRNSYS standard component library as well. The outlet state of the air is determined by an enthalpy based energy balance that takes pressure effects into account.

TYPE 941: AIR-TO-WATER HEAT PUMP

This component models a single-stage air to water heat pump. The heat pump conditions a water stream by rejecting energy to (cooling mode) or absorbing energy from (heating mode) the air stream. This model is based on user-supplied data files containing catalog data for the capacity (for the water), and power, based on the entering water temperature to the heat pump and the entering air temperature to the heat pump. Type941 takes either air relative humidity or absolute humidity ratio as an input and considers the effects of air humidity.

TYPE 954: AIR-SOURCE HEAT PUMP/SPLIT SYSTEM HEAT PUMP

Type954 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 utilizes normalized off-performance data so that the heat pump may be quickly resized without having to resort to finding new data files.

TYPE 964: AIR-CONDITIONER – DOE2 APPROACH

This subroutine models an air-conditioner using curves provided by the DOE-2 program. This model was written for internal use only on the ORNL Building America project. This model was used to prove that the loads from DOE-2 can be imposed on a "lumped" building in **TRNSYS, CONTROLLED WITH THERMOStATs**, and then provides similar HVAC energy consumption.

TYPE 966: AIR-SOURCE HEAT PUMP – DOE2 APPROACH

Using the approach popularized by the DOE-2 simulation program, the performance of an electric air-source heat pump can be characterized by bi-quadratic curve fits. In this model, normalized multipliers for the total cooling capacity, the sensible cooling capacity, the cooling power, the total heating capacity, the heating power, and the coil bypass fraction are calculated based on the coil entering air conditions and the ambient temperature. The capacity is assumed to ramp up exponentially to its steady state value based on a user-specified time constant.

TYPE 967: GAS-FIRED FURNACE – DOE2 APPROACH

In this model, the performance of a forced-air furnace is characterized by a constant heat input ratio. The heating capacity is assumed to ramp up exponentially to its steady state value based on a user-specified time constant.

TYPE 987: 4-PIPE PERFORMANCE MAP FAN COIL

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

TYPE 995: PERFORMANCE MAP COOLING COIL

This component models a cooling coil where the performance of the coil is read from an external data file containing the normalized total and sensible cooling data as a function of the entering air dry bulb and wet bulb temperatures, the air flow rate, the liquid flow rate and the entering liquid temperature.

TYPE 996: 2 PIPE FAN COIL

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

TYPE 1221: NORMALIZED 2-STAGE WATER-TO-WATER HEAT PUMP

This component models a two-stage water-to-water heat pump. The heat pump conditions a liquid stream by rejecting energy to (cooling mode) or absorbing energy from (heating mode) a second liquid stream. This model is based on user-supplied data files containing catalog data for the normalized capacity and power draw, based on the entering load and source temperatures and the normalized source and load flow rates. Type221 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 1225: ROTARY DESICANT DEHUMIDIFIER

This subroutine models a rotary desiccant dehumidifier using a catalog data approach. The format of the data file was developed based on a freely available tool available for predicting the performance of a NovellAire rotary desiccant wheel. The data file has three independent variables: process air inlet temperature, process air inlet humidity, and regeneration air inlet humidity. The data file is developed for a particular combination of process and regeneration air stream flow rates and for a particular regeneration temperature. The process air and regeneration air flow rates as well as the regeneration air temperature are taken as inputs by the model so that when the wheel is OFF, the device can act as a pass through.

TYPE 1231: RADIATOR

Type1231 models low-temperature hydronic heat-distributing units such as radiators, convectors, and baseboard and finned-tube units. These type of units supply heat through a combination of radiation and convection without fans. This model is based on the information in the ASHRAE Handbook – HVAC Systems and Equipment [ASHRAE 2004].

TYPE 1246: AUXILIARY COOLER

Type1246 models an external, proportionally controlled fluid cooler. External proportional control (an input signal between 0 and 1) is in effect as long as a lower limit fluid set point temperature is not exceeded. If the lower limit is encountered, the proportional control is internally modified to limit the fluid outlet temperature to the set point.

TYPE 1247: WATER-TO-AIR HEAT PUMP SECTION FOR AN AIR HANDLER

This component models a single-stage liquid source heat pump. The heat pump conditions a moist air stream by rejecting energy to (cooling mode) or absorbing energy from (heating mode) a liquid stream. This model is based on user-supplied data files containing catalog data for the normalized capacity (both total and sensible in cooling mode), and normalized 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.

TYPE 1248: AIR-TO-AIR HEAT PUMP SECTION FOR AN AIR HANDLER

Type1248 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 utilizes normalized off-performance data so that the heat pump may be quickly resized without having to resort to finding new data files.

TYPE 1716: ROTARY DESICANT DEHUMIDIFIER

This component models a rotary desiccant dehumidifier containing nominal silica gel and whose performance is based on equations for F1-F2 potentials developed by Jurinak. The model calculates the outlet conditions of a process stream and a regeneration stream based on known process and inlet temperature and either relative humidity or humidity ratio.

THE HYDRONICS COMPONENT LIBRARY

TYPE 604: BI-DIRECTIONAL, NODED PIPE WITH WALL & INSULATION MASS

Unlike the standard Type 31 pipe model in TRNSYS, this component considers the impact of the pipe mass, and insulation mass. The model calculates the heat loss coefficient based on the fluid properties, the pipe properties, the insulation properties, and convection (forced and natural) and radiation from the outer surface to the environment. The model assumes that the pipe can be characterized by a series of inter-connected, fully-mixed, fluid nodes (mimics plug-flow when the number of nodes is high). Unlike any other pipe model that we know of in TRNSYS, this model allows you to flow fluid through either direction in the pipe (just not both directions in the same time step).

TYPE 607: AIR DUCT

This component allows the user to estimate the heat losses/gains by an air stream as it moves through a duct (circular or non-circular ducts can be modeled). The model assumes that the duct can be characterized by a series of inter-connected, fully-mixed, air nodes. Pressure drop effects are not calculated. The duct may be insulated and both forced convection and free convection (natural convection) effects are considered.

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 flow. The limit of 100 inlet flows can be modified in the Fortran source code. The outlet flow rate is simply the sum of the inlet flow rates. The outlet temperature is calculated from a mass and energy balance on the air streams. This component checks to make sure that the sum of the inlet fractions is 1.0. If not, the last fraction is calculated from a mass balance and not from the specified fraction.

TYPE 654: CONSTANT SPEED PUMP

Type654, donated as 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 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

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)

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.

TYPE 740: CONSTANT SPEED PUMP, CONTROL SIGNAL INPUT, POWER CALCULATED FROM PRESSURE DROP AND PUMP EFFICIENCY

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

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

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

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

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

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

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

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

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

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

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.

TYPE 924: TWO SPEED FAN – VOLUMETRIC VERSION

Type924 models a fan that is able to spin at one of two speeds, thereby maintaining one of two constant volumetric flow rates of air. As with most pumps and fans in TRNSYS, Type924 takes mass flow rate as an input but ignores the value except in order to perform mass balance checks. Type924 sets the downstream flow rate based on its rated flow rate parameters and the current value of its control signal inputs.

TYPE 925: SINGLE SPEED FAN – VOLUMETRIC VERSION

Type925 models a fan that is able to spin at a single speed and thereby maintain a constant volumetric flow rate of air. As with most pumps and fans in TRNSYS, Type925 takes mass flow rate as an input but ignores the value except in order to perform mass balance checks. Type925 sets the downstream flow rate based on its rated flow rate parameter and the current value of its control signal input.

TYPE 926: VARIABLE SPEED FAN – VOLUMETRIC VERSION

Type926 models a fan that is able to turn at any speed between 0 (full stop) and its rated speed. While the volumetric flow rate of air moved by the fan is linearly related to the control signal, the power drawn by the fan at a given flow rate can be any polynomial expression of the control signal. As with most pumps and fans in TRNSYS, Type926 takes mass flow rate as an input but ignores the value except to perform mass balance checks. Type926 sets the downstream flow rate based on its rated flow rate parameters and the current value of its control signal inputs.

TYPE 976: TWO SPEED PUMP – MASS FLOW RATE VERSION

Type976 models a two (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, Type976 takes mass flow rate as an input but ignores the value except in order to perform mass balance checks. Type976 sets the downstream flow rate based on its rated flow rate parameters and the current value of its control signal inputs.

TYPE 977: VARIABLE SPEED PUMP – VOLUMETRIC VERSION

Type977 models a variable speed pump that is able to maintain any outlet volumetric flow rate between zero and a rated value. The volumetric 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, Type977 takes mass flow rate as an input but ignores the value except in order to perform mass balance checks. Type977 sets the downstream flow rate based on its rated volumetric flow rate parameter and the current value of its control signal input.

TYPE 978: TWO SPEED FAN – VOLUMETRIC VERSION

Type978 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, Type978 takes mass flow rate as an input but ignores the value except in order to perform mass balance checks. Type978 sets the downstream flow rate based on its rated flow rate parameter and the current value of its control signal input. This model varies from its predecessor (Type 656) in that it includes a diverting valve upstream of the pump.

THE LOADS & STRUCTURES COMPONENT LIBRARY

Library of Building Templates

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.

TYPE 56 Window Library

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 660: 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.

TYPE 682: 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.

TYPE 686: SYNTHETIC BUILDING LOADS GENERATOR

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.

TYPE 687: NATIONAL FENESTRATION RATING COUNCIL (NFRC) WINDOW

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. Namely, the U Value, Solar Heat Gain Coefficient (SHGC) and the transmittance to visible light.

TYPE 690: ENERGY RATE LOADS CONVERSION

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.

TYPE 693: LOAD IMPOSED ON AN AIR 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. 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.

TYPE 759: LUMPED CAPACITANCE MULTIZONE BUILDING WITH NO CONTROLS

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.

TYPE 912: OPEN WINDOW MODEL

This component models the opening and closing of windows in a residence by the occupants. Windows may be opened by the occupant based upon a probability of the window being opened provided:

1. the ambient temperature (and possibly enthalpy) are less than the current zone conditions
2. the zone temperature is above some minimum temperature
3. the window is not currently "locked-out" (a user input signal)
4. mechanical ventilation is not being supplied to the zone
5. the window has not been closed in the last DT hours (DT is a user provided value)

Once opened, the window remains open unless one of the first four conditions listed above occurs.

TYPE 936: REFRIGERATOR MODEL

This subroutine models a refrigerator as a lumped capacitance system. The model also references an external data file for the performance of the device as a function of the zone and evaporator temperature.

TYPE 963: LUMP MODEL

This component models a lump of mass which can be characterized by a single differential equation relating the temperature of the mass to time, heat transfer to the environment through the skin of the mass. Capacitance effects are included.

TYPE 1227: STACK EFFECT

This subroutine calculates the air flow through an opening due to stack effect (inside/ outside temperature difference. It is based on ASHRAE Fundamentals 2005.

TYPE 2280: LATENT LOAD CALCULATOR

This subroutine calculates the latent cooling and associated moisture removal rate for a particular sensible cooling rate given the zone and ambient conditions and assuming that cooling is being done by rejecting energy to ambient using something like a cooling coil and condenser. The correlations for latent cooling come from DOE2.1 curves.

The Optimization Component Library

TYPE 758: 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.

THE SOLAR COMPONENT LIBRARY

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 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 (TIN)

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. The component now has the capability to operate at a user specified outlet temperature (the component passes a control signal to a variable speed pump).

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 546: BEAM/DIFFUSE SPLIT CALCULATOR

This routine determines the split of beam and diffuse radiation on a surface from knowledge of only the total radiation on a tilted surface.

TYPE 550: TUBULAR INTEGRAL COLLECTOR STORAGE (ICS) SYSTEM

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)

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

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

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)

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: SERPENTINE TUBE SOLAR COLLECTOR MODEL

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.

TYPE 942: THEORETICAL FLAT PLATE SOLAR COLLECTOR MODEL – 1 COVER

The thermal model of this collector relies on algorithms presented in Chapter 6 of the classic "Solar Engineering of Thermal Processes" textbook by Duffie and Beckman.

TYPE 944: THEORETICAL FLAT PLATE SOLAR COLLECTOR MODEL – 2 COVER

The thermal model of this collector relies on algorithms presented in Chapter 6 of the classic "Solar Engineering of Thermal Processes" textbook by Duffie and Beckman.

TYPE 1245: XCPC COLLECTOR MODEL

This subroutine models an XCPC concentrating solar collector where the collector efficiency and off-normal performance are modeled with curve-fits found from collector tests. An XCPC collector has an external reflective concentrator located behind an evacuated tube which houses the absorber and heat transfer fluid. This routine is based on the original Type 539 source code from TESS.

TYPE 1252: BEAM SHADING CALCULATOR

This model calculates whether the beam radiation that would have struck a surface is blocked by an object located near the surface. The user provides the starting and ending angle for the obstruction as well as the distance to the object and the height of the object relative to the surface. The user may also enter the angle of the obstruction by setting the distance to zero or less.

TYPE 1262: CONCENTRATING COLLECTOR SHADING

This subroutine models the shading of parabolic trough collectors that are arranged in consecutive rows. The work is based on the work of Stuetzle (2002) and assumes that the collectors are oriented with a North-South axis (collectors track east to west during the day) and are on flat ground.

TYPE 1288: CONCENTRATING COLLECTOR

This subroutine models a concentrating solar collector where the collector efficiency and off-normal performance are provided from the OG100 specification sheet for concentrating collectors. In this version, the incidence angle modifiers are to be provided in a look-up table as a function of the longitudinal and transverse angles. The OG100 efficiency equation for concentrators is based on the EN12975-2-2006 standard using the dynamic efficiency equation approach.

TYPE 1289: GLAZED FLAT PLATE COLLECTOR – DYNAMIC EFFICIENCY

This subroutine models a flat plate solar collect using the EN12975-2 dynamic efficiency approach (1D IAMs).

TYPE 1290: GLAZED FLAT PLATE COLLECTOR – IAMS FROM ASHRAE

This subroutine models a flat plate solar collect using the EN12975-2 dynamic efficiency approach (ASHRAE IAMs).

The Storage Component Library

TYPE 531: RECTANGULAR STORAGE TANK WITH OPTIONAL IMMERSED HEAT EXCHANGERS

This subroutine models a fluid-filled, constant volume storage tank with immersed heat exchangers. This component models a storage tank with a flat bottom and a constant perimeter with height. 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 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

This subroutine models a fluid-filled, constant volume storage tank with immersed heat exchangers. This component models a spherical tank. 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 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

This subroutine models a fluid-filled, constant volume storage tank with immersed heat exchangers. This component models a cylindrical tank with a horizontal configuration. 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 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

All of the TESS tank components, Type531, 532, 533, and 544 have different physical geometry, yet the subroutines have very similar physics. These subroutines model a fluid-filled, constant volume storage tanks with immersed heat exchangers. 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 938: HEAT PUMP WATER HEATER

A heat pump water heats an entering liquid stream by removing energy from an air stream passing across the evaporator coil of the device. In this model, the performance of the device is read from normalized external data files as a function of the entering liquid temperature, entering air temperature and entering air relative humidity. The model calculates all of the component energy flows (evaporator, condenser, compressor, blower) in the device and reports them each time step.

TYPE 940: TANKLESS WATER HEATER (ZIP HEATER)

This component models a gas (natural gas, propane, even electric by setting the efficiency to1.) tankless water heater. In simple terms it is an auxiliary heater with internal controls to modulate the heat input to the fluid.

TYPE 1226: HEATING DEVICE FOR STORAGE TANKS

This subroutine models an energy input device for water heaters. The energy to the fluid is the product of the first three inputs (capacity, efficiency and control signal). The consumed energy is the product of the capacity and the control signal. This component can easily be implemented with the aquastat components and the storage tank components.

TYPE 1237: VERTICAL CYLINDRICAL STORAGE TANK WITH WRAP-AROUND HEAT EXCHANGER AND DIP TUBE

This subroutine models a vertical cylindrical storage tank with a wrap-around heat exchanger. The model was written by Jeff Thornton of TESS in summer 2009 based on earlier work with Oak Ridge National Laboratory on a heat pump water heater with a wrap-around refrigerant condenser. The model also adds a diptube inlet possibility.

TYPE 1502: N-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 a single or multiple stage heating source(s).

TYPE 1503: N-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 a single or multiple stage cooling source(s).

TYPE 2270: MASTER-SLAVE HEATING DEVICE FOR STORAGE TANKS

This subroutine models an energy input device(s) for water heaters. When in operation mode 1, the dual element system operates as the master-slave where the lower element (slave) has the ability to be activated only when the upper element (master) is off and has the appropriate control signal(from an aquastat controller such as Type1502).

In mode 0 there is no master-slave operation, and both elements can function simultaneously based on their control signal(s) from the aquastat.

The energy to the fluid is the product of the inputs (capacity, efficiency and control signal). The consumed energy is the product of the capacity and the control signal.

THE UTILITY COMPONENT LIBRARY

TYPE 535: TRIGGERED PRINTER

The triggered event printer component is used to output (or "print") selected system variable not at specified intervals of time but whenever the value of the first input is set to a number greater than or equal to 1.

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 581: MULTI DIMENSIONAL DATA INTERPOLATION

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.

This subroutine returns between 1 and 5 dependent variables whose values depend on between 1 and 4 dependent variables. It can be used to model the performance of any equipment or as direct access to a 4 dimensional data file to interpolate in up to 4 dimensions. The format of the data file should conform to the standard for files read by the data or dynamic data routines.

TYPE 582: LIFE CYCLE COST ANALYSIS

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

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.

TYPE 586: PIPING NETWORK PRESSURE DROP CALCULATOR

This subroutine calculated the pressure drop through a piping network.

TYPE 932: SHERMAN GRIMSRUD INFILTRATION MODEL

This component contains the Sherman-Grimsrud infiltration model as described in the ASHRAE Handbook of Fundamentals, 2005. The model bases infiltration effects on an effective leakage area, indoor/outdoor temperature difference, and wind speed. The model is semi empirical, requiring that the user enter a stack coefficient (Cs) and a wind coefficient (Cw). While the ASHRAE Handbook gives these values as functions of a factor that it calls shelter class and the height of the building (in stories), this model takes the factors directly so that the user may, if desired, interpolate and extrapolate the ASHRAE tables.

TYPE 939: RUNNING AVERAGE CALCULATOR

This component calculates the running totals (integrated) and running averages over a running user-specified time range. For example, this program could calculate the average temperature over the last 24 hours or the water heater gas consumption over the last 4 hours.

TYPE 960: LBNL INFILTRATION MODEL

This component contains the Sherman-Grimsrud infiltration model as described in the ASHRAE Handbook of Fundamentals, 2005. The model bases infiltration effects on an effective leakage area, indoor/outdoor temperature difference, and wind speed. The model is semi empirical, requiring that the user enter a stack coefficient (Cs) and a wind coefficient (Cw). While the ASHRAE Handbook gives these values as functions of a factor that it calls shelter class and the height of the building (in stories), this model takes the factors directly so that the user may, if desired, interpolate and extrapolate the ASHRAE tables.

TYPE 980: ON/OFF TIME CALCULATOR

This component watches a control signal and calculates the current "on" and "off" times of the signal. After convergence, if the input control signal is greater than 0.5 then the "on time" output control signal is incremented by the timestep and the "off- time" signal is set to zero. If the input control signal is zero, the "on time" control signal is set to zero and the "off time" control signal is incremented by the timestep.

TYPE 1232: CONVECTION CALCULATOR

This component will calculate the convection coefficient from a flat surface (plate) to the ambient air using a series of correlations.

TYPE 1236: EQUIPMENT OUTAGE

This component models a piece of equipment (utility grid, air conditioner, etc.) that becomes unavailable at planned and/or random intervals throughout a simulation. As parameters, it takes the number of random outages in a given year, the minimum and the maximum allowable outage length, a random number seed, the number of planned outages, and the start time and duration of each planned outage.

TYPE 1238: SIMULATION EVENT ALERT

At TESS, we often find ourselves working on one TRNSYS project while another one is running in the background. More often than we would care to remember, we switch to the background TRNSYS only to find that it got an error and stopped, that it completed quite some time ago, or that some event occurred during the simulation that we wanted to know about (a temperature went too high, a controller tripped, a mass balance on a pump failed, etc.). This component was written as a flexible method for alerting us to such situations. Type222 takes a series of logical unit numbers as parameters and an equal number of inputs. Type222 also takes one additional "tolerance" parameter. Each logical unit is assigned to a *.wav file. Whenever the input that corresponds to a given *.wav file changes by a value greater than the tolerance parameter, the *.wav file is played.

NOTE: because of the TRNSYS Studio structure, Logical Unit numbers ASSIGNed to external files cannot by cycled the way PARAMETERS and INPUTS can. While the underlying source code of this component allows anywhere from 1 to 10 different alerts, proformas for only 1 and 5 alerts have been created. It should also be noted that the code can be expanded to accept more than 10 alerts.

TYPE 1243: WATER DRAW PROFILES AS PARAMETERS

This component takes the daily total, 24 hourly fractions from the normalized data of ASHRAE 90.2 and 24 maximum rates and creates a profile for timesteps less than an hour. For example, if a household used 6.3 gallons of hot water between midnight and 1 am, at a flow rate of 1 gallon per minute, this component would output the following flow rates:

Minute 1 = 1 gpm
Minute 2 = 1 gpm
Minute 3 = 1 gpm

Minute 4 = 1 gpm
Minute 5 = 1 gpm
Minute 6 = 1 gpm
Minute 7 = 0.3 gpm
Minute 8:60 = 0 gpm

If the user specifies a flow rate less than that required to meet the hourly total, the model will report a total that is less than that specified for the hour. For example if the hourly total is 70 gallons and the maximum flow rate is 1 gallon per minute, then 10 gallons of water will be "missed" as the model will only output 60 gallons for that hour (1 gpm * 60 minutes/hour).
The user should enter the "rate" parameters in units of the daily total variable per hour. For example if gallons are specified for the total then gallons per hour should be used for the rate parameters.

TYPE 1251: WATER DRAW PROFILES FROM DATA FILE

This component takes the daily total, 24 hourly fractions and maximum hourly rate and creates a profile for timesteps less than an hour. The 24 hourly fractions (normalized) are read from an external data file - usually created by the TESS application program "sched.exe" or "sched-norm.exe" that is associated with Type 517.
As an example, if a household used 6.3 gallons of hot water between midnight and 1 am, at a maximum flow rate of 1 gallon per minute, (and with a timestep of 1 minute) this component would output the following flow rates:

Minute 1 = 1 gpm
Minute 2 = 1 gpm
Minute 3 = 1 gpm
Minute 4 = 1 gpm
Minute 5 = 1 gpm
Minute 6 = 1 gpm
Minute 7 = 0.3 gpm
Minutes 8:60 = 0 gpm

If the user specifies a flow rate less than that required to meet the hourly total, the model will meet the specified total using the entire hour and surpassing the maximum rate supplied. For example if the hourly total is 72 gallons and the maximum flow rate is 1 gallon per minute, then 12 gallons of water would have been "missed" so the model outputs a rate of 1.2 gallons per minute.
The user should enter the "rate" parameters in units of the daily total variable per hour. For example if gallons are specified for the total then gallons per hour should be used for the rate parameters.

TYPE 1252: BEAM SHADING CALCULATOR

This model calculates whether the beam radiation that would have struck a surface is blocked by an object located near the surface. The user provides the starting and ending angle for the obstruction as well as the distance to the object and the height of the object relative to the surface. The user may also enter the angle of the obstruction by setting the distance to zero or less.

TYPE 1576: TWO DIMENSIONAL BIN SORTER - INTEGRATED

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, integrating the values; producing a 2-D grid upon completion. The outputs from this model are written to a user-specified file.

TYPE 2260: WIND SPEED CONVERTER

This subroutine takes wind speed measured at one site (described by a measurement height and wind velocity profile exponent (terrain roughness) and converts it to wind speed at a different height (presumably a building height) and wind velocity profile exponent.

THE COGENERATION/COMBINED HEAT & POWER (CHP) COMPONENT LIBRARY

TYPE 506: EVAPORATIVE COOLER (SWAMP COOLER)

This routine models an evaporative cooling device which cools an inlet air stream by passing the air through or across a wetted surface; evaporating the water from the surface and cooling the air stream in the process. The ideal exiting air state for an evaporative cooler is if the air exits with a dry-bulb temperature equal to its inlet wet-bulb temperature. The model takes the saturation efficiency of the device as an input in order to calculate the air outlet conditions. The saturation efficiency is defined as: Saturation Efficiency = (Tair,db,in - Tair,db,out) / (Tair,db,in - Tair,wb,in) where in refers to the inlet condition, out refers to the air outlet condition, db refers to the air dry-bulb temperature and wb refers to the air wet bulb temperature.

The power output is simply the parasitic power if the machine is operating. The machine is assumed to be off (inlet conditions = outlet conditions) if the control signal is less than 0.5 or if the inlet air flow rate is zero.

TYPE 507: FOGGING DEVICE

This routine models an evaporative cooling device which cools an inlet air stream by injecting tiny droplets of water into the air stream - causing the water to evaporate and removing sensible energy from the flow stream. The user must supply the inlet air conditions, and the desired relative humidity for the outlet air stream. The model then iterates on outlet dry bulb temperature until the desired outlet relative humidity is met given the wet bulb temperature. This model is similar to the Type 506 evaporative cooler but includes internal controls to keep the outlet air at the user-defined relative humidity set-point. The power used by the machine is the parasitic power (Parameter 1) whenever the machine is operating and zero otherwise.

TYPE 508: COOLING COIL (VARIOUS CONTROL MODES)

This component models a simple cooling coil where the air is cooled as it passes across a coil containing a cooler fluid (typically water). This model uses the bypass fraction approach for cooling coils to solve for the outlet air and water conditions. The bypass factor approach assumes that a portion of the air stream comes to temperature equilibrium with the average coil water temperature and the other portion of the air stream (the bypass fraction) is completely unaffected by the coil in the air stream. These two flows then mix to produce the outlet air condition. The device also contains controls that bypass a fraction of the fluid stream past the coil to maintain a desired outlet condition (air or fluid). This coil may operate in 1 of 5 control modes:

0 - The coil operates in a free-floating condition where the air and water temperatures aren't controlled.
1 - The outlet air temperature is controlled to be at or above a user-specified temperature
2 - The outlet air relative humidity is controlled to be at or below a user-specified percent RH
3 - The outlet air humidity ratio is controlled to be at or above a user-specified minimum

4 - The outlet water temperature is controlled to be at or below a user-specified maximum temperature

The device is assumed to be off if either the air flow rate or fluid flow rate is zero. The fluid stream is assumed to bypass the coil completely if the inlet air temperature is at or below the coil inlet fluid temperature. The air is also assumed to completely bypass the coil if; in mode 1 if the inlet air temperature is already at or below the desired air outlet temperature, if in mode 2 the inlet air relative humidity is already at or above the desired air outlet relative humidity, if in mode 3 the inlet air humidity ratio is already at or below the desired air outlet humidity ratio, or if in mode 4 the inlet fluid temperature is already at or above the desired fluid outlet temperature.

This model relies on an iterative approach to solve for the fluid and air outlet conditions. If the results appear “spiky” or unreasonably slow, the user may want to adjust the convergence criteria within the source code.

TYPE 591: LOAD FOLLOWING STEAM TURBINE

This model simulates a steam turbine that meets a user-specified electrical load by varying the mass flow rate of steam entering the turbine. As the model calculates the required steam flow at turbine inlet, the INPUT steam flow rate to the model is not used except as a mass balance check upon convergence at each time step. This model relies on an isentropic efficiency approach to calculate the performance of the steam turbine given the steam inlet conditions and the turbine back-pressure. Users are able to specify up to 5 injection and 5 extraction ports along the length of the turbine. The steam conditions at these ports may be provided in any order to the model - the type will arrange them correctly based on the pressure of the streams. The turbine will automatically place the injection and extraction streams at the correct locations along the turbine to match the pressures of the streams with the local pressure of the turbine. The delivered output power from the turbine is limited by the capacity of the turbine (Parameter 1). Specifying a required power (Input 6) greater than the capacity of the machine will cause the machine to operate at its rated capacity and report the load not met (Output 6).

TYPE 592: FLOW FOLLOWING STEAM TURBINE

This model simulates a steam turbine; relying on an isentropic efficiency approach to calculate the performance of the steam turbine given the steam inlet conditions and the turbine back-pressure. Users are able to specify up to 5 injection and 5 extraction ports along the length of the turbine. The steam conditions at these ports may be provided in any order to the model - the type will arrange them correctly based on the pressure of the streams. The turbine will automatically place the injection and extraction streams at the correct locations along the turbine to match the pressures of the streams with the local pressure of the turbine. If the delivered output power calculated by the turbine model is greater than the capacity of the turbine (Parameter 1), a warning will be issued but the power will not be limited.

TYPE 593: STEAM CONDENSER – KNOWN CONDENSING PRESSURE

This component models a condenser for steam applications where the condensing pressure is known and provided to the model as an input. This model calculates the resultant heat transfer and outlet steam conditions given the desired degrees of subcooling leaving the condenser (provided by the user). The outlet steam pressure is set to the condensing pressure even when the flow rate is zero to avoid convergence problems in components that rely on this model to set the back-pressure for the steam flow loop.

TYPE 594: STEAM DIVERTING VALVE

This component models a simple steam diverting valve which can have up to 100 separate outlet ports. The outlet steam properties at each port are set identical to the inlet steam properties. The outlet flow rate at each port is simply the inlet flow rate multiplied by the user-designated fraction of flow to that port. This component checks to make sure that the sum of the outlet fractions is 1.0. If not, the last fraction is calculated from a mass balance and not from the specified fraction. This device is assumed to be perfectly insulated.

TYPE 595: STEAM MIXING VALVE

This component models a simple steam mixing valve which can have up to 100 separate inlet ports. The outlet fluid properties are set by an overall energy balance on the inlet flow streams - assuming that each of the inlet streams adiabatically expands to the pressure of the lowest pressure inlet fluid (ports with flow only). The outlet flow rate is simply the sum of the inlet flow rates.

TYPE 596: PRESSURE REDUCING VALVE

This component models a steam pressure-reducing valve. The steam entering this valve adiabatically expands to the provided outlet pressure. If the desired outlet pressure is above the inlet steam pressure the steam passes through the device without a change in state.

TYPE 597: CONDENSATE PUMP (SETS THE FLOW RATE)

This component models a steam condensate pump. The user specifies the inlet steam condensate conditions and the desired outlet pressure and the model calculates the theoretical power from a compressed liquid calculation (specific volume times pressure differential). The actual power is found by dividing the theoretical power by the pump efficiency. A user-supplied fraction of the actual pump power is assumed to be lost from the pump shell to the surroundings while the remaining energy ends up as an energy gain to the fluid. This model sets the flow rate for the steam loop by multiplying the rated pump flow rate (Parameter 2) by the input control signal (Input 6). The input flow rate to this model is used only for convergence checking.

TYPE 598: STEAM CONDENSER

This component models a steam condenser. The component relies on the pinch-point temperature difference approach to solve for the heat transfer between the condensing steam and the cooling fluid. In this model, the saturation pressure of the steam is calculated such that the pinch-point temperature is just reached at the critical point in the condenser. For parallel flow applications, the pinch-point occurs at the outlet of the steam (and therefore at the outlet of the cooling fluid). For counter-flow applications, the pinch-point can occur at one of four locations; the steam inlet (and cooling fluid outlet), the steam saturated vapor point, the steam saturated liquid point, and the steam outlet (cooling fluid inlet). The model also allows the user to specify a minimum condensing pressure so that the system does not float too low with low cooling fluid temperatures. This routine is typically used to set the back-pressure for the rest of the steam components in the loop. As this component sets the low-side pressure in many applications, the condensing pressure is calculated even when there is no flow of cold-fluid through the condenser to avoid zero-pressure convergence problems. In this case, the saturation pressure is calculated assuming the steam saturation temperature is the cooling fluid inlet temperature plus the pinch-point temperature difference.

TYPE 599: ELECTRICAL GENERATOR

This component models an electrical generator; a device that creates electrical power from a spinning input shaft. The model takes the generation capacity (Parameter 1) and the input shaft power (Input 1) and calculates the part-load ratio of the device. With the part-load ratio known, the efficiency in converting shaft power to electrical power is read from a user-supplied catalog data file and the output power and thermal losses are then calculated. The user-supplied data file must contain the generation efficiency as a function of the part-load ratio on the device. A sample data file is included for reference.

TYPE 602: GEAR BOX (EFFICIENCY FROM DATA FILE)

This component models a mechanical gear box. The user provides the rated rotational speed, the input rotational speed and the input power and the model calculates the efficiency of the gear box by interpolating from a user-supplied data file of gearbox efficiency as a function of the fraction of the rated speed. With the efficiency found, the output power and thermal losses can be found. The outlet rotational speed is found by dividing the inlet rotational speed by the gear ratio. The user-supplied data file must contain the gear box efficiency as a function of the fraction of rated speed for the device. A sample data file is included for reference.

TYPE 603: CONSTANT EFFICIENCY GEAR BOX

This component models a mechanical gear box. The user provides the input power and the gearbox efficiency. With the efficiency, the output power and thermal losses can be found. The outlet rotational speed is found by dividing the inlet rotational speed by the gear ratio.

TYPE 605: IMPOSED LOAD ON A STEAM FLOW

This component models a simple heating load imposed on a flow of steam. The user must specify the inlet steam conditions, the load to be imposed, and the outlet steam pressure. The model will remove the specified amount of energy from the steam flow - checking to make sure that the outlet steam temperature is above the minimum user-specified temperature (for pinch-point calculations etc.). If the calculated outlet temperature falls below the user-specified minimum temperature, the steam exits at the user-specified minimum temperature and the load-met and load-not-met are calculated by the model. This component is commonly used to model a steam load device where the physics of the device are not important to the simulation and only the removal of the correct amount of energy from the system is important.

TYPE 606: LOAD REMOVAL FROM A STEAM FLOW (WITH CONDENSATE)

This component models a simple steam end-use device. The user must specify the inlet steam conditions, the outlet steam conditions, and the fraction of steam flow (usually condensate) that will be returned by the system. This component is useful for modeling a complicated device like a steam absorption chiller or a detailed building steam heating and distribution system without having to model the physics of the detailed heat transfer in the device. The model calculates the amount of useful energy consumed by the load, the amount of energy that is dumped to the environment by the failure to return a fraction of the steam (usually condensate), and the total energy removal from the steam flow (sum of useful energy and dumped energy).

TYPE 608: CONDENSATE PREHEATER – PINCHPOINT METHOD

This component models a pre-heater for steam condensate using the pinch-point temperature difference approach. In typical applications, waste heat is used to elevate the temperature of a condensate stream before it enters the heat recovery steam generator. In this model, the inlet hot-side fluid attempts to heat a flow of steam condensate to a user-specified temperature just below the condensate saturation temperature. The model may operate in one of two heat exchanger configuration modes; parallel flow or counter flow. The pinch-point represents the location in the heat exchanger where the two fluids are closest in temperature. The location of the pinch-point depends on the flow rates of the hot and cold streams and the configuration of the heat exchanger. The model will attempt to elevate the steam condensate to the user-specified condition; checking the pinch-point at several critical locations in the device. If a pinch-point problem is encountered, the outlet condensate conditions are re-calculated to alleviate the problem and the outlet condensate leaves the heat exchanger cooler than desired. The device is assumed to be off if either of the flow rates is zero, if the inlet hot-side fluid temperature is below the inlet condensate temperature, or if the inlet condensate temperature is already above the desired condensate outlet temperature.

TYPE 609: CONDENSATE PREHEATER – EFFECTIVENESS APPROACH

This component models a pre-heater for steam condensate using the heat exchanger effectiveness approach. The effectiveness is a measure of the heat transfer at the inlet fluid conditions to the maximum possible heat transfer given the fluid inlet conditions. Refer to the documentation for Type 5 in Volume 1 of the TRNSYS documentation set for more information of the effectiveness concept. In typical applications, waste heat is used to elevate the temperature of a condensate stream before it enters the heat recovery steam generator. In this model, the inlet hot-side fluid attempts to heat a flow of steam condensate to a user-specified temperature just below the condensate saturation temperature. The device is assumed to be off if either of the flow rates is zero, if the inlet hot-side fluid temperature is below the inlet condensate temperature, or if the inlet condensate temperature is already above the desired condensate outlet temperature.

TYPE 610: STEAM DESUPERHEATER

This component models a steam desuperheater using the pinch-point temperature difference approach. In typical applications, a low-temperature fluid (usually water) is used to desuperheat a steam flow before entering a steam load device. In this model, the inlet cold-side fluid attempts to cool a flow of steam to just above the steam saturation temperature. The model may operate in one of two heat exchanger configuration modes; parallel flow or counter flow. The pinch-point represents the location in the heat exchanger where the two fluids are closest in temperature. The location of the pinch-point depends on the flow rates of the hot and cold streams and the configuration of the heat exchanger. The model will attempt to lower the steam temperature to the user-specified condition; checking the pinch-point at several critical locations in the device. If a pinch-point problem is encountered, the outlet steam conditions are re-calculated to alleviate the problem and the outlet steam flow leaves the heat exchanger warmer than desired. The device is assumed to be off if either of the flow rates is zero, if the inlet cold-side fluid temperature is above the inlet steam temperature, or if the inlet steam temperature is already below the desired steam outlet temperature.

TYPE 611: FLASH TANK

This component models a steam flash tank; a device used to make higher quality saturated steam or superheated steam from lower quality or condensed steam by expanding the steam into a low-pressure vessel. The steam entering this device instantaneously expands from the higher inlet pressure to the user-specified lower outlet pressure. The steam in the vessel than loses energy to the surroundings (environment) as it flows through the device before exiting. This component operates with a steady-state steady-flow assumption; the capacitance of the device and the steam are not accounted for in the model. The device has two outlet streams, one for steam condensate (liquid) and one for steam vapor.

TYPE 612: STEAM TRAP OR SINGLE INLET STEAM SEPARATOR

This component models a steam trap or single-port steam separator; a device used for removing any liquid in a steam flow from the system. The device has two outlet streams; one for liquid that is drained from the system, and one for the remaining vapor. The device is assumed to be perfectly insulated.

TYPE 613: STEAM PIPE

This component models a steam pipe where the steam loses heat and pressure as it travels along the pipe. The user must break this pipe up into N segments (from 1 to 50). The greater the number of segments, the more accurate the thermal loss calculations but the slower the simulation. This pipe model is unlike the standard TRNSYS Type 31 pipe model that operates in plug flow fashion. Rather this pipe operates under the steady-state steady-flow approach and the assumption that is made is that the outlet fluid state at this time-step is simply the result of the inlet fluid state flowing along this pipe at this time step with no residue (no mass left over) from previous time steps. There is no heat transfer between nodes along the length of the pipe and each node is assumed to be isothermal. This pipe is intended to model the physics of heat transfer in a pipe and should not be used for capacitance purposes like other pipe models in TRNSYS.

TYPE 614: TWO- INLET STEAM SEPARATOR

This component models a two-port steam separator; a device used for separating the liquid steam from the steam vapor after two steam flows have been mixed together. The device is assumed to be perfectly insulated such that an adiabatic mixing of the two fluids occurs. The higher pressure steam instantaneously and adiabatically expands to the outlet pressure; provided that the lower pressure steam port has a non-zero flow rate. The two fluids are then mixed together and the resultant steam state found. Any liquid from the mixed steam condition is drained via the liquid outlet port while any steam vapor exits the device from the vapor outlet port.

TYPE 615: DOUBLE-EFFECT STEAM-FIRED ABSORPTION CHILLER

This component models a double-effect, steam-fired absorption chiller that reads catalog performance data from user-supplied data files. The machine will attempt to deliver the user-specified set point temperature for the chilled water stream based on the current cooling capacity. The capacity is a function of the chilled water set point temperature, the inlet cooling water temperature, and the inlet steam condition. The user must supply four external data files for this component.

The first external data file must contain values of the fraction of design capacity as a function of the steam inlet gauge pressure. The fraction of design capacity value, when multiplied by the design capacity, gives the nominal capacity of the machine given the steam pressure. The second external data file must contain values of the ratio of available capacity to the nominal capacity as a function of the inlet cooling water and inlet chilled water temperatures. When multiplied by the nominal capacity, this ratio allows the current machine capacity to be calculated at the current inlet conditions. The third external data file must contain values of the fraction of design energy input as a function of the fraction of design capacity and inlet cooling water temperature. The fraction of design capacity is calculated by dividing the required chilled water energy by the design capacity of the machine. The fourth external data file must contain the outlet condensed steam temperature and pressure as a function of the inlet steam gauge pressure. Refer to the sample data files that accompany this model for more information on the format of these data files.

The model calculates the energy required to meet the current load (required chilled water energy) based on the chilled water set-point temperature (Input 9), the chilled water flow rate (Input 2), and the inlet chilled water temperature (Input 1). Based on the inlet steam gauge pressure, the nominal machine capacity is calculated by finding the fraction of design capacity (from the first external data file) and multiplying by the design capacity of the machine (Parameter 1). The fraction of nominal capacity is then found from the second external data file (as a function of the inlet chilled water temperature (Input 1) and the inlet cooling water temperature (Input 3). The capacity of the machine is then found by multiplying the fraction of nominal capacity value by the nominal capacity. The fraction of design capacity is then calculated by dividing the required chilled water energy by the design capacity (Parameter 1) in order to find the fraction of design energy input from the third external data file. The required steam energy is then found by multiplying the fraction of design energy input value by the energy input at design conditions (the design capacity (Parameter 1) divided by the design C.O.P (Parameter 2)). The outlet steam condensate temperature and pressure is then interpolated from the fourth external data file as a function of the inlet steam gauge pressure and the outlet steam enthalpy can be calculated. The required steam flow rate can then be calculated; the inlet steam flow rate is just for convergence checking and is not used by the model. Based on the current capacity and the chilled water load, the energy delivery to the chilled water stream, and the outlet chilled water temperature can be calculated. The amount of energy added to the cooling water stream can then be found by summing the chilled water energy removal rate, the steam energy input rate, and the auxiliary power rate; the outlet cooling water temperature can then be found. Finally the COP can be calculated as the chilled water energy rate divided by the sum of the steam energy input rate and the auxiliary energy input.

The chiller is assumed to be off if the input control signal is less than 0.5 or if either the chilled water flow rate or cooling water flow rate inputs are zero.

TYPE 616: SINGLE-EFFECT STEAM-FIRED ABSORPTION CHILLER

This component models a single-effect, steam-fired absorption chiller that reads catalog performance data from user-supplied data files. The machine will attempt to deliver the user-specified set point temperature for the chilled water stream based on the current cooling capacity. The capacity is a function of the chilled water set point temperature, the inlet cooling water temperature, and the inlet steam condition. The user must supply two external data files for this component.

The first catalog data file must contain the ratio of the cooling capacity to the nominal cooling capacity, and the fraction of the design energy input, as a function of the chilled water set point temperature, the inlet cooling water temperature, the inlet hot water temperature, and the fraction of design load. The second file must contain the outlet condensed steam temperature as a function of the inlet steam gauge pressure. Refer to the sample data files which accompany this model for more information on the format of these data files.

The model calculates the energy required to meet the current load (required capacity) based on the chilled water set-point temperature (Input 9), the chilled water flow rate (Input 2), and the inlet chilled water temperature (Input 1). The fraction of design capacity is then calculated by dividing the required capacity by the rated capacity of the machine (Parameter 1). The fraction of nominal capacity (required capacity divided by nominal capacity), and the fraction of design energy input are interpolated from the first external data file based on the calculated fraction of design capacity, the steam gauge pressure, the inlet cooling water temperature and the chilled water set-point temperature. The nominal capacity and required steam energy are then calculated by the model. The outlet steam condensate temperature is then interpolated from the second external file as a function of the steam gauge pressure. The steam outlet is assumed to be saturated liquid at the temperature found from the external file and the outlet enthalpy can be calculated. The required steam flow rate can then be calculated; the inlet steam flow rate is just for convergence checking and is not used by the model. Based on the current capacity and the chilled water load, the energy delivery to the chilled water stream, and the outlet chilled water temperature can be calculated. The amount of energy added to the cooling water stream can then be found by summing the chilled water energy removal rate, the steam energy input rate, and the auxiliary power rate; the outlet cooling water temperature can then be found. Finally the COP can be calculated as the chilled water energy rate divided by the sum of the steam energy input rate and the auxiliary energy input.

The chiller is assumed to be off if the input control signal is less than 0.5 or if either the chilled water flow rate or cooling water flow rate inputs are zero.

TYPE 617: STEAM SUPERHEATER

This component models a steam superheater using the pinch-point temperature difference approach. In typical applications, high-temperature waste heat is used to superheat a steam flow before entering a steam turbine or other high-temperature steam load device. In this model, the inlet hot-side fluid attempts to heat a flow of steam to a user-specified degrees of superheat. The model may operate in one of two heat exchanger configuration modes; parallel flow or counter flow. The pinch-point represents the location in the heat exchanger where the two fluids are closest in temperature. The location of the pinch-point depends on the flow rates of the hot and cold streams and the configuration of the heat exchanger. The model will attempt to elevate the steam condensate to the user-specified condition; checking the pinch-point at several critical locations in the device. If a pinch-point problem is encountered, the outlet condensate conditions are re-calculated to alleviate the problem and the outlet steam flow leaves the heat exchanger cooler than desired. The device is assumed to be off if either of the flow rates is zero, if the inlet hot-side fluid temperature is below the inlet steam temperature, or if the inlet steam temperature is already above the desired steam outlet temperature.

TYPE 618: CONDENSATE PUMP (FLOW RATE NOT SET)

This component models a steam condensate pump. The user specifies the inlet steam condensate conditions and the desired outlet pressure and the model calculates the theoretical power from a compressed liquid calculation (specific volume times pressure differential). The actual power is found by dividing the theoretical power by the pump efficiency. A user-supplied fraction of the actual pump power is assumed to be lost from the pump shell to the surroundings while the remaining energy ends up as an energy gain to the fluid. Unlike other TRNSYS pump models that set the flow rate for the steam loop by multiplying the rated pump flow rate by an input control signal, this pump simply sets the outlet flow rate to the inlet flow rate. The pump is assumed to be off if the input control signal is less than 0.5 or if the inlet steam flow rate is zero.

TYPE 619: OPEN FEEDWATER HEATER / DEAERATING HEATER /OPEN STEAM HEATER – STEAM FLOW CALCULATED

This component models an open steam heater in which high-temperature steam at a variable flow-rate is mixed with low-temperature steam at a known flow-rate in order to elevate the low-temperature steam to a user-specified outlet condition. This component calculates the flow rate of high-temperature steam required to meet the desired outlet conditions; bounded by a user-defined maximum high-temperature steam flow rate. This component also models an open feedwater heater in which saturated or superheated steam is mixed with sub-cooled condensate in order to bring the temperature of the condensate at or near its saturation temperature. This component will calculate the required steam flow rate in order to meet the user-specified outlet condition. The inlet high-temperature steam flow rate (Input 2) is used strictly for convergence checking at each time step. The high-temperature steam flow rate is set to zero if the low-temperature steam enthalpy is already above the desired outlet enthalpy or if the high-temperature steam is at a lower enthalpy than the low-temperature steam inlet. The high-temperature steam flow rate is set to the user-defined maximum mixing flow rate if the enthalpy of the high-temperature steam is above the inlet low-temperature steam enthalpy and below the desired outlet enthalpy. The outlet pressure from the device is the lower of the two inlet pressures with the high-pressure steam flow instantaneously and adiabatically expanding to the lower pressure. This device is assumed to be perfectly insulated.

TYPE 620: FITTING PRESSURE LOSS

This component models a pressure drop in a steam component. It takes inlet pressure, enthalpy temperature and mass flow rate as well as the desired pressure drop across the fitting. The model calculates the outlet steam conditions after the pressure has dropped isenthalpically. The component can be used to determine outlet conditions if the steam comes in as condensate, or condenses due to the pressure drop. An error will be detected if the specified pressure drop across the fitting is greater than the inlet pressure. This device is assumed to be perfectly insulated.

TYPE 621: CLOSED FEEDWATER HEATER – STEAM FLOW CALCULATED TO ACHIEVE USER-DESIGNATED OUTLET CONDITION

This component models a closed feedwater heater; a device in which higher-temperature steam is mixed with sub-cooled steam condensate in order to bring the temperature of the condensate at or near its saturation temperature. This device operates with a counter-flow configuration. Closed feedwater heaters do not mix the flow streams. This device is not equipped with a drain cooler; a device used to sub-cool the higher-temperature steam flow and transfer additional heat to the condensate flow stream. In devices without drain coolers, the higher-temperature steam flow may only exit at the saturated liquid point or above. This model uses the terminal temperature difference (TTD) approach to model the heat transfer in the device. The terminal temperature difference is defined as the saturation temperature of the higher-temperature steam minus the desired outlet temperature of the condensate flow. The terminal temperature difference may be negative if the higher-temperature steam flow enters in a superheated condition. Care should be taken to specify proper values of the TTD as poor values of the TTD may result in a pinch-point problem at the saturated vapor point of the higher-temperature steam. For this reason the pinch-point temperature difference at both outlets and at the saturated vapor point of the higher-temperature steam is reported by the model and should be checked by the user for reasonableness. The outlet temperature of the condensate flow is set to the minimum of either the condensate saturation temperature or the saturated steam temperature minus the terminal temperature difference. The outlet temperature of the steam flow is set to the saturated steam. If the calculated steam flow required to make the desired outlet condensate condition is greater than the maximum steam flow rate (Parameter 1), the heat transfer will be re-calculated with the steam flow at its maximum flow rate and the outlet conditions reset. The device is assumed to be off if the condensate flow rate is zero or if the inlet steam enthalpy is less than the enthalpy of the condensate at the inlet.

This component calculates the required high-temperature steam flow rate in order to meet the user -specified condensate outlet condition. The inlet steam flow rate (Input 2) is just used for convergence checking in the model.

TYPE 622: CLOSED FEEDWATER HEATER WITH DRAIN COOLER – STEAM FLOW CALCULATED

This component models a closed feedwater heater; a device in which higher-temperature steam is mixed with sub-cooled steam condensate in order to bring the temperature of the condensate at or near its saturation temperature. This device operates with a counter-flow configuration. Closed feedwater heaters do not mix the flow streams. This device is equipped with a drain cooler; a device used to sub-cool the higher-temperature steam flow and transfer additional heat to the condensate flow stream. In devices without drain coolers, the higher-temperature steam flow may only exit at the saturated liquid point or above. This model uses the terminal temperature difference (TTD) and drain cooler temperature difference (DCTD) approach to model the heat transfer in the device. The terminal temperature difference is defined as the saturation temperature of the higher-temperature steam minus the desired outlet temperature of the condensate flow. The terminal temperature difference may be negative if the higher-temperature steam flow enters in a superheated condition. The drain cooler temperature difference is defined as the outlet steam temperature minus the inlet condensate temperature and must always be greater than zero. The TTD and DCTD define the heat transfer and outlet conditions from the model, but care should be taken to specify proper values of these INPUTs. Poor values of the TTD and DCDT may result in a pinch-point problem at the saturated vapor point of the higher-temperature steam. For this reason the pinch-point temperature difference at both outlets and at the saturated vapor point of the higher-temperature steam is reported by the model and should be checked by the user for reasonableness. The outlet temperature of the condensate flow is set to the minimum of either the condensate saturation temperature or the saturated steam temperature minus the terminal temperature difference. The outlet temperature of the steam flow is set to the minimum of either the saturated steam temperature or the inlet condensate temperature plus the drain cooler temperature difference. If the calculated steam flow required to make the desired outlet condensate condition is greater than the maximum steam flow rate (Parameter 1), the heat transfer will be re-calculated with the steam flow at its maximum flow rate and the outlet conditions reset. The device is assumed to be off if the condensate flow rate is zero or if the inlet steam enthalpy is less than the enthalpy of the condensate at the inlet.

This component calculates the required high-temperature steam flow rate in order to meet the user -specified condensate outlet condition. The inlet steam flow rate (Input 2) is just used for convergence checking in the model.

TYPE 623: GAS COMPRESSOR

This component models a gas compressor. The user specifies the inlet gas conditions, the desired outlet pressure, and the efficiency and the model calculates the power required and the outlet conditions. The model assumes that the gas behaves like an ideal gas with constant properties. The theoretical power is calculated using ideal gas relationships and then the actual power is found using the provided efficiency. With the actual power known, the outlet gas conditions are calculated. The device is assumed to be off if either the control signals indicates it is off (< 0.5), if the inlet flow rate is zero, or if the inlet pressure is above the desired outlet pressure.

TYPE 624: STEAM OR WATER INJECTION DEVICE

This component models a steam or water injection device used to humidify an air stream. These systems are typically used to increase the mass flow rate entering a gas turbine in order to boost its power output. This component is similar to the evaporative cooling models in the TESS HVAC library for TRNSYS, but does not rely on the psychrometrics subroutine due to pressure limitations that are commonly encountered in gas turbine simulations. The user specifies the inlet air and steam (water) conditions and the desired outlet RH for the air and the model solves the heat and mass balance equations to determine the outlet states of the air and steam streams. The steam that is not consumed by the device exits at the same temperature, pressure, and enthalpy with which it entered the device.

TYPE 625: GAS TURBINE WITH OR WITHOUT WATER INJECTION (CATALOG DATA)

This component models a gas turbine based on a user-supplied performance data file. The performance data file supplied to this model should be specific to the desired capacity, site elevation, and fuel-type for the application. The data file should contain the capacity (kW), air inlet flow rate (kg/hr), heat rate (kJ/kWh), exhaust flow rate (kg/hr), exhaust temperature (C), exhaust heat (GJ/hr), and water injection ratio (kgH2O/kgfuel) as a function of the current part-load ratio, water injection ratio, and ambient temperature. Two example data files are provided

The turbine will attempt to deliver the user-specified power (Input 3), but may be limited by the operating capacity of the machine based on the current inlet conditions.

TYPE 626: HEAT RECOVERY HOT WATER GENERATOR

This component models a heat recovery hot water generator; a device which uses the waste heat (usually from a gas turbine or a reciprocating engine) to make hot water. This model relies on an effectiveness approach to calculate the heat exchange between the two fluids. The device is internally controlled to bypass a portion of the hot-side fluid in order to keep the cold side at or below a user-specified temperature. The model also makes sure that the non-bypassed portion of the hot-side fluid remains above a user-specified minimum temperature (minimum stack temperature for example) and that the mixed hot-side temperature (bypasses plus non-bypassed flows) is also above a minimum temperature specified by the user.

TYPE 627: HEAT RECOVERY HOT WATER GENERATOR WITH LOAD FLOW CALCULATED

This component models a heat recovery hot water generator; a device which uses the waste heat (usually from a gas turbine or a reciprocating engine) to make hot water. This model relies on an effectiveness approach to calculate the heat exchange between the two fluids. If the device is running at its maximum load side flow rate (par 1) and the outlet load-side temperature is still above the desired outlet temperature, the device provides internal control to bypass a portion of the hot-side fluid in order to keep the cold side at or below its set point.

This model calculates the flow rate of load-side fluid that may be raised to its set point temperature based on the inlet source conditions- the input flow rate is not used!!

TYPE 628: PERFORMANCE MAP FULL LOAD STEAM TURBINE

This model uses an external data file to compute the power produced from a steam turbine given the inlet steam conditions, the turbine back pressure, and the required rotational speed. The turbine operates at its rated capacity at all times. The model calculates the steam inlet flow rate required - the steam flow rate INPUT to this model is NOT used except to check whether continuity is maintained. The external data file contains the full-load capacity and corresponding turbine efficiency as a function of the rotational speed, the inlet steam pressure and the turbine back pressure. A sample data file is provided for the user.

TYPE 629: AIR COMPRESSOR (MOIST AIR CALCULATIONS)

This component models an air compressor. The user specifies the inlet air conditions, the desired outlet pressure, and the efficiency and the model calculates the power required and the outlet conditions. The model assumes that the gas behaves like an ideal gas with constant but average properties. The average specific heat of the air stream is calculated from an integrated correlation based on the inlet and outlet temperatures of the air stream. The ideal outlet temperature is calculated using ideal gas relationships and then the actual outlet temperature is found using the provided efficiency. With the outlet temperature known, the remaining moist air properties can be calculated and the required power found. The device is assumed to be off if either the control signals indicates it is off (< 0.5), if the inlet air flow rate is zero, or if the inlet air pressure is above the desired outlet air pressure.

TYPE 630: AIR COMPRESSOR (DRY AIR)

This component models an air compressor. The user specifies the inlet air conditions, the desired outlet pressure, and the efficiency and the model calculates the power required and the outlet conditions. The model assumes that the gas behaves like an ideal gas with constant but average properties. The average specific heat of the air stream is calculated from an integrated correlation based on the inlet and outlet temperatures of the air stream. The ideal outlet temperature is calculated using ideal gas relationships and then the actual outlet temperature is found using the provided efficiency. With the outlet temperature known, the required power can be found. The device is assumed to be off if either the control signals indicates it is off (< 0.5), if the inlet air flow rate is zero, or if the inlet air pressure is above the desired outlet air pressure.

TYPE 631: AIR PREHEATER / AIR COOLED INTERCOOLER / REGENERATOR – THEORETICAL GAS TURBINE SYSTEMS

This component has the ability to model several similar gas turbine components; an air-to-air regenerator device, an air-cooled intercooler, and an air pre-heater. A regenerator is a device that preheats the air after the compression process (and before the combustion process) by using the hot exhaust gases from a gas turbine. An air-cooled intercooler is a device that uses cooler supply air to cool an air stream between multiple compression steps. An air preheater is a device that exchanges waste heat from one air stream in order to elevate the temperature of a second air stream.

This model is basically an air-to-air heat exchanger where the moist-air calculations are not considered and the air is assumed to act like an ideal gas with constant (but average) properties. The average specific heat of the air stream is calculated from an integrated correlation based on the inlet and outlet temperatures of the air stream. The intercooler heat transfer is calculated using the heat exchanger effectiveness approach – refer to the documentation for the Type 5 heat exchanger in Volume 1 of the TRNYS Manual for more information on the effectiveness concept.

TYPE 632: FLUID COOLED INTERCOOLER – THEORETICAL GAS TURBINE SYSTEMS

This component models a fluid-cooled intercooler; a device that uses a cooler supply fluid to cool an air stream between multiple compression steps. This model is basically a fluid-to-air heat exchanger where the moist-air calculations are not considered and the air is assumed to act like an ideal gas with constant (but average) properties. Although it is described as a fluid-cooled intercooler, this model could also be used to heat an air stream using a warm inlet fluid. The average specific heat of the air stream is calculated from an integrated correlation based on the inlet and outlet temperatures of the air stream. The intercooler heat transfer is calculated using the heat exchanger effectiveness approach – refer to the documentation for the Type 5 heat exchanger in Volume 1 of the TRNYS Manual for more information on the effectiveness concept.

TYPE 633: COMBUSTION DEVICE – THEORETICAL GAS TURBINE SYSTEMS

This component models a simple heat addition device for a gas-turbine system. The combustion process is simply modeled as a heat gain to the air with a user-defined efficiency. The products of combustion are ignored in this model. The air is assumed to act like an ideal gas with constant (but average) properties. The average specific heat of the air stream is calculated from an integrated correlation based on the inlet and outlet temperatures of the air stream. The outlet temperature is set to the desired set-point temperature if the capacity of the machine is not exceeded in doing so. If the capacity of the machine is reached, the device will run at its capacity and the resultant outlet temperature calculated. The device is assumed to be off if either the control signals dictates it is off (< 0.5), if the inlet flow rate is zero, or if the inlet temperature is above the set-point temperature.

TYPE 634: TURBINE SECTION – THEORETICAL GAS TURBINE SYSTEMS

This component models a turbine section for a gas turbine application. The user specifies the inlet air conditions and the outlet pressure and efficiency and the model calculates the power produced and the outlet air conditions. In this model, the moist-air calculations are not considered and the air is assumed to act like an ideal gas with constant (but average) properties. The average specific heat of the air stream is calculated from an integrated correlation based on the inlet and outlet temperatures of the air stream. The theoretical power produced is calculated from an ideal gas relationship using the inlet and outlet pressures. The actual power is then found by multiplying the theoretical power by the user-supplied efficiency and the outlet air conditions then found. The device is assumed to be off if either the control signals dictates it is off (< 0.5), if the inlet air flow rate is zero, or if the inlet pressure is below the desired outlet pressure.

TYPE 635: STEAM-STEAM HEAT EXCHANGER

This component models a steam-to-steam heat exchanger; transferring heat from the inlet hot-side steam flow to the inlet cold-side steam flow. The model includes internal controls to keep the cold-side outlet fluid at or below a user-specified maximum enthalpy condition and to keep the hot-side outlet fluid at or above a user-specified maximum enthalpy condition. If either of the outlet conditions are to be free floating (not controlled), simply set the corresponding desired outlet enthalpy less than zero and the controls for that outlet will be disabled. This feature is useful if the user wishes to keep the hot-side in a saturated condition or keep the cold side below saturation for example. The device is controlled to be off if either the hot side or cold-side flow rates are zero, or if heat transfer from the hot-side to the cold-side is not physically possible. The component relies on both an effectiveness approach and a pinch-point approach to model the complex heat transfer between the two steam flows. The effectiveness (Input 11) is used to set the maximum possible heat transfer between the flow streams based on the inlet temperatures. For this model, the maximum possible heat transfer (ignoring pinch-point effects) is when the outlet temperature of the cold-side flow rate is equal to the inlet temperature of the hot-side flow stream. With this maximum heat transfer rate known, the temperatures of the steam flows at several critical points are calculated to make sure that the pinch-point temperature difference (Parameter 1) is not encountered. If a pinch-point problem is encountered, the outlet steam conditions are re-calculated to avoid the pinch-point problem and the effectiveness is re-calculated. While having the user designate both an effectiveness and a pinch-point temperature difference is somewhat redundant, it does increase the flexibility of the model.

For parallel flow configurations, the pinch-point temperature difference is checked at the outlet of the device. For counter-flow configurations, the pinch-point temperature difference is checked at the outlet of the hot-side flow (the inlet of the cold-side flow), the outlet of the cold-side flow (the inlet of the hot-side flow), the saturated liquid points of both streams, and the saturated vapor points of both streams.

With the provided flexibility of this component, it can model a closed feedwater heater (with or without a drain cooler), a steam pre-heater, a steam economizer, a superheater, a desuperheater etc.. Basically any steam-to-steam or steam-to-water, or water-to-water heat exchanger.

TYPE 636: HEAT RECOVERY STEAM-GENERATOR

This component models a heat recovery steam generator (HSRG); a device which uses high-temperature waste heat (usually from a gas turbine) to heat a steam flow. This component can also model a steam super-heater, or a condensate pre-heater. This model will attempt to meet the user-specified steam outlet condition but may be limited by the entering hot-side temperatures and flow rate. This device may operate in either a counter-flow or parallel-flow configuration. The model relies on the pinch-point temperature difference approach to check for impossible (or unrealistic) heat exchange conditions. The pinch-point temperature difference is defined to be the minimum temperature difference between the hot-source fluid and the steam that allows for heat transfer between the fluids. In parallel-flow mode the pinch-point is checked only at the outlet of the device (the outlet of the steam and the outlet of the hot source fluid) as this represents the minimum temperature difference between the two fluids. In counter-flow mode, the pinch-point is checked at the outlet of the steam flow (inlet of the hot source flow), the outlet of the hot source flow (the steam inlet), at the steam saturated liquid point, and at the steam saturated vapor point. If the temperature difference at these points is less than the pinch-point temperature difference, the heat transfer is re-calculated such that the pinch-point problem is not encountered. The device is assumed to be off if either of the flow rate inlets is zero, or if the inlet steam enthalpy is already at or above the desired outlet steam enthalpy.

TYPE 637: HEAT RECOVERY STEAM-GENERATOR – MAXIMUM STEAM FLOW

This component models a heat recovery steam generator (HSRG); a device which uses high-temperature waste heat (usually from a gas turbine) to heat a steam flow. This component can also model a steam super-heater, or a condensate pre-heater. This model will attempt to meet the user-specified steam outlet condition but may be limited by the entering hot-side temperatures and flow rate. This device may operate in either a counter-flow or parallel-flow configuration. The model relies on the pinch-point temperature difference approach to check for impossible (or unrealistic) heat exchange conditions. The pinch-point temperature difference is defined to be the minimum temperature difference between the hot-source fluid and the steam that allows for heat transfer between the fluids. In parallel-flow mode the pinch-point is checked only at the outlet of the device (the outlet of the steam and the outlet of the hot source fluid) as this represents the minimum temperature difference between the two fluids. In counter-flow mode, the pinch-point is checked at the outlet of the steam flow (inlet of the hot source flow), the outlet of the hot source flow (the steam inlet), at the steam saturated liquid point, and at the steam saturated vapor point. If the temperature difference at these points is less than the pinch-point temperature difference, the heat transfer is re-calculated such that the pinch-point problem is not encountered. The device is assumed to be off if either of the flow rate inlets is zero, or if the inlet steam enthalpy is already at or above the desired outlet steam enthalpy.

This version of the heat recovery steam generator calculates the maximum steam flow rate which can be produced given the inlet hot-side source conditions and the desired steam outlet enthalpy; constrained by the specified pinch-point. In this model, the inlet steam flow rate is not used and is just provided for continuity.

TYPE 638: STEAM BOILER (EFFICIENCY AS INPUT)

This component models a steam boiler. This model will attempt to meet the user-specified steam outlet condition but may be limited by capacity restraints. The available capacity is calculated by multiplying the rated capacity (Parameter 1) by the input control signal (Input 5). The capacity refers to the heat input to the fluid and not the gross capacity of the device. In this model, the user enters the boiler efficiency (Input 6) which is then divided into the required steam input energy to calculate the required fuel input to the model. The user also provides the combustion efficiency (Input 7) which is used to calculate the boiler thermal losses. Overall efficiency is lower than the combustion efficiency due to boiler thermal losses and any cycling effects. This model accepts, condensate, saturated or superheated steam. The boiler is assumed to be off if the inlet steam flow rate is zero, the input control signal is zero, or if the inlet steam enthalpy is greater than or equal to the desired outlet steam enthalpy. If the desired outlet steam conditions cannot be met due to capacity limitations, the machine will run at its available capacity and the outlet steam state calculated.

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

TYPE 639: STEAM BOILER (EFFICIENCY FROM DATA FILE)

This component models a steam boiler. This model will attempt to meet the user-specified steam outlet condition but may be limited by capacity restraints. The available capacity is calculated by multiplying the rated capacity (Parameter 1) by the input control signal (Input 5). The capacity refers to the heat input to the fluid and not the gross capacity of the device. In this model, the user provides a file of boiler and combustion efficiency at various combinations of the inlet steam temperature and the boiler part-load ratio. The boiler efficiency is then divided into the required steam input energy to calculate the required fuel input to the model. The combustion efficiency is used to calculate the boiler thermal losses. Overall efficiency is lower than the combustion efficiency due to boiler thermal losses and any cycling effects. This model accepts, condensate, saturated or superheated steam. The boiler is assumed to be off if the inlet steam flow rate is zero, the input control signal is zero, or if the inlet steam enthalpy is greater than or equal to the desired outlet steam enthalpy. If the desired outlet steam conditions cannot be met due to capacity limitations, the machine will run at its available capacity and the outlet steam state calculated.

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

TYPE 640: FEEDWATER STORAGE TANK

This component models a feedwater storage tank with two steam inlets and two steam outlets. The tank is assumed to be kept at a constant pressure and any steam inlets that are below this tank pressure are diverted around the storage tank (outlet state = inlet state). Steam inlets at pressures higher than the tank pressure are assumed to instantaneously and adiabatically expand to the tank pressure before mixing with the tank fluid. The tank is modeled as a fully-mixed, constant-volume storage tank with losses to the surroundings. This device is meant to store sub-cooled liquid steam and will vent any steam that occurs from a boiling condition within the tank. The inlet steam flows are completely mixed with the storage fluid and the resultant storage tank condition is then outlet. For example, if 100 kg/hr of steam enters at inlet 1 then 100 kg/h of storage fluid exit the tank at outlet one. The tank can be of any geometry (cylindrical, spherical etc) as the user enters the storage volume and the surface area. The model accounts for the capacitance of the storage fluid and uses a 1st-order differential equation to solve for the tank temperatures given the inlet steam conditions and the tank losses.

TYPE 659: EXHAUST GAS SUPPLEMENTAL FIRING OR PROPORTIONAL HOT WATER BOILER

An auxiliary heater is modeled to elevate the temperature of a flow stream using either internal control, external control or a combination of both types of control. The heater is designed to add heat to the flow stream at a user-designated rate (Qmax *Y) whenever the heater outlet temperature is less than a user-specified maximum (Tset).

By specifying a constant value of the control function of one and specifying a sufficiently large value of Qmax, this routine will perform like an auxiliary heater with internal control to maintain an outlet temperature of Tset.

By providing a control function between zero and one from a thermostat or controller, this routine will perform like a furnace adding heat at a rate of Qmax*Y but not exceeding an outlet temperature of Tset. In this application, a constant outlet temperature is not sought and Tset may be thought of as an arbitrary safety limit.

TYPE 682: HEATING AND COOLING LOADS IMPOSED ON A FLOW STREAM

This component is by no means the shining jewel of TRNSYS models. It is however, a simple model that proves very useful in a wide variety of applications. This model simply imposes a user-specified load (cooling = positive load, heating = negative load) on a flow stream and calculates the resultant outlet fluid conditions. Boiling and freezing effects are ignored so be careful when using this component. This simple model can represent any number of devices such as chillers, water-loop building loads, radiators, heat pumps etc. where the physics of the device are not important and the removal of the correct amount of energy from a flow stream IS important.

TYPE 717: DOUBLE-EFFECT STEAM-FIRED ABSORPTION CHILLER (THREE-FILE FORMAT)

This component 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.

TYPE 718: DOUBLE-EFFECT STEAM-FIRED ABSORPTION CHILLER (TRANE FILE FORMAT)

This component 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. The format of the data files matches the type of performance data that is typically reported by Trane (an absorption chiller manufacturer).

TYPE 719: DOUBLE-EFFECT STEAM-FIRED ABSORPTION CHILLER (YORK FILE FORMAT)

This component 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. The format of the data files matches the type of performance data that is typically reported by York (an absorption chiller manufacturer).

TYPE 722: STEAM TURBINE – LOAD FLOWING

This component models a load following steam turbine. This model takes the load, turbine efficiency, inlet steam conditions, maximum allowable steam flow and required exhaust pressure as inputs. It determines the ideal outlet enthalpy based on the required outlet pressure, then determines actual outlet conditions based on isentropic efficiency. If the load is higher than the capacity, the turbine meets capacity and returns an output of load not met. If either the control signal indicates that the device is off or if the outlet enthalpy is determined to be less than or equal to the inlet enthalpy, the turbine outlet conditions are set to the inlet conditions.

TYPE 907: INTERNAL COMBUSTION ENGINE/GENERATOR SET

This component models an engine generator; a device used to generate electricity by burning fuel in an internal combustion engine. The model relies on an external data file which contains efficiency, air flow rate (fraction of rated flow rate) and heat transfer data (fraction of total energy output) as a function of the intake temperature and the part load ratio (power over rated power).

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TYPE 647: DIVERTING VALVE

This component 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 661: DELAYED OUTPUTS

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 1257: TROUGH COLLECTOR

This subroutine models one or more concentrating parabolic trough solar collectors connected in series. The model accounts for the mass of the fluid in the absorber tube and the change in fluid properties with temperature. The energy absorption, heat losses, and fluid properties are based on the work of Patnode, Price and Forrestall among others.

TYPE 1258: VOLUMETRIC DIVERTING VALVE

This component models a diverting valve that splits an inlet volumetric flow into fractional outlet volumetric 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 1259: SOLAR FIELD PIPING

This subroutine models a noded pipe where the properties of the fluid change with temperature. The outlet mass flow rate is calculated by the model and does not necessarily equal the inlet flow rate (dm/dt term).

TYPE 1260: MIXING VALVE

This subroutine models a simple mixing valve for fluids that have temperature dependent thermal properties.

TYPE 1261: EXPANSION TANK

This subroutine models an expansion tank for fluids with variable properties.

TYPE 1262: ARRAY SHADING

This component determines incident radiation upon an array of collectors that shade one another. This model is for single axis tracking parabolic trough collectors that utilize beam radiation only. The tracking axis is assumed to be horizontal (parallel to the ground), on a north-south axis such that the collectors track east to west over the day.

TYPE 1263: VARIABLE SPEED PUMP

This component models a variable speed pump in a manner similar to most other pump models. It differs in that the user is able to specify either a linear or a quadratic relationship between fluid temperature and enthalpy and between fluid temperature and fluid density over the pump's working temperature range. This feature is intended to allow users to deal with the working fluids that are typical in high temperature solar applications.