T.E.S.S. COMPONENT LIBRARIES v2.0

for TRNSYS v16.x and the TRNSYS Simulation Studio

Parameter / Input / Output Reference Manual

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APPLICATION COMPONENTS

Application Components

TYPE 514: DAILY HEATING AND COOLING SETPOINT SCHEDULER

The daily heating and cooling set point scheduler is a bit different than most TRNSYS Types because it launches a preprocessing program that allows you to set up forcing functions using sliders instead of by specifying PARAMETERS as in Type14. To use Type514, drop the Type icon on your Simulation Studio project, then double click it and click the "Launch Plugin" icon and Type514.exe plugin will launch. Within Type514.exe, you set the heating and cooling set points in the fields at the bottom and the times at which the thermostat enters its set up and set back periods using the sliders. The Parameter / Input / Output description here below is included for users wishing to employ Type514 and the companion program ThermoSched.exe in distributable TRNSED applications. For information on other uses of this application, please refer to the technical documentation located in the \TESS Models\Documentation\Applications Library\ directory.

PARAMETERS

Parameter Number	Name	Unit	Typical Value	Comment
1	Logical unit number for data file	-	20	The logical unit that will be ASSIGNed to the data file that is created by the slider program.

OUTPUTS

Output Number	Name	Unit	Comment
1	Average function value	-	The average value of the heating set point over the previous time step.
2	Average function value	-	The average value of the cooling set point over the previous time step.
3	Instantaneous function value	-	The instantaneous value of the heating set point at the end of the current time step.
4	Instantaneous function value	-	The instantaneous value of the cooling set point at the end of the current time step.

TYPE 515: HEATING AND COOLING SEASON SCHEDULER

The heating and cooling scheduler is a bit different than most TRNSYS Types because it launches a preprocessing program that allows you to set up forcing functions using a series of sliders instead of by specifying PARAMETERS as in Type14. To use Type515, drop the Type icon on your Simulation Studio project, then double click it and click the "Launch Plugin" icon and Type515.exe plugin will launch. Within Type515.exe, you set the value of the sliders to represent the start and end of your heating and cooling seasons. The Parameter / Input / Output description here below is included for users wishing to employ Type515 and the companion program SeasonsSched.exe in distributable TRNSED applications. For information on other uses of this application, please refer to the technical documentation located in the \TESS Models\Documentation\Applications Library\ directory.

PARAMETERS

Parameter Number	Name	Unit	Typical Value	Comment
1	Logical unit number for data file	-	20	The logical unit that will be ASSIGNed to the data file that is created by the slider program.

OUTPUTS

Output Number	Name	Unit	Comment
1	Heating allowed	-	A value of 0 indicates that heating equipment should be OFF because the current time is not within the heating season range. A value of 1 indicates that heating equipment can be ON if appropriate because the current value of time falls within the heating season range.
2	Cooling allowed	-	A value of 0 indicates that cooling equipment should be OFF because the current time is not within the cooling season range. A value of 1 indicates that cooling equipment can be ON if appropriate because the current value of time falls within the cooling season range.

TYPE 516: WEEKLY FORCING FUNCTION SCHEDULER

The weekly forcing function scheduler is a bit different than most TRNSYS Types because it launches a preprocessing program that allows you to set up forcing functions using a series of sliders instead of by specifying PARAMETERS as in Type14. To use Type516, drop the Type icon on your Simulation Studio project, then double click it and click the "Launch Plugin" icon and Type516.exe plugin will launch. Within Type516.exe, you set the value of the sliders to represent your intended weekday, Saturday and Sunday forcing functions. The sliders have a range between 0 and 1 but you can increase the range by entering a non-unity value in the Scaling Factor for Sliders window. The Parameter / Input / Output description here below is included for users wishing to employ Type516 and the companion program MultSched.exe in distributable TRNSED applications. For information on other uses of this application, please refer to the technical documentation located in the \TESS Models\Documentation\Applications Library\ directory.

PARAMETERS

Parameter Number	Name	Unit	Typical Value	Comment
1	Logical unit number for data file	-	20	The logical unit that will be ASSIGNed to the data file that is created by the slider program.
2	Day on which 1st Monday falls	-	2	The day of the week on which the first Monday in the simulation occurs. If the simulation starts on Monday, this value should be set to 1. If the simulation starts on Sunday, this parameter should be set to 2.

OUTPUTS

Output Number	Name	Unit	Comment
1	Function value	-	The value of the forcing function at the current time step.

TYPE 517: DAILY FORCING FUNCTION SCHEDULER

The daily forcing function scheduler is a bit different than most TRNSYS Types because it launches a preprocessing program that allows you to set up forcing functions using a series of sliders instead of by specifying PARAMETERS as in Type14. To use Type517, drop the Type icon on your Simulation Studio project, then double click it and click the "Launch Plugin" icon and Type517.exe plugin will launch. Within Type517.exe, you set the value of the sliders to represent your intended forcing function with a range between 0 and 1. Use the Scaling Factor for Sliders window to change the range from 0 to 1 to 0 to ScaleFactor. The Parameter / Input / Output description here below is included for users wishing to employ Type517 and the companion program Sched.exe in distributable TRNSED applications. For information on other uses of this application, please refer to the technical documentation located in the \TESS Models\Documentation\Applications Library\ directory.

PARAMETERS

Parameter Number	Name	Unit	Typical Value	Comment
1	Logical Unit number for data file	-	20	The logical unit that will be ASSIGNed to the data file that is created by the slider program.

OUTPUTS

Output Number	Name	Unit	Comment
1	Function value	-	The value of the forcing function at the current time step.

TYPE 518: MONTHLY FORCING FUNCTION SCHEDULER

The monthly forcing function scheduler is a bit different than most TRNSYS Types because it launches a preprocessing program that allows you to set up forcing functions using a series of sliders instead of by specifying PARAMETERS as in Type14. To use Type518, drop the Type icon on your Simulation Studio project, then double click it and click the "Launch Plugin" icon and Type518.exe plugin will launch. Within Type518.exe, you set the value of the sliders to represent your intended forcing function with a range between 0 and 1. Use the Scaling Factor for Sliders window to change the range from 0 to whatever range is desired. The user may also choose whether the output value is to be linearly interpolated or held constant throughout each month. The Parameter / Input / Output description here below is included for users wishing to employ Type518 and the companion program MonthSched.exe in distributable TRNSED applications. For information on other uses of this application, please refer to the technical documentation located in the \TESS Models\Documentation\Applications Library\ directory.

PARAMETERS

Parameter Number	Name	Unit	Typical Value	Comment
1	Logical Unit number for data file	-	20	The logical unit that will be ASSIGNed to the data file that is created by the slider program.

OUTPUTS

Output Number	Name	Unit	Comment
1	Function value	-	The value of the forcing function at the current time step.

TYPE 519: HOLIDAY SCHEDULER

The holiday scheduler is a bit different than most TRNSYS Types because it launches a preprocessing program that allows you to set up forcing functions using a dedicated applet instead of by specifying PARAMETERS as in Type14. To use Type519, drop the Type icon on your Simulation Studio project, then double click it and click the "Launch Plugin" icon and Type519.exe plugin will launch. Within Type519.exe, you first choose the length of the desired simulation and the starting month of the simulation. The user is then asked to set a schedule for the simulation; a window pops up allowing the user to scroll through a calendar of each simulated month designating each desired day as a holiday or weekend. The Parameter / Input / Output description here below is included for users wishing to employ Type519 and the companion program Scheduler.exe in distributable TRNSED applications. For information on other uses of this application, please refer to the technical documentation located in the \TESS Models\Documentation\Applications Library\ directory.

PARAMETERS

Parameter Number	Name	Unit	Typical Value	Comment
1	Logical Unit number for data file	-	20	The logical unit that will be ASSIGNed to the data file that is created by the slider program.
2	Time mode	-	1	Setting this parameter to 1 indicates that the data file for use by this model starts on January 1st. Setting this parameter to 0 indicates that the data file starts on a day other than January 1st. The simulation may not start before the start of the data file.

OUTPUTS

Output Number	Name	Unit	Comment
1	Function value	-	The value of the forcing function at the current time step. A value of 0 indicates that the current day is designated as a holiday or weekend.

TYPE 520: WEEKLY HEATING AND COOLING SETPOINT SCHEDULER

The weekly heating and cooling set point scheduler is a bit different than most TRNSYS Types because it launches a preprocessing program that allows you to set up forcing functions using sliders instead of by specifying PARAMETERS as in Type14. To use Type520, drop the Type icon on your Simulation Studio project, then double click it and click the "Launch Plugin" icon and Type520.exe plugin will launch. Within Type520.exe, you set the heating and cooling set points in the fields at the bottom and the times at which the thermostat enters its set up and set back periods using the sliders. Tabs are available for setting different weekday, Saturday, and Sunday schedules. The Parameter / Input / Output description here below is included for users wishing to employ Type520 and the companion program MultThermoSched.exe in distributable TRNSED applications. For information on other uses of this application, please refer to the technical documentation located in the \TESS Models\Documentation\Applications Library\ directory.

PARAMETERS

Parameter Number	Name	Unit	Typical Value	Comment
1	Logical unit number for data file	-	20	The logical unit that will be ASSIGNed to the data file that is created by the slider program.
2	Day on which 1st Monday falls	-	2	The day of the week on which the first Monday in the simulation occurs. If the simulation starts on Monday, this value should be set to 1. If the simulation starts on Sunday, this parameter should be set to 2.

OUTPUTS

Output Number	Name	Unit	Comment
1	Heating set point	C	The average heating set point temperature over the time step.
2	Cooling set point	C	The average cooling set point temperature over the time step.
3	Instantaneous heating set point	C	The instantaneous heating set point temperature at the end of the current time step.
4	Instantaneous cooling set point	C	The instantaneous cooling set point temperature at the end of the current time step.

CONTROLLER COMPONENTS

Controller Components

TYPE 502: THREE-STAGE AQUASTAT IN HEATING MODE

PARAMETERS

Parameter Number	Name	Unit	Typical Value	Comment
1	Number of oscillations permitted	-	5	The number of oscillations of the controller state allowed in one time step before the output will be fixed and the solution found. -If the number of oscillations is set to an odd number, the control may bounce between two control states for successive time steps -If the number of oscillations is set to an even number, the control system may stay longer in one regime than actually intended.
2	1st stage heating in 2nd stage?	-	1	This controller will disable the 1st stage heating system when the 2nd stage heating system comes on (set this parameter to 0), or continue to operate the 1st stage heating system while the 2nd stage heating system is operating (set this parameter to 1).
3	2nd stage heating in 3rd stage?	-	1	This controller will disable the 2nd stage heating system when operating in 3rd stage heating mode (set this parameter to 0) or continue to operate the 2nd stage heating system when operating in 3rd stage heating mode (set this parameter to 1)
4	1st stage heating in 3rd stage?	-	1	This controller will disable the first stage heating system when in third stage heating mode (value = 0), or continue to operate the 1st stage heating system when in third stage heating mode (value = 1)
5	Dead band temperature	ΔC	5.0	The controller will turn the heaters ON at (set point – deadband/2) and OFF at (set point + deadband/2).

INPUTS

Input Number	Name	Unit	Typical Value	Comment
1	Fluid temperature	C	20.0	The temperature of the fluid being monitored by the controller
2	1st stage heating temperature	C	20.0	The tank (water) temperature below which first stage heating is commanded
3	2nd stage heating temperature	C	18.0	The tank (water) temperature below which second stage heating is commanded.
4	3rd stage heating temperature	C	16.0	The tank (water) temperature below which third stage heating (auxiliary) is commanded.

OUTPUTS

Output Number	Name	Unit	Comment
1	Control signal for 1st stage heating	-	The control signal for first stage heating 1 = 1st stage heating is require 0 = 1st stage heating is not require
2	Control signal for 2nd stage heating	-	The control signal for the second stage heating equipment 1 = 2nd stage heating is require 0 = 2nd stage heating is not required
3	Control signal for 3rd stage heating	-	The control signal for third stage heating: 0 = 3rd stage heating is not required 1 = 3rd stage heating is required
4	Conditioning signal	-	If any of the heating signals is non-zero, this output will be set to 1. This output can be used to control a pump or fan

TYPE 503: THREE-STAGE AQUASTAT IN COOLING MODE

PARAMETERS

Parameter Number	Name	Unit	Typical Value	Comment
1	Number of oscillations permitted	-	5	The number of oscillations of the controller state allowed in one time step before the output will be fixed and the solution found. -If the number of oscillations is set to an odd number, the control may bounce between two control states for successive time steps -If the number of oscillations is set to an even number, the control system may stay longer in one regime than actually intended.
2	1st stage cooling in 2nd stage?	-	1	This controller will disable the first-stage cooling system when the 2nd stage cooling system comes on (set this parameter to 0), or continue to operate the 1st stage cooling system while the 2nd stage cooling system is operating (set this parameter to 1)
3	2nd stage cooling in 3rd stage?	-	1	This controller will disable the 2nd stage cooling system when operating in 3rd stage cooling mode (set this parameter to 1) or continue to operate the 2nd stage cooling system when operating in 3rd stage cooling mode (set this parameter to 0)
4	1st stage cooling in 3rd stage?	-	1	This controller will disable the 1st stage cooling system when in 3rd stage cooling mode (set this parameter to 0), or continue to operate the 1st stage cooling system when in 3rd stage cooling mode (set this parameter to 1)
5	Dead band temperature	ΔC	5.0	The controller will turn the coolers ON at (set point + deadband/2) and OFF at (set point - deadband/2).

INPUTS

Input Number	Name	Unit	Typical Value	Comment
1	Fluid temperature	C	20.0	The temperature of the fluid being monitored by the controller
2	1st stage cooling temperature	C	20.0	The tank (water) temperature above which first stage cooling is commanded
3	2nd stage cooling temperature	C	18.0	The tank (water) temperature above which second stage cooling is commanded.
4	3rd stage cooling temperature	C	16.0	The tank (water) temperature above which third stage cooling (auxiliary) is commanded.

OUTPUTS

Output Number	Name	Unit	Comment
1	Control signal for 1st stage cooling	-	The control signal for first stage cooling 1 = 1st stage cooling is required 0 = 1st stage cooling is not required
2	Control signal for 2nd stage cooling	-	The control signal for the second stage cooling equipment 1 = 2nd stage cooling is required 0 = 2nd stage cooling is not required
3	Control signal for 3rd stage cooling	-	The control signal for third stage cooling 0 = 3rd stage cooling is not required 1 = 3rd stage cooling is required
4	Conditioning signal	-	If any of the cooling signals is non-zero, this output will be set to 1. This output can be used to control a pump or fan.

TYPE 658: HUMIDISTAT

PARAMETERS

Parameter Number	Name	Unit	Typical Value	Comment
1	Number of oscillations	-	5	The number of control oscillations allowed in one time step before the controller is "stuck" so that the calculations can be solved. Setting this parameter to an odd number may cause the controller to oscillate between control states for successive time steps.
2	Upper dead band RH%	-	10.0	The upper dead band relative humidity difference for the controller.
3	Lower dead band RH%	-	2.0	The lower dead band relative humidity difference for the controller
4	High limit cut-out (%)	%	100.0	The high limit cut-out relative humidity of the controller The controller will set the controller to the OFF position, regardless of the dead bands, if the relative humidity of the zone exceeds the high limit cut-out. The controller will remain OFF until the zone relative humidity falls below the high limit cut-out value.
5	RH set point multiplier	-	1.0	The multiplier used to calculate the relative humidity set point from the inlet air temperature.
6	RH set point constant	-	0.0	The relative humidity constant term in the calculation of the relative humidity set point from the inlet air condition.

INPUTS

Input Number	Name	Unit	Typical Value	Comment
1	Zone temperature	C	20.0	The temperature of the zone air being monitored by this device.
2	Zone humidity ratio	-	0.008	The humidity ratio of the zone air being monitored by this device.
3	Inlet air temperature	C	10.0	The inlet air temperature to the controller. This temperature is used to calculate the relative humidity set point for the controller.
4	Humidistat ON/OFF signal	-	1.0	The on/off control signal for the humidistat. If this control function is set less than 0.5, the humidistat output will be set to zero regardless of the zone and inlet conditions. If this input is greater than or equal to 0.5, the humidistat will output a control signal depending on the current conditions.
5	Input control function	-	1.0	The input control function is used to promote controller stability by the use of hysteresis. The control decision will be based on the dead band conditions and controller state at the previous time step.

OUTPUTS

Output Number	Name	Unit	Comment
1	Output control function	-	The output control function from the humidistat: 1 = Humidify inlet air stream 0 = Do not humidify inlet air stream
2	Room relative humidity	%	The calculated relative humidity of the zone (%).
3	Relative humidity set point	%	The calculated relative humidity set point based on the current inlet air temperature.

TYPE 661: DELAYED OUTPUT DEVICE

PARAMETERS

Parameter Number	Name	Unit	Typical Value	Comment
1	Number of inputs (n)	-	2	The number of inputs to be delayed by this component.
Cycle based on PAR 1	Number of time steps to hold each value	-	5	The number of time steps that this device should hold each input value before releasing it as an output value.
	Initial value of each input	any	0	The initial values of the function for each output. The output will be set to this initial value until the required number of time steps has elapsed.

INPUTS

Input Number	Name	Unit	Typical Value	Comment
Cycle based on PAR 1	Input value	any	0	The input that will be held in storage until the correct time step for output is reached.

OUTPUTS

Output Number	Name	Unit	Comment
Cycle based on PAR 1	Output value	any	Each output value at the current time step. This output is the input value from a user-defined number of previous time steps.

TYPE 669: PROPORTIONAL CONTROLLER

PARAMETERS

Parameter Number	Name	Unit	Typical Value	Comment
1	Number of signals (n)	-	1	The number of unique proportional control signals to be generated by this component.

INPUTS

Input Number	Name	Unit	Typical Value	Comment
Cycle based on PAR 1	Upper set point value	any	30.0	The upper set point for the specified signal (the value at which the function will return a control signal of 1).
	Lower set point value	any	20.0	The value of the lower set point; the value at which the function will return a zero value.
	Input value	any	25.0	Each input value which will be compared to the upper and lower set points in order to generate a proportional signal.

OUTPUTS

Output Number	Name	Unit	Comment
Cycle based on PAR 1	Control signal	-	The proportional signal calculated from each input value and the specified upper and lower set point values.

TYPE 671: N-STAGE DIFFERENTIAL CONTROLLER IN HEATING

PARAMETERS

Parameter Number	Name	Unit	Typical Value	Comment
1	Number of levels (n)	-	2	The number of different levels of control function to be modeled. For each level, the user must specify the set point condition and the model will calculate the output control signal.
2	Number of oscillations permitted	-	5	The number of oscillations of the controller state allowed in one time step before the output will be fixed and the solution found. -If the number of oscillations is set to an odd number, the control may bounce between two control states for successive time steps. -If the number of oscillations is set to an even number, the control system may stay longer in one regime than actually intended Refer to Section 4.4 of Volume 1 of the TRNSYS documentation set for more details on controller sticking.
3	Staged heating control mode	-	1	CTRL < 0.5 : This controller will disable all control functions below the currently active ON level. CTRL ≥ 0.5 : This controller will enable all control functions below the currently active ON level. For example, if 1st and 2nd stage heating are desired when the third-stage heating signal is ON, set this parameter to 1.
4	Controller dead band	any	2.0	The dead band difference of the controller. In this model hysteresis effects can be modeled by use of this parameter.

INPUTS

Input Number	Name	Unit	Typical Value	Comment
1	Value to watch	any	20.0	The value of the function which will be compared to the set points in order to set the output control signals.
Cycle based on PAR 1	Set point for each stage	any	20.0	The set point for each of the n stages

OUTPUTS

Output Number	Name	Unit	Comment
Cycle based on PAR 1	Stage control signal	-	The output control signal for the each stage 1 = this stage control is required 0 = this stage control is not required
n+1	Conditioning signal	-	If any of the signals are non-zero, this output will be set to 1. This output can be used to control a pump or a fan.

TYPE 672: N-STAGE DIFFERENTIAL CONTROLLER IN COOLING

PARAMETERS

Parameter Number	Name	Unit	Typical Value	Comment
1	Number of levels	-	3	The number of different levels of control function to be modeled. For each level, the user must specify the set point condition. The model will calculate the output control signal.
2	Number of oscillations permitted	-	5	The number of oscillations of the controller state allowed in one time step before the output will be fixed and the solution found. -If the number of oscillations is set to an odd number, the control may bounce between two control states for successive time steps. -If the number of oscillations is set to an even number, the control system may stay longer in one regime than actually intended Refer to Section 4.4 of Volume 1 of the TRNSYS documentation set for more details on controller sticking.
3	Staged cooling control mode	-	1.0	CTRL < 0.5 : This controller will disable all control functions below the currently active ON level. CTRL ≥ 0.5 : This controller will enable all control functions below the currently active ON level. For example, if 1st and 2nd stage cooling is desired when the third-stage cooling signal is ON, set this parameter to 1.
4	Controller dead band	any	2.0	The dead band difference of the controller. In this model hysteresis effects can be modeled by use of this parameter.

INPUTS

Input Number	Name	Unit	Typical Value	Comment
1	Value to watch	any	20.0	The value of the function which will be compared to the set points in order to set the output control signals.
Cycle based on PAR 1	Set point for each stage	any	20.0	The set point for each of the n stages

OUTPUTS

Output Number	Name	Unit	Comment
Cycle based on PAR 1	Stage control signal	-	The output control signal for the each stage 1 = this stage control is required 0 = this stage control is not required

n+1	Conditioning signal	-	If any of the signals are non-zero, this output will be set to 1. This output can be used to control a pump or a fan.

TYPE 698: FIVE-STAGE ROOM THERMOSTAT EVALUATING N LEVELS

PARAMETERS

Parameter Number	Name	Unit	Typical Value	Comment
1	Number of zones	-	1	The number of zones to monitor with this controller. For each zone, the input condition will be compared against the set points and output control signals will be generated.
2	Number of oscillations permitted	-	5	The number of oscillations of the controller state allowed in one time step before the output will be fixed and the solution found. - If the number of oscillations is set to an odd number, the control may bounce between two control states for successive time steps. - If the number of oscillations is set to an even number, the control system may stay longer in one regime than actually intended.
3	1st stage heating in 2nd stage?	-	1	This controller will disable the 1st stage heating system when the 2nd stage heating system comes on (set this parameter to 0), or continue to operate the 1st stage heating system while the 2nd stage heating system is operating (set this parameter to 1).
4	2nd stage heating in 3rd stage?	-	1	This controller will disable the 2nd stage heating system when the 3rd stage heating system comes on (set this parameter to 0), or continue to operate the 2nd stage heating system while the 3rd stage heating system is operating (set this parameter to 1).
5	1st stage heating in 3rd stage?	-	1	This controller will disable the 1st stage heating system when the 3rd stage heating system comes on (set this parameter to 0), or continue to operate the 1st stage heating system while the 3rd stage heating system is operating (set this parameter to 1).
6	1st stage cooling in 2nd stage?	-	1	This controller will disable the 1st stage cooling system when the 2nd stage cooling system comes on (set this parameter to 0), or continue to operate the 1st stage cooling system while the 2nd stage cooling system is operating (set this parameter to 1).
7	Temperature dead band	ΔC	2.0	The dead band temperature difference of the controller. In this model, hysteresis effects can be modeled by the use of this parameter. This parameter is used to modify the heating and cooling set temperatures based on the state of this controller at the previous time step. If hysteresis is not desired for this controller, simply set this parameter to 0.0

INPUTS

Input Number	Name	Unit	Typical Value	Comment
1	1st stage heating set point temperature	C	20.0	The room temperature below which first stage heating is commanded.
2	2nd stage heating set point temperature	C	18.0	The room temperature below which second stage heating is commanded.
3	3rd stage heating set point temperature	C	16.0	The room temperature below which third stage heating is commanded.
4	1st stage cooling set point temperature	C	24.0	The room temperature above which first stage cooling is commanded.
5	2nd stage cooling set point temperature	C	26.0	The room temperature above which second stage cooling is commanded.
Cycle based on PAR 1	Zone temperature	C	25.0	The temperature of the specified zone to be monitored by the controller.

OUTPUTS

Output Number	Name	Unit	Comment
Cycle based on PAR 1	Control signal for 1st stage heating	-	The output control signal for first stage heating in each zone 1 = 1st stage heating is required 0 = 1st stage heating is not required
	Control signal for 2nd stage heating	-	The output control signal for the second stage heating in each zone 1 = 2nd stage heating is required 0 = 2nd stage heating is not required
	Control signal for 3rd stage heating	-	The output control signal for third stage heating in each zone: 0 = 3rd stage heating is not required 1 = 3rd stage heating is required
	Control signal for 1st stage cooling	-	The output control signal for 1st stage cooling in each zone: 1 = 1st stage cooling is required 0 = 1st stage cooling is not required
	Control signal for 2nd stage cooling	-	The output control signal for 2nd stage cooling in each zone: 1 = 2nd stage cooling is required 0 = 2nd stage cooling is not required
	Conditioning signal	-	If any of the heating or cooling signals is non-zero, this output will be set to 1. This output can be used to control a pump or fan.
6*PAR 1 + 1	Overall conditioning signal	-	If any of the zones have triggered an ON condition for an output, this output will be set to 1. This output can be used to control a pump or fan.

GEOTHERMAL HEAT PUMP COMPONENTS

Geothermal Heat Pump Components

TYPE 501: GROUND TEMPERATURE

PARAMETERS

Parameter Number	Name	Unit	Typical Value	Comment
1	Number of temperature nodes	-	1	The number of temperatures that will be output from the model. For each output temperature desired, the user has to specify the depth at which the output temperature should be calculated. These depths should be entered in parameters 8 to 7 +n, where n is the number of temperature nodes (this parameter).
2	Mean surface temperature	C	10.0	The mean (average) surface temperature of the ground during the year. The temperature of the ground at an infinite depth will be this temperature. This temperature is typically the average annual air temperature for the given location.
3	Amplitude of surface temperature	ΔC	5.0	The amplitude of the surface temperature function throughout the year. The maximum temperature of the surface will be TMEAN+TAMPL.
4	Time shift	day	30	The time difference (in days) between the beginning of the calendar year and the occurrence of the minimum surface temperature.
5	Soil thermal conductivity	kJ/hr-m-K	8.72	The thermal conductivity of the soil for which the temperature is being calculated.
6	Soil density	kg/m^3	3200.0	The density of the soil for which the temperature is being calculated.
7	Soil specific heat	kJ/kg-K	0.84	The specific heat of the soil for which the temperature is being calculated.
Cycle based on PAR 1	Depth at point	m	0.25	The depth of the soil at which the temperature for each node should be evaluated. 0 = Surface

OUTPUTS

Output Number	Name	Unit	Comment
Cycle based on PAR 1	Soil temperature at node	C	The soil temperature at the specified depth for each node specified in the cycle at the end of the parameter list.

TYPE 504: WATER SOURCE HEAT PUMP

PARAMETERS

Parameter Number	Name	Unit	Typical Value	Comment
1	Humidity mode	-	1	The humidity mode indicates which of the INPUT humidity values will be used to calculate the inlet moist air state: 1= the inlet humidity ratio will be used, 2=the inlet relative humidity (%) will be used
2	Logical unit number for cooling data file	-	12	The logical unit which is ASSIGNed to the data file which contains the heat pump cooling performance data.
3	Logical unit number for heating data file	-	13	The logical unit which is ASSIGNed to the data file containing the heat pump heating performance data.
4	Logical unit number for cooling correction data file	-	14	The logical unit which is ASSIGNed to the data file which contains the cooling correction factor for off-design indoor air temperatures.
5	Logical unit number for heating correction data file	-	15	The logical unit which is ASSIGNed to the data file containing the heating correction factors for off-design indoor air temperatures.
6	Number of water flow steps	-	3	The number of water flow rates for which data is provided in the performance data files. (samp_c.dat and samp_h.dat)
7	Number of water temperatures – cooling	-	4	The number of water temperatures for which cooling performance data is provided in the associated data files. (samp_c.dat)
8	Number of water temperatures – heating	-	4	The number of water temperatures for which heating data is provided in the associated heating performance data file. (samp_h.dat)
9	Number of wet bulb steps	-	6	The number of indoor wet-bulb temperatures for which cooling correction factors are supplied in the associated data file. (samp_ct.dat)
10	Number of dry bulb steps – cooling	-	4	The number of indoor dry-bulb temperatures for which cooling correction factors are supplied in the associated data file. (samp_ct.dat)
11	Number of dry bulb steps – heating	-	6	The number of entering air dry-bulb temperatures for which heating correction factor data in supplied in the associated data file. (samp_ht.dat)
12	Number of airflow steps – cooling	-	2	The number of air flow rate steps for which cooling performance data will be supplied in the associated data file. (samp_c.dat)
13	Number of airflow steps - heating	-	2	The number of air flow rate steps for which heating performance data is supplied in the associated data file. (samp_h.dat)
14	Density of liquid stream	kg/m^3	1000.0	The density of the liquid stream entering the heat pump. The liquid stream is used for heat rejection when in cooling mode and for heat absorption when in heating mode.
15	Specific heat of liquid stream	kJ/kg-K	4.190	The specific heat of the liquid stream entering the heat pump. The liquid stream is used for heat rejection when in cooling mode and for heat absorption when in heating mode.

16	Specific heat of DHW fluid	kJ/kg-K	4.190	The specific heat of the domestic hot water fluid which will be heated using the desuperheater of the heat pump.
17	Blower power	kJ/hr	671.1	The power of the blower motor when the heat pump is operating. Typically, the entire heat pump package power (compressor + blower + controls) is given for the reported heat pump power in the catalog data. The blower and controller power will be subtracted from the calculated power in order to calculate the compressor power.
18	Controller power	kJ/hr	36.0	The power of the controller in the packaged heat pump unit. Typically, the total packaged heat pump power (blower + controls + compressor) is reported for heat pump power in the catalog data. The blower and controller power will be subtracted from the total calculated heat pump power in order to get the compressor power.
19	Capacity of stage-1 auxiliary	kJ/hr	0.0	The heating capacity of the first-stage auxiliary heating device.
20	Capacity of stage-2 auxiliary	kJ/hr	0.0	The heating capacity of the 2nd-stage auxiliary heating device.
21	Total air flow rate	l/s	300.0	The flow-rate on the air-side of the heat pump. This flow-rate is the total flow rate (return plus outside air).

INPUTS

Input Number	Name	Unit	Typical Value	Comment
1	Inlet liquid temperature	C	20.0	The temperature of the heat transfer fluid entering the heat pump.
2	Inlet liquid flow rate	kg/hr	1000.0	The flow rate of heat transfer fluid entering the heat pump.
3	Return air temperature	C	20.0	The temperature of the air returning to the heat pump from the zone. This is typically the room air temperature. This air will be mixed with a user-controlled amount of outside air before entering the heat pump
4	Return air humidity ratio	-	0.008	The absolute humidity ratio of the air returning to the heat pump from the zone. This air is typically at room air conditions. This return air will be mixed with a user-specified amount of outside air before entering the heat pump. NOTE: in humidity mode 2, this INPUT is ignored.
5	Return air relative humidity	%	50.0	The relative humidity of the air returning to the heat pump from the zone. This air is typically at room air conditions. This return air will be mixed with a user-specified amount of outside air before entering the heat pump. NOTE: in humidity mode 1, this INPUT is ignored.
6	Return air pressure	atm	1.0	The absolute pressure of the air returning to the heat pump from the zone. This air is typically at room air conditions. This return air will be mixed with a user-specified amount of outside air before entering the heat pump.
7	Return air damper pressure drop	atm	0.0	The pressure drop of the return air stream as it passes across the return air damper.

8	Fresh air temperature	C	20.0	The dry-bulb temperature of the ambient air
9	Fresh humidity ratio	-	0.008	The absolute humidity ratio of the ambient air. NOTE: in humidity mode 2, this INPUT is ignored.
10	Fresh air relative humidity	%	50.0	The relative humidity of the ambient air. NOTE: in humidity mode 1, this INPUT is ignored.
11	Fresh air pressure	atm	1.0	The absolute pressure of the fresh air available to the heat pump. The heat pump will mix a user-specified amount of fresh air with the return air before conditioning this air in the heat pump.
12	Fresh air damper pressure drop	atm	0.0	The pressure drop of the fresh air stream as it passes across the outside air damper..
13	Inlet DHW temperature	C	40.0	The temperature of the entering domestic hot water stream to be heated by the desuperheater.
14	Inlet DHW flow rate	kg/hr	400.0	The flow rate of domestic hot water entering the heat pump to be heated by the desuperheater.
15	Cooling control signal	-	1.0	The control signal for cooling operation: CTRL < 0.5 : cooling mode is OFF CTRL ≥ 0.5 : cooling mode is ON
16	Heating control signal	-	0.0	The control signal for heating operation: CTRL < 0.5 : heating mode is OFF CTRL ≥ 0.5 : heating mode is ON
17	Stage 1 auxiliary signal	-	0.0	The control signal for the 1st stage auxiliary heater: CTRL < 0.5 : Auxiliary heating device 1 is OFF CTRL ≥ 0.5 : Auxiliary heating device 1 is ON
18	Stage 2 auxiliary signal	-	0.0	The control signal for the operation of the 2nd-stage auxiliary heater: CTRL < 0.5 : Auxiliary heating device 2 is OFF CTRL ≥ 0.5 : Auxiliary heating device 2 is ON
19	Fan control signal	-	0.0	The control signal for operation of the ventilation fan when the heat pump is not operating in heating or cooling mode CTRL < 0.5 : fan is OFF if heat pump compressor is OFF. CTRL ≥ 0.5 : fan is ON regardless of compressor operation.
20	Fraction of outside air	0..1	0.15	The heat pump will mix this user-specified amount of fresh air with the remaining fraction of return air before conditioning this air in the heat pump.
21	Cooling desuperheater temperature	C	60.0	The temperature of the refrigerant in the heat pump desuperheater when the heat pump is operating in cooling mode. This temperature will be used to calculate the heat transfer to the domestic hot water flow stream.
22	Heating desuperheater temperature	C	55.0	The temperature of the refrigerant in the heat pump desuperheater when the heat pump is operating in heating mode. This temperature will be used to calculate the heat transfer to the domestic hot water flow stream.
23	Desuperheater UA - cooling	kJ/hr-K	1500.0	The overall heat transfer coefficient from the heat pump to the desuperheater flow stream in cooling mode.
24	Desuperheater UA - heating	kJ/hr-K	1500.0	The overall heat transfer coefficient between the heat pump and the desuperheater flow stream in heating mode.
25	Fraction of rated cooling power	-	1.0	The fraction of rated catalog cooling power that will be used for this heat pump. The actual power will be the power (interpolated from the data file based on the current

				conditions) multiplied by this parameter.
26	Fraction of rated cooling capacity	-	1.0	The fraction of the catalog cooling capacity that will be used for this heat pump.
27	Fraction of rated heating power	-	1.0	The fraction of rated catalog heating power that will be used for this heat pump.
28	Fraction of rated heating capacity	-	1.0	The fraction of rated catalog heating capacity that will be used for this heat pump.
29	Pressure rise	atm	0.0	The pressure rise (positive) of the air as it flows through the heat pump. The pressurization is due to the internal heat pump fan.

OUTPUTS

Output Number	Name	Unit	Comment
1	Exiting fluid temperature	C	The temperature of the liquid stream exiting the heat pump.
2	Exiting fluid flow rate	kg/hr	The flow rate of the liquid stream exiting the heat pump.
3	Exiting air temperature	C	The dry-bulb temperature of the air exiting the heat pump.
4	Exiting air humidity ratio	kgH2O/kgAir	The absolute humidity ratio of the air exiting the heat pump.
5	Exiting air relative humidity	%	The relative humidity of air exiting the heat pump.
6	Exiting air flow rate	kg/hr	The flow rate of dry air exiting the heat pump.
7	Exiting air pressure	atm	The absolute pressure of air exiting the heat pump.
8	Exiting DHW temperature	C	The temperature of the domestic hot water stream exiting the heat pump.
9	Exiting DHW flow rate	kg/hr	The flow rate of domestic hot water exiting the heat pump.
10	Total heat transfer to air	kJ/hr	The total heat transfer to the air (sensible and latent). In cooling mode this quantity will be negative.
11	Sensible heat transfer to air	kJ/hr	The sensible heat transfer to the air. In heating mode, this value will be positive.
12	Latent heat transfer to air	kJ/hr	The latent heat transfer rate to the air stream. In cooling mode (dehumidification), this value will be negative.
13	Heat transfer to water	kJ/hr	The heat transfer to the water stream during heat pump operation. This value can be positive (heat rejection in cooling mode) or negative (heat absorption in heating mode).
14	Heat transfer to DHW stream	kJ/hr	The heat transfer to the domestic hot water stream during heat pump operation. This value will always be greater than or equal to zero.
15	Compressor power	kJ/hr	The power consumed by the heat pump compressor while operating.
16	Heat pump power	kJ/hr	The total power (compressor + controls + blower) consumed by the heat pump while operating.

17	C.O.P.	-	The Coefficient of Performance of the heat pump.
18	EER	-	The Energy Efficiency Rating of the heat pump during the timestep.
19	Auxiliary heater power	kJ/hr	The rate at which the heat pump is using auxiliary energy to heat the outgoing air stream.
20	Condensate temperature	C	The temperature of the condensate leaving the heat pump.
21	Condensate flow rate	kg/hr	The flow rate of condensate leaving the heat pump.

Sample Data Files

.\TESS Models\SampleCatalogData\GeothermalHeatPump\Samp_C.dat
.\TESS Models\SampleCatalogData\GeothermalHeatPump\Samp_CT.dat
.\TESS Models\SampleCatalogData\GeothermalHeatPump\Samp_H.dat
.\TESS Models\SampleCatalogData\GeothermalHeatPump\Samp_HT.dat

TYPE 556: DETAILED BURIED PIPE

PARAMETERS

Parameter Number	Name	Unit	Typical Value	Comment
1	Length of buried pipe	m	10.0	The length of buried horizontal pipe.
2	Number of horizontal nodes	-	10	The number of nodes that the horizontal pipe will be broken into in the horizontal direction for the finite difference calculations. Increasing the number of horizontal nodes will increase the accuracy at the expense of simulation time. Changing this parameter may necessitate a change to the last parameter, the number of internal iterations per time step.
3	Number of radial nodes	-	2	The number of nodes in the radial direction for the finite difference calculations (2 nodes = hemispherical calculations). Increasing the number of radial nodes will increase the accuracy at the expense of simulation time. Changing this parameter may necessitate a change to the last parameter, the number of internal iterations per time step.
4	Number of soil nodes	-	4	The number of soil nodes. The soil nodes are cylindrical in shape along the pipe axis. Increasing the number of soil nodes will increase the accuracy of the calculations at the expense of simulation time. Changing the number of soil nodes may also necessitate a change to the last parameter; the number of internal iterations per time step.
5	Buried pipe depth	m	1.0	The depth at which the horizontal pipe is buried. The depth should be measured from the surface to the center of the pipe.
6	Inner radius of pipe	m	0.0254	The inner radius of the pipe containing the working fluid.
7	Outer radius of pipe	m	0.03	The outer radius of the pipe containing the working fluid.
8	Radius of backfill material	m	0.3048	The outer radius of the backfill material. This radius is also the radius of the trench that was dug in the soil to hold the pipe.
9	Farfield radius	m	2.4384	The farfield radius. This radius is the distance away from the buried pipe that the earth temperature will remain undisturbed over the length of the simulation.
 based on PAR 4	Radial distance of each node	m	0.00	The radial distance that each specified soil node is away from the outer edge of the buried pipe. The first node must be touching the edge of the pipe (=0.0). Typically, the internodal distance increases exponentially. For example, a 5 node distribution may be: 0.0 0.0254 0.058 0.3084 2.4384
10+PAR(4)	Density of pipe material	kg/m^3	770.0	The density of the buried pipe.
11+PAR(4)	Density of backfill	kg/m^3	2400.0	The density of the material that was used to backfill around the horizontal buried pipe.
12+PAR(4)	Density of soil	kg/m^3	3200.0	The density of the soil in which the horizontal pipe is buried.
13+PAR(4)	Density of fluid	kg/m^3	1000.0	The density of the working fluid flowing through the horizontal buried pipe.
14+PAR(4)	Specific heat of pipe	kJ/kg-K	0.64	The specific heat of the buried pipe.

	material			
15+PAR(4)	Specific heat of backfill	kJ/kg-K	0.84	The specific heat of the material used to backfill the buried horizontal pipe.
16+PAR(4)	Specific heat of soil	kJ/kg-K	0.84	The specific heat of the soil in which the horizontal pipe is buried.
17+PAR(4)	Specific heat of fluid	kJ/kg-K	4.19	The specific heat of the working fluid flowing through the buried pipe.
18+PAR(4)	Thermal conductivity of pipe material	kJ/hr-m.K	6.96	The thermal conductivity of the horizontal buried pipe.
19+PAR(4)	Thermal conductivity of backfill	kJ/hr-m.K	8.72	The thermal conductivity of the material that was used to backfill the horizontal buried pipe.
20+PAR(4)	Thermal conductivity of soil	kJ/hr-m.K	8.72	The thermal conductivity of the soil in which the horizontal pipe is buried.
21+PAR(4)	Flow convection coefficient	kJ/hr-m^2-K	5000.0	The convection coefficient between the fluid and the pipe wall during flow conditions.
22+PAR(4)	No-flow convection coefficient	kJ/hr-m^2-K	500.0	The convection coefficient between the fluid and the pipe wall during no-flow conditions.
23+PAR(4)	Average surface temperature	C	20.0	The average surface temperature during the year. This temperature will be used as the deep earth temperature for the calculations.
24+PAR(4)	Amplitude of surface temperature	deltaC	9.0	The difference in temperature between the maximum surface temperature and the average surface temperature.
25+PAR(4)	Day of minimum surface temperature	day	32	The day of the year in which the minimum surface temperature occurs.
26+PAR(4)	Number of internal iterations	-	20	Because of the finite difference scheme used in the calculations, the critical time step for this component is typically less than the TRNSYS time step. Therefore, this component must be called N times internally per TRNSYS time step in order to solve the calculations. This parameter is dependent on the values of parameters 2,3 and 4 (the node parameters). If the user gets an error message about solution problems in this type, increase this value and re-run the simulations.

INPUTS

Parameter Number	Name	Unit	Typical Value	Comment
1	Inlet fluid temperature	C	15.0	The temperature of the fluid flowing into the buried horizontal pipe.
2	Inlet fluid flow rate	kg/hr	100.0	The flow rate of fluid into the buried horizontal pipe.
3	Run-time fraction	-	1.0	The fraction of time that the fluid flows through the ground heat exchanger during the time step. For simulations that are in temperature level control, this fraction should be always set to a constant of 1.0. Only when operating in energy rate control should the run-time fraction be used as a value other than 1.0.

OUTPUTS

Output Number	Name	Unit	Comment
1	Outlet fluid temperature	C	The temperature of the fluid exiting the buried horizontal pipe.
2	Outlet fluid flow rate	kg/hr	The flow rate of fluid exiting the buried horizontal pipe.
3	Fluid temperature at half-way point	C	The temperature of the fluid at the halfway point in the buried horizontal pipe.
4	Undisturbed ground temperature	C	The temperature of the undisturbed soil at the same depth as the buried horizontal pipe.
5	Heat transfer to the ground	kJ/hr	The heat transfer to the ground during flow through the horizontal buried pipe.

TYPE 557: VERTICAL U-TUBE GROUND HEAT EXCHANGER

PARAMETERS

Parameter Number	Name	Unit	Typical Value	Comment
1	Storage volume	m^3	4000.0	The volume of the cylindrically shaped storage region that contains the boreholes. The boreholes will be placed uniformly within the storage volume The properties of the ground within the storage volume are considered uniform while the properties of the ground outside the storage volume may be described for several vertical layers. If the spacing between boreholes is known, the storage volume can be calculated from the relationship: Storage Volume = π * Number of Boreholes * Borehole Depth * (0.525 * Borehole Spacing)^2
2	Borehole depth	m	100.0	The depth of one borehole (from the surface). This depth is also considered the height of the storage volume for determining the cross-sectional storage area. This value is also the length of one of the u-tube heat exchangers from the ground surface to the bottom of the u-tube bend.
3	Header depth	m	1.0	The depth below the surface of the top of the u-tube ground heat exchangers. This value is also typically the depth below the surface of the horizontal header pipe that feeds the ground heat exchangers.
4	Number of boreholes	-	2	The total number of boreholes within the storage volume. If each borehole contains one U-tube ground heat exchanger (which is the most common application here in the U.S.) then this value is also the number of U-tube ground heat exchangers.
5	Borehole radius	m	0.1016	The radius of one of the identical boreholes (the holes that were drilled for the heat exchangers).
6	Number of boreholes in series	-	1	The number of boreholes that are connected in series per parallel loop. The flow rate per heat exchanger is then the total flow rate times the number of boreholes in series divided by the total number of boreholes.
7	Number of radial regions	-	1	The number of radial subregions that the storage volume will be divided into for the calculation of the local solution. The number of radial subregions must be less than or equal to the number of boreholes connected in series.
8	Number of vertical regions	-	10	The number of vertical subregions of the storage volume for the computation of the local solution. The number of vertical subregions times the number of radial subregions must be less than 121 or an error will be generated.
9	Storage thermal conductivity	kJ/hr-m-K	4.68	The thermal conductivity of the ground comprising the storage volume. The properties of the ground are assumed uniform within the storage volume but can be specified later for ground layers beyond the storage volume boundary.
10	Storage heat capacity	kJ/m^3-K	2016.0	The heat capacity (density * specific heat) of the ground comprising the storage volume. The properties of the soil

				within the storage volume are considered uniform. The properties of the soil past the boundary of the storage volume can be specified for vertical layers later in the parameter description.
11	Mode	-	-1	≥ 0: Thermal resistance between the fluid in the pipes and the ground at the borehole wall per unit of borehole length [K-h-m/kJ] -10 ≤ MODE ≤ -1, -MODE is the number of U-tubes per borehole and the thermal resistance will be calculated using the next nine parameters. -11: Concentric tube ground heat exchangers. The thermal resistance will be calculated using the next nine parameters. ≤ -12: Flow and temperature dependent thermal resistances will be read from a file which has been ASSIGNed to logical unit (-MODE)
If PAR(11) > 0		Z = 0		
If -10 < PAR(11) < 0		Z = 9		
12	Outer radius of u-tube pipe	m	0.01664	The outer radius of the pipe comprising the U-tube ground heat exchanger.
13	Inner radius of u-tube pipe	m	0.01372	The inner radius of the pipe comprising the U-tube ground heat exchanger.
14	Center-to-center half distance	m	0.0254	One half the horizontal distance from the center of the downward flowing U-tube pipe to the center of the upward flowing U-tube pipe (same borehole). This value is also called the half shank spacing.
15	Fill thermal conductivity	kJ/hr-m-K	4.68	The thermal conductivity of the material used to fill the borehole after the U-tube ground heat exchanger has been installed.
16	Pipe thermal conductivity	kJ/hr-m-K	1.5122	The thermal conductivity of the material comprising the U-tube ground heat exchanger pipes.
17	Gap thermal conductivity	kJ/hr-m-K	5.040	The thermal conductivity of the material in the gap between the U-tube pipes and the fill material. The gaps are usually air or water depending on the water table and other factors.
18	Gap thickness	m	0.0	The thickness of the gap between the U-tube pipes and the fill material.
19	Reference borehole flow rate	kg/hr	613.04	The reference fluid flow rate per borehole for the calculation of the fluid to ground thermal resistance (borehole thermal resistance). This parameter is very important and should correspond to the expected borehole flow rate during operation.
20	Reference temperature	C	30.0	The reference fluid temperature for the calculation of the fluid to ground thermal resistance.
If PAR(11) = -11		Z = 9		
12	Outer radius of inner pipe	m	0.01664	The outer radius of the inner pipe comprising the tube in tube ground heat exchanger.
13	Inner radius of inner pipe	m	0.01372	The inner radius of the inner pipe comprising the tube in tube ground heat exchanger.
14	Inner radius of outer pipe	m	0.0254	The inner radius of the outer pipe comprising the tube in tube ground heat exchanger.
15	Fill thermal conductivity	kJ/hr-m-K	4.68	The thermal conductivity of the material used to fill the borehole after the U-tube ground heat exchanger has been installed.

16	Pipe thermal conductivity	kJ/hr-m-K	1.5122	The thermal conductivity of the material comprising the U-tube ground heat exchanger pipes.
17	Gap thermal conductivity	kJ/hr-m-K	5.040	The thermal conductivity of the material in the gap between the U-tube pipes and the fill material. The gaps are usually air or water depending on the water table and other factors.
18	Gap thickness	m	0.0	The thickness of the gap between the U-tube pipes and the fill material.
19	Reference borehole flow rate	kg/hr	613.04	The reference fluid flow rate per borehole for the calculation of the fluid to ground thermal resistance (borehole thermal resistance). This parameter is very important and should correspond to the expected borehole flow rate during operation.
20	Reference temperature	C	30.0	The reference fluid temperature for the calculation of the fluid to ground thermal resistance.
If PAR(11) < -12		Z = 0		
12+z	Pipe to pipe heat transfer	-	-1	Indicator for calculation of heat transfer between upward and downward fluid. The sign of this PARAMETER indicates whether the ground heat exchanger is a U-tube or a concentric tube. The heat transfer is calculated using the nine preceding parameters if PAR(11) is calculated using the nine preceding parameters. Otherwise, the absolute value of this parameter is the thermal resistance between the upward and downward fluid in the pipes per unit of borehole length. [h-m-K/kJ] > 0: Concentric tube ground heat exchanger = 0: The heat transfer between the upward and downward fluid is not taken into account. < 0: U-tube ground heat exchanger. If PAR(11) ≥ 0, The absolute value of PAR(12+z) is the thermal resistance between the upward and downward fluid in the pipes. If -11 ≤ PAR(11) ≤ -1: The thermal resistance between the upward and downward fluid in the pipes is calculated using the previous nine parameters. If PAR(11) ≤ -12: Flow and temperature dependent thermal resistance between the upward and downward fluid in the pipes will be read from a file which has been ASSIGNed to logical unit –PAR(11)
13+z	Fluid specific heat	kJ/kg-K	4.190	The specific heat of the fluid flowing through the ground heat exchanger pipes.
14+z	Fluid density	kg/m^3	1000.0	The density of the fluid flowing through the ground heat exchanger pipes.
15+z	Insulation indicator	-	0	An indicator for the placement of thermal insulation on the boundaries of the storage volume. 0 = No insulation 1 = Insulation on the upper side of the cylindrical storage volume. The upper user-specified fraction of the storage height (next parameter) is covered with thermal insulation. 2 = Insulation on the top of the storage volume that extends a user-specified fraction of the storage height (next parameter) beyond the boundary of the storage volume.
16+z	Insulation height fraction	-	0.5	The fraction of the height of the storage volume that is insulated (if previous parameter=1) or the fraction of the

				height of the storage volume that the insulation on top of the storage extends beyond the boundary of the storage volume (previous parameter=2).
17+z	Insulation thickness	m	0.0254	The thickness of the insulation
18+z	Insulation thermal conductivity	kJ/hr-m-K	1.0	The thermal conductivity of the insulation on the top and sides of the storage volume (if specified).
19+z	Number of simulation years	-	1	The length in years of the simulation to be performed. This value should include the number of years of preheating used to heat up the surrounding ground. This parameter is used to determine the mesh extension for the finite difference calculations.
20+z	Maximum storage temperature	C	100.0	The maximum temperature of the fluid entering the ground heat exchangers.
21+z	Initial surface temperature	C	20.0	The initial temperature of the surface of the undisturbed ground past the boundary of the storage volume.
22+z	Initial thermal gradient	C/m	0.0	The initial thermal gradient in the undisturbed ground outside the storage volume boundary.
23+z	Number of preheating years	-	0	The number of preheating years run before the simulation begins (0 = no preheating). During preheating, a sinusoidal yearly variation of the average storage volume temperature is used to heat up the ground surrounding the storage volume.
24+z	Maximum preheat temperature	C	30.0	The maximum temperature (average) of the storage volume ground for preheating calculations. This temperature is used in a sinusoidal calculation to preheat the soil surrounding the storage volume. This parameter is also used in the calculation to set the initial temperature of the storage volume ground at the beginning of the simulation. See the description of the phase delay parameter for more information on the initial storage temperature.
25+z	Minimum preheat temperature	C	10.0	The minimum temperature (average) of the storage volume ground for preheating calculations. This temperature is used in a sinusoidal calculation to preheat the ground surrounding the storage volume. This parameter is also used in the calculation to determine the initial temperature of the storage volume ground. Refer to the description of the preheating phase delay for more information on the initial storage volume temperature.
26+z	Preheat phase delay	day	90	The phase delay in the preheating sinusoidal temperature curve. This phase delay is simply 90 minus the day of maximum storage temperature, or 270 minus the day of minimum storage temperature.
27+z	Average air temperature	C	20.0	The yearly average air temperature for preheating calculations. The average air temperature is used to calculate the air temperature as a function of time. The air temperature (and storage temperature) variation throughout the preheat years are used to calculate the temperature of the ground past the storage volume boundary at the beginning of the simulation.
28+z	Amplitude of air temperature	deltaC	15.0	The amplitude of the air temperature over the year. This parameter is used to calculate the air temperature as a function of time. The air temperature and the average storage temperature (both as a function of time) are used to calculate the temperature of the ground outside the storage volume

				boundary at the beginning of the simulation.
29+z	Air temperature phase delay	day	240	The phase delay in air temperature for the preheating calculations. The delay can be simply calculated as the 90 minus the day of the maximum air temperature or 270 minus the day of minimum air temperature.
30+z	Number of ground layers	-	1	The number of unique vertical soil layers that comprise the ground outside the boundary of the storage volume (the storage volume soil is assumed uniform). For each layer, the user must specify the thermal conductivity, heat capacity, and layer thickness.
Cycle	Thermal conductivity of each layer	kJ/hr-m-K	4.68	The thermal conductivity of each vertical layer at the outside boundary of the storage volume.
	Heat capacity of each layer	kJ/m^3-K	2016.0	The volumetric heat capacitance of each vertical soil layer at the outside boundary of the storage volume.
	Thickness of each layer	m	1000.0	The thickness of each vertical soil layer at the outside boundary of the storage volume.
31 + z + 3*PAR(8)	Not used (printing 1)	-	0	
32 + z + 3*PAR(8)	Not used (printing 2)	-	0	

INPUTS

Parameter Number	Name	Unit	Typical Value	Comment
1	Inlet fluid temperature	C	20.0	The temperature of the fluid entering the ground heat exchangers.
2	Inlet flow rate (total)	kg/hr	0.0	The flow rate of fluid (total, not per borehole) entering the ground heat exchangers.
3	Temperature on top of storage	C	20.0	The temperature of the air directly above the storage volume. In most cases, this is the ambient temperature. In some cases (like the storage volume being located beneath an asphalt parking lot) this temperature must be calculated and passed to this model.
4	Air temperature	C	20.0	The ambient temperature.
5	Circulation switch	-	1	This input determines how the fluid is circulated through the boreholes. 1 = Circulate from center to border of storage volume -1 = Circulate from border to center This input should only be used when multiple boreholes are connected in series and when the flow direction through the boreholes is changed depending on operation. For most geothermal applications, this input should be set to a constant value of 1. If however, a radial stratification of the ground is desired (such as heat storage), the fluid should circulate from the center to the border in heat injection (=1) and from the border to the center during heat abstraction (= -1).

OUTPUTS

Output Number	Name	Unit	Comment
1	Outlet temperature	C	The outlet fluid temperature from the ground heat exchangers.
2	Outlet flow rate (total)	kg/hr	The flow rate of fluid leaving the ground heat exchangers (total, not per borehole).
3	Average storage temperature	C	The average temperature of the ground in the storage volume.
4	Average heat transfer rate	kJ/hr	The rate at which heat is added to the storage volume ground from the fluid.
5	Heat loss through top of storage	kJ/hr	The rate at which heat is lost to the ambient through the top of the storage volume.
6	Heat loss through side of storage	kJ/hr	The rate at which heat is lost from the sides of the storage volume to the surrounding ground.
7	Heat loss through bottom of storage	kJ/hr	The rate at which heat is lost from the bottom of the storage volume to the ground layer beneath the storage.
8	Internal energy variation	kJ/hr	Storage internal energy variation during the last time step.

GREEN BUILDING COMPONENTS

Green Building Components

TYPE 551: PV ARRAY SHADING

PARAMETERS

Parameter Number	Name	Unit	Typical Value	Comment
1	Array configuration	-	1	1: rows are oriented in a generally horizontal manner 2: rows are oriented in a generally vertical manner
2	Row height	m	2.0	The height (measured along the slope) of a row.
3	Row width	m	20.0	The width of a row.
4	Row slope	degrees	45	The slope of the row (measured from the horizontal plane)
5	Row separation	m	2	The distance between the base of one row and the base of the next (measured along the horizontal)
6	Array azimuth	degrees	0.0	The azimuth of the array
7	Field slope	degrees	5.0	The slope of the plane on which the rows are arranged.

INPUTS

Input Number	Name	Unit	Typical Value	Comment
1	Unshaded diffuse radiation on row slope	kJ/m^2-hr	0.0	Diffuse radiation incident on an unshaded module
2	Beam radiation on row slope	kJ/m^2-hr	0.0	Beam radiation incident on an unshaded module
3	Solar zenith	degrees	90.0	Solar zenith angle
4	Solar azimuth	degrees	-90.0	Solar azimuth angle
5	Total horizontal radiation	kJ/m^2-hr	0.0	Total radiation on the horizontal
6	Horizontal diffuse radiation	kJ/m^2-hr	0.0	Diffuse radiation on the horizontal
7	Beam radiation on array field	kJ/m^2-hr	0.0	Beam radiation incident on the plane of the array field.
8	Ground reflectance	-	0.7	Ground reflectance

OUTPUTS

Output Number	Name	Unit	Comment
1	Total unshaded radiation	kJ/m^2-hr	Total radiation on an unshaded row – including ground reflectance effects.
2	Unshaded beam radiation	kJ/m^2-hr	Beam radiation on an unshaded row.
3	Unshaded diffuse radiation	kJ/m2-hr	Diffuse radiation on an unshaded row.

4	Linearly shaded total radiation	kJ/m^2-hr	Total radiation on a shaded row (including ground reflectance) and assuming linear shading effects of beam radiation.
5	Linearly shaded beam radiation	kJ/m^2-hr	Beam radiation on a shaded row assuming linear shading effects.
6	Linearly shaded diffuse radiation	kJ/m^2-hr	Diffuse radiation on a shaded row assuming linear shading effects.
7	Conservative total radiation estimate	kJ/m^2-hr	Total radiation on a shaded row (including ground reflectance) and using the conservative shading effect assumption.
8	Conservative beam radiation estimate	kJ/m^2-hr	Beam radiation on a shaded row using the conservative shading effect assumption.
9	Conservative diffuse radiation estimate	kJ/m^2-hr	Diffuse radiation on a shaded row using the conservative shading effect assumption.

TYPE 560: COMBINED PV / THERMAL SOLAR COLLECTOR (INTERACTS WITH ZONE AIR TEMPERATURE)

PARAMETERS

Parameter Number	Name	Unit	Typical Value	Comment
1	Length	m	1.0	The length of the collector (direction along the tubes).
2	Width	m	1.0	The width of the collector (direction across the tubes).
3	Absorber thickness	m	0.0005	The thickness of the absorber plate (the plate bonded to the tubes).
4	Thermal conductivity of the absorber	kJ/h-m-K	1386.	The thermal conductivity of the absorber plate (the plate bonded to the tubes).
5	Number of tubes	-	10	The number of identical fluid tubes bonded to the absorber plate.
6	Tube diameter	m	0.01	The diameter of the fluid tubes bonded to the absorber plate.
7	Bond width	m	0.01	The average width of the bond between the tube and the absorber plate.
8	Bond thickness	m	0.001	The average thickness of the bond between the tube and the absorber plate.
9	Bond thermal conductivity	kJ/h-m-K	1386.	The thermal conductivity of the bond between the absorber plate and the tubes.
10	Resistance of substrate material	$h\text{-}m^2\text{-}K/kJ$	0.01	The resistance to heat transfer of the material located between the PV cells and the absorber plate (adhesive, substrate etc.).
11	Resistance of back material	$h\text{-}m^2\text{-}K/kJ$	3.0	The resistance to heat transfer for the back of the collector (material(s) located between the absorber plate and the back-side air)
12	Fluid specific heat	kJ/kg-K	4.190	The specific heat of the fluid flowing through the solar collector.
13	Reflectance	-	0.15	The overall reflectance of the collector surface at normal incidence. The transmittance-absorptance product at normal incidence is found by subtracting this value from 1.
14	Emissivity	-	0.9	The emissivity of the collector surface for long-wave radiation exchange with the sky.
15	1^{st} order IAM	-	0.1	1^{st} order coefficient in the IAM function (b_0).
16	PV cell reference temperature	C	20.0	The reference temperature at which the efficiency of the PV cell is provided..
17	PV cell reference radiation	$kJ/h\text{-}m^2$	3600.0	The reference total incident solar radiation at which the efficiency of the PV cell is provided..
18	PV efficiency at reference condition	-	0.12	The efficiency of the PV cells in converting incident radiation to electricity at the provided reference conditions.
19	Efficiency modifier - temperature	1/C	-0.005	The multiplier to correct the rated PV cell efficiency as a function of cell temperature
20	Efficiency modifier - radiation	$h\text{-}m^2/kJ$	0.000025	The multiplier to correct the rated PV cell efficiency as a function of incident solar radiation

INPUTS

Input Number	Name	Unit	Typical Value	Comment
1	Inlet temperature	C	20.0	The temperature of the fluid entering the collector at the flow inlet.
2	Inlet flow rate	kg/hr	200.0	The flow rate of fluid entering the collector at the fluid inlet.
3	Ambient temperature	C	20.0	The temperature of the environment for calculating losses from the collector surfaces (top and back).
4	Sky temperature	C	20.0	The temperature of the sky for calculating long-wave radiation losses from the collector surface.
5	Back-surface environment temperature	C	20.0	The temperature of the air located behind the back surface of the collector.
6	Incident solar radiation	kJ/hr-m^2	0.0	The rate at which incident solar radiation (beam + diffuse) strikes the sloped collector surface.
7	Total horizontal radiation	kJ/hr-m^2	0.0	The rate at which total solar radiation (beam + diffuse) strikes a horizontal surface.
8	Horizontal diffuse radiation	kJ/hr-m^2	0.0	The rate at which diffuse radiation strikes a horizontal surface.
9	Ground reflectance	-	0.2	The reflectance to solar radiation of the surface upon which the collector is located.
10	Incidence angle	degrees	0.0	The angle of incidence between beam solar radiation and the sloped collector surface.
11	Collector slope	degrees	45.0	The slope of the collector surface of the ICS enclosure (0=horizontal, 90=vertical facing the azimuth).
12	Top loss convection coefficient	kJ/hr-m^2-K	20.0	The convective heat loss coefficient from the top of the collector to the ambient (does not include radiative losses).
13	Back loss coefficient	kJ/hr-m^2-K	20.0	The loss coefficient from the back of the collector to the ambient (includes radiative losses).
14	Fluid heat transfer coefficient	kJ/hr-m^2-K	200.0	The heat transfer coefficient from the fluid in the flow channels to the walls of the fluid channel enclosure.

OUTPUTS

Output Number	Name	Unit	Comment
1	Temperature at outlet	C	The temperature of the fluid exiting the collector.
2	Flow rate at outlet	kg/hr	The flow rate of fluid exiting the collector.
3	Useful energy gain	kJ/hr	The net rate at which energy is transferred to the fluid flowing through the solar collector.
4	PV power	kJ/hr	The rate at which the photovoltaic cells are producing electrical power.
5	PV efficiency	-	The efficiency of the PV cells in converting incident solar radiation to electrical energy; expressed as a fraction.
6	Thermal efficiency	-	The efficiency of the solar collector in converting incident solar radiation to delivered fluid energy.
7	Collector F_R	-	The calculated collector heat removal factor.
8	Mean PV	C	The temperature of the PV cells.

	temperature		
9	Mean fluid temperature	C	The mean temperature of the fluid in the solar collector.
10	Overall IAM	-	The overall (beam plus diffuse) incidence angle modifier for the collector.
11	Collector top losses - convective	kJ/hr	The rate at which energy is lost to the environment through convection from the top surface of the collector.
12	Collector top losses - radiative	kJ/hr	The rate at which energy is lost to the environment through radiation losses from the top surface of the collector.
13	Back losses	kJ/hr	The rate at which energy is lost to the environment through the back surface of the collector.
14	Absorbed solar radiation	kJ/hr	The net rate at which solar radiation is absorbed by the collector. This value does not include the radiation that was absorbed by the PV cells and converted to electrical energy.
15	Collector U_L	kJ/hr-m^2-K	The calculated overall loss coefficient for this collector.
16	$F_R\tau\alpha_N$	-	The intercept term for the collector efficiency equation.
17	F_RU_L	kJ/hr-m^2-K	The linear term for the collector efficiency equation.

TYPE 562: SIMPLE GLAZED OR UNGLAZED PHOTOVOLTAIC ARRAY

PARAMETERS

Parameter Number	Name	Unit	Typical Value	Comment
1	PV Efficiency Mode	-	1	The mode defining how the PV efficiency should be calculated by the model: 1 = Constant PV efficiency 2 = Linear modifiers for off-rated cell temperature and incident radiation 3 = Efficiency provided as an INPUT to the model 4 = User-provided data file of PV efficiency as a function of cell temperature and incident radiation
2	Cover mode	-	1	This parameter indicates whether the PV system has a transparent cover: 0 = No cover, 1 = Covered
3	Area	m^2	1.0	The area of the PV array; consistent with the provided efficiency parameters and inputs
4	Resistance of back material	$h.m^2.K/kJ$	3.0	The resistance to heat transfer for the back of the collector (material(s) located between the absorber plate and the upper surface of the roof)
5	Top emissivity	0..1	0.9	The emissivity of the outer surface for long-wave radiation exchange with the sky.
6	Back emissivity	0..1	0.9	The emissivity of the collector back surface for long-wave radiation exchange with the zone.
7	Absorptance	0..1	0.9	The absorptance of the PV surface for solar radiation.
PV Efficiency Mode 1 (constant PV efficiency) and Cover Mode 0 (uncovered PV)				
8	PV efficiency	0..1	0.12	The efficiency of the PV cells in converting absorbed solar radiation to electrical energy.
PV Efficiency Mode 1 (constant PV efficiency) and Cover Mode 1 (covered PV)				
8	PV efficiency	0..1	0.12	The efficiency of the PV cells in converting absorbed solar radiation to electrical energy.
9	Cover refractive index	-	1.562	The index of refraction of the transparent cover material. Glass=1.526, Polycarbonate=1.60, Polyvinylflouride=1.45,
10	Cover conductivity	kJ/hr-m-K	5.04	The thermal conductivity of the transparent glazing acting as a cover for the PV system.
11	Cover thickness	m	0.006	The thickness of the transparent cover material.
12	Cover extinction coefficient	m^{-1}	4	The extinction coefficient for the transparent glazing material. The extinction coefficient for glass ranges from 4 for "milky white glass" to 32 for poor glass ("greenish").
PV Efficiency Mode 2 (PV efficiency modifiers) and Cover Mode 0 (uncovered PV)				
8	Reference PV efficiency	0..1	0.12	The efficiency of the PV cells in converting incident radiation to electricity at the provided reference conditions.
9	Reference temperature	C	25.0	The reference temperature at which the efficiency of the PV cell is provided.
10	Reference radiation	$kJ/hr.m^2$	3600.0	The reference total incident solar radiation at which the efficiency of the PV cell is provided.
11	Efficiency modifier -	1/C	-0.005	The multiplier to correct the rated PV cell efficiency as a

	temperature			function of cell temperature. Efficiency = Nominal Efficiency * Xt*Xr where Xt = 1 + this parameter*(Tpv-Treference)
12	Efficiency modifier - radiation	hr-m^2/kJ	0.000025	The multiplier to correct the rated PV cell efficiency as a function of incident solar radiation. Efficiency = Nominal Efficiency * Xt*Xr where Xr = 1 + this parameter*(Incident solar-Incident solar at reference condition)
PV Efficiency Mode 2 (PV efficiency modifiers) and Cover Mode 1 (covered PV)				
8	Reference PV efficiency	0..1	0.12	The efficiency of the PV cells in converting incident radiation to electricity at the provided reference conditions.
9	Reference temperature	C	25.0	The reference temperature at which the efficiency of the PV cell is provided.
10	Reference radiation	kJ/hr.m^2	3600.0	The reference total incident solar radiation at which the efficiency of the PV cell is provided.
11	Efficiency modifier - temperature	1/C	-0.005	The multiplier to correct the rated PV cell efficiency as a function of cell temperature. Efficiency = Nominal Efficiency * Xt*Xr where Xt = 1 + this parameter*(T_{pv}-$T_{reference}$)
12	Efficiency modifier - radiation	hr-m^2/kJ	0.000025	The multiplier to correct the rated PV cell efficiency as a function of incident solar radiation. Efficiency = Nominal Efficiency * Xt*Xr where Xr = 1 + this parameter*(Incident solar-Incident solar at reference condition)
13	Cover refractive index	-	1.562	The index of refraction of the transparent cover material. Glass=1.526, Polycarbonate=1.60, Polyvinylflouride=1.45,
14	Cover conductivity	kJ/hr-m-K	5.04	The thermal conductivity of the transparent glazing acting as a cover for the PV system.
15	Cover thickness	m	0.006	The thickness of the transparent cover material.
16	Cover extinction coefficient	m^{-1}	4	The extinction coefficient for the transparent glazing material. The extinction coefficient for glass ranges from 4 for "milky white glass" to 32 for poor glass ("greenish").
PV Efficiency Mode 3 (input PV efficiency) and Cover Mode 0 (uncovered PV) – no more PARAMETERS required.				
PV Efficiency Mode 3 (input PV efficiency) and Cover Mode 1 (covered PV)				
8	Cover refractive index	-	1.562	The index of refraction of the transparent cover material. Glass=1.526, Polycarbonate=1.60, Polyvinylflouride=1.45,
9	Cover conductivity	kJ/hr-m-K	5.04	The thermal conductivity of the transparent glazing acting as a cover for the PV system.
10	Cover thickness	m	0.006	The thickness of the transparent cover material.
11	Cover extinction coefficient	m^{-1}	4	The extinction coefficient for the transparent glazing material. The extinction coefficient for glass ranges from 4 for "milky white glass" to 32 for poor glass ("greenish").
PV Efficiency Mode 4 (PV efficiency from file) and Cover Mode 0 (uncovered PV)				
8	Logical unit of data file	-	10	The logical unit which has been ASSIGNed to the external data file containing the PV efficiency as a function of the cell temperature and incident radiation.
9	Number of temperature points	-	21	The number of PV cell temperatures for which PV efficiency is provided in the external data file.
10	Number of radiation points	-	2	The number of incident solar radiation values for which PV efficiency is provided in the external data file.
PV Efficiency Mode 4 (PV efficiency from file) and Cover Mode 1 (covered PV)				
8	Logical unit of data file	-	10	The logical unit which has been ASSIGNed to the external data file containing the PV efficiency as a function of the

				cell temperature and incident radiation.
9	Number of temperature points	-	21	The number of PV cell temperatures for which PV efficiency is provided in the external data file.
10	Number of radiation points	-	2	The number of incident solar radiation values for which PV efficiency is provided in the external data file.
11	Cover refractive index	-	1.562	The index of refraction of the transparent cover material. Glass=1.526, Polycarbonate=1.60, Polyvinylflouride=1.45,
12	Cover conductivity	kJ/hr-m-K	5.04	The thermal conductivity of the transparent glazing acting as a cover for the PV system.
13	Cover thickness	m	0.006	The thickness of the transparent cover material.
14	Cover extinction coefficient	m^{-1}	4	The extinction coefficient for the transparent glazing material. The extinction coefficient for glass ranges from 4 for "milky white glass" to 32 for poor glass ("greenish").

INPUTS

Input Number	Name	Unit	Typical Value	Comment
1	Ambient temperature	C	20.0	The temperature of the environment for calculating losses from the collector surfaces (top and back).
2	Sky temperature	C	20.0	The temperature of the sky for calculating long-wave radiation losses from the collector surface.
3	Zone temperature	C	20.0	The temperature of the air located behind the back surface of the collector.
4	Back radiant temperature	C	20.0	The temperature of the surfaces located behind the collector. This temperature will be used for radiative loss calculations from the back surface of the collector.
5	Top heat loss coefficient	kJ/hr-m^2-K	64.0	The convective heat transfer coefficient from the cover surface to the ambient air. A commonly used correlation is hconv=3.6*(5.7+3.8* windspeed in m/s)
6	Back heat loss coefficient	kJ/hr-m^2-K	11.0	The convective heat transfer coefficient from the back surface of the collector to the zone air.
7	Incident solar radiation	kJ/hr-m^2	0.0	The rate at which incident solar radiation (beam + diffuse) strikes the sloped collector surface.
PV Efficiency Mode 1 (constant PV efficiency) , 2 (PV efficiency modifiers), and 4 (PV efficiency from file)				
8	Total horizontal radiation	kJ/hr-m^2	0.0	The rate at which total solar radiation (beam + diffuse) strikes a horizontal surface.
9	Horizontal diffuse radiation	kJ/hr-m^2	0.0	The rate at which diffuse radiation strikes a horizontal surface.
10	Ground reflectance	-	0.2	The reflectance to solar radiation of the surface upon which the collector is located.
11	Incidence angle	degrees	0.0	The angle of incidence between beam solar radiation and the sloped collector surface.
12	Collector slope	degrees	45.0	The slope of the collector surface of the ICS enclosure (0=horizontal, 90=vertical facing the azimuth).
PV Efficiency Mode 3 (input PV efficiency)				
8	PV efficiency	0..1	0.12	The efficiency of the PV cells in converting absorbed solar radiation to electrical energy.
9	Total horizontal	kJ/hr-m^2	0.0	The rate at which total solar radiation (beam + diffuse)

	radiation			strikes a horizontal surface.
10	Horizontal diffuse radiation	kJ/hr-m^2	0.0	The rate at which diffuse radiation strikes a horizontal surface.
11	Ground reflectance	-	0.2	The reflectance to solar radiation of the surface upon which the collector is located.
12	Incidence angle	degrees	0.0	The angle of incidence between beam solar radiation and the sloped collector surface.
13	Collector slope	degrees	45.0	The slope of the collector surface of the ICS enclosure (0=horizontal, 90=vertical facing the azimuth).

OUTPUTS

Output Number	Name	Unit	Comment
1	PV efficiency	-	The efficiency of the PV cells in converting incident solar radiation to electrical energy; expressed as a fraction.
2	PV power	kJ/hr	The rate at which the photovoltaic cells are producing electrical power.
3	Mean PV temperature	C	The temperature of the PV cells.
4	Back surface temperature	C	The temperature of the back surface of the collector (zone air / collector back interface).
5	Absorbed solar radiation	kJ/hr	The net rate at which solar radiation is absorbed by the collector. This value does not include the radiation that was absorbed by the PV cells and converted to electrical energy.
6	Collector top losses - convective	kJ/hr	The rate at which energy is lost to the environment through convection from the top surface of the collector.
7	Collector top losses - radiative	kJ/hr	The rate at which energy is lost to the environment through radiation losses from the top surface of the collector.
8	Collector back losses - convective	kJ/hr	The rate at which energy is convected from the back of the collector to the zone air.
9	Collector back losses - radiative	kJ/hr	The net rate at which energy is radiated from the back of the collector to the zone surfaces.

TYPE 563: COMBINED PV / THERMAL SOLAR COLLECTOR (INTERACTS WITH TYPE 56)

PARAMETERS

Parameter Number	Name	Unit	Typical Value	Comment
1	Length	m	1.0	The length of the collector (direction along the tubes).
2	Width	m	1.0	The width of the collector (direction across the tubes).
3	Absorber thickness	m	0.0005	The thickness of the absorber plate (the plate bonded to the tubes).
4	Thermal conductivity of the absorber	kJ/h.m.K	1386.	The thermal conductivity of the absorber plate (the plate bonded to the tubes).
5	Number of tubes	-	10	The number of identical fluid tubes bonded to the absorber plate.
6	Tube diameter	m	0.01	The diameter of the fluid tubes bonded to the absorber plate.
7	Bond width	m	0.01	The average width of the bond between the tube and the absorber plate.
8	Bond thickness	m	0.001	The average thickness of the bond between the tube and the absorber plate.
9	Bond thermal conductivity	kJ/h.m.K	1386.	The thermal conductivity of the bond between the absorber plate and the tubes.
10	Resistance of substrate material	$h.m^2.K/kJ$	0.01	The resistance to heat transfer of the material located between the PV cells and the absorber plate (adhesive, substrate etc.).
11	Resistance of back material	$h.m^2.K/kJ$	3.0	The resistance to heat transfer for the back of the collector (material(s) located between the absorber plate and the upper surface of the roof)
12	U-value of roof material	$h.m^2.K/kJ$	0.677	The conductance (U-value) of the surface on which the collector is directly mounted (usually the roof). This should include only the material(s) located between the back of the collector and the zone air and should not include the convective or radiative effects at the inside surface of the roof)
13	Fluid specific heat	kJ/kg.K	4.190	The specific heat of the fluid flowing through the solar collector.
14	Reflectance	-	0.15	The overall reflectance of the collector surface at normal incidence. The transmittance-absorptance product at normal incidence is found by subtracting this value from 1.
15	Emissivity	-	0.9	The emissivity of the collector surface for long-wave radiation exchange with the sky.
16	1^{st} order IAM	-	0.1	1^{st} order coefficient in the IAM function (b_0).
17	PV cell reference temperature	C	20.0	The reference temperature at which the efficiency of the PV cell is provided..
18	PV cell reference radiation	kJ/h.m2	3600.0	The reference total incident solar radiation at which the efficiency of the PV cell is provided..
19	PV efficiency at reference condition	-	0.12	The efficiency of the PV cells in converting incident radiation to electricity at the provided reference conditions..

20	Efficiency modifier - temperature	1/C	-0.005	The multiplier to correct the rated PV cell efficiency as a function of cell temperature
21	Efficiency modifier - radiation	h.m2/kJ	0.000025	The multiplier to correct the rated PV cell efficiency as a function of incident solar radiation

INPUTS

Input Number	Name	Unit	Typical Value	Comment
1	Inlet temperature	C	20.0	The temperature of the fluid entering the collector at the flow inlet.
2	Inlet flow rate	kg/hr	200.0	The flow rate of fluid entering the collector at the fluid inlet.
3	Ambient temperature	C	20.0	The temperature of the environment for calculating losses from the collector surfaces (top and back).
4	Sky temperature	C	20.0	The temperature of the sky for calculating long-wave radiation losses from the collector surface.
5	Back-surface temperature	C	20.0	The temperature of the air located behind the back surface of the collector.
6	Incident solar radiation	kJ/hr-m^2	0.0	The rate at which incident solar radiation (beam + diffuse) strikes the sloped collector surface.
7	Total horizontal radiation	kJ/hr-m^2	0.0	The rate at which total solar radiation (beam + diffuse) strikes a horizontal surface.
8	Horizontal diffuse radiation	kJ/hr-m^2	0.0	The rate at which diffuse radiation strikes a horizontal surface.
9	Ground reflectance	-	0.2	The reflectance to solar radiation of the surface upon which the collector is located.
10	Incidence angle	degrees	0.0	The angle of incidence between beam solar radiation and the sloped collector surface.
11	Collector slope	degrees	45.0	The slope of the collector surface of the ICS enclosure (0=horizontal, 90=vertical facing the azimuth).
12	Top loss convection coefficient	kJ/hr-m^2-K	20.0	The convective heat loss coefficient from the top of the collector to the ambient (does not include radiative losses).
13	Fluid heat transfer coefficient	kJ/hr-m^2-K	200.0	The heat transfer coefficient from the fluid in the flow channels to the walls of the fluid channel enclosure.

OUTPUTS

Output Number	Name	Unit	Comment
1	Temperature at outlet	C	The temperature of the fluid exiting the collector.
2	Flow rate at outlet	kg/hr	The flow rate of fluid exiting the collector.
3	Useful energy gain	kJ/hr	The net rate at which energy is transferred to the fluid flowing through the solar collector.
4	PV power	kJ/hr	The rate at which the photovoltaic cells are producing electrical power.
5	PV efficiency	-	The efficiency of the PV cells in converting incident solar radiation to electrical energy; expressed as a fraction.
6	Thermal efficiency	-	The efficiency of the solar collector in converting incident solar

			radiation to delivered fluid energy.
7	Collector F_R	-	The calculated collector heat removal factor.
8	Mean PV temperature	C	The temperature of the PV cells.
9	Mean fluid temperature	C	The mean temperature of the fluid in the solar collector.
10	Overall IAM	-	The overall (beam plus diffuse) incidence angle modifier for the collector.
11	Collector top losses - convective	kJ/hr	The rate at which energy is lost to the environment through convection from the top surface of the collector.
12	Collector top losses - radiative	kJ/hr	The rate at which energy is lost to the environment through radiation losses from the top surface of the collector.
13	Back losses	kJ/hr	The rate at which energy is lost to the environment through the back surface of the collector.
14	Absorbed solar radiation	kJ/hr	The net rate at which solar radiation is absorbed by the collector. This value does not include the radiation that was absorbed by the PV cells and converted to electrical energy.
15	Collector U_L	kJ/hr-m^2-K	The calculated overall loss coefficient for this collector.
16	$F_R\tau\alpha_N$	-	The intercept term for the collector efficiency equation.
17	F_RU_L	kJ/hr-m^2-K	The linear term for the collector efficiency equation.
18	Q_{BASE}	kJ/hr	The useful energy transferred to the fluid via the area of the collector directly above the tubes.
19	Q_{FIN}	kJ/hr	The useful energy transferred to the fluid via the area of the collector between the tubes.
20	T_{back}	C	The temperature of the back surface of the collector (the interface between the collector and the roof).

TYPE 566: GLAZED BUILDING INTEGRATED PHOTOVOLTAIC ARRAY (INTERACTS WITH ZONE AIR TEMPERATURE)

PARAMETERS

Parameter Number	Name	Unit	Typical Value	Comment
1	Collector length	m	1.0	The length of the collector along the direction of the air flow through the channel.
2	Collector width	m	1.0	The width of the collector across the direction of the air flow through the channel.
3	Cover emissivity	-	0.9	The emissivity of the cover surface for long-wave radiation exchange with the sky.
4	Thermal conductivity of cover material	kJ/h.m.K	5.04	The thermal conductivity of the transparent glazing acting as a cover for the PV system.
5	Thickness of cover	m	0.00635	The thickness of the transparent cover material.
6	Resistance of substrate material	$h.m^2.K/kJ$	0.01	The resistance to heat transfer of the material located between the absorbing PV surface and the upper flow channel surface. This resistance includes any conductive resistance of the absorber plate as well as any material between the absorber and the flow channel.
7	Emissivity – top surface of flow channel	-	0.9	The emissivity of the top surface of the flow channel (for radiation across the flow channel).
8	Emissivity – bottom surface of flow channel	-	0.9	The emissivity of the bottom surface of the flow channel (for radiation across the flow channel).
9	Resistance of back material	$h.m^2.K/kJ$	1.0	The resistance to heat transfer for material(s) located between the bottom of the flow channel and the back of the collector.
10	Emissivity – back surface	-	0.9	The emissivity of the collector back surface for long-wave radiation exchange with the zone.
11	Channel height	m	0.0508	The separation distance between the parallel plates defining the flow channel.
12	IAM Mode	-	1	The mode defining how off-normal solar radiation effects are calculated by the model: 1= Linear IAM approach from ASHRAE 2= Calculated from cover and absorber properties
13	PV Mode	-	1	The mode defining how the PV efficiency should be calculated by the model: 1= Linear modifiers for off-rated cell temperature and incident radiation 2= User-provided data file of PV efficiency as a function of cell temperature and incident radiation 3=Efficiency provided as an INPUT
If IAM Mode = 1 (NPAR=15)				
14	Transmittance-absorptance product at normal incidence	-	0.85	The transmittance of the cover material multiplied by the absorptance of the PV surface when the incident solar radiation is normal to the surface.

15	1st order IAM	-	0.1	1st order coefficient in the IAM function (b_0).
If IAM Mode = 2 (NPAR=16)				
14	Absorptance of PV surface	-	0.9	The absorptance of the PV surface for solar radiation.
15	Cover index of refraction	-	1.526	The index of refraction of the transparent cover material.
16	Extinction coefficient	1/m	4.0	The index of refraction of the transparent cover material.
If PV Mode = 1				
NPAR+1	PV efficiency at reference condition	-	0.12	The efficiency of the PV cells in converting incident radiation to electricity at the provided reference conditions.
NPAR+2	PV cell reference temperature	C	20.0	The reference temperature at which the efficiency of the PV cell is provided.
NPAR+3	PV cell reference radiation	kJ/h.m2	3600.0	The reference total incident solar radiation at which the efficiency of the PV cell is provided.
NPAR+4	Efficiency modifier – temperature	1/C	-0.005	The multiplier to correct the rated PV cell efficiency as a function of cell temperature.
NPAR+5	Efficiency modifier – radiation	h.m2/kJ	0.000025	The multiplier to correct the rated PV cell efficiency as a function of incident solar radiation.
If PV Mode = 2				
NPAR+1	Logical unit for data file	-	10	The logical unit which has been ASSIGNed to the external data file containing the PV efficiency as a function of the cell temperature and incident radiation.
NPAR+2	Number of temperature points	-	21	The number of PV cell temperatures for which PV efficiency is provided in the external data file.
NPAR+3	Number of radiation points	-	2	The number of incident solar radiation values for which PV efficiency is provided in the external data file.

INPUTS

Input Number	Name	Unit	Typical Value	Comment
1	Inlet air temperature	C	20.0	The temperature of the air entering the collector at the flow inlet.
2	Inlet air flow rate	kg/hr	200.0	The flow rate of dry air entering the collector at the fluid inlet.
3	Ambient temperature	C	20.0	The temperature of the environment for calculating losses from the top collector surface.
4	Sky temperature	C	20.0	The temperature of the sky for calculating long-wave radiation losses from the collector surface.
5	Back-surface environment temperature	C	20.0	The temperature of the air located behind the back surface of the collector. This temperature is typically the zone temperature in a BIPV application.
6	Back-surface radiant temperature	C	20.0	The temperature of the surfaces located behind the back surface of the collector for long-wave radiation loss calculations. For BIPV applications, this value is typically set to the wall surface temperature of the zone.
7	Incident solar radiation	kJ/hr-m^2	0.0	The rate at which incident solar radiation (beam + diffuse) strikes the sloped collector surface.
8	Total horizontal	kJ/hr-m^2	0.0	The rate at which total solar radiation (beam + diffuse)

	radiation			strikes a horizontal surface.
9	Horizontal diffuse radiation	kJ/hr-m^2	0.0	The rate at which diffuse radiation strikes a horizontal surface.
10	Ground reflectance	-	0.2	The reflectance to solar radiation of the surface upon which the collector is located.
11	Incidence angle	degrees	0.0	The angle of incidence between beam solar radiation and the sloped collector surface.
12	Collector slope	degrees	45.0	The slope of the collector surface (0=horizontal, 90=vertical facing the azimuth).
13	Top loss convection coefficient	kJ/hr-m^2-K	20.0	The convective heat loss coefficient from the cover to the ambient (should not include radiative losses).
14	Back loss convection coefficient	kJ/hr-m^2-K	20.0	The convective heat loss coefficient from the back of the collector to the environment (should not include radiative losses).
15	Atmospheric pressure	Atm	1.0	The absolute pressure of the air stream flowing through the collector (used to evaluate the fluid properties).
If PV Mode = 3				
16	PV efficiency	-	0.12	The efficiency of the PV cells in converting incident radiation to electricity at the current timestep.

OUTPUTS

Output Number	Name	Unit	Comment
1	Outlet air temperature	C	The temperature of the air exiting the collector.
2	Outlet air flow rate	kg/hr	The flow rate of dry air exiting the collector.
3	Useful energy gain	kJ/hr	The net rate at which energy is transferred to the fluid flowing through the solar collector.
4	Thermal efficiency	-	The efficiency of the solar collector in converting incident solar radiation to delivered fluid energy.
5	Electrical power	kJ/hr	The rate at which the PV cells are producing electrical power.
6	Electrical efficiency	-	The efficiency of the PV cells in converting incident solar radiation to electrical energy.
7	Cover temperature	C	The mean surface temperature of the cover.
8	PV cell temperature	C	The mean temperature of the absorbing PV surface.
9	Upper air channel surface temperature	C	The mean temperature of the upper air channel surface.
10	Mean fluid temperature	C	The mean temperature of the fluid in the solar collector.
11	Lower air channel surface temperature	C	The mean temperature of the lower air channel surface.
12	Back surface temperature	C	The mean temperature of the back surface of the collector (zone air/collector back interface).
13	Overall IAM	-	The overall (beam plus diffuse) incidence angle modifier for the collector.
14	Top losses - convective	kJ/hr	The rate at which energy is lost to the environment through convection from the cover surface to the ambient.

15	Top losses - radiative	kJ/hr	The rate at which energy is lost to the environment through radiation exchange from the cover surface to the sky.
16	Back losses - convective	kJ/hr	The rate at which energy is lost to the zone through convection from the back surface to the zone air.
17	Back losses - radiative	kJ/hr	The rate at which energy is lost to the zone through radiation exchange from the back surface to the zone surfaces.
18	Absorbed solar radiation	kJ/hr	The net rate at which solar radiation is absorbed by the collector. This value does not include the radiation that was absorbed by the PV cells and converted to electrical energy.

TYPE 567: GLAZED BUILDING INTEGRATED PHOTOVOLTAIC ARRAY (INTERACTS WITH TYPE 56)

PARAMETERS

Parameter Number	Name	Unit	Typical Value	Comment
1	Collector length	m	1.0	The length of the collector along the direction of the air flow through the channel.
2	Collector width	m	1.0	The width of the collector across the direction of the air flow through the channel.
3	Cover emissivity	-	0.9	The emissivity of the cover surface for long-wave radiation exchange with the sky.
4	Thermal conductivity of cover material	kJ/h-m-K	5.04	The thermal conductivity of the transparent glazing acting as a cover for the PV system.
5	Thickness of cover	M	0.00635	The thickness of the transparent cover material.
6	Resistance of substrate material	$h\text{-}m^2\text{-}K/kJ$	0.01	The resistance to heat transfer of the material located between the absorbing PV surface and the upper flow channel surface. This resistance includes any conductive resistance of the absorber plate as well as any material between the absorber and the flow channel.
7	Emissivity – top surface of flow channel	-	0.9	The emissivity of the top surface of the flow channel (for radiation across the flow channel).
8	Emissivity – bottom surface of flow channel	-	0.9	The emissivity of the bottom surface of the flow channel (for radiation across the flow channel).
9	Resistance of back material	$h\text{-}m^2\text{-}K/kJ$	1.0	The resistance to heat transfer for material(s) located between the bottom of the flow channel and the back of the collector.
10	Channel height	m	0.0508	The separation distance between the parallel plates defining the flow channel.
11	IAM Mode	-	1	The mode defining how off-normal solar radiation effects are calculated by the model: 1= Linear IAM approach from ASHRAE 2= Calculated from cover and absorber properties
12	PV Mode	-	1	The mode defining how the PV efficiency should be calculated by the model: 1= Linear modifiers for off-rated cell temperature and incident radiation 2= User-provided data file of PV efficiency as a function of cell temperature and incident radiation 3=Efficiency provided as an INPUT
If IAM Mode = 1 (NPAR=14)				
13	Transmittance-absorptance product at normal incidence	-	0.85	The transmittance of the cover material multiplied by the absorptance of the PV surface when the incident solar radiation is normal to the surface.
14	1^{st} order IAM	-	0.1	1^{st} order coefficient in the IAM function (b_0).
If IAM Mode = 2 (NPAR=15)				

13	Absorptance of PV surface	-	0.9	The absorptance of the PV surface for solar radiation.
14	Cover index of refraction	-	1.526	The index of refraction of the transparent cover material.
15	Extinction coefficient	1/m	4.0	The index of refraction of the transparent cover material.
If PV Mode = 1				
NPAR+1	PV efficiency at reference condition	-	0.12	The efficiency of the PV cells in converting incident radiation to electricity at the provided reference conditions.
NPAR+2	PV cell reference temperature	C	20.0	The reference temperature at which the efficiency of the PV cell is provided.
NPAR+3	PV cell reference radiation	kJ/h.m2	3600.0	The reference total incident solar radiation at which the efficiency of the PV cell is provided.
NPAR+4	Efficiency modifier – temperature	1/C	-0.005	The multiplier to correct the rated PV cell efficiency as a function of cell temperature.
NPAR+5	Efficiency modifier – radiation	$h\text{-}m^2/kJ$	0.000025	The multiplier to correct the rated PV cell efficiency as a function of incident solar radiation.
If PV Mode = 2				
NPAR+1	Logical unit for data file	-	10	The logical unit which has been ASSIGNed to the external data file containing the PV efficiency as a function of the cell temperature and incident radiation.
NPAR+2	Number of temperature points	-	21	The number of PV cell temperatures for which PV efficiency is provided in the external data file.
NPAR+3	Number of radiation points	-	2	The number of incident solar radiation values for which PV efficiency is provided in the external data file.

INPUTS

Input Number	Name	Unit	Typical Value	Comment
1	Inlet air temperature	C	20.0	The temperature of the air entering the collector at the flow inlet.
2	Inlet air flow rate	kg/hr	200.0	The flow rate of dry air entering the collector at the fluid inlet.
3	Ambient temperature	C	20.0	The temperature of the environment for calculating losses from the top collector surface.
4	Sky temperature	C	20.0	The temperature of the sky for calculating long-wave radiation losses from the collector surface.
5	Back-surface temperature	C	20.0	The temperature of the back surface of the collector (collector back/ zone air interface). This value should be provided by the detailed zone model.
6	Incident solar radiation	$kJ/hr\text{-}m^2$	0.0	The rate at which incident solar radiation (beam + diffuse) strikes the sloped collector surface.
7	Total horizontal radiation	$kJ/hr\text{-}m^2$	0.0	The rate at which total solar radiation (beam + diffuse) strikes a horizontal surface.
8	Horizontal diffuse radiation	$kJ/hr\text{-}m^2$	0.0	The rate at which diffuse radiation strikes a horizontal surface.
9	Ground reflectance	-	0.2	The reflectance to solar radiation of the surface upon which the collector is located.
10	Incidence angle	degrees	0.0	The angle of incidence between beam solar radiation and the

				sloped collector surface.
11	Collector slope	degrees	45.0	The slope of the collector surface (0=horizontal, 90=vertical facing the azimuth).
12	Top loss convection coefficient	kJ/hr-m^2-K	20.0	The convective heat loss coefficient from the cover to the ambient (should not include radiative losses).
13	Atmospheric pressure	Atm	1.0	The absolute pressure of the air stream flowing through the collector (used to evaluate the fluid properties).
If PV Mode = 3				
14	PV efficiency	-	0.12	The efficiency of the PV cells in converting incident radiation to electricity at the current timestep.

OUTPUTS

Output Number	Name	Unit	Comment
1	Outlet air temperature	C	The temperature of the air exiting the collector.
2	Outlet air flow rate	kg/hr	The flow rate of dry air exiting the collector.
3	Useful energy gain	kJ/hr	The net rate at which energy is transferred to the fluid flowing through the solar collector.
4	Thermal efficiency	-	The efficiency of the solar collector in converting incident solar radiation to delivered fluid energy.
5	Electrical power	kJ/hr	The rate at which the PV cells are producing electrical power.
6	Electrical efficiency	-	The efficiency of the PV cells in converting incident solar radiation to electrical energy.
7	Cover temperature	C	The mean surface temperature of the cover.
8	PV cell temperature	C	The mean temperature of the absorbing PV surface.
9	Upper air channel surface temperature	C	The mean temperature of the upper air channel surface.
10	Mean fluid temperature	C	The mean temperature of the fluid in the solar collector.
11	Lower air channel surface temperature	C	The mean temperature of the lower air channel surface.
12	Back surface temperature	C	The mean temperature of the back surface of the collector (zone air/collector back interface).
13	Overall IAM	-	The overall (beam plus diffuse) incidence angle modifier for the collector.
14	Top losses - convective	kJ/hr	The rate at which energy is lost to the environment through convection from the cover surface to the ambient.
15	Top losses - radiative	kJ/hr	The rate at which energy is lost to the environment through radiation exchange from the cover surface to the sky.
16	Back losses	kJ/hr	The rate at which energy is lost to the zone from the back surface of the collector.
17	Absorbed solar radiation	kJ/hr	The net rate at which solar radiation is absorbed by the collector. This value does not include the radiation that was absorbed by the PV cells and converted to electrical energy.

TYPE 568: UNGLAZED BUILDING INTEGRATED PHOTOVOLTAIC ARRAY (INTERACTS WITH TYPE 56)

PARAMETERS

Parameter Number	Name	Unit	Typical Value	Comment
1	Collector length	m	1.0	The length of the collector along the direction of the air flow through the channel.
2	Collector width	m	1.0	The width of the collector across the direction of the air flow through the channel.
3	Absorptance of PV surface	-	0.9	The absorptance of the PV surface for solar radiation.
4	Emissivity of PV surface	-	0.9	The emissivity of the PV surface (absorbing surface) for long-wave radiation exchange with the sky.
5	Resistance of substrate material	$h\text{-}m^2\text{-}K/kJ$	0.01	The resistance to heat transfer of the material located between the absorbing PV surface and the upper flow channel surface. This resistance includes any conductive resistance of the absorber plate as well as any material between the absorber and the flow channel.
6	Emissivity – top surface of flow channel	-	0.9	The emissivity of the top surface of the flow channel (for radiation across the flow channel).
7	Emissivity – bottom surface of flow channel	-	0.9	The emissivity of the bottom surface of the flow channel (for radiation across the flow channel).
8	Resistance of back material	$h\text{-}m^2\text{-}K/kJ$	1.0	The resistance to heat transfer for material(s) located between the bottom of the flow channel and the back of the collector.
9	Channel height	m	0.0508	The separation distance between the parallel plates defining the flow channel.
10	PV Mode	-	1	The mode defining how the PV efficiency should be calculated by the model: 1= Linear modifiers for off-rated cell temperature and incident radiation 2= User-provided data file of PV efficiency as a function of cell temperature and incident radiation 3=Efficiency provided as an INPUT
If PV Mode = 1				
11	PV efficiency at reference condition	-	0.12	The efficiency of the PV cells in converting incident radiation to electricity at the provided reference conditions.
12	PV cell reference temperature	C	20.0	The reference temperature at which the efficiency of the PV cell is provided.
13	PV cell reference radiation	$kJ/h\text{-}m^2$	3600.0	The reference total incident solar radiation at which the efficiency of the PV cell is provided.
14	Efficiency modifier – temperature	1/C	-0.005	The multiplier to correct the rated PV cell efficiency as a function of cell temperature.
15	Efficiency modifier – radiation	h.m2/kJ	0.000025	The multiplier to correct the rated PV cell efficiency as a function of incident solar radiation.

If PV Mode = 2				
11	Logical unit for data file	-	10	The logical unit which has been ASSIGNed to the external data file containing the PV efficiency as a function of the cell temperature and incident radiation.
12	Number of temperature points	-	21	The number of PV cell temperatures for which PV efficiency is provided in the external data file.
13	Number of radiation points	-	2	The number of incident solar radiation values for which PV efficiency is provided in the external data file.

INPUTS

Input Number	Name	Unit	Typical Value	Comment
1	Inlet air temperature	C	20.0	The temperature of the air entering the collector at the flow inlet.
2	Inlet air flow rate	kg/hr	200.0	The flow rate of dry air entering the collector at the fluid inlet.
3	Ambient temperature	C	20.0	The temperature of the environment for calculating losses from the top collector surface.
4	Sky temperature	C	20.0	The temperature of the sky for calculating long-wave radiation losses from the collector surface.
5	Back-surface temperature	C	20.0	The temperature of the back surface of the collector (collector back/ zone air interface). This value should be provided by the detailed zone model.
6	Incident solar radiation	kJ/hr-m^2	0.0	The rate at which incident solar radiation (beam + diffuse) strikes the sloped collector surface.
7	Collector slope	degrees	45.0	The slope of the collector surface (0=horizontal, 90=vertical facing the azimuth).
8	Top loss convection coefficient	kJ/hr-m^2-K	20.0	The convective heat loss coefficient from the cover to the ambient (should not include radiative losses).
9	Atmospheric pressure	Atm	1.0	The absolute pressure of the air stream flowing through the collector (used to evaluate the fluid properties).
If PV Mode = 3				
10	PV efficiency	-	0.12	The efficiency of the PV cells in converting incident radiation to electricity at the current timestep.

OUTPUTS

Output Number	Name	Unit	Comment
1	Outlet air temperature	C	The temperature of the air exiting the collector.
2	Outlet air flow rate	kg/hr	The flow rate of dry air exiting the collector.
3	Useful energy gain	kJ/hr	The net rate at which energy is transferred to the fluid flowing through the solar collector.
4	Thermal efficiency	-	The efficiency of the solar collector in converting incident solar radiation to delivered fluid energy.

5	Electrical power	kJ/hr	The rate at which the PV cells are producing electrical power.
6	Electrical efficiency	-	The efficiency of the PV cells in converting incident solar radiation to electrical energy.
7	PV cell temperature	C	The mean temperature of the absorbing PV surface.
8	Upper air channel surface temperature	C	The mean temperature of the upper air channel surface.
9	Mean fluid temperature	C	The mean temperature of the fluid in the solar collector.
10	Lower air channel surface temperature	C	The mean temperature of the lower air channel surface.
11	Back surface temperature	C	The mean temperature of the back surface of the collector (zone air/collector back interface).
12	Top losses - convective	kJ/hr	The rate at which energy is lost to the environment through convection from the cover surface to the ambient.
13	Top losses - radiative	kJ/hr	The rate at which energy is lost to the environment through radiation exchange from the cover surface to the sky.
14	Back losses	kJ/hr	The rate at which energy is lost to the zone from the back surface of the collector.
16	Absorbed solar radiation	kJ/hr	The net rate at which solar radiation is absorbed by the collector. This value does not include the radiation that was absorbed by the PV cells and converted to electrical energy.

TYPE 569: UNGLAZED BUILDING INTEGRATED PHOTOVOLTAIC ARRAY (INTERACTS WITH ZONE AIR TEMPERATURE)

PARAMETERS

Parameter Number	Name	Unit	Typical Value	Comment
1	Collector length	m	1.0	The length of the collector along the direction of the air flow through the channel.
2	Collector width	m	1.0	The width of the collector across the direction of the air flow through the channel.
3	Absorptance of PV surface	-	0.9	The absorptance of the PV surface for solar radiation.
4	Emissivity of PV surface	-	0.9	The emissivity of the PV surface (absorbing surface) for long-wave radiation exchange with the sky.
5	Resistance of substrate material	$h.m^2.K/kJ$	0.01	The resistance to heat transfer of the material located between the absorbing PV surface and the upper flow channel surface. This resistance includes any conductive resistance of the absorber plate as well as any material between the absorber and the flow channel.
6	Emissivity – top surface of flow channel	-	0.9	The emissivity of the top surface of the flow channel (for radiation across the flow channel).
7	Emissivity – bottom surface of flow channel	-	0.9	The emissivity of the bottom surface of the flow channel (for radiation across the flow channel).
8	Resistance of back material	$h.m^2.K/kJ$	1.0	The resistance to heat transfer for material(s) located between the bottom of the flow channel and the back of the collector.
9	Emissivity – back surface	-	0.9	The emissivity of the collector back surface for long-wave radiation exchange with the zone.
10	Channel height	m	0.0508	The separation distance between the parallel plates defining the flow channel.
11	PV Mode	-	1	The mode defining how the PV efficiency should be calculated by the model: 1= Linear modifiers for off-rated cell temperature and incident radiation 2= User-provided data file of PV efficiency as a function of cell temperature and incident radiation 3=Efficiency provided as an INPUT
If PV Mode = 1				
12	PV efficiency at reference condition	-	0.12	The efficiency of the PV cells in converting incident radiation to electricity at the provided reference conditions.
13	PV cell reference temperature	C	20.0	The reference temperature at which the efficiency of the PV cell is provided.
14	PV cell reference radiation	kJ/h.m2	3600.0	The reference total incident solar radiation at which the efficiency of the PV cell is provided.
15	Efficiency modifier – temperature	1/C	-0.005	The multiplier to correct the rated PV cell efficiency as a function of cell temperature.

16	Efficiency modifier – radiation	h.m2/kJ	0.000025	The multiplier to correct the rated PV cell efficiency as a function of incident solar radiation.
If PV Mode = 2				
12	Logical unit for data file	-	10	The logical unit which has been ASSIGNed to the external data file containing the PV efficiency as a function of the cell temperature and incident radiation.
13	Number of temperature points	-	21	The number of PV cell temperatures for which PV efficiency is provided in the external data file.
14	Number of radiation points	-	2	The number of incident solar radiation values for which PV efficiency is provided in the external data file.

INPUTS

Input Number	Name	Unit	Typical Value	Comment
1	Inlet air temperature	C	20.0	The temperature of the air entering the collector at the flow inlet.
2	Inlet air flow rate	kg/hr	200.0	The flow rate of dry air entering the collector at the fluid inlet.
3	Ambient temperature	C	20.0	The temperature of the environment for calculating losses from the top collector surface.
4	Sky temperature	C	20.0	The temperature of the sky for calculating long-wave radiation losses from the collector surface.
5	Back-surface environment temperature	C	20.0	The temperature of the air located behind the back surface of the collector. This temperature is typically the zone temperature in a BIPV application.
6	Back-surface radiant temperature	C	20.0	The temperature of the surfaces located behind the back surface of the collector for long-wave radiation loss calculations. For BIPV applications, this value is typically set to the wall surface temperature of the zone.
7	Incident solar radiation	kJ/hr-m^2	0.0	The rate at which incident solar radiation (beam + diffuse) strikes the sloped collector surface.
8	Collector slope	degrees	45.0	The slope of the collector surface (0=horizontal, 90=vertical facing the azimuth).
9	Top loss convection coefficient	kJ/hr-m^2-K	20.0	The convective heat loss coefficient from the cover to the ambient (should not include radiative losses).
10	Back loss convection coefficient	kJ/hr-m^2-K	20.0	The convective heat loss coefficient from the back of the collector to the environment (should not include radiative losses).
11	Atmospheric pressure	Atm	1.0	The absolute pressure of the air stream flowing through the collector (used to evaluate the fluid properties).
If PV Mode = 3				
12	PV efficiency	-	0.12	The efficiency of the PV cells in converting incident radiation to electricity at the current timestep.

OUTPUTS

Output Number	Name	Unit	Comment
1	Outlet air temperature	C	The temperature of the air exiting the collector.
2	Outlet air flow rate	kg/hr	The flow rate of dry air exiting the collector.
3	Useful energy gain	kJ/hr	The net rate at which energy is transferred to the fluid flowing through the solar collector.
4	Thermal efficiency	-	The efficiency of the solar collector in converting incident solar radiation to delivered fluid energy.
5	Electrical power	kJ/hr	The rate at which the PV cells are producing electrical power.
6	Electrical efficiency	-	The efficiency of the PV cells in converting incident solar radiation to electrical energy.
7	PV cell temperature	C	The mean temperature of the absorbing PV surface.
8	Upper air channel surface temperature	C	The mean temperature of the upper air channel surface.
9	Mean fluid temperature	C	The mean temperature of the fluid in the solar collector.
10	Lower air channel surface temperature	C	The mean temperature of the lower air channel surface.
11	Back surface temperature	C	The mean temperature of the back surface of the collector (zone air/collector back interface).
12	Top losses - convective	kJ/hr	The rate at which energy is lost to the environment through convection from the cover surface to the ambient.
13	Top losses - radiative	kJ/hr	The rate at which energy is lost to the environment through radiation exchange from the cover surface to the sky.
14	Back losses - convective	kJ/hr	The rate at which energy is lost to the zone through convection from the back surface to the zone air.
15	Back losses - radiative	kJ/hr	The rate at which energy is lost to the zone through radiation exchange from the back surface to the zone surfaces.
16	Absorbed solar radiation	kJ/hr	The net rate at which solar radiation is absorbed by the collector. This value does not include the radiation that was absorbed by the PV cells and converted to electrical energy.

TYPE 687: NATIONAL FENESTRATION RATINGS COUNCIL (NFRC) WINDOW

PARAMETERS

Parameter Number	Name	Unit	Typical Value	Comment
1	Area	m^2	0.5	The overall area of the window. Since the u-value given for the NFRC window includes frame effects, so too should this area parameter.
2	Number of units	-	1	The number of identical windows modeled by this component and subject to the same incident radiation levels.
3	Loss coefficient	W/m^2	5.0	The overall (glazing and frame) thermal energy loss coefficient for the window per unit area.
4	SHGC	-	0.41	The solar heat gain factor for window
5	Visible transmittance	0..1	0.7	The transmittance of the window to visible light.

INPUTS

Input Number	Name	Unit	Typical Value	Comment
1	Ambient temperature	C	10.0	The outdoor environmental temperature
2	Zone temperature	C	20.0	The indoor zone temperature
3	Incident radiation	$kJ/hr\text{-}m^2$	0.0	The total amount of radiation incident on the window.
4	Beam radiation	$kJ/hr\text{-}m^2$	0.0	The beam radiation incident on the window.
5	Incidence angle	degrees	90.0	The angle of incidence of beam radiation on the window. The angle between the beam radiation and the line normal to the glazing surface.

OUTPUTS

Output Number	Name	Unit	Comment
1	Solar gains	kJ/h	The energy gain to the zone from solar.
2	Thermal gains	kJ/h	The energy gain to the zone from the indoor/outdoor temperature difference.
3	Net gains	kJ/h	The combined solar and thermal gains to the zone.
4	Luminous flux	Lumens	The luminous flux coming through the window(s)
5	Luminous efficacy	Lumens/ W	The efficacy of the visible light coming through the window(s)
6	Ratio	0..1	The ratio of luminous flux from beam radiation to total luminous flux.

TYPE 726: PROPORTIONAL LIGHTING CONTROLLER

PARAMETERS

Parameter Number	Name	Unit	Typical Value	Comment
1	Number of signals (n)	-	1	The number of unique proportional control signals to be generated by this component.
2	Minimum allowable signal	-	0	The minimum signal that this controller can output.

INPUTS

Input Number	Name	Unit	Typical Value	Comment
1	Upper set point value	any	30.0	The upper set point for the specified signal (the value at which the function will return the minimum allowable control signal).
2	Lower set point value	any	20.0	The value of the lower set point; (the value at which the function will return a control signal of 1)
	Input values	any	25.0	The input value which will be compared to the upper and lower set points in order to generate a proportional signal.

OUTPUTS

Output Number	Name	Unit	Comment
	Control signal	-	The proportional signal calculated from each input value and the specified upper and lower set point values.

TYPE 727: CONTINUOUSLY STEPPED LIGHT FIXTURES

PARAMETERS

Parameter Number	Name	Unit	Typical Value	Comment
1	Time delay	hr	0.125	The time between the first control signal going to zero and when the light actually switches off.
2	Fixture power	W	140	Power drawn by the fixture
3	Lamp power	W	120	Power drawn by the lamps in the fixture
4	Special allowance factor	-	1.0	A factor included to account for lighting fixtures that are designed so that not all of the heat that they generate enters the conditioned space. In cases where the special allowance factor is greater than unity, the additional heat gain is primarily due to ballast losses.
5	Convective fraction	-	0.85	The fraction of heat gains associated with the fixture that are convective. The remaining heat gains are assumed to be radiative
6	Heat to space fraction	-	1.0	The fraction of heat gains associated with the fixture that enter the conditioned space.

INPUTS

Input Number	Name	Unit	Typical Value	Comment
1	Occupancy control	-	1	Digital control signal. The lamp is ON only if both control signals are ON. When this control signal switches OFF, the lamp stays on for a time equal to PAR(2) before switching OFF.
2	Daylight control	-	1	Analog control signal that sets lamp power level betweem 0 and its maximum value. The lamp is ON only if both control signals are ON. When this control signal switches OFF, the lamp turns OFF immediately.

OUTPUTS

Output Number	Name	Unit	Comment
1	Fixture power draw	W	The electrical power drawn by the lamp fixture
2	Total heat gain	kJ/h	The total heat gain from the lamp fixture
3	Convective heat gain	kJ/h	The convective portion of lamp fixture heat gain

4	Radiative heat gain	kJ/h	The radiative portion of lamp fixture heat gain
5	Heat gain to space	kJ/h	Heat gain to the conditioned space
6	Heat gain not to space	kJ/h	Heat gain that does not go to the conditioned space.

TYPE 728: MULTIPLE POWER LEVEL LIGHT FIXTURES

PARAMETERS

Parameter Number	Name	Unit	Typical Value	Comment
1	Number of lamp power levels	-	3	The number of discrete power levels at which the lamp may be operated.
2	Time delay	hr	0.125	The time between the first control signal going to zero and when the light actually switches off.
3	Fixture power	W	140	Power drawn by the fixture
4	Lamp power	W	120	Power drawn by the lamps in the fixture
5	Special allowance factor	-	1.0	A factor included to account for lighting fixtures that are designed so that not all of the heat that they generate enters the conditioned space. In cases where the special allowance factor is greater than unity, the additional heat gain is primarily due to ballast losses.
6	Convective fraction	-	0.85	The fraction of heat gains associated with the fixture that are convective. The remaining heat gains are assumed to be radiative
7	Heat to space fraction	-	1.0	The fraction of heat gains associated with the fixture that enter the conditioned space.
Cycle	Discrete power level fraction	-	0.33	The fraction of maximum power corresponding to each discrete power level at which the lamp may operate.

INPUTS

Input Number	Name	Unit	Typical Value	Comment
1	Occupancy control	-	1	The lamp is ON only if both control signals are ON. When this control signal switches OFF, the lamp stays on for a time equal to PAR(2) before switching OFF.
2	Daylight control	-	1	The lamp is ON only if both control signals are ON. When this control signal switches OFF, the lamp turns OFF immediately.
3	Power level	-	2	The input that will be held in storage until the correct time step for output is reached.

OUTPUTS

Output Number	Name	Unit	Comment
1	Fixture power draw	W	The electrical power drawn by the lamp fixture
2	Total heat gain	kJ/h	The total heat gain from the lamp fixture
3	Convective heat gain	kJ/h	The convective portion of lamp fixture heat gain
4	Radiative heat gain	kJ/h	The radiative portion of lamp fixture heat gain
5	Heat gain to space	kJ/h	Heat gain to the conditioned space
6	Heat gain not to space	kJ/h	Heat gain that does not go to the conditioned space.

GROUND COUPLING COMPONENTS

Ground Coupling Components

TYPE 501: GROUND TEMPERATURE

PARAMETERS

Parameter Number	Name	Unit	Typical Value	Comment
1	Number of temperature nodes	-	1	The number of temperatures that will be output from the model. For each output temperature desired, the user has to specify the depth at which the output temperature should be calculated. These depths should be entered in parameters 8 to 7 +n, where n is the number of temperature nodes (this parameter).
2	Mean surface temperature	C	10.0	The mean (average) surface temperature of the ground during the year. The temperature of the ground at an infinite depth will be this temperature. This temperature is typically the average annual air temperature for the given location.
3	Amplitude of surface temperature	ΔC	5.0	The amplitude of the surface temperature function throughout the year. The maximum temperature of the surface will be TMEAN+TAMPL.
4	Time shift	day	30	The time difference (in days) between the beginning of the calendar year and the occurrence of the minimum surface temperature.
5	Soil thermal conductivity	kJ/hr-m-K	8.72	The thermal conductivity of the soil for which the temperature is being calculated.
6	Soil density	kg/m^3	3200.0	The density of the soil for which the temperature is being calculated.
7	Soil specific heat	kJ/kg-K	0.84	The specific heat of the soil for which the temperature is being calculated.
 based on PAR 1	Depth at point	m	0.25	The depth of the soil at which the temperature for each node should be evaluated. 0 = Surface

OUTPUTS

Output Number	Name	Unit	Comment
 based on PAR 1	Soil temperature at node	C	The soil temperature at the specified depth for each node specified in the cycle at the end of the parameter list.

TYPE 653: SIMPLE FLOOR HEATING SYSTEM

PARAMETERS

Parameter Number	Name	Unit	Typical Value	Comment
1	Capacitance of floor slab	-	7500.0	The capacitance of the massive slab for the floor heating system.
2	Specific heat of fluid	kJ/kg-K	4.190	The specific heat of the fluid flowing through the slab heat exchanger system.
3	Initial slab temperature	C	400.0	The initial temperature of the slab.

INPUTS

Input Number	Name	Unit	Typical Value	Comment
1	Fluid inlet temperature	C	45.0	The temperature of the fluid flowing into the slab floor heating system.
2	Fluid flow rate	kg/hr	10,000.0	The flow rate of fluid entering the slab floor heating system.
3	Zone air temperature	C	20.0	The dry-bulb temperature of the zone in which the floor heating system is located.
4	Environment temperature	C	5.0	The temperature to which the thermal losses from the slab heating system occur. This is usually set to the ambient dry-bulb temperature or to a soil temperature.
5	Loss coefficient to ambient	kJ/hr-K	4.0	The overall loss coefficient from the slab to the ground (UA).
6	Slab-to-zone heat transfer coefficient	kJ/hr-K	2000.0	The overall heat transfer coefficient from the heated slab to the zone (UA).
7	Heat exchanger effectiveness	-	0.6	The effectiveness of the slab as a heat exchanger device in the floor heating .

OUTPUTS

Output Number	Name	Unit	Comment
1	Exiting fluid temperature	C	The temperature of the fluid exiting the floor heating system.
2	Fluid flow rate	kg/hr	The flow rate of fluid exiting the floor heating system.
3	Slab temperature	C	The temperature of the slab at the current timestep.
4	Energy input from flow stream	kJ/hr	The rate at which heat is transferred from the flow stream to the slab of the floor heating system.
5	Heat transfer to room	kJ/hr	The rate at which heat is transferred from the slab to the room.
6	Thermal losses	kJ/hr	The rate at which heat is transferred from the slab to the ambient.

TYPE 701: BASEMENT CONDUCTION (INTERFACES WITH TYPE 56)

PARAMETERS

Parameter Number	Name	Unit	Typical Value	Comment
1	Nodes along length (Nx_adj)	-	3	The number of nodes located along the length of the basement.
2	Nodes beyond length (Nx_ext)	-	6	The number of soil nodes located in the x-direction beyond the edges of the basement.
3	Nodes along width (Ny_adj)	-	5	The number of nodes located along the width of the basement.
4	Nodes beyond width (Ny_ext)	-	4	The number of soil nodes located in the y-direction beyond the edges of the basement.
5	Nodes along depth (Nz_adj)	-	3	The number of nodes located along the depth of the basement.
6	Nodes beyond depth (Nz_ext)	-	4	The number of soil nodes located in the z-direction beneath the basement
7	Mean surface temperature	C	10.0	The mean (average) surface temperature of undisturbed soil.
8	Amplitude of surface temperature	ΔC	5.0	The amplitude of the surface temperature of undisturbed soil over the course of a year.
9	Day of minimum surface temperature	Day	36	The day of the year at which the minimum undisturbed surface temperature occurs.
10	Soil conductivity	kJ/h.m.K	8.722	The thermal conductivity of the soil.
11	Soil density	kg/m3	3200.0	The density of the soil.
12	Soil specific heat	kJ/kg.K	0.84	The specific heat of the soil.
13	Surface emissivity	-	0.9	The emissivity of the soil surface beyond the edges of the slab.
14	Surface absorptance	-	0.6	The absorptance of the soil surface beyond the edges of the slab to solar radiation.
15	Side boundary heat transfer mode	-	1	Setting this value greater than zero allows the soil nodes to interact thermally with the soil beyond the boundary in the x and y directions.
16	Bottom boundary heat transfer mode	-	1	Setting this value greater than zero allows the soil nodes to interact thermally with the soil beyond the boundary in the depth (z) direction.
17	Front wall U-value	kJ/h.m2.K	10.0	The u-value of the basement front wall (plus any insulation) from the inside surface (inside the zone) to the outside surface of the wall, which is in direct contact with the soil.
18	Left wall U-value	kJ/h.m2.K	10.0	The u-value of the basement left wall (plus any insulation) from the inside surface (inside the zone) to the outside surface of the wall, which is in direct contact with the soil.
19	Back wall U-value	kJ/h.m2.K	10.0	The u-value of the basement back wall (plus any insulation) from the inside surface (inside the zone) to the outside surface of the wall, which is in direct contact with the soil.
20	Right wall U-value	kJ/h.m2.K	10.0	The u-value of the basement right wall (plus any insulation) from the inside surface (inside the zone) to the outside

				surface of the wall, which is in direct contact with the soil.
21	Basement floor U-value	kJ/h.m2.K	10.0	The u-value of the basement floor (plus any insulation) from the top surface (inside the zone) to the bottom surface of the wall, which is in direct contact with the soil.
22	Logical unit for output file	-	11	The logical unit which has been ASSIGNed to the file which will contain the temperatures of all soil nodes; to be printed at the very end of the simulation. Set this value less than 0 to turn-off the auto-print feature. Logical units must be unique integers greater than 10 in TRNSYS.
23	Logical unit for input file	-	12	The logical unit which has been ASSIGNed to the file which contains the temperatures of all soil nodes at the very beginning of the simulation. Set this value less than 0 to turn-off the import feature. Setting this value less than zero will cause the model to calculate the initial soil temperatures based on a correlation (Kasuda). Logical units must be unique integers greater than 10 in TRNSYS.
24	Surface mode	-	1	The mode for the surface temperatures of the near-field soil: Use an Energy Balance on the Soil Surface to Calculate the Surface Temperature Use the Surface Temperature as Calculated by the Kasuda Correlation Use the User-Supplied Surface Temperature
Cycle based on PAR 1 + 2*PAR 2	Length of node - Dx(i)	-	0.1	The length of the nodes (x-direction) starting at the origin, proceeding towards the basement, through the basement, then back into the soil towards the far-field
Cycle based on PAR 3 + 2*PAR 4	Width of node - Dy(j)	-	0.1	The width of the nodes (y-direction) starting at the origin, proceeding towards the basement, through the basement, then back into the soil towards the far-field
Cycle based on PAR 5 + PAR 6	Depth of node - Dz(k)	-	0.1	The depth of the nodes (z-direction) starting at the origin, proceeding downwards through the soil.

INPUTS

Input Number	Name	Unit	Typical Value	Comment
1	Ambient temperature	C	20.0	The dry-bulb temperature of the ambient air (in contact with the near and far-field soil).
2	Sky temperature	C	10.0	The temperature of the sky for radiative exchange calculations with the soil surface.
3	Incident solar radiation	kJ/h.m2	1000.0	The solar radiation (beam + diffuse) incident upon the soil surface.
4	Convection coefficient	kJ/h.m2.K	15.0	The heat transfer coefficient between the soil surface and the ambient air.
5	Inner surface temperature of front wall	C	10.0	The temperature of the front basement wall at the inner surface (the surface not in contact with the soil)

6	Inner surface temperature of left wall	C	10.0	The temperature of the left basement wall at the inner surface (the surface not in contact with the soil)
7	Inner surface temperature of back wall	C	10.0	The temperature of the back basement wall at the inner surface (the surface not in contact with the soil)
8	Inner surface temperature of right wall	C	10.0	The temperature of the right basement wall at the inner surface (the surface not in contact with the soil)
9	Inner surface temperature of floor	C	10.0	The temperature of the basement floor at the inner surface (the surface not in contact with the soil)
10	Near-field surface temperature	C	10.0	The temperature of the near-field soil surface. This input is only used if Parameter 24 = 3
11	Far-field surface temperature	C	10.0	The temperature of the far-field soil surface. This input is only used if Parameter 24 = 3

OUTPUTS

Output Number	Name	Unit	Comment
1	Front wall/soil interface temperature	C	The temperature of the outside surface of the basement front wall (the surface in contact with the soil).
2	Left wall/soil interface temperature	C	The temperature of the outside surface of the basement left wall (the surface in contact with the soil).
3	Back wall/soil interface temperature	C	The temperature of the outside surface of the basement back wall (the surface in contact with the soil).
4	Right wall/soil interface temperature	C	The temperature of the outside surface of the basement right wall (the surface in contact with the soil).
5	Floor/soil interface temperature	C	The temperature of the outside surface of the basement floor (the surface in contact with the soil).
6	Near-field surface temperature	C	The average temperature of the soil surface in the near-field.
7	Front wall heat transfer rate	kJ/h	The rate at which heat is transferred from the basement front wall into the zone. NOTE: this is also the negative of the rate at which heat is transferred from the front wall into the ground.
8	Left wall heat transfer rate	kJ/h	The rate at which heat is transferred from the basement left wall into the zone. NOTE: this is also the negative of the rate at which heat is transferred from the left wall into the ground.
9	Back wall heat transfer rate	kJ/h	The rate at which heat is transferred from the basement back wall into the zone. NOTE: this is also the negative of the rate at which heat is transferred from the back wall into the ground.
10	Right wall heat transfer rate	kJ/h	The rate at which heat is transferred from the basement right wall into the zone. NOTE: this is also the negative of the rate at which heat is transferred from the right wall into the ground.
11	Floor heat transfer rate	kJ/h	The rate at which heat is transferred from the basement floor into the zone. NOTE: this is also the negative of the rate at which heat is transferred from the floor into the ground.
12	Bottom boundary heat transfer rate	kJ/h	The rate at which heat is transferred from the soil in the near-field to the soil in the far-field through the bottom boundary of the storage.

13	Top boundary heat transfer rate	kJ/h	The rate at which heat is transferred from the soil in the near-field to the ambient through the top boundary (surface) of the storage.
14	Side boundary heat transfer rate	kJ/h	The rate at which heat is transferred from the soil in the near-field to the soil in the far-field through the side boundary of the storage.
15	Heat storage rate	kJ/h	The rate at which heat is being stored in the soil.
16	Energy balance error	%	The percent error in the energy balance on the basement.

TYPE 702: BASEMENT CONDUCTION (INTERFACES WITH ZONE AIR TEMPERATURE)

PARAMETERS

Parameter Number	Name	Unit	Typical Value	Comment
1	Nodes along length (Nx_adj)	-	3	The number of nodes located along the length of the basement.
2	Nodes beyond length (Nx_ext)	-	6	The number of soil nodes located in the x-direction beyond the edges of the basement.
3	Nodes along width (Ny_adj)	-	5	The number of nodes located along the width of the basement.
4	Nodes beyond width (Ny_ext)	-	4	The number of soil nodes located in the y-direction beyond the edges of the basement.
5	Nodes along depth (Nz_adj)	-	3	The number of nodes located along the depth of the basement.
6	Nodes beyond depth (Nz_ext)	-	4	The number of soil nodes located in the z-direction beneath the basement
7	Mean surface temperature	C	10.0	The mean (average) surface temperature of undisturbed soil.
8	Amplitude of surface temperature	ΔC	5.0	The amplitude of the surface temperature of undisturbed soil over the course of a year.
9	Day of minimum surface temperature	Day	36	The day of the year at which the minimum undisturbed surface temperature occurs.
10	Soil conductivity	kJ/h.m.K	8.722	The thermal conductivity of the soil.
11	Soil density	kg/m3	3200.0	The density of the soil.
12	Soil specific heat	kJ/kg.K	0.84	The specific heat of the soil.
13	Surface emissivity	-	0.9	The emissivity of the soil surface beyond the edges of the slab.
14	Surface absorptance	-	0.6	The absorptance of the soil surface beyond the edges of the slab to solar radiation.
15	Side boundary heat transfer mode	-	1	Setting this value greater than zero allows the soil nodes to interact thermally with the soil beyond the boundary in the x and y directions.
16	Bottom boundary heat transfer mode	-	1	Setting this value greater than zero allows the soil nodes to interact thermally with the soil beyond the boundary in the depth (z) direction.
17	Front wall U-value	kJ/h.m2.K	10.0	The u-value of the basement front wall (plus any insulation) from the inside surface (inside the zone) to the outside surface of the wall, which is in direct contact with the soil.
18	Left wall U-value	kJ/h.m2.K	10.0	The u-value of the basement left wall (plus any insulation) from the inside surface (inside the zone) to the outside surface of the wall, which is in direct contact with the soil.
19	Back wall U-value	kJ/h.m2.K	10.0	The u-value of the basement back wall (plus any insulation) from the inside surface (inside the zone) to the outside surface of the wall, which is in direct contact with the soil.
20	Right wall U-value	kJ/h.m2.K	10.0	The u-value of the basement right wall (plus any insulation) from the inside surface (inside the zone) to the outside

				surface of the wall, which is in direct contact with the soil.
21	Basement floor U-value	kJ/h.m2.K	10.0	The u-value of the basement floor (plus any insulation) from the top surface (inside the zone) to the bottom surface of the wall, which is in direct contact with the soil.
22	Wall emissivity	-	0.7	The emissivity of the basement wall surfaces.
23	Floor emissivity	-	0.7	The emissivity of the basement floor surface.
24	Wall absorptance	-	0.6	The absorptance of the basement wall surfaces.
25	Floor absorptance	-	0.6	The absorptance of the basement floor surface.
26	Logical unit for output file	-	11	The logical unit which has been ASSIGNed to the file which will contain the temperatures of all soil nodes; to be printed at the very end of the simulation. Set this value less than 0 to turn-off the auto-print feature. Logical units must be unique integers greater than 10 in TRNSYS.
27	Logical unit for input file	-	12	The logical unit which has been ASSIGNed to the file which contains the temperatures of all soil nodes at the very beginning of the simulation. Set this value less than 0 to turn-off the import feature. Setting this value less than zero will cause the model to calculate the initial soil temperatures based on a correlation (Kasuda). Logical units must be unique integers greater than 10 in TRNSYS.
28	Surface mode	-	1	The mode for the surface temperatures of the near-field soil: Use an Energy Balance on the Soil Surface to Calculate the Surface Temperature Use the Surface Temperature as Calculated by the Kasuda Correlation Use the User-Supplied Surface Temperature
Cycle based on PAR 1 + 2*PAR 2	Length of node - Dx(i)	-	0.1	The length of the nodes (x-direction) starting at the origin, proceeding towards the basement, through the basement, then back into the soil towards the far-field
Cycle based on PAR 3 + 2*PAR 4	Width of node - Dy(j)	-	0.1	The width of the nodes (y-direction) starting at the origin, proceeding towards the basement, through the basement, then back into the soil towards the far-field
Cycle based on PAR 5 + PAR 6	Depth of node - Dz(k)	-	0.1	The depth of the nodes (z-direction) starting at the origin, proceeding downwards through the soil.

INPUTS

Input Number	Name	Unit	Typical Value	Comment
1	Ambient temperature	C	20.0	The dry-bulb temperature of the ambient air (in contact with the near and far-field soil).
2	Sky temperature	C	10.0	The temperature of the sky for radiative exchange calculations with the soil surface.
3	Incident solar radiation	kJ/h.m2	1000.0	The solar radiation (beam + diffuse) incident upon the soil surface.
4	Convection	kJ/h.m2.	15.0	The heat transfer coefficient between the soil surface and the

	coefficient	K		ambient air.
5	Zone temperature	C	10.0	The temperature of air in the zone.
6	Surface temperature	C	10.0	The temperature of the ceiling within the zone to which the basement surfaces radiate.
7	Interior wall convection coefficient	$kJ/h.m^2.K$		The convection coefficient between the wall surfaces and zone air.
8	Interior floor convection coefficient	$kJ/h.m^2.K$		The convection coefficient between the floor surface and zone air.
9	Radiation incident on front wall	$kJ/h.m^2$	0.0	The radiation (from lights and transmitted solar radiation) that falls on the basement front wall.
10	Radiation incident on left wall	$kJ/h.m^2$	0.0	The radiation (from lights and transmitted solar radiation) that falls on the basement left wall.
11	Radiation incident on back wall	$kJ/h.m^2$	0.0	The radiation (from lights and transmitted solar radiation) that falls on the basement back wall.
12	Radiation incident on right wall	$kJ/h.m^2$	0.0	The radiation (from lights and transmitted solar radiation) that falls on the basement right wall.
13	Radiation incident on floor	$kJ/h.m^2$	0.0	The radiation (from lights and transmitted solar radiation) that falls on the basement floor
14	Near-field surface temperature	C	10.0	The temperature of the near-field soil surface. This input is only used if Parameter 28 = 3
15	Far-field surface temperature	C	10.0	The temperature of the far-field soil surface. This input is only used if Parameter 28 = 3

OUTPUTS

Output Number	Name	Unit	Comment
1	Front wall/soil interface temperature	C	The temperature of the outside surface of the basement front wall (the surface in contact with the soil).
2	Left wall/soil interface temperature	C	The temperature of the outside surface of the basement left wall (the surface in contact with the soil).
3	Back wall/soil interface temperature	C	The temperature of the outside surface of the basement back wall (the surface in contact with the soil).
4	Right wall/soil interface temperature	C	The temperature of the outside surface of the basement right wall (the surface in contact with the soil).
5	Floor/soil interface temperature	C	The temperature of the outside surface of the basement floor (the surface in contact with the soil).
6	Near-field surface temperature	C	The average temperature of the soil surface in the near-field.
7	Front wall/zone interface temperature	C	The temperature of the inside surface of the basement front wall (the surface in contact with the zone air).
8	Left wall/zone interface temperature	C	The temperature of the inside surface of the basement left wall (the surface in contact with the zone air).
9	Back wall/zone interface temperature	C	The temperature of the inside surface of the basement back wall (the surface in contact with the zone air).
10	Right wall/zone interface temperature	C	The temperature of the inside surface of the basement right wall (the surface in contact with the zone air).

11	Floor/zone interface temperature	C	The temperature of the inside surface of the basement floor (the surface in contact with the zone air).
12	Front wall heat transfer rate	kJ/h	The rate at which heat is transferred from the basement front wall into the zone. NOTE: this is also the negative of the rate at which heat is transferred from the front wall into the ground.
13	Left wall heat transfer rate	kJ/h	The rate at which heat is transferred from the basement left wall into the zone. NOTE: this is also the negative of the rate at which heat is transferred from the left wall into the ground.
14	Back wall heat transfer rate	kJ/h	The rate at which heat is transferred from the basement back wall into the zone. NOTE: this is also the negative of the rate at which heat is transferred from the back wall into the ground.
15	Right wall heat transfer rate	kJ/h	The rate at which heat is transferred from the basement right wall into the zone. NOTE: this is also the negative of the rate at which heat is transferred from the right wall into the ground.
16	Floor heat transfer rate	kJ/h	The rate at which heat is transferred from the basement floor into the zone. NOTE: this is also the negative of the rate at which heat is transferred from the floor into the ground.
17	Bottom boundary heat transfer rate	kJ/h	The rate at which heat is transferred from the soil in the near-field to the soil in the far-field through the bottom boundary of the storage.
18	Top boundary heat transfer rate	kJ/h	The rate at which heat is transferred from the soil in the near-field to the ambient through the top boundary (surface) of the storage.
19	Side boundary heat transfer rate	kJ/h	The rate at which heat is transferred from the soil in the near-field to the soil in the far-field through the side boundary of the storage.
20	Heat storage rate	kJ/h	The rate at which heat is being stored in the soil.
21	Total heat transfer	kJ/h	The combined rate at which heat is transferred from the soil to the basement through the four walls and floor.
22	Energy balance error	%	The percent error in the energy balance on the basement.

TYPE 703: SLAB ON GRADE (INTERFACES WITH TYPE 56)

PARAMETERS

Parameter Number	Name	Unit	Typical Value	Comment
1	Slab length	m	10.0	The length of the slab in the x-direction.
2	Slab width	m	10.0	The width of the slab in the y-direction.
3	Nodes along length (Nx_adj)	-	3	The number of nodes located along the length of the slab.
4	Nodes beyond length (Nx_ext)	-	6	The number of nodes located along the x-direction and beyond the edges of the slab.
5	Nodes along width (Ny_adj)	-	5	The number of nodes located along the width of the slab.
6	Nodes beyond width (Ny_ext)	-	4	The number of nodes located along the y-direction and beyond the edges of the slab.
7	Depth nodes (Nz_ext)	-	4	The number of nodes located along the z-direction and beneath the surface of the slab.
8	Mean surface temperature	C	10.0	The mean (average) surface temperature of undisturbed soil.
9	Amplitude of surface temperature	ΔC	5.0	The amplitude of the surface temperature of undisturbed soil over the course of a year.
10	Day of minimum surface temperature	Day	36	The day of the year at which the minimum undisturbed surface temperature occurs.
11	Soil conductivity	kJ/h.m.K	8.722	The thermal conductivity of the soil.
12	Soil density	kg/m3	3200.0	The density of the soil.
13	Soil specific heat	kJ/kg.K	0.84	The specific heat of the soil.
14	Surface emissivity	-	0.9	The emissivity of the soil surface beyond the edges of the slab.
15	Surface absorptance	-	0.6	The absorptance of the soil surface beyond the edges of the slab to solar radiation.
16	Insulated nodal depth	-	3	The number of nodes in the depth direction for which the perimeter of the slab is insulated.
17	R-value of perimeter insulation	h.m2.K/kJ	0.0	The resistance to heat transfer (R-value) for the material used to insulate the perimeter of the slab in the depth direction.
18	Insulated nodal width		3	The number of nodes in the width direction for which the perimeter of the slab is insulated in the horizontal direction (starting at the edge of the slab and moving outwards toward the farfield).
19	R-value of top insulation		0.0	The resistance to heat transfer (R-value) for the material used to insulate the perimeter of the slab in the width direction.
20	Side boundary heat transfer mode	-	1	Setting this value greater than zero allows the soil nodes to interact thermally with the soil beyond the boundary in the x and y directions.
21	Bottom boundary heat transfer mode	-	1	Setting this value greater than zero allows the soil nodes to interact thermally with the soil beyond the boundary in the

				depth (z) direction.
22	Slab U-value	kJ/h.m2.K	10.0	The u-value of the slab (plus any insulation) from the top surface (inside the house) to the bottom surface of the slab which is in direct contact with the soil.
23	Logical unit for output file	-	11	The logical unit which has been ASSIGNed to the file which will contain the temperatures of all soil nodes; to be printed at the very end of the simulation. Set this value less than 0 to turn-off the auto-print feature. Logical units must be unique integers greater than 10 in TRNSYS.
24	Logical unit for input file	-	12	The logical unit which has been ASSIGNed to the file which contains the temperatures of all soil nodes at the very beginning of the simulation. Set this value less than 0 to turn-off the import feature. Setting this value less than zero will cause the model to calculate the initial soil temperatures based on a correlation (Kasuda). Logical units must be unique integers greater than 10 in TRNSYS.
25	Surface mode	-	1	The mode for the surface temperatures of the near-field soil: Use an Energy Balance on the Soil Surface to Calculate the Surface Temperature Use the Surface Temperature as Calculated by the Kasuda Correlation Use the User-Supplied Surface Temperature
26	Far field distance	m	20.0	The distance away from the slab in the horizontal direction at which the soil is undisturbed by the heat transfer from the slab.
27	Deep earth depth	m	20.0	The distance beneath the slab in the vertical direction at which the soil is undisturbed by the heat transfer from the slab.

INPUTS

Input Number	Name	Unit	Typical Value	Comment
1	Ambient temperature	C	20.0	The dry-bulb temperature of the ambient air (in contact with the near and far-field soil).
2	Sky temperature	C	10.0	The temperature of the sky for radiative exchange calculations with the soil surface.
3	Incident solar radiation	kJ/h.m2	1000.0	The solar radiation (beam + diffuse) incident upon the soil surface.
4	Convection coefficient	kJ/h.m2.K	15.0	The heat transfer coefficient between the soil surface and the ambient air.
5	Inner surface slab temperature	C	10.0	The temperature of the slab at the inner surface (the surface not in contact with the soil)
6	Near-field surface temperature	C	10.0	The temperature of the near-field soil surface. This input is only used if Parameter 23 = 3
7	Far-field surface temperature	C	10.0	The temperature of the far-field soil surface. This input is only used if Parameter 23 = 3

OUTPUTS

Output Number	Name	Unit	Comment
1	Slab/soil interface temperature	C	The temperature of the bottom surface of the slab (the surface in contact with the soil).
2	Slab heat transfer rate	kJ/h	The rate at which heat is transferred from the slab into the zone. NOTE: this is also the negative of the rate at which heat is transferred from the slab into the ground.
3	Bottom boundary heat transfer rate	kJ/h	The rate at which heat is transferred from the soil in the near-field to the soil in the far-field through the bottom boundary of the storage.
4	Top boundary heat transfer rate	kJ/h	The rate at which heat is transferred from the soil in the near-field to the ambient through the top boundary (surface) of the storage.
5	Side boundary heat transfer rate	kJ/h	The rate at which heat is transferred from the soil in the near-field to the soil in the far-field through the side boundary of the storage.
6	Heat storage rate	kJ/h	The rate at which heat is being stored in the soil.
7	Near-field surface temperature	C	The average temperature of the soil surface in the near-field.
8	Long-term average surface temperature	C	The average temperature of the soil surface in the near-field if predicted by the Kasuda correlation.
9	Deep earth temperature	C	The temperature of the soil located beneath the bottom boundary of the storage.
10	Far-field surface temperature	C	The average temperature of the soil surface in the far-field.
11	Energy balance error	%	The percent error in the energy balance on the slab.

TYPE 704: SLAB ON GRADE (INTERFACES WITH ZONE AIR TEMPERATURE)

PARAMETERS

Parameter Number	Name	Unit	Typical Value	Comment
1	Slab length	m	10.0	The length of the slab in the x-direction.
2	Slab width	m	10.0	The width of the slab in the y-direction.
3	Nodes along length (Nx_adj)	-	3	The number of nodes located along the length of the slab.
4	Nodes beyond length (Nx_ext)	-	6	The number of nodes located along the x-direction and beyond the edges of the slab.
5	Nodes along width (Ny_adj)	-	5	The number of nodes located along the width of the slab.
6	Nodes beyond width (Ny_ext)	-	4	The number of nodes located along the y-direction and beyond the edges of the slab.
7	Depth nodes (Nz_ext)	-	4	The number of nodes located along the z-direction and beneath the surface of the slab.
8	Mean surface temperature	C	10.0	The mean (average) surface temperature of undisturbed soil.
9	Amplitude of surface temperature	ΔC	5.0	The amplitude of the surface temperature of undisturbed soil over the course of a year.
10	Day of minimum surface temperature	Day	36	The day of the year at which the minimum undisturbed surface temperature occurs.
11	Soil conductivity	kJ/h.m.K	8.722	The thermal conductivity of the soil.
12	Soil density	kg/m^3	3200.0	The density of the soil.
13	Soil specific heat	kJ/kg.K	0.84	The specific heat of the soil.
14	Surface emissivity	-	0.9	The emissivity of the soil surface beyond the edges of the slab.
15	Surface absorptance	-	0.6	The absorptance of the soil surface beyond the edges of the slab to solar radiation.
16	Insulated nodal depth	-	3	The number of nodes in the depth direction for which the perimeter of the slab is insulated.
17	R-value of perimeter insulation	$h.m^2.K/kJ$	0.0	The resistance to heat transfer (R-value) for the material used to insulate the perimeter of the slab in the depth direction.
18	Insulated nodal width	-	3	The number of nodes (starting at the edge of the slab and moving towards the far field) that are insulated in the horizontal direction.
19	R-value of horizontal insulation	$h.m^2.K/kJ$	0.0	The resistance to heat transfer of the insulation layer that is located on the soil surface and extends from the slab edges towards the far field.
20	Side boundary heat transfer mode	-	1	Setting this value greater than zero allows the soil nodes to interact thermally with the soil beyond the boundary in the x and y directions.
21	Bottom boundary heat transfer mode	-	1	Setting this value greater than zero allows the soil nodes to interact thermally with the soil beyond the boundary in the depth (z) direction.

22	Slab U-value	kJ/h.m^2.K	10.0	The u-value of the slab (plus any insulation) from the top surface (inside the house) to the bottom surface of the slab which is in direct contact with the soil.
23	Slab emissivity	-	0.7	The emissivity of the slab surface.
24	Slab absorptance	-	0.6	The absorptance of the slab surface.
25	Logical unit for output file	-	11	The logical unit which has been ASSIGNed to the file which will contain the temperatures of all soil nodes; to be printed at the very end of the simulation. Set this value less than 0 to turn-off the auto-print feature. Logical units must be unique integers greater than 10 in TRNSYS.
26	Logical unit for input file	-	12	The logical unit which has been ASSIGNed to the file which contains the temperatures of all soil nodes at the very beginning of the simulation. Set this value less than 0 to turn-off the import feature. Setting this value less than zero will cause the model to calculate the initial soil temperatures based on a correlation (Kasuda). Logical units must be unique integers greater than 10 in TRNSYS.
27	Surface mode	-	1	The mode for the surface temperatures of the near-field soil: Use an Energy Balance on the Soil Surface to Calculate the Surface Temperature Use the Surface Temperature as Calculated by the Kasuda Correlation Use the User-Supplied Surface Temperature
28	Far field distance	m	20.0	The distance away from the edges of the slab in which the soil is undisturbed by the heat transfer from the slab.
29	Deep earth depth	m	20.0	The distance away from the bottom of the slab in the vertical direction in which the soil is undisturbed by the heat transfer from the slab.

INPUTS

Input Number	Name	Unit	Typical Value	Comment
1	Ambient temperature	C	20.0	The dry-bulb temperature of the ambient air (in contact with the near and far-field soil).
2	Sky temperature	C	10.0	The temperature of the sky for radiative exchange calculations with the soil surface.
3	Incident solar radiation	kJ/h.m^2	1000.0	The solar radiation (beam + diffuse) incident upon the soil surface.
4	Convection coefficient	kJ/h.m^2.K	15.0	The heat transfer coefficient between the soil surface and the ambient air.
5	Zone temperature	C	10.0	The temperature of air in the zone.
6	Surface temperature	C	10.0	The temperature of surfaces within the zone to which the slab radiates.
7	Interior convection coefficient	kJ/h.m^2.K		The convection coefficient between the slab surface and zone air.
8	Incident interior radiation	kJ/h.m^2	0.0	The radiation (from lights and transmitted solar radiation) that falls on the slab surface.
9	Near-field surface temperature	C	10.0	The temperature of the near-field soil surface. This input is only used if Parameter 25 = 3

10	Far-field surface temperature	C	10.0	The temperature of the far-field soil surface. This input is only used if Parameter 25 = 3

OUTPUTS

Output Number	Name	Unit	Comment
1	Temperature of the slab top	C	The temperature of the top surface of the slab (the surface in contact with the zone air).
2	Temperature of the slab bottom	C	The temperature of the bottom surface of the slab (the surface in contact with the soil).
3	Slab heat transfer rate	kJ/h	The rate at which heat is transferred from the slab into the zone. NOTE: this is also the negative of the rate at which heat is transferred from the slab into the ground.
4	Bottom boundary heat transfer rate	kJ/h	The rate at which heat is transferred from the soil in the near-field to the soil in the far-field through the bottom boundary of the storage.
5	Top boundary heat transfer rate	kJ/h	The rate at which heat is transferred from the soil in the near-field to the ambient through the top boundary (surface) of the storage.
6	Side boundary heat transfer rate	kJ/h	The rate at which heat is transferred from the soil in the near-field to the soil in the far-field through the side boundary of the storage.
7	Heat storage rate	kJ/h	The rate at which heat is being stored in the soil.
8	Near-field surface temperature	C	The average temperature of the soil surface in the near-field.
9	Long-term average surface temperature	C	The average temperature of the soil surface in the near-field if predicted by the Kasuda correlation.
10	Deep earth temperature	C	The temperature of the soil located beneath the bottom boundary of the storage.
11	Far-field surface temperature	C	The average temperature of the soil surface in the far-field.
12	Energy balance error	%	The percent error in the energy balance on the slab.

TYPE 705: IN GROUND RADIANT SLAB WITH PIPES (INTERFACES WITH TYPE 56)

PARAMETERS

Parameter Number	Name	Unit	Typical Value	Comment
1	Slab length	m	10.0	The length of the slab in the x-direction.
2	Slab width	m	10.0	The width of the slab in the y-direction.
3	Slab depth	m	0.10	The depth (thickness) of the slab in the z-direction.
4	Nodes along length (Nx_adj)	-	3	The number of nodes located along the length of the slab.
5	Nodes beyond length (Nx_ext)	-	6	The number of nodes located along the x-direction and beyond the edges of the slab.
6	Nodes along width (Ny_adj)	-	5	The number of nodes located along the width of the slab.
7	Nodes beyond width (Ny_ext)	-	4	The number of nodes located along the y-direction and beyond the edges of the slab.
8	Depth nodes (Nz_ext)	-	4	The number of nodes located along the z-direction and beneath the bottom surface of the slab.
9	Mean surface temperature	C	10.0	The mean (average) surface temperature of undisturbed soil.
10	Amplitude of surface temperature	ΔC	5.0	The amplitude of the surface temperature of undisturbed soil over the course of a year.
11	Day of minimum surface temperature	day	36	The day of the year at which the minimum undisturbed surface temperature occurs.
12	Soil conductivity	kJ/h.m.K	8.722	The thermal conductivity of the soil.
13	Soil density	kg/m^3	3200.0	The density of the soil.
14	Soil specific heat	kJ/kg.K	0.84	The specific heat of the soil.
15	Surface emissivity	-	0.9	The emissivity of the soil surface beyond the edges of the slab.
16	Surface absorptance	-	0.6	The absorptance of the soil surface beyond the edges of the slab to solar radiation.
17	Insulated nodal depth	-	1	The number of nodes in the depth direction for which the perimeter of the slab is insulated (including the slab node).

18	R-Value of perimeter insulation	$h.m^2.K/kJ$	0.0	The resistance to heat transfer (R-value) for the material used to insulate the perimeter of the slab in the depth direction.
19	R-Value of bottom insulation	$h.m^2.K/kJ$	0.0	The resistance to heat transfer (R-value) for the material used to insulate the bottom of the slab from the soil.
20	Side boundary heat transfer	-	1	Setting this value greater than zero allows the soil nodes to interact thermally with the soil beyond the boundary in the x and y directions.
21	Bottom boundary heat transfer	-	1	Setting this value greater than zero allows the soil nodes to interact thermally with the soil beyond the boundary in the depth (z) direction.
22	Logical unit for output file	-	11	The logical unit that has been ASSIGNed to the file which will contain the temperatures of all nodes (soil, slab, pipe and far-field); to be printed at the very end of the simulation. Set this value less than 0 to turn-off the auto-print feature. Logical units must be unique integers greater than 10 in TRNSYS.
23	Logical unit for input file	-	12	The logical unit which has been ASSIGNed to the file which contains the temperatures of all nodes (soil, slab, pipe and far-field) at the very beginning of the simulation. Set this value less than 0 to turn-off the import feature. Setting this value less than zero will cause the model to calculate the initial soil temperatures based on a correlation (Kasuda). Logical units must be unique integers greater than 10 in TRNSYS.
24	Surface mode	-	1	The mode for the surface temperatures of the near-field and far-field soil: 1: Use an Energy Balance on the Soil Surface to Calculate the Surface Temperature. Conduction effects will impose this boundary conditions on all nodes below the surface node. 2: Use the Surface Temperature, as Calculated by the Kasuda Correlation, to Set the Surface Temperature. In the near-field, conduction effects will impose this boundary conditions on all nodes below the surface node. In the far-field, the temperature of all nodes will be set with the Kasuda correlation. 3: Use the User-Supplied Surface Temperature. Conduction effects will impose this boundary conditions on all nodes below the surface node.
25	Far field distance	m	20.0	The horizontal distance from the edge of the radiant slab at which the soil is considered undisturbed by the heat transfer into the soil from the slab.
26	Deep earth depth	m	20.0	The vertical distance from the bottom of the radiant slab at which the soil is considered undisturbed by the heat transfer into the soil from the slab.
27	Slab conductivity	kJ/h.m.K	8.722	The thermal conductivity of the slab material.
28	Slab density	kg/m^3	3200.0	The density of the slab material.

29	Slab specific heat	kJ/kg.K	0.84	The specific heat of the slab material.
30	U-value of cover material	kJ/hr.m^2.K	0	The U-value of the material that lies on top of the slab and is considered as the wall material in Type 56. Refer to the Type 56 INF file for this value.
31	Slab initial temperature	C	20.0	The initial temperature of the slab.
32	Pipe/slab contact resistance	h.m2.K/kJ	0	The contact resistance between the slab material and the buried pipe. This value is assumed to be between the pipe outer surface temperature and the soil nodal temperature.
33	Number of HX pipes	-	0	The number of unique HX pipes that are embedded in the slab.
Cycle	Number of HX nodes for pipe	-	0	The number of uniform segments into which the specified HX pipe will be divided.
Cycle	Logical unit for pipe configuration	-	0	The logical unit which will be ASSIGNed to the data file containing the HX pipe configuration for the specified pipe.
Cycle	Length of HX pipe	m	0	The length of the specified HX pipe.
MPAR = 33 + 3 * Number of HX Pipes				
MPAR+1	Pipe conductivity	kJ/h.m.K	1.4	The thermal conductivity of the pipe material.
MPAR+2	Pipe density	kg/m3	1200.0	The density of the pipe material.
MPAR+3	Pipe specific heat	kJ/kg.K	0.65	The specific heat of the pipe material.
MPAR+4	Pipe outer diameter	m	0.033	The outer diameter of the pipe.
MPAR+5	Pipe inner diameter	m	0.027	The inner diameter of the pipe.
MPAR+6	Fluid specific heat	kJ/kg.K	4.19	The specific heat of the fluid flowing through the pipes.
MPAR+7	Fluid density	kg/m3	1000.0	The density of the fluid flowing through the pipes.
MPAR+8	Fluid conductivity	kJ/h.m.K	6.23	The thermal conductivity of the fluid flowing through the pipes.
MPAR+9	Fluid viscosity	kg.h/m	3.06	The viscosity of the fluid flowing through the pipes.

INPUTS

Input Number	Name	Unit	Typical Value	Comment
1	Ambient temperature	C	20.0	The dry-bulb temperature of the ambient air (in contact with the near and far-field soil).
2	Sky temperature	C	10.0	The temperature of the sky for radiative exchange calculations with the soil surface.
3	Incident solar radiation	kJ/h.m2	0.0	The solar radiation (beam + diffuse) incident upon the soil surface.
4	Outer convection coefficient	kJ/h.m2.K	25.0	The convective heat transfer coefficient between the soil surface and the ambient air.
5	Cover material temperature	C	20.0	The temperature of the slab cover / zone air interface. This is typically provided by the zone model as the inner surface temperature.
6	Near-field surface temperature	C	10.0	The temperature of the near-field soil surface. This input is only used if Parameter 24 = 3
7	Far-field surface temperature	C	10.0	The temperature of the far-field soil surface. This input is only used if Parameter 24 = 3
Cycle based on PAR 33	Fluid inlet temperature	C	30.0	The temperature of the fluid entering the specified pipe. These two inputs are cycled with the number of pipes
	Fluid flow rate	kg/h	0.0	The flow rate of the fluid entering the specified pipe. These two inputs are cycled with the number of pipes

OUTPUTS

Output Number	Name	Unit	Comment
1	Slab/cover interface temperature	C	The temperature at the interface between the cover of the slab and the slab. This temperature is usually connected back to the Type 56 model as the boundary temperature for the cover wall.
2	Slab heat transfer rate	kJ/h	The rate at which heat is transferred from the slab into the cover material.
3	Bottom boundary heat transfer rate	kJ/h	The rate at which heat is transferred from the soil in the near-field to the soil in the far-field through the bottom boundary of the storage.
4	Top boundary heat transfer rate	kJ/h	The rate at which heat is transferred from the soil in the near-field to the ambient through the top boundary (surface) of the storage.
5	Side boundary heat transfer rate	kJ/h	The rate at which heat is transferred from the soil in the near-field to the soil in the far-field through the side boundary of the storage.

6	Heat storage rate	kJ/h	The rate at which heat is being stored in the soil.
7	Pipe heat transfer rate	kJ/h	The rate at which heat is being transferred from the fluid in the pipes to the slab/soil nodes.
8	Near-field surface temperature	C	The average temperature of the soil surface in the near-field.
9	Long-term average surface temperature	C	The average temperature of the soil surface in the near-field if predicted by the Kasuda correlation.
10	Deep earth temperature	C	The temperature of the soil located just beneath the bottom boundary of the storage.
11	Far-field surface temperature	C	The average temperature of the soil surface in the far-field.
12	Energy balance error	%	The error in the energy balance for the entire storage volume expressed as a percentage.
 based on PAR 3	Fluid outlet temperature	C	The temperature of the fluid exiting the specified pipe. These two outputs are cycled with the number of pipes (PAR (NPAR+7)).
	Fluid flow rate	kg/h	The flow rate of the fluid exiting the specified pipe. These two outputs are cycled with the number of pipes (PAR (NPAR+7)).

TYPE 706: IN GROUND RADIANT SLAB WITH PIPES (INTERFACES WITH ZONE AIR TEMPERATURE)

PARAMETERS

Parameter Number	Name	Unit	Typical Value	Comment
1	Slab length	m	10.0	The length of the slab in the x-direction.
2	Slab width	m	10.0	The width of the slab in the y-direction.
3	Slab depth	m	0.10	The depth (thickness) of the slab in the z-direction.
4	Nodes along length (Nx_adj)	-	3	The number of nodes located along the length of the slab.
5	Nodes beyond length (Nx_ext)	-	6	The number of nodes located along the x-direction and beyond the edges of the slab.
6	Nodes along width (Ny_adj)	-	5	The number of nodes located along the width of the slab.
7	Nodes beyond width (Ny_ext)	-	4	The number of nodes located along the y-direction and beyond the edges of the slab.
8	Depth nodes (Nz_ext)	-	4	The number of nodes located along the z-direction and beneath the bottom surface of the slab.
9	Mean surface temperature	C	10.0	The mean (average) surface temperature of undisturbed soil.
10	Amplitude of surface temperature	ΔC	5.0	The amplitude of the surface temperature of undisturbed soil over the course of a year.
11	Day of minimum surface temperature	day	36	The day of the year at which the minimum undisturbed surface temperature occurs.
12	Soil conductivity	kJ/h.m.K	8.722	The thermal conductivity of the soil.
13	Soil density	kg/m^3	3200.0	The density of the soil.
14	Soil specific heat	kJ/kg.K	0.84	The specific heat of the soil.
15	Surface emissivity	-	0.9	The emissivity of the soil surface beyond the edges of the slab.
16	Surface absorptance	-	0.6	The absorptance of the soil surface beyond the edges of the slab to solar radiation.

17	Insulated nodal depth	-	1	The number of nodes in the depth direction for which the perimeter of the slab is insulated (including the slab node).
18	R-Value of perimeter insulation	$h.m^2.K/kJ$	0.0	The resistance to heat transfer (R-value) for the material used to insulate the perimeter of the slab in the depth direction.
19	R-Value of bottom insulation	$h.m^2.K/kJ$	0.0	The resistance to heat transfer (R-value) for the material used to insulate the bottom of the slab from the soil.
20	Side boundary heat transfer mode	-	1	Setting this value greater than zero allows the soil nodes to interact thermally with the soil beyond the boundary in the x and y directions.
21	Bottom boundary heat transfer mode	-	1	Setting this value greater than zero allows the soil nodes to interact thermally with the soil beyond the boundary in the depth (z) direction.
22	Logical unit for output file	-	11	The logical unit that has been ASSIGNed to the file which will contain the temperatures of all nodes (soil, slab, pipe and far-field); to be printed at the very end of the simulation. Set this value less than 0 to turn-off the auto-print feature. Logical units must be unique integers greater than 10 in TRNSYS.
23	Logical unit for input file	-	12	The logical unit which has been ASSIGNed to the file which contains the temperatures of all nodes (soil, slab, pipe and far-field) at the very beginning of the simulation. Set this value less than 0 to turn-off the import feature. Setting this value less than zero will cause the model to calculate the initial soil temperatures based on a correlation (Kasuda). Logical units must be unique integers greater than 10 in TRNSYS.
24	Surface mode	-	1	The mode for the surface temperatures of the near-field and far-field soil: 1: Use an Energy Balance on the Soil Surface to Calculate the Surface Temperature. Conduction effects will impose this boundary conditions on all nodes below the surface node. 2: Use the Surface Temperature, as Calculated by the Kasuda Correlation, to Set the Surface Temperature. In the near-field, conduction effects will impose this boundary conditions on all nodes below the surface node. In the far-field, the temperature of all nodes will be set with the Kasuda correlation. 3: Use the User-Supplied Surface Temperature. Conduction effects will impose this boundary conditions on all nodes below the surface node.
25	Far field distance	-	20.0	The distance away from the slab in the horizontal direction at which the soil is no longer influenced by the heat transfer from the slab into the soil.
26	Deep earth depth	-	20.0	The distance away from the slab in the vertical direction at which the soil is no longer influenced by the heat transfer from the slab into the soil.
27	Slab conductivity	kJ/h.m.K	8.722	The thermal conductivity of the slab.

28	Slab density	kg/m^3	3200.0	The density of the slab.
29	Slab specific heat	kJ/kg.K	0.84	The specific heat of the slab.
30	Slab cover emissivity	-	0.9	The emissivity of the slab surface. Setting this value to zero effectively causes the radiative exchange between the slab surface and the zone interior surfaces to be neglected.
31	Slab cover absorptance	-	0.6	The absorptance of the slab surface to incident radiation. Setting this value to zero effectively causes the radiative exchange between the slab surface and the zone interior surfaces to be neglected.
32	Initial slab temperature	C	20.0	The temperature of the slab, pipes, and fluid at the beginning of the simulation.
33	Slab cover R value			The R-value (resistance to heat transfer) of the material on top of the slab (carpeting, linoleum etc.)
34	Contact resistance between pipe and soil	h.m^2.K/kJ	0.0	The resistance to heat transfer (R-value) from the outer pipe surface to the center of the soil/slab node.
35	Number of buried pipes	-	1	The number of different pipes that are contained within the soil/slab boundary. For each pipe the user must specify the inlet fluid conditions and the pipe layout through the storage volume.
Cycle based on PAR 35	Number of pipe nodes	-	9	The number of nodes that this pipe will be divided into along the flow direction. Each node is assumed to be of uniform temperature and fluid conduction in the axial direction is not accounted for. This parameter is cycled with the number of pipes (Par (NPAR+8)).
Cycle based on PAR 35	Logical unit for pipe layout file	-	13	The logical unit which has been ASSIGNed to the file which contains the pipe layout information for this pipe. The file must contain one line for each pipe node and provide the fraction of total pipe length for this node and the x, y, and z coordinates of the soil/slab node in which this pipe node is contained. Logical units must be unique integers greater than 10 in TRNSYS.
Cycle based on PAR 35	Length of pipe	m	75.0	The total length of this pipe.
MPAR = 35 + 3 * Number of Buried Pipes				
MPAR+1	Pipe conductivity	kJ/h.m.K	1.4	The thermal conductivity of the pipe material.
MPAR+2	Pipe density	kg/m^3	1200.0	The density of the pipe material.
MPAR+3	Pipe specific heat	kJ/kg.K	0.65	The specific heat of the pipe material.
MPAR+4	Pipe outer diameter	m	0.033	The outer diameter of the pipe.

MPAR+5	Pipe inner diameter	m	0.027	The inner diameter of the pipe.
MPAR+6	Fluid specific heat	kJ/kg.K	4.19	The specific heat of the fluid flowing through the pipes.
MPAR+7	Fluid density	kg/m3	1000.0	The density of the fluid flowing through the pipes.
MPAR+8	Fluid conductivity	kJ/h.m.K	6.23	The thermal conductivity of the fluid flowing through the pipes.
MPAR+9	Fluid viscosity	kg.h/m	3.06	The viscosity of the fluid flowing through the pipes.

INPUTS

Input Number	Name	Unit	Typical Value	Comment
1	Ambient temperature	C	20.0	The dry-bulb temperature of the ambient air (in contact with the near and far-field soil).
2	Sky temperature	C	10.0	The temperature of the sky for radiative exchange calculations with the soil surface.
3	Incident solar radiation	kJ/h.m2	0.0	The solar radiation (beam + diffuse) incident upon the soil surface.
4	Outer convection coefficient	kJ/h.m2.K	25.0	The convective heat transfer coefficient between the soil surface and the ambient air.
5	Zone temperature	C	20.0	The dry-bulb temperature of the zone air (in contact with the surface of the slab).
6	Surroundings temperature	C	20.0	The temperature of the surroundings for radiative exchange calculations with the slab surface.
7	Incident radiation	kJ/h.m2	0.0	The total radiation (lights, solar etc.) incident upon the slab surface.
8	Inner convection coefficient	kJ/h.m2.K	15.0	The convective heat transfer coefficient between the slab surface and the zone air.
9	Near-field surface temperature	C	10.0	The temperature of the near-field soil surface. This input is only used if Parameter 24 = 3
10	Far-field surface temperature	C	10.0	The temperature of the far-field soil surface. This input is only used if Parameter 24 = 3
 based on PAR 35	Fluid inlet temperature	C	30.0	The temperature of the fluid entering the specified pipe. These two inputs are cycled with the number of pipes.
	Fluid flow rate	kg/h	0.0	The flow rate of the fluid entering the specified pipe. These two inputs are cycled with the number of pipes.

OUTPUTS

Output Number	Name	Unit	Comment
1	Slab surface temperature	C	The temperature of the top surface of the slab (the surface in contact with the zone air).
2	Slab heat transfer rate	kJ/h	The rate at which heat is transferred from the slab into the zone.
3	Bottom boundary heat transfer rate	kJ/h	The rate at which heat is transferred from the soil in the near-field to the soil in the far-field through the bottom boundary of the storage.
4	Top boundary heat transfer rate	kJ/h	The rate at which heat is transferred from the soil in the near-field to the ambient through the top boundary (surface) of the storage.
5	Side boundary heat transfer rate	kJ/h	The rate at which heat is transferred from the soil in the near-field to the soil in the far-field through the side boundary of the storage.
6	Heat storage rate	kJ/h	The rate at which heat is being stored in the soil.
7	Pipe heat transfer rate	kJ/h	The rate at which heat is being transferred from the fluid in the pipes to the slab/soil nodes.
8	Near-field surface temperature	C	The average temperature of the soil surface in the near-field.
9	Long-term average surface temperature	C	The average temperature of the soil surface in the near-field if predicted by the Kasuda correlation.
10	Deep earth temperature	C	The temperature of the soil located just beneath the bottom boundary of the storage.
11	Far-field surface temperature	C	The average temperature of the soil surface in the far-field.
12	Energy balance error	%	The error in the energy balance for the entire storage volume expressed as a percentage.
 based on PAR 35	Fluid outlet temperature	C	The temperature of the fluid exiting the specified pipe. These two outputs are cycled with the number of pipes.
	Fluid flow rate	kg/h	The flow rate of the fluid exiting the specified pipe. These two outputs are cycled with the number of pipes.

TYPE 707: BURIED VERTICALLY CYLINDRICAL STORAGE TANK WRAPPER

PARAMETERS

Parameter Number	Name	Unit	Typical Value	Comment
1	Total vertical nodes	-	10	The total number of nodes located in the soil along the vertical direction.
2	Nodes above tank	-	2	The number of nodes located above the storage tank in the vertical direction.
3	Nodes vertically along tank	-	5	The number of nodes located along the height of the vertical cylindrical storage tank. At least one soil node per storage tank node should be considered.
4	Radial nodes	-	6	The number of nodes desired in the soil in the radial direction (moving horizontally away from the storage tank).
5	Outer radius of tank	m	1.0	The outer radius of the cylindrical storage tank.
6	U value for tank top	kJ/hr-m^2-K	5.0	The overall heat transfer coefficient from the fluid in the top of the storage tank to the soil located just above the top of the storage tank. This value should include the fluid convection coefficient, the effects of the tank top material and any insulation that may be located between the tank and the soil. This value should be identical to the U-value provided to the storage tank model.
Cycle based on PAR 3	U value for tank wall or tank wall node	kJ/hr-m^2-K	5.0	The overall heat transfer coefficient from the fluid in the storage tank to the soil located just outside the wall of the storage tank. This value should include the fluid convection coefficient, the effects of the tank wall material and any insulation that may be located between the tank and the soil. This value will be specified for each vertical node of the soil located adjacent to the storage tank. This value should be identical to the U-value provided to the storage tank model.
7 + PAR 3	U value for tank bottom	kJ/hr-m^2-K	5.0	The overall heat transfer coefficient from the fluid in the bottom of the storage tank to the soil located just below the storage tank. This value should include the fluid convection coefficient, the effects of the tank top material and any insulation that may be located between the tank and the soil. This value should be identical to the U-value provided to the storage tank model.
8 + PAR 3	Mean surface temperature	C	10	The mean (average) surface temperature of undisturbed soil.
9 + PAR 3	Amplitude of surface temperature	ΔC	5	The amplitude of the surface temperature of undisturbed soil over the course of a year.
10 + PAR 3	Day of minimum surface temperature	day	36	The day of the year at which the minimum undisturbed surface temperature occurs.

11 + PAR 3	Soil conductivity	kJ/hr-m-K	8.772	The thermal conductivity of the soil surrounding the tank.
12 + PAR 3	Soil density	kg/m^3	3200.0	The density of the soil surrounding the tank
13 + PAR 3	Soil specific heat	kJ/kg-K	0.84	The specific heat of the soil surrounding the tank
14 + PAR 3	Surface emissivity	-	0.90	The emissivity of the soil surface.
15 + PAR 3	Surface absorptance	-	0.6	The absorptance of the soil surface to solar radiation.
16 + PAR 3	R value of top insulation	hr-m2-K/kJ	0.0	The resistance of any insulation material placed on the top of the ground surface that is insulating the near field from the ambient.
17 + PAR 3	R value of perimeter insulation	hr-m2-K/kJ	0.0	The resistance to heat transfer (R-value) for the material used to insulate the perimeter of the near-field from heat transfer with the far-field.
18 + PAR 3	R value of bottom insulation	hr-m2-K/kJ	0.0	The resistance to heat transfer of any insulation material placed below the storage tank that is insulating the near field from the far-field at the very bottom of the near-field.
19 + PAR 3	Surface mode	-	1	1. Use an Energy Balance on the Soil Surface to Calculate the Surface Temperature 2. Use the Surface Temperature as Calculated by the Kasuda Correlation 3. Use the User-Supplied Surface Temperature
20 + PAR 3	Logical unit of output file	-	11	The logical unit which has been ASSIGNed to the file which will contain the temperatures of all soil nodes; to be printed at the very end of the simulation. Set this value less than 0 to turn-off the auto-print feature.
21 + PAR 3	Logical unit of input file	-	12	The logical unit ASSIGNed to the file which contains the temperatures of all soil nodes at the beginning of the simulation. Set this value less than 0 to turn-off the import feature.
Cycle based on PAR 1	Height of soil node	m	0.1	The length of the specified storage nodes (in the z-direction) starting at the surface and proceeding downwards towards the far-field.
Cycle based on PAR 4	Thickness of radial node	m	0.1	The thickness of the specified node (radial-direction) starting he soil/tank boundary and proceeding towards the far-field ng the horizontal direction).

INPUTS

Input Number	Name	Unit	Typical Value	Comment
1	Ambient temperature	C	20.0	The dry-bulb temperature of the ambient air (in contact with the near and far-field soil).

2	Sky temperature	C	10.0	The temperature of the sky for radiative exchange calculations with the soil surface.
3	Incident solar radiation	$kJ/h.m^2$	0.0	The solar radiation (beam + diffuse) incident upon the soil surface.
4	Outer convection coefficient	$kJ/h.m^2.K$	25.0	The convective heat transfer coefficient between the soil surface and the ambient air.
5	Surface temperature	C	20.0	The dry-bulb temperature of the zone air (in contact with the surface of the slab).
Cycle based on PAR 3	Storage tank node temperature	C	20.0	The temperature of the storage tank node adjacent to the specified soil node; where the nodes are referenced downwards from the top of the storage tank

OUTPUTS

Output Number	Name	Unit	Comment
1	Tank top loss temperature	C	The temperature of the soil directly above the top of the buried storage tank. This temperature should be used as the top loss temperature for the storage tank model.
2	Tank edge loss temperature	C	The average temperature of the soil directly in contact with the edges (walls) of the storage tank. This value should be connected to the edge loss temperature for models which require an overall temperature that is not broken down by node.
3	Tank bottom loss temperature	C	The temperature of the soil directly below the bottom of the buried storage tank. This temperature should be used as the bottom loss temperature for the storage tank model.
4	Tank top losses	kJ/hr	The rate at which heat is transferred into the soil through the top of the storage tank.
5	Tank edge losses	kJ/hr	The rate at which heat is transferred into the soil through the walls of the storage tank.
6	Tank bottom losses	kJ/hr	The rate at which heat is transferred into the soil through the bottom of the storage tank.
7	Total tank losses	kJ/hr	The rate at which heat is transferred into the soil through the top, bottom and walls of the storage tank.
7	Top boundary heat transfer	kJ/hr	The rate at which energy is transferred out of the soil through the boundary of the near-field soil with the air.
8	Bottom boundary heat transfer	kJ/hr	The rate at which energy is transferred out of the near-field soil through the bottom boundary (boundary between near-field and far-field).
9	Perimeter boundary heat transfer	kJ/hr	The rate at which energy is transferred out of the near-field soil through the perimeter boundary (boundary between near-field and far-field).
10	Heat storage rate	kJ/hr	The rate at which heat is being stored in the soil.

11	Energy balance error	%	The percent error in the energy balance calculated on the near-field soil volume.
Cycle	Edge loss temperature	C	The temperature of the soil in direct contact with the storage tank for the specified node. Nodes start at the top of the storage tank (1) and proceed downwards.
Cycle	Edge losses for node	kJ/hr	The rate at which heat is transferred into the specified soil node through the walls of the storage tank.

TYPE 711: BURIED HORIZONTAL PIPE WRAPPER

PARAMETERS

Parameter Number	Name	Unit	Typical Value	Comment
1	Pipe outer diameter	m	0.06	The outer diameter of the pipe buried in the soil.
2	Buried pipe length	m	10.0	The total length of the buried horizontal pipe.
3	Buried pipe depth	m	3.0	The depth at which the horizontal pipe is buried. The depth should be measured from the surface to the center of the pipe.
4	Soil thermal conductivity	kJ/hr-m-K	8.72	The thermal conductivity of the soil in which the horizontal pipe is buried.
5	Soil density	kg/m^3	3200.0	The density of the soil in which the horizontal pipe is buried.
6	Soil specific heat	kJ/kg-K	0.84	The specific heat of the soil in which the horizontal pipe is buried.
7	Number of radial nodes	-	6	The number of nodes in the radial direction for the calculations. The greater the number of radial nodes, the greater the amount of soil in the near-field storage. Increasing the number of radial nodes will increase the accuracy at the expense of simulation time.
8	Number of axial nodes	-	10	The number of nodes that the horizontal pipe will be subdivided into in the horizontal direction for the calculations. Increasing the number of horizontal nodes will increase the accuracy at the expense of simulation time.
9	Number of circumferential nodes	-	4	The number of nodes that the horizontal pipe will be subdivided into in the circumferential direction for the calculations. Increasing the number of circumferential nodes will increase the accuracy at the expense of simulation time. Due to symmetry, only one-half of the pipe (split along a vertical plane running alone the center of the pipe) will be modeled.
10	Average surface temperature	C	10.0	The average surface temperature during the year. This temperature will be used as the deep earth temperature for the calculations.
11	Amplitude of surface temperature	ΔC	9	The difference in temperature between the maximum surface temperature and the average surface temperature.
12	Day of minimum surface temperature	day	32	The day of the year in which the minimum surface temperature occurs.
Cycle based on PAR 7	Thickness of radial node	m	0.1	The radial thickness of the specified soil nodes. Best results are usually obtained with small nodes near the pipe wall that increase in size the farther they get from the pipe. Typical a pattern of 6 nodes with 0.1, 0.2, 0.4, 0.8, 1.6, and 3.2 meters

				works well. Be careful that the total distance does not exceed the depth of the buried pipe.

INPUTS

Input Number	Name	Unit	Typical Value	Comment
1	Pipe U value	kJ/hr-m	5.0	The overall loss coefficient from the fluid in the buried pipe to the outer pipe wall surface.
Cycle based on PAR 8	Fluid temperature	C	20.0	The average temperature of the fluid in the specified node of the buried horizontal pipe.

OUTPUTS

Output Number	Name	Unit	Comment
1	Average loss temperature	C	The average temperature of the soil in direct contact with the outer surface of the buried pipe.
2	Pipe heat transfer	C	The rate at which energy is transferred from the fluid in the pipe into the soil.
3	Radial boundary heat transfer	kJ/hr	The rate at which energy is transferred from the soil in the pipe near-field through the radial boundary with the far-field soil.
4	Storage heat transfer	kJ/hr	The rate at which energy is stored in the near-field soil nodes.
5	Energy balance	%	The percent error in the energy balance for the near-field soil.
Cycle based on PAR 8	Loss temperature for node	C	The temperature of the soil/pipe interface. This temperature should be connected to the loss temperature of the pipe model.

TYPE 712: RADIANT SLAB WITH PIPES AND NO GROUND STORAGE EFFECTS (INTERFACES WITH TYPE 56)

PARAMETERS

Parameter Number	Name	Unit	Typical Value	Comment
1	Slab length	m	10.0	The length of the slab in the x-direction.
2	Slab width	m	10.0	The width of the slab in the y-direction.
3	Slab depth	m	0.10	The depth (thickness) of the slab in the z-direction.
4	Nodes along length (Nx_adj)	-	3	The number of nodes located along the length of the slab.
5	Nodes along width (Ny_adj)	-	5	The number of nodes located along the width of the slab.
6	Mean surface temperature	C	10.0	The mean (average) surface temperature of undisturbed soil.
7	Amplitude of surface temperature	ΔC	5.0	The amplitude of the surface temperature of undisturbed soil over the course of a year.
8	Day of minimum surface temperature	day	36	The day of the year at which the minimum undisturbed surface temperature occurs.
9	Slab conductivity	kJ/h.m.K	8.722	The thermal conductivity of the slab material.
10	Slab density	kg/m^3	3200.0	The density of the slab material.
11	Slab specific heat	kJ/kg.K	0.84	The specific heat of the slab material.
12	U-value of cover material	$kJ/hr.m^2.K$	0	The U-value of the material that lies on top of the slab and is considered as the wall material in Type 56. Refer to the Type 56 INF file for this value.
13	Slab initial temperature	C	20.0	The initial temperature of the slab.
14	Pipe/slab contact resistance	h.m2.K/kJ	0	The contact resistance between the slab material and the buried pipe. This value is assumed to be between the pipe outer surface temperature and the soil nodal temperature.
15	R-Value of perimeter insulation	$h.m^2.K/kJ$	0.0	The resistance to heat transfer (R-value) for the material used to insulate the perimeter of the slab in the depth direction.
16	R-Value of bottom insulation	$h.m^2.K/kJ$	0.0	The resistance to heat transfer (R-value) for the material used to insulate the bottom of the slab from the soil.

17	Number of HX pipes	-	0	The number of unique HX pipes that are embedded in the slab.
Cycle based on PAR 17	Number of HX nodes for pipe	-	0	The number of uniform segments into which the specified HX pipe will be divided.
Cycle based on PAR 17	Logical unit for pipe configuration	-	0	The logical unit which will be ASSIGNed to the data file containing the HX pipe configuration for the specified pipe.
Cycle based on PAR 17	Length of HX pipe	m	0	The length of the specified HX pipe.
MPAR = 17 + 3 * Number of HX Pipes				
MPAR+1	Pipe conductivity	kJ/h.m.K	1.4	The thermal conductivity of the pipe material.
MPAR+2	Pipe density	kg/m3	1200.0	The density of the pipe material.
MPAR+3	Pipe specific heat	kJ/kg.K	0.65	The specific heat of the pipe material.
MPAR+4	Pipe outer diameter	m	0.033	The outer diameter of the pipe.
MPAR+5	Pipe inner diameter	m	0.027	The inner diameter of the pipe.
MPAR+6	Fluid specific heat	kJ/kg.K	4.19	The specific heat of the fluid flowing through the pipes.
MPAR+7	Fluid density	kg/m3	1000.0	The density of the fluid flowing through the pipes.
MPAR+8	Fluid conductivity	kJ/h.m.K	6.23	The thermal conductivity of the fluid flowing through the pipes.
MPAR+9	Fluid viscosity	kg.h/m	3.06	The viscosity of the fluid flowing through the pipes.

INPUTS

Input Number	Name	Unit	Typical Value	Comment
1	Cover material temperature	C	20.0	The temperature of the slab cover / zone air interface. This is typically provided by the zone model as the inner surface temperature.
Cycle	Fluid inlet temperature	C	30.0	The temperature of the fluid entering the specified pipe. These two inputs are cycled with the number of pipes

based on PAR 17	Fluid flow rate	kg/h	0.0	The flow rate of the fluid entering the specified pipe. These two inputs are cycled with the number of pipes

OUTPUTS

Output Number	Name	Unit	Comment
1	Slab/cover interface temperature	C	The temperature at the interface between the cover of the slab and the slab. This temperature is usually connected back to the Type 56 model as the boundary temperature for the cover wall.
2	Slab heat transfer rate	kJ/hr	The rate at which heat is transferred from the slab into the cover material.
3	Heat storage rate	kJ/hr	The rate at which heat is being stored in the soil.
4	Pipe heat transfer rate	kJ/hr	The rate at which energy is transferred from the fluid in the heat exchanger pipes to the slab.
5	Perimeter heat loss	kJ/hr	The rate at which energy is lost from the slab through the perimeter of the slab.
6	Bottom heat loss	kJ/hr	The rate at which energy is lost from the slab through the bottom of the slab.
7	Long term average surface temperature	C	The temperature of the undisturbed soil surface as predicted by the Kasuda correlation.
8	Energy balance error	%	The percent error in the energy balance calculated on the soil/slab interface.
 based on PAR 17	Fluid outlet temperature	C	The temperature of the fluid exiting the specified pipe.
	Fluid flow rate	kg/hr	The flow rate of the fluid exiting the specified pipe.

TYPE 713: RADIANT SLAB WITH PIPES AND NO GROUND STORAGE EFFECTS (INTERFACES WITH ZONE AIR TEMPERATURE)

PARAMETERS

Parameter Number	Name	Unit	Typical Value	Comment
1	Slab length	m	10.0	The length of the slab in the x-direction.
2	Slab width	m	10.0	The width of the slab in the y-direction.
3	Slab depth	m	0.10	The depth (thickness) of the slab in the z-direction.
4	Nodes along length (Nx_adj)	-	3	The number of nodes located along the length of the slab.
5	Nodes along width (Ny_adj)	-	5	The number of nodes located along the width of the slab.
6	Mean surface temperature	C	10.0	The mean (average) surface temperature of undisturbed soil.
7	Amplitude of surface temperature	ΔC	5.0	The amplitude of the surface temperature of undisturbed soil over the course of a year.
8	Day of minimum surface temperature	day	36	The day of the year at which the minimum undisturbed surface temperature occurs.
9	Slab conductivity	kJ/h.m.K	8.722	The thermal conductivity of the slab material.
10	Slab density	kg/m^3	3200.0	The density of the slab material.
11	Slab specific heat	kJ/kg.K	0.84	The specific heat of the slab material.
12	Slab emissivity	0..1	0.9	The emissivity of the slab.
13	Slab absorptance	0..1	0.6	The absorptance of the slab for incident radiation.
14	Slab initial temperature	C	20.0	The initial temperature of the slab.
15	Pipe/slab contact resistance	h.m2.K/kJ	0	The contact resistance between the slab material and the buried pipe. This value is assumed to be between the pipe outer surface temperature and the soil nodal temperature.
16	R-Value of perimeter insulation	$h.m^2.K/kJ$	0.0	The resistance to heat transfer (R-value) for the material used to insulate the perimeter of the slab in the depth direction.

17	R-Value of bottom insulation	$h.m^2.K/kJ$	0.0	The resistance to heat transfer (R-value) for the material used to insulate the bottom of the slab from the soil.
18	Number of HX pipes	-	0	The number of unique HX pipes that are embedded in the slab.
Cycle based on PAR 18	Number of HX nodes for pipe	-	0	The number of uniform segments into which the specified HX pipe will be divided.
Cycle based on PAR 18	Logical unit for pipe configuration	-	0	The logical unit which will be ASSIGNed to the data file containing the HX pipe configuration for the specified pipe.
Cycle based on PAR 18	Length of HX pipe	m	0	The length of the specified HX pipe.
MPAR = 18 + 3 * Number of HX Pipes				
MPAR+1	Pipe conductivity	kJ/h.m.K	1.4	The thermal conductivity of the pipe material.
MPAR+2	Pipe density	kg/m3	1200.0	The density of the pipe material.
MPAR+3	Pipe specific heat	kJ/kg.K	0.65	The specific heat of the pipe material.
MPAR+4	Pipe outer diameter	m	0.033	The outer diameter of the pipe.
MPAR+5	Pipe inner diameter	m	0.027	The inner diameter of the pipe.
MPAR+6	Fluid specific heat	kJ/kg.K	4.19	The specific heat of the fluid flowing through the pipes.
MPAR+7	Fluid density	kg/m3	1000.0	The density of the fluid flowing through the pipes.
MPAR+8	Fluid conductivity	kJ/h.m.K	6.23	The thermal conductivity of the fluid flowing through the pipes.
MPAR+9	Fluid viscosity	kg.h/m	3.06	The viscosity of the fluid flowing through the pipes.

INPUTS

Input Number	Name	Unit	Typical Value	Comment
1	Zone temperature	C	10.0	The temperature of the air above the slab.

2	Radiation temperature	C	20.0	The effective temperature of the walls, windows, ceiling, etc. above the slab for long-wave radiation calculations.
3	Incident interior radiation	kJ/hr-m^2	0	The incident radiation upon the slab/cover (a portion of this will be absorbed by the cover surface).
4	Interior convection coefficient	kJ/hr-m^2	11.0	The convection coefficient from the top surface of the cover/slab to the air in the zone.
Cycle based on PAR 18	Fluid inlet temperature	C	20.0	The temperature of the fluid entering the specified pipe. These two inputs are cycled with the number of pipes
	Fluid flow rate	kg/hr	0.0	The flow rate of the fluid entering the specified pipe. These two inputs are cycled with the number of pipes

OUTPUTS

Output Number	Name	Unit	Comment
1	Slab/cover interface temperature	C	The temperature at the interface between the cover of the slab and the slab. This temperature is usually connected back to the Type 56 model as the boundary temperature for the cover wall.
2	Slab heat transfer rate	kJ/hr	The rate at which heat is transferred from the slab into the cover material.
3	Heat storage rate	kJ/hr	The rate at which heat is being stored in the soil.
4	Pipe heat transfer rate	kJ/hr	The rate at which energy is transferred from the fluid in the heat exchanger pipes to the slab.
5	Perimeter heat loss	kJ/hr	The rate at which energy is lost from the slab through the perimeter of the slab.
6	Bottom heat loss	kJ/hr	The rate at which energy is lost from the slab through the bottom of the slab.
7	Long term average surface temperature	C	The temperature of the undisturbed soil surface as predicted by the Kasuda correlation.
8	Energy balance error	%	The percent error in the energy balance calculated on the soil/slab interface.
Cycle based on PAR 18	Fluid outlet temperature	C	The temperature of the fluid exiting the specified pipe.
	Fluid flow rate	kg/hr	The flow rate of the fluid exiting the specified pipe.

TYPE 714: ASHRAE FUNDAMENTALS 2001 SLAB METHOD

PARAMETERS

Parameter Number	Name	Unit	Typical Value	Comment
1	Slab area	m^2	100.0	The area of the slab.
2	Perimeter length	m	40.0	The length of the perimeter of the slab.
3	R value of slab	hr-m^2-K/kJ	5.0	The resistance to heat transfer through the slab. This value should include the convective and radiative resistance from the slab surface to the air but should not include any under-slab insulation.
4	Average annual indoor temperature	C	22.0	The average annual temperature of the air above the slab (typically conditioned space).
5	Average annual outdoor temperature	C	10.0	The average annual temperature of the ambient air for the desired location.
6	Amplitude of indoor temperature	ΔC	20.0	The amplitude of the ambient temperature over the year. This value is typically found in literature listed as the amplitude of the ground surface temperature.
7	Day of maximum heat transfer	day	31	The day of the year at which the peak heat transfer from the soil occurs. The phase lag between the slab heat loss/gain and the soil surface temperature will be calculated from this value.
8	Soil thermal conductivity	kJ/hr-m-K	8.72	The thermal conductivity of the soil beneath the slab.
9	Soil density	kg/m^3	3200.0	The density of the soil beneath the slab.
10	Soil specific heat	kJ/kg-K	0.84	The specific heat of the soil beneath the slab.
11	Insulation mode	-	0	This parameter indicates the type of insulation found beneath the slab (the slab/soil boundary): 0 = no under-slab insulation, 1 = partial under-slab insulation, 2 = uniform under-slab insulation
If Insulation mode (PARAMETER 11) = 0, no more parameters are required.				
If Insulation mode (PARAMETER 11) = 1, two more parameters are required				
12	R value of insulation	hr-m^2-K/kJ	5.0	The resistance to heat transfer of the insulation material located beneath the slab (horizontal).
13	Insulated edge length	m	1.0	The width of insulation around the perimeter of the slab. The insulation is assumed to be of uniform width around the perimeter starting at the edge of the slab towards the middle of the slab (the insulation is horizontal).

If Insulation mode (PARAMETER 11) = 2, one more parameter is required				
12	R value of insulation	hr-m^2-K/kJ	5.0	The resistance to heat transfer of the insulation material located beneath the slab (horizontal).

OUTPUTS

Output Number	Name	Unit	Comment
1	Slab heat transfer	W	The rate at which energy is transferred into the soil through the slab.
2	Design heat transfer	kJ/hr	The design rate at which energy is transferred into the soil through the slab.

TYPE 715: ASHRAE FUNDAMENTALS 2001 BASEMENT METHOD

PARAMETERS

Parameter Number	Name	Unit	Typical Value	Comment
1	Length of basement	m	10.0	The length of the floor of the basement.
2	Width of basement	m	10.0	The width of the floor of the basement.
3	Depth of basement	m	3.0	The depth of the floor of the basement beneath the soil surface (the height of the buried section of the basement walls).
4	R value of slab and walls	hr-m^2-K/kJ	5.0	The resistance to heat transfer through the walls and floor of the basement. This value should include the convective and radiative resistance from the surfaces to the air but should not include any under-slab or outer-wall insulation.
5	R value of insulation	hr-m^2-K/kJ	5.0	The resistance to heat transfer of the insulation material located beneath the floor and on the outside of the walls. The insulation is assumed to be uniform over all surfaces.
6	Average annual indoor temperature	C	22.0	The average annual temperature of the air above the slab (typically conditioned space).
7	Average annual outdoor temperature	C	10.0	The average annual temperature of the ambient air for the desired location.
8	Amplitude of indoor temperature	ΔC	20.0	The amplitude of the ambient temperature over the year. This value is typically found in literature listed as the amplitude of the ground surface temperature.
9	Day of maximum heat transfer	day	31	The day of the year at which the peak heat transfer from the soil occurs. The phase lag between the slab heat loss/gain and the soil surface temperature will be calculated from this value.
10	Soil thermal conductivity	kJ/hr-m-K	8.72	The thermal conductivity of the soil beneath the slab.
11	Soil density	kg/m^3	3200.0	The density of the soil beneath the slab.
12	Soil specific heat	kJ/kg-K	0.84	The specific heat of the soil beneath the slab.

OUTPUTS

Output Number	Name	Unit	Comment
1	Basement heat transfer	W	The rate at which energy is transferred into the soil through the floor and walls of the basement.
2	Design heat transfer	kJ/hr	The design rate at which energy is transferred into the soil through the floor and walls of the basement.

HEATING VENTILATING AND AIR CONDITIONING EQUIPMENT COMPONENTS

HVAC Equipment Components

TYPE 505: WATER SOURCE HEAT PUMP

PARAMETERS

Parameter Number	Name	Unit	Typical Value	Comment
1	Humidity mode	-	1	The humidity mode indicates which of the INPUT humidity values will be used to calculate the inlet moist air state: 1= the inlet humidity ratio will be used, 2=the inlet relative humidity (%) will be used
2	Logical unit number for cooling data file	-	12	The logical unit which is ASSIGNed to the data file which contains the heat pump cooling performance data.
3	Logical unit number for heating data file	-	13	The logical unit which is ASSIGNed to the data file containing the heat pump heating performance data.
4	Logical unit number for cooling correction data file	-	14	The logical unit which is ASSIGNed to the data file which contains the cooling correction factor for off-design indoor air temperatures.
5	Logical unit number for heating correction data file	-	15	The logical unit which is ASSIGNed to the data file containing the heating correction factors for off-design indoor air temperatures.
6	Number of water flow steps	-	3	The number of water flow rates for which data is provided in the performance data files. (samp_c.dat and samp_h.dat)
7	Number of water temperatures – cooling	-	4	The number of water temperatures for which cooling performance data is provided in the associated data files. (samp_c.dat)
8	Number of water temperatures – heating	-	4	The number of water temperatures for which heating data is provided in the associated heating performance data file. (samp_h.dat)
9	Number of wet bulb steps	-	6	The number of indoor wet-bulb temperatures for which cooling correction factors are supplied in the associated data file. (samp_ct.dat)
10	Number of dry bulb steps – cooling	-	4	The number of indoor dry-bulb temperatures for which cooling correction factors are supplied in the associated data file. (samp_ct.dat)
11	Number of dry bulb steps – heating	-	6	The number of entering air dry-bulb temperatures for which heating correction factor data in supplied in the associated data file. (samp_ht.dat)
12	Number of airflow steps – cooling	-	2	The number of air flow rate steps for which cooling performance data will be supplied in the associated data file. (samp_c.dat)
13	Number of airflow steps - heating	-	2	The number of air flow rate steps for which heating performance data is supplied in the associated data file. (samp_h.dat)
14	Density of liquid stream	kg/m^3	1000.0	The density of the liquid stream entering the heat pump. The liquid stream is used for heat rejection when in cooling mode and for heat absorption when in heating mode.

15	Specific heat of liquid stream	kJ/kg-K	4.190	The specific heat of the liquid stream entering the heat pump. The liquid stream is used for heat rejection when in cooling mode and for heat absorption when in heating mode.
16	Specific heat of DHW fluid	kJ/kg-K	4.190	The specific heat of the domestic hot water fluid which will be heated using the desuperheater of the heat pump.
17	Blower power	kJ/hr	671.1	The power of the blower motor when the heat pump is operating. Typically, the entire heat pump package power (compressor + blower + controls) is given for the reported heat pump power in the catalog data. The blower and controller power will be subtracted from the calculated power in order to calculate the compressor power.
18	Controller power	kJ/hr	36.0	The power of the controller in the packaged heat pump unit. Typically, the total packaged heat pump power (blower + controls + compressor) is reported for heat pump power in the catalog data. The blower and controller power will be subtracted from the total calculated heat pump power in order to get the compressor power.
19	Capacity of stage-1 auxiliary	kJ/hr	0.0	The heating capacity of the first-stage auxiliary heating device.
20	Capacity of stage-2 auxiliary	kJ/hr	0.0	The heating capacity of the 2nd-stage auxiliary heating device.
21	Total air flow rate	l/s	300.0	The flow-rate on the air-side of the heat pump. This flow-rate is the total flow rate (return plus outside air).

INPUTS

Input Number	Name	Unit	Typical Value	Comment
1	Inlet liquid temperature	C	20.0	The temperature of the heat transfer fluid entering the heat pump.
2	Inlet liquid flow rate	kg/hr	1000.0	The flow rate of heat transfer fluid entering the heat pump.
3	Return air temperature	C	20.0	The temperature of the air returning to the heat pump from the zone. This is typically the room air temperature. This air will be mixed with a user-controlled amount of outside air before entering the heat pump
4	Return air humidity ratio	-	0.008	The absolute humidity ratio of the air returning to the heat pump from the zone. This air is typically at room air conditions. This return air will be mixed with a user-specified amount of outside air before entering the heat pump. NOTE: in humidity mode 2, this INPUT is ignored.
5	Return air relative humidity	%	50.0	The relative humidity of the air returning to the heat pump from the zone. This air is typically at room air conditions. This return air will be mixed with a user-specified amount of outside air before entering the heat pump. NOTE: in humidity mode 1, this INPUT is ignored.
6	Return air pressure	atm	1.0	The absolute pressure of the air returning to the heat pump from the zone. This air is typically at room air conditions. This return air will be mixed with a user-specified amount of outside air before entering the heat pump.

7	Return air damper pressure drop	atm	0.0	The pressure drop of the return air stream as it passes across the return air damper.
8	Fresh air temperature	C	20.0	The dry-bulb temperature of the ambient air
9	Fresh humidity ratio	-	0.008	The absolute humidity ratio of the ambient air. NOTE: in humidity mode 2, this INPUT is ignored.
10	Fresh air relative humidity	%	50.0	The relative humidity of the ambient air. NOTE: in humidity mode 1, this INPUT is ignored.
11	Fresh air pressure	atm	1.0	The absolute pressure of the fresh air available to the heat pump. The heat pump will mix a user-specified amount of fresh air with the return air before conditioning this air in the heat pump.
12	Fresh air damper pressure drop	atm	0.0	The pressure drop of the fresh air stream as it passes across the outside air damper..
13	Inlet DHW temperature	C	40.0	The temperature of the entering domestic hot water stream to be heated by the desuperheater.
14	Inlet DHW flow rate	kg/hr	400.0	The flow rate of domestic hot water entering the heat pump to be heated by the desuperheater.
15	Cooling control signal	-	1.0	The control signal for cooling operation: CTRL < 0.5 : cooling mode is OFF CTRL ≥ 0.5 : cooling mode is ON
16	Heating control signal	-	0.0	The control signal for heating operation: CTRL < 0.5 : heating mode is OFF CTRL ≥ 0.5 : heating mode is ON
17	Stage 1 auxiliary signal	-	0.0	The control signal for the 1st stage auxiliary heater: CTRL < 0.5 : Auxiliary heating device 1 is OFF CTRL ≥ 0.5 : Auxiliary heating device 1 is ON
18	Stage 2 auxiliary signal	-	0.0	The control signal for the operation of the 2nd-stage auxiliary heater: CTRL < 0.5 : Auxiliary heating device 2 is OFF CTRL ≥ 0.5 : Auxiliary heating device 2 is ON
19	Fan control signal	-	0.0	The control signal for operation of the ventilation fan when the heat pump is not operating in heating or cooling mode CTRL < 0.5 : fan is OFF if heat pump compressor is OFF. CTRL ≥ 0.5 : fan is ON regardless of compressor operation.
20	Fraction of outside air	-	0.15	The heat pump will mix this user-specified amount of fresh air with the remaining fraction of return air before conditioning this air in the heat pump.
21	Cooling desuperheater temperature	C	60.0	The temperature of the refrigerant in the heat pump desuperheater when the heat pump is operating in cooling mode. This temperature will be used to calculate the heat transfer to the domestic hot water flow stream.
22	Heating desuperheater temperature	C	55.0	The temperature of the refrigerant in the heat pump desuperheater when the heat pump is operating in heating mode. This temperature will be used to calculate the heat transfer to the domestic hot water flow stream.
23	Desuperheater UA - cooling	kJ/hr-K	1500.0	The overall heat transfer coefficient from the heat pump to the desuperheater flow stream in cooling mode.
24	Desuperheater UA - heating	kJ/hr-K	1500.0	The overall heat transfer coefficient between the heat pump and the desuperheater flow stream in heating mode.

25	Fraction of rated cooling power	-	1.0	The fraction of rated catalog cooling power that will be used for this heat pump. The actual power will be the power (interpolated from the data file based on the current conditions) multiplied by this parameter.
26	Fraction of rated cooling capacity	-	1.0	The fraction of the catalog cooling capacity that will be used for this heat pump.
27	Fraction of rated heating power	-	1.0	The fraction of rated catalog heating power that will be used for this heat pump.
28	Fraction of rated heating capacity	-	1.0	The fraction of rated catalog heating capacity that will be used for this heat pump.
29	Pressure rise	atm	0.0	The pressure rise (positive) of the air as it flows through the heat pump. The pressurization is due to the internal heat pump fan.

OUTPUTS

Output Number	Name	Unit	Comment
1	Exiting fluid temperature	C	The temperature of the liquid stream exiting the heat pump.
2	Exiting fluid flow rate	kg/hr	The flow rate of the liquid stream exiting the heat pump.
3	Exiting air temperature	C	The dry-bulb temperature of the air exiting the heat pump.
4	Exiting air humidity ratio	kgH2O/kgAir	The absolute humidity ratio of the air exiting the heat pump.
5	Exiting air relative humidity	%	The relative humidity of air exiting the heat pump.
6	Exiting air flow rate	kg/hr	The flow rate of dry air exiting the heat pump.
7	Exiting air pressure	atm	The absolute pressure of air exiting the heat pump.
8	Exiting DHW temperature	C	The temperature of the domestic hot water stream exiting the heat pump.
9	Exiting DHW flow rate	kg/hr	The flow rate of domestic hot water exiting the heat pump.
10	Total heat transfer to air	kJ/hr	The total heat transfer to the air (sensible and latent). In cooling mode this quantity will be negative.
11	Sensible heat transfer to air	kJ/hr	The sensible heat transfer to the air. In heating mode, this value will be positive.
12	Latent heat transfer to air	kJ/hr	The latent heat transfer rate to the air stream. In cooling mode (dehumidification), this value will be negative.
13	Heat transfer to water	kJ/hr	The heat transfer to the water stream during heat pump operation. This value can be positive (heat rejection in cooling mode) or negative (heat absorption in heating mode).
14	Heat transfer to DHW stream	kJ/hr	The heat transfer to the domestic hot water stream during heat pump operation. This value will always be greater than or equal to zero.
15	Compressor power	kJ/hr	The power consumed by the heat pump compressor while operating.

16	Heat pump power	kJ/hr	The total power (compressor + controls + blower) consumed by the heat pump while operating.
17	C.O.P.	-	The Coefficient of Performance of the heat pump.
18	EER	-	The Energy Efficiency Rating of the heat pump during the timestep.
19	Auxiliary heater power	kJ/hr	The rate at which the heat pump is using auxiliary energy to heat the outgoing air stream.
20	Condensate temperature	C	The temperature of the condensate leaving the heat pump.
21	Condensate flow rate	kg/hr	The flow rate of condensate leaving the heat pump.

Sample Data Files

.\TESS Models\SampleCatalogData\GeothermalHeatPump\Samp_C.dat
.\TESS Models\SampleCatalogData\GeothermalHeatPump\Samp_CT.dat
.\TESS Models\SampleCatalogData\GeothermalHeatPump\Samp_H.dat
.\TESS Models\SampleCatalogData\GeothermalHeatPump\Samp_HT.dat

TYPE 506: DIRECT EVAPORATIVE COOLER (SWAMP COOLER)

PARAMETERS

Parameter Number	Name	Unit	Typical Value	Comment
1	Humidity mode	-	1	A switch to specify how inlet air humidity will be specified. 1: humidity ratio of inlet air will be used. 2: relative humidity of inlet air will be used.
2	Parasitic power	kJ/hr	335.56	The power consumption of the evaporative cooler (fans, pumps, etc.) when operating.

INPUTS

Input Number	Name	Unit	Typical Value	Comment
1	Inlet air temperature	C	20.0	The dry-bulb temperature of the air entering the humidifier.
2	Inlet air humidity ratio	kgH_2O/kgAir	0.003	The absolute humidity ratio of the air entering the humidifier. This input is ignored if Humidity Mode (parameter 1) = 2
3	Inlet air relative humidity	%	50	The relative humidity of the air entering the humidifier. This input is ignored if Humidity Mode (parameter 1) = 1
4	Inlet air flow rate	kg/hr	2000.0	The rate at which dry air flows through the humidifier.
5	Inlet air pressure	atm	1.0	The absolute pressure of air entering the humidifier.
6	Air side pressure drop	atm	0.0	The pressure drop of the air stream as it flows through the device.
7	Control signal	0..1	1.0	1: the device is ON and operating 0: the device is OFF
8	Saturation efficiency	0..1	0.9	The saturation efficiency of the evaporative cooler. The saturation efficiency is defined as: Efficiency = (Inlet air dry-bulb temperature - Outlet air dry bulb temperature) / (Inlet air dry bulb temperature - Inlet air wet-bulb temperature)

OUTPUTS

Output Number	Name	Unit	Comment
1	Outlet air temperature	C	The average dry-bulb temperature of the air exiting the humidifier over the time step.
2	Outlet air humidity ratio	kgH_2O/kgAir	The average humidity ratio of the air exiting the humidifier over the time step.
3	Outlet air %RH	%	The average relative humidity of air exiting the humidifier over the time step.
4	Outlet air flow rate	kg/hr	The flow rate of dry air exiting the humidifier.

5	Outlet air pressure	atm	The absolute pressure of the air exiting the humidifier.
6	Power consumption	kJ/hr	The power consumed by the device.
7	Air heat transfer	kJ/hr	The rate at which heat is removed from the air stream by the device.

TYPE 507: CONTROLLED DIRECT EVAPORATIVE COOLING DEVICE (FOGGING DEVICE)

PARAMETERS

Parameter Number	Name	Unit	Typical Value	Comment
1	Humidity mode	-	1	A switch to specify how inlet air humidity will be specified. 1: humidity ratio of inlet air will be used. 2: relative humidity of inlet air will be used.
2	Parasitic power	kJ/hr	335.56	The power consumption of the evaporative cooler (fans, pumps, etc.) when operating.

INPUTS

Input Number	Name	Unit	Typical Value	Comment
1	Inlet air temperature	C	20.0	The dry-bulb temperature of the air entering the humidifier.
2	Inlet air humidity ratio	$kgH_2O/kgAir$	0.003	The absolute humidity ratio of the air entering the humidifier. This input is ignored if Humidity Mode (parameter 1) = 2
3	Inlet air relative humidity	%	50	The relative humidity of the air entering the humidifier. This input is ignored if Humidity Mode (parameter 1) = 1
4	Inlet air flow rate	kg/hr	2000.0	The rate at which dry air flows through the humidifier.
5	Inlet air pressure	atm	1.0	The absolute pressure of air entering the humidifier.
6	Air side pressure drop	atm	0.0	The pressure drop of the air stream as it flows through the device.
7	Control signal	0..1	1.0	1: the device is ON and operating 0: the device is OFF
8	Desired outlet air relative humidity	%	95	The desired percent relative humidity of the air exiting the device.

OUTPUTS

Output Number	Name	Unit	Comment
1	Outlet air temperature	C	The average dry-bulb temperature of the air exiting the humidifier over the time step.
2	Outlet air humidity ratio	$kgH_2O/kgAir$	The average humidity ratio of the air exiting the humidifier over the time step.
3	Outlet air %RH	%	The average relative humidity of air exiting the humidifier over the time step.
4	Outlet air flow rate	kg/hr	The flow rate of dry air exiting the humidifier.
5	Outlet air pressure	atm	The absolute pressure of the air exiting the humidifier.

6	Power consumption	kJ/hr	The power consumed by the device.
7	Air heat transfer	kJ/hr	The rate at which heat is removed from the air stream by the device.

TYPE 508: COOLING COIL (VARIOUS CONTROL MODES)

PARAMETERS

Parameter Number	Name	Unit	Typical Value	Comment
1	Control mode	-	1	0: free floating coil mode 1: control the outlet air temperature 2: control the outlet air absolute humidity ratio. 3: control the liquid outlet temperature
2	Humidity mode	-	1	A switch to specify how inlet air humidity will be specified. 1: humidity ratio of inlet air will be used. 2: relative humidity of inlet air will be used.
3	Liquid specific heat	kJ/kg-K	4.19	The specific heat of the liquid stream flowing through the cooling coil.

INPUTS

Input Number	Name	Unit	Typical Value	Comment
1	Liquid inlet temperature			The temperature of the liquid stream fluid flowing into the cooling coil.
2	Liquid inlet flow rate			The flow rate of the liquid stream fluid flowing into the cooling coil.
3	Inlet air temperature	C	20.0	The dry-bulb temperature of the air entering the humidifier.
4	Inlet air humidity ratio	$kgH_2O/kgAir$	0.003	The absolute humidity ratio of the air entering the humidifier. This input is ignored if Humidity Mode (parameter 2) = 2
5	Inlet air relative humidity	%	50	The relative humidity of the air entering the humidifier. This input is ignored if Humidity Mode (parameter 2) = 1
6	Inlet air flow rate	kg/hr	2000.0	The rate at which dry air flows through the humidifier.
7	Inlet air pressure	atm	1.0	The absolute pressure of air entering the humidifier.
8	Air side pressure drop	atm	0.0	The pressure drop of the air stream as it flows through the cooling coil.
9	Coil bypass fraction	0..1	0.15	The fraction of the air flow through the cooling coil that is assumed to be unaffected by the coil. The remaining air will come to the equilibrium temperature with the average fluid temperature (water) in the coil. These two air streams will then mix to form the air outlet conditions.
Control Mode (PARAMETER 1) = 1				
10	Outlet air set point	C	10.0	The desired outlet air temperature from the cooling coil. A portion of the liquid stream may be bypassed around the coil in order to keep the air at its set point condition.
Control Mode (PARAMETER 1) = 2				
10	Outlet air set point	$kgH_2O/kgAir$	0.004	The desired outlet air absolute humidity ratio from the cooling coil. A portion of the liquid stream may be bypassed around the coil in order to keep the air at its set point

				condition.
Control Mode (PARAMETER 1) = 3				
10	Outlet liquid set point	C	10.0	The maximum desired outlet liquid temperature from the cooling coil. A portion of the liquid stream may be bypassed around the coil in order to keep the air at its set point condition.

OUTPUTS

Output Number	Name	Unit	Comment
1	Liquid outlet temperature	C	The temperature of the liquid exiting the cooling coil.
2	Liquid Outlet flow rate	kg/hr	The mass flow rate at which liquid exits the cooling coil
3	Outlet air temperature	C	The average dry-bulb temperature of the air exiting the cooling coil over the time step.
4	Outlet air humidity ratio	$kgH_2O/kgAir$	The average humidity ratio of the air exiting the cooling coil over the time step.
5	Outlet air %RH	%	The average relative humidity of air exiting the cooling coil over the time step.
6	Outlet air flow rate	kg/hr	The flow rate of dry air exiting the cooling coil.
7	Outlet air pressure	atm	The absolute pressure of the air exiting the cooling coil.
8	Air side heat transfer	kJ/hr	The rate at which energy is removed from the air stream (sensible plus latent).
9	Liquid heat transfer	kJ/hr	The rate at which energy is transferred to the coil fluid from the air stream. The difference between this term and the total heat transfer from the air stream is the energy leaving the cooling coil via condensation flow.
10	Condensate temperature	C	The temperature of the condensed water from the air stream leaving the cooling coil.
11	Condensate flow rate	kg/hr	The rate at which condensed water from the air stream exits the cooling coil.
12	Coil liquid outlet temperature	C	The temperature of the fluid stream exiting the cooling coil BEFORE the controlled bypass fluid is mixed back in.
13	Coil liquid flow rate	kg/hr	The rate at which liquid passes through the coil (does not include the liquid that is bypassed around the coil and later mixed back in).
14	Bypass liquid outlet temperature	C	The temperature of the liquid stream that is bypassed around the cooling coil for control purposes (before the mixing process).
15	Bypass liquid flow rate	kg/hr	The flow rate of the liquid stream that is bypassed around the cooling coil for control purposes (before the mixing process).
16	Bypass fraction for liquid side	0..1	The calculated bypass fraction for the liquid-side fluid. The cooling coil fluid (typically water) is bypassed around the cooling coil in order to control the temperature or humidity of the coil outlet fluids: 1 = the entire liquid stream is bypassed around the cooling coil and no heat or mass transfer takes place, 0 = the entire liquid stream flows through the cooling coil.

TYPE 510: CLOSED CIRCUIT COOLING TOWER

PARAMETERS

Parameter Number	Name	Unit	Typical Value	Comment
1	Humidity mode	-	1	A switch to specify how inlet air humidity will be specified. 1: humidity ratio of inlet air will be used. 2: relative humidity of inlet air will be used.
2	Design inlet fluid temperature	C	32.2	The entering fluid temperature at design conditions.
3	Design outlet fluid temperature	C	29.4	The exiting fluid temperature at design conditions.
4	Design fluid flow rate	kg/hr	5678.0	The flow rate of fluid through the closed circuits at design conditions.
5	Fluid specific heat	kJ/kg-K	4.190	The specific heat of the fluid flowing through the closed circuits of the cooling tower.
6	Design ambient temperature	C	35.0	The dry-bulb temperature of the air at design conditions.
7	Design wet bulb temperature	C	25.55	The wet-bulb temperature of the ambient air at design conditions.
8	Design air flow rate	kg/hr	5678.0	The flow rate of dry air through the tower at design conditions.
9	Air pressure at design condition	atm	1.0	The atmospheric pressure of the air at design conditions.
10	Rated fan power	kJ/hr	5369.0	The power draw of the fan at design conditions. The fan power draw at current conditions will be calculated from this rated value and a multiplier based on the fraction of design air flow.
11	Number of power coefficients	-	3	The number of coefficients that the user will provide in the relationship between fan power and fraction of design flow rate.
12	Power coefficient	-	0	The coefficient for the polynomial relating normalized fan power to normalized air flow rate. The fan power will be calculated as: Power=Power_rated*(a0 + a1*γ + a2*γ^2 + a3*γ^3 +...) where a0, a1, a2 are these parameters and gamma is the ratio of air flow to rated air flow (an input)

INPUTS

Input Number	Name	Unit	Typical Value	Comment
1	Fluid inlet temperature	C	10.0	The temperature of the fluid flowing into the closed circuits of the cooling tower.
2	Fluid flow rate	kg/hr	0.0	The flow rate of the fluid flowing into the closed circuits of

				the cooling tower.
3	Ambient temperature	C	20.0	The dry-bulb temperature of the ambient air.
4	Ambient humidity ratio	kgH_2O /kgAir	0.005	The absolute humidity ratio of the ambient air. This input is ignored in humidity mode 2
5	Ambient relative humidity	%	50.0	The percent relative humidity of the ambient air. This input is ignored in humidity mode 1
6	Ambient air pressure	atm	1.0	The absolute pressure of the ambient air.
7	Fan control signal	-	0.0	The control signal for fan operation: 0 = off, 1 = fan is on at its rated flow rate, 0 < x < 1 = the fan is operating at an air flow rate which is the design air flow rate multiplied by this input value.

OUTPUTS

Output Number	Name	Unit	Comment
1	Fluid outlet temperature	C	The temperature of the fluid exiting the closed circuits of the cooling tower.
2	Outlet fluid flow rate	kg/hr	The flow rate of the fluid exiting the closed circuits of the cooling tower.
3	Tower heat transfer	kJ/hr	The rate at which energy is transferred from the coil fluid to the air stream.
4	Fan power	kJ/hr	The rate at which the fan is consuming electricity.

TYPE 641: SIMPLE ADIABATIC HUMIDIFIER

PARAMETERS

Parameter Number	Name	Unit	Typical Value	Comment
1	Humidity mode	-	1	A switch to specify how inlet air humidity will be specified. 1: humidity ratio of inlet air will be used. 2: relative humidity of inlet air will be used.
2	Steady-state moisture addition rate	kg/hr	10.0	The rate at which moisture is added to the air stream at steady-state conditions (rated capacity of the machine). The actual rate will depend on the length of time that the humidifier has been operating.
3	Time constant	hr	0.0	The time constant for the operation of the humidifier. The time constant relates the rate at which the moisture is added to the flow stream to the length of time that the humidifier has been operating. A larger time constant implies that the humidifier takes longer to reach a steady-state condition. A time constant of zero implies that the humidifier instantly reaches its steady-state condition.
4	Rated power	kJ/hr		The power consumed by the humidifier when it is operating.
5	Outlet water temperature factor	-	0..1	A factor which indicates how the outlet water (water not absorbed by the air stream) temperature is calculated: 0: The outlet water stream temperature is unaffected by the air conditions $0 < f < 1$: The outlet water stream is partially affected by the air outlet conditions 1: The air and water outlet streams exit at the same temperature.

INPUTS

Input Number	Name	Unit	Typical Value	Comment
1	Inlet air temperature	C	20.0	The dry-bulb temperature of the air entering the humidifier.
2	Inlet air humidity ratio	$kgH_2O/kgAir$	0.003	The absolute humidity ratio of the air entering the humidifier. This input is ignored if Humidity Mode (parameter 1) = 2
3	Inlet air relative humidity	%	50	The relative humidity of the air entering the humidifier. This input is ignored if Humidity Mode (parameter 1) = 1
4	Inlet air flow rate	kg/hr	2000.0	The rate at which dry air flows through the humidifier.
5	Inlet air pressure	atm	1.0	The absolute pressure of air entering the humidifier.
6	Control function	-	1.0	The control function for humidifier operation: Control function < 0.5 --- Humidifier is OFF. Control function ≥ 0.5 --- Humidifier is ON.
7	Air side pressure drop	atm	0.0	The pressure drop for air as it flows through the humidifier.

8	Inlet water temperature	C	10.0	The temperature of water being injected into the air stream.

OUTPUTS

Output Number	Name	Unit	Comment
1	Outlet air temperature	C	The average dry-bulb temperature of the air exiting the humidifier over the time step.
2	Outlet air humidity ratio	kgH_2O/kgAir	The average humidity ratio of the air exiting the humidifier over the time step.
3	Outlet air %RH	%	The average relative humidity of air exiting the humidifier over the time step.
4	Outlet air flow rate	kg/hr	The flow rate of dry air exiting the humidifier.
5	Outlet air pressure	atm	The absolute pressure of the air exiting the humidifier.
6	Moisture addition rate	kg/hr	The average rate over the time step at which moisture is supplied by the humidifier. In case of saturated exiting air, this output is not the rate at which moisture was added to the air, but the rate at which moisture was added by the system. Excess moisture is assumed to drain from the system.
7	Air stream moisture addition rate	kg/hr	The average rate over the time step at which moisture is added to the air stream.
8	Outlet water temperature	C	The temperature of the excess water stream that is drained from the system.
9	Outlet water flow rate	kg/hr	The rate at which excess water is drained from the humidifier.
10	Power consumption	kJ/hr	The rate at which the humidifier is consuming power.
11	Air stream energy	kJ/hr	The rate at which energy was added to the air stream as it flows through the humidifier (sensible + latent).
12	Capacity indicator	0..1	The ratio of current humidifier capacity to the steady-state capacity.

TYPE 643: SIMPLE FURNACE/AIR HEATER

PARAMETERS

Parameter Number	Name	Unit	Typical Value	Comment
1	Humidity mode	-	1	A switch to specify how inlet air humidity will be specified. 1: humidity ratio of inlet air will be used. 2: relative humidity of inlet air will be used.
2	Surface area	m^2	1.0	The surface area of the furnace based on which, thermal loss calculations will be made.

INPUTS

Input Number	Name	Unit	Typical Value	Comment
1	Inlet air temperature	C	20.0	The dry-bulb temperature of the air entering the humidifier.
2	Inlet air humidity ratio	kgH_2O/kg Air	0.003	The absolute humidity ratio of the air entering the furnace. This input is ignored if Humidity Mode (parameter 1) = 2
3	Inlet air relative humidity	%	50	The relative humidity of the air entering the furnace. This input is ignored if Humidity Mode (parameter 1) = 1
4	Inlet air flow rate	kg/hr	2000.0	The rate at which dry air flows through the furnace.
5	Inlet air pressure	atm	1.0	The absolute pressure of air entering the furnace.
6	Heating capacity	kJ/hr	40,000.0	The nameplate capacity of the furnace. This value includes efficiency effects so the actual heat transferred to the air is less than the nameplate capacity.
7	Heat loss coefficient	kJ/hr	3.0	The heat transfer coefficient (U-value) from the device to its surroundings.
8	Efficiency	0..1	0.87	The efficiency of the device in converting fuel to heat. Typical values might include: 1: Electric resistance 0.7 to 0.9: Natural gas, propane etc.
9	Control function	-	1.0	The control function for the device. 0: OFF 1: Running at full capacity unless constrained by the set point temperature 0 < x <1: Running at fractional capacity
10	Air side pressure drop	atm	0.0	The pressure drop across the device for the air flow stream.
11	Environment temperature	C	20.0	Dry bulb ambient temperature for loss calculations.
12	Set point temperature	C	60.0	The target dry bulb temperature for air exiting the furnace.

OUTPUTS

Output Number	Name	Unit	Comment
1	Outlet air temperature	C	The average dry-bulb temperature of the air exiting the furnace over the time step.
2	Outlet air humidity ratio	kgH_2O/kg Air	The average humidity ratio of the air exiting the furnace over the time step.
3	Outlet air %RH	%	The average relative humidity of air exiting the furnace over the time step.
4	Outlet air flow rate	kg/hr	The flow rate of dry air exiting the furnace.
5	Outlet air pressure	atm	The absolute pressure of the air exiting the furnace.
6	Required heating rate	kJ/hr	The rate at which energy must be supplied to the device in order to heat the air to its outlet temperature; including the effects of losses and conversion inefficiencies.
7	Thermal losses	kJ/hr	The rate at which the furnace loses energy to its surroundings.
8	Rate of energy delivery to air stream	kJ/hr	The rate at which energy is delivered to the air stream.

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

PARAMETERS

Parameter Number	Name	Unit	Typical Value	Comment
1	Effectiveness of heat exchanger	-	0.65	The effectiveness of the heat exchanger. The effectiveness is a dimensionless parameter that relates the heat transfer in the heat exchanger to the maximum possible heat transfer in the heat exchanger given the inlet temperatures.
2	Specific heat of hot-side fluid	kJ/kg-K	4.190	The specific heat of the fluid flowing through the source (hot) side of the heat exchanger.
3	Specific heat of cold-side fluid	kJ/kg-K	4.190	The specific heat of the fluid flowing through the load (cold) side of the heat exchanger.
4	Number of possible steps	-	1000	The number of possible diverter valve setting steps for diverting source (hot) side fluid past the heat exchanger. If the flow is continuously variable, this parameter should be set to a large number. Doing so, however, can have negative effects on simulation speed.

INPUTS

Input Number	Name	Unit	Typical Value	Comment
1	Hot-side inlet temperature	C	20.0	The temperature of the hot-side fluid flowing into the heat exchanger
2	Hot-side flow rate	kg/hr	200.0	The flow rate of the hot-side fluid flowing into the heat exchanger.
3	Cold-side inlet temperature	C	10.0	The temperature of the cold-side fluid flowing into the heat exchanger.
4	Cold-side flow rate	kg/hr	200.0	The flow rate of the cold-side fluid flowing into the heat exchanger
5	Cold-side set temperature	C	14.0	The maximum desired temperature of the fluid exiting the cold side of the heat exchanger.
6	Modulation control	-	0	When this control function is greater than 0.5, the hot-side flow will not modulate and instead pass completely through the heat exchanger; possibly resulting in temperatures greater than the specified set temperature for the exiting cold-side flow.

OUTPUTS

Output	Name	Unit	Comment

Number			
1	Hot-side HX outlet temperature	C	The temperature of the fluid leaving the hot side of the heat exchanger *before* the hot-side bypass fluid has been mixed back in.
2	Hot-side HX outlet flow rate	kg/hr	The flow rate of fluid leaving the hot-side of the heat exchanger *before* the hot-side bypass fluid has been mixed back in.
3	Hot-side bypass temperature	C	The temperature of the hot-side fluid that is bypassing the hot-side of the heat exchanger.
4	Hot-side bypass flow rate	kg/hr	The flow rate of the hot-side fluid that is bypassing the hot-side of the heat exchanger.
5	Hot-side outlet temperature	C	The temperature of the fluid leaving the hot side of the heat exchanger *after* the hot-side bypass fluid has been mixed back in.
6	Hot-side outlet flow rate	kg/hr	The flow rate of fluid leaving the hot-side of the heat exchanger *after* the hot-side bypass fluid has been mixed back in.
7	Cold-side outlet temperature	C	The temperature of the cold-side fluid exiting the heat exchanger.
8	Cold-side outlet flow rate	kg/hr	The flow rate of the cold-side fluid exiting the heat exchanger.
9	Bypass fraction for hot-side	-	The calculated bypass fraction for the hot-side fluid: 1 = The entire hot-side stream is bypassed around the heat exchanger 0 = The entire stream flows through the heat exchanger
10	Heat transfer rate	kJ/hr	The rate at which heat is transferred from the hot-side fluid to the cold-side fluid.

TYPE 651: RESIDENTIAL COOLING COIL (RESIDENTIAL AIR CONDITIONER)

PARAMETERS

Parameter Number	Name	Unit	Typical Value	Comment
1	Humidity mode	-	1	A switch to specify how inlet air humidity will be specified. 1: humidity ratio of inlet air will be used. 2: relative humidity of inlet air will be used.
2	Logical unit for performance data	-	11	The logical unit number ASSIGNed to the data file that contains the cooling coil performance data (the total cooling capacity and power draw as a function of the ambient dry-bulb temperature, indoor wet-bulb temperature, and the evaporator flow rate.
3	Logical unit for sensible ratio	-	12	The logical unit number ASSIGNed to the data file that contains the sensible heat ratio performance data (sensible heat ratio as a function of the indoor wet-bulb temperature, the evaporator flow rate, and the indoor dry-bulb temperature.
4	Number of condenser temperatures	-	4	The number of ambient dry-bulb temperature data points for which the cooling coil capacity and power draw are given in the performance data file.
5	Number of evaporator flows in performance file	-	3	The number of evaporator flow rate data points for which the cooling coil capacity and power draw are given in the performance data file.
6	Number of indoor wet bulbs in performance file	-	3	The number of indoor wet-bulb temperature data points for which the cooling coil capacity and power draw are given in the performance data file.
7	Number of evaporator flow rates in SHR file	-	3	The number of evaporator flow rate data points for which the sensible heat ratio of the cooling coil is given in the sensible heat ratio data file.
8	Number of indoor wet bulbs in SHR file	-	3	The number of indoor wet-bulb temperature data points for which sensible heat ratios are given in the sensible heat ratio data file.
9	Number of indoor dry bulb temps.	-	3	The number of indoor dry-bulb temperature data points for which the sensible heat ratio of the cooling coil is given in the sensible heat ratio data file.
10	Specific heat of air	kJ/kg-K	1.007	The specific heat of the indoor air (the air flowing across the evaporator coil).
11	Blower power draw	kJ/hr	671.1	The power draw of the indoor blower for the cooling coil while operating.
12	Controller power draw	kJ/hr	36.0	The power draw of the internal controls for the cooling coil.

INPUTS

Input Number	Name	Unit	Typical Value	Comment
1	Ambient temperature	C	30.0	The ambient dry-bulb temperature (the temperature of the air flowing across the outdoor coil (the condenser)).
2	Indoor air temperature	C	20.0	The indoor dry-bulb temperature (the temperature of the air flowing across the indoor coil (the evaporator))
3	Indoor air humidity ratio	$kgH_2O/kgAir$	0.003	The absolute humidity ratio of the air flowing across the indoor coil (the evaporator). This input is ignored if Humidity Mode (parameter 1) = 2
4	Indoor air relative humidity	%	50	The relative humidity of the air flowing across the indoor coil (the evaporator). This input is ignored if Humidity Mode (parameter 1) = 1
5	Evaporator air flow rate	kg/hr	2000.0	The rate at which dry air flows across the evaporator.
6	Indoor air pressure	atm	1.0	The absolute pressure of the indoor air (the air flowing across the indoor coil (the evaporator))
7	Air side pressure drop	atm	0.0	The pressure drop of the indoor air as it flows across the indoor coil (the evaporator).
8	Control signal	-	1	The on/off control signal for the cooling coil ≥ 0.5: ON < 0.5: OFF

OUTPUTS

Output Number	Name	Unit	Comment
1	Return air temperature	C	The dry-bulb temperature of the indoor air after it has passed across the cooling coil.
2	Return air humidity ratio	-	The absolute humidity ratio of the indoor air after it has passed across the cooling coil.
3	Return air %RH	%	The relative humidity of the indoor air after it has passed across the cooling coil.
4	Return air flow rate	kg/hr	The flow rate of dry air flowing across the indoor coil (evaporator).
5	Return air pressure	atm	The absolute pressure of the indoor air after it has passed through the air conditioner (across the evaporator section).
6	Total energy removal	kJ/hr	The total (sensible + latent) energy removal rate from the indoor air stream across the cooling coil.
7	Sensible energy removal	kJ/hr	The rate at which sensible energy is removed from the air stream as it passes across the indoor coil (evaporator).
8	Heat rejection	kJ/hr	The rate at which heat is rejected to the ambient by the outdoor coil (condenser).
9	Power	kJ/hr	The rate at which power is consumed by the cooling coil (compressor + blower + controls).
10	Compressor power	kJ/hr	The rate at which the cooling coil compressor consumes power.
11	Blower power	kJ/hr	The rate at which power is consumed by the blower for the indoor coil (evaporator).

12	Controller power	kJ/hr	The rate at which power is consumed by the internal controls (only when the coil is operating).
13	C.O.P	-	The coefficient of performance of the cooling coil.
14	EER	-	The energy efficiency ratio of the cooling coil.
15	Sensible heat ratio	-	The ratio of sensible energy removal to total energy removal for the indoor coil (evaporator).
16	Condensate temperature	C	The temperature of the condensate being drained from the air conditioner.
17	Condensate flow rate	kg/hr	The flow rate of condensate being drained from the device.

Sample Data Files

.\TESS Models\SampleCatalogData\UnitaryAirConditioner\SeparatedFileFormat\Res_st.dat
.\TESS Models\SampleCatalogData\UnitaryAirConditioner\SeparatedFileFormat\rescool_1ton.dat

TYPE 652: HEAT EXCHANGER WITH HOT-SIDE BYPASS TO KEEP COLD-SIDE OUTLET ABOVE MINIMUM TEMPERATURE

PARAMETERS

Parameter Number	Name	Unit	Typical Value	Comment
1	Effectiveness of heat exchanger	-	0.65	The effectiveness of the heat exchanger. The effectiveness is a dimensionless parameter that relates the heat transfer in the heat exchanger to the maximum possible heat transfer in the heat exchanger given the inlet temperatures.
2	Specific heat of hot-side fluid	kJ/kg-K	4.190	The specific heat of the fluid flowing through the source (hot) side of the heat exchanger.
3	Specific heat of cold-side fluid	kJ/kg-K	4.190	The specific heat of the fluid flowing through the load (cold) side of the heat exchanger.
4	Number of possible steps	-	1000	The number of possible diverter valve setting steps for diverting source (hot) side fluid past the heat exchanger. If the flow is continuously variable, this parameter should be set to a large number. Doing so, however, can have negative effects on simulation speed.

INPUTS

Input Number	Name	Unit	Typical Value	Comment
1	Hot-side inlet temperature	C	20.0	The temperature of the hot-side fluid flowing into the heat exchanger
2	Hot-side flow rate	kg/hr	200.0	The flow rate of the hot-side fluid flowing into the heat exchanger.
3	Cold-side inlet temperature	C	10.0	The temperature of the cold-side fluid flowing into the heat exchanger.
4	Cold-side flow rate	kg/hr	200.0	The flow rate of the cold-side fluid flowing into the heat exchanger
5	Cold-side set temperature	C	14.0	The minimum desired temperature of the fluid exiting the cold side of the heat exchanger.
6	Modulation control	-	0	When this control function is greater than 0.5, the hot-side flow will not modulate and instead pass completely through the heat exchanger; possibly resulting in temperatures lower than the specified set temperature for the exiting cold-side flow.

OUTPUTS

Output	Name	Unit	Comment

Number			
1	Hot-side HX outlet temperature	C	The temperature of the fluid leaving the hot side of the heat exchanger *before* the hot-side bypass fluid has been mixed back in.
2	Hot-side HX outlet flow rate	kg/hr	The flow rate of fluid leaving the hot-side of the heat exchanger *before* the hot-side bypass fluid has been mixed back in.
3	Hot-side bypass temperature	C	The temperature of the hot-side fluid that is bypassing the hot-side of the heat exchanger.
4	Hot-side bypass flow rate	kg/hr	The flow rate of the hot-side fluid that is bypassing the hot-side of the heat exchanger.
5	Hot-side outlet temperature	C	The temperature of the fluid leaving the hot side of the heat exchanger *after* the hot-side bypass fluid has been mixed back in.
6	Hot-side outlet flow rate	kg/hr	The flow rate of fluid leaving the hot-side of the heat exchanger *after* the hot-side bypass fluid has been mixed back in.
7	Cold-side outlet temperature	C	The temperature of the cold-side fluid exiting the heat exchanger.
8	Cold-side outlet flow rate	kg/hr	The flow rate of the cold-side fluid exiting the heat exchanger.
9	Bypass fraction for hot-side	-	The calculated bypass fraction for the hot-side fluid: 1 = The entire hot-side stream is bypassed around the heat exchanger 0 = The entire stream flows through the heat exchanger
10	Heat transfer rate	kJ/hr	The rate at which heat is transferred from the hot-side fluid to the cold-side fluid.

TYPE 655: AIR COOLED CHILLER

PARAMETERS

Parameter Number	Name	Unit	Typical Value	Comment
1	Rated capacity	kJ/hr	1.27E+06	The capacity of the machine at its rated condition (typical 35 C (95F) ambient and 7 C (44F) chilled water set point temperature). The data file associated with this model should be consistent with the rating conditions.
2	Rated C.O.P.	-	3.0	The coefficient of performance (C.O.P) of the chiller at its rated conditions (typically 95 F ambient and 44 F chilled water set point temperature). The data file associated with this model should be consistent with the rating conditions.
3	Logical unit for performance data	-	20	The logical unit ASSIGNed to the data file containing the capacity and C.O.P. ratios as a function of ambient and chilled water set point temperatures.
4	Logical unit for PLR data file	-	21	The logical unit ASSIGNed to the data file which contains the fraction of full-load power data as a function of the chiller part load ratio.
5	Fluid specific heat	kJ/kg-K	4.190	The specific heat of the fluid flowing through the chiller.
6	Number of ambient temperatures	-	10	The number of ambient dry-bulb temperature data points for which capacity and C.O.P. ratios are provided in the performance data file.
7	Number of chilled water set points	-	5	The number of chilled water set point temperature data points for which the capacity and C.O.P. ratios are provided in the performance data file.
8	Number of part-load ratios	-	5	The number of part-load ratio data points for which fraction of full-load power are supplied in the part-load performance data file.

INPUTS

Input Number	Name	Unit	Typical Value	Comment
1	Chilled water inlet temperature	C	12.222	The temperature of the chilled water stream entering the chiller.
2	Chilled water flow rate	kg/hr	50,000.0	The mass flow rate at which chilled water enters the chiller.
3	Chilled water set point temperature	C	6.67	The set-point temperature for the chilled water stream. If the chiller has the capacity to meet the current load, the chiller will modulate to meet the load and chilled water stream will leave at this temperature.
4	Ambient temperature	C	30.0	The dry-bulb temperature of the ambient air (or the temperature of the air used as the heat sink for the heat rejection from this chiller).
5	Chiller control signal	-	1.0	The control signal for the operation of the chiller:

				≥ 0.5 = ON, <0.5 = OFF

OUTPUTS

Output Number	Name	Unit	Comment
1	Chilled water outlet temperature	C	The temperature of the chilled water stream exiting the chiller.
2	Chilled water flow rate	kg/hr	The flow rate of the chilled water stream exiting the chiller.
3	Chiller power	kJ/hr	The power required to operate the chiller given the current inlet conditions.
4	Chiller capacity	kJ/hr	The capacity of the chiller given the current ambient dry-bulb temperature and chilled water set-point temperature.
5	C.O.P.	-	The coefficient of performance (capacity divided by power) of the chiller given the current ambient dry-bulb temperature and chilled water set-point temperature.
6	Chiller load	kJ/hr	The load that the chiller is attempting to meet at the current timestep. The load is simply the chilled water mass flow rate multiplied by the fluid specific heat multiplied by the temperature difference between the chilled water inlet temperature and chilled water set-point. The machine may or may not be able to meet this load depending on its current capacity.
7	Chiller load met	kJ/hr	The load that the chiller was able to meet at the current timestep. If the chiller was unable to meet the entire load, the temperature of the exiting flow stream will be higher than the chilled water set-point temperature.
8	Chiller part-load ratio	-	The chiller part load ratio at the current conditions. The part load ratio is defined as the load met by the chiller divided by the capacity of the chiller at the given conditions.
9	Fraction of full-load power	-	The fraction of full-load power for the chiller. The fraction of full-load power is a ratio of the chiller power at the current part-load conditions to the chiller power at the current conditions if the chiller was operating at full-load.
10	Heat of rejection	kJ/hr	The rate at which heat is rejected to the cooling air stream by the chiller.

Sample Data Files

.\Tess Models\SampleCatalogData\AirCooledChiller\Samp_C.Dat
.\Tess Models\SampleCatalogData\AirCooledChiller\Samp_PLR.Dat

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

PARAMETERS

Parameter Number	Name	Unit	Typical Value	Comment
1	Effectiveness of heat exchanger	-	0.65	The effectiveness of the heat exchanger. The effectiveness is a dimensionless parameter that relates the heat transfer in the heat exchanger to the maximum possible heat transfer in the heat exchanger given the inlet temperatures.
2	Specific heat of hot-side fluid	kJ/kg-K	4.190	The specific heat of the fluid flowing through the hot side of the heat exchanger.
3	Specific heat of cold-side fluid	kJ/kg-K	4.190	The specific heat of the fluid flowing through the cold side of the heat exchanger.
4	Number of possible steps	-	1000	The number of possible diverter valve setting steps for diverting cold side fluid past the heat exchanger. If the flow is continuously variable, this parameter should be set to a large number. Doing so, however, can have negative effects on simulation speed.

INPUTS

Input Number	Name	Unit	Typical Value	Comment
1	Hot-side inlet temperature	C	20.0	The temperature of the hot-side fluid flowing into the heat exchanger
2	Hot-side flow rate	kg/hr	200.0	The flow rate of the hot-side fluid flowing into the heat exchanger.
3	Cold-side inlet temperature	C	10.0	The temperature of the cold-side fluid flowing into the heat exchanger.
4	Cold-side flow rate	kg/hr	200.0	The flow rate of the cold-side fluid flowing into the heat exchanger
5	Hot-side set temperature	C	14.0	The maximum desired temperature of the fluid exiting the hot side of the heat exchanger.
6	Modulation control	-	0	When this control function is greater than 0.5, the cold-side flow will not modulate and instead pass completely through the heat exchanger; possibly resulting in temperatures greater than the specified set temperature for the exiting hot-side flow.

OUTPUTS

Output	Name	Unit	Comment

Number			
1	Hot-side outlet temperature	C	The temperature of the fluid leaving the hot side of the heat exchanger.
2	Hot-side outlet flow rate	kg/hr	The flow rate of fluid leaving the hot-side of the heat exchanger.
3	Cold-side HX outlet temperature	C	The temperature of the cold-side fluid exiting the heat exchanger *before* the bypass is mixed back in.
4	Cold-side HX outlet flow rate	kg/hr	The flow rate of the cold-side fluid exiting the heat exchanger *before* the bypass is mixed back in.
5	Cold-side bypass temperature	C	The temperature of the cold-side fluid bypassing the heat exchanger.
6	Cold-side bypass flow rate	kg/hr	The flow rate of the cold-side fluid bypassing the heat exchanger.
7	Cold-side outlet temperature	C	The temperature of the cold-side fluid exiting the heat exchanger *after* the bypass is mixed back in.
6	Cold-side outlet flow rate	kg/hr	The flow rate of the cold-side fluid exiting the heat exchanger *after* the bypass is mixed back in.
9	Bypass fraction for cold-side	-	The calculated bypass fraction for the cold-side fluid: 1 = The entire cold-side stream is bypassed around the heat exchanger 0 = The entire stream flows through the heat exchanger
10	Heat transfer rate	kJ/hr	The rate at which heat is transferred from the hot-side fluid to the cold-side fluid.

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

PARAMETERS

Parameter Number	Name	Unit	Typical Value	Comment
1	Rated capacity	kJ/hr	500,000.0	The rated capacity (the maximum possible energy transfer to the fluid stream) of the boiler. The maximum available energy transfer to the fluid stream will be the product of this parameter and the conversion efficiency.
2	Specific heat of fluid	kJ/kg-K	4.19	Specific heat of fluid

INPUTS

Input Number	Name	Unit	Typical Value	Comment
1	Inlet fluid temperature	C	20.0	The inlet fluid temperature to the boiler.
2	Inlet flow rate	kg/hr	10,000.0	Inlet fluid flow rate to the boiler.
3	Control function	-	1	The input control function is used to set the fraction of capacity available to the boiler at the current time step. The control function can have a value between 0 and 1.
4	Set point temperature	C	50.0	The set point temperature of the boiler.
5	Overall loss coefficient	kJ/hr-K	0.0	The loss coefficient (UA) from the heater during operation.
6	Boiler efficiency	-	1.0	The boiler thermal conversion efficiency. Typical values: Electric Resistance = 1.0 Natural Gas = 0.81
7	Temperature of surroundings	C	20	The temperature of the boiler surroundings for thermal loss calculations.

OUTPUTS

Output Number	Name	Unit	Comment
1	Outlet fluid temperature	C	The outlet fluid temperature from the boiler.
2	Outlet fluid flow rate	kg/hr	The outlet fluid flow rate from the boiler.
3	Heating rate	kJ/hr	The rate at which energy was supplied to the boiler. A fraction of this energy may be lost to the surroundings and/or wasted in converting to useful heat.
4	Thermal losses	kJ/hr	The rate at which energy is lost from the boiler to the environment.

5	Rate of energy delivery to fluid stream	kJ/hr	The rate at which useful energy is delivered to the flow stream in the boiler.

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

PARAMETERS

Parameter Number	Name	Unit	Typical Value	Comment
1	Humidity mode	-	1	A switch to specify how inlet air humidity will be specified. 1: humidity ratio of inlet air will be used. 2: relative humidity of inlet air will be used.
2	Rated flow rate	kg/hr	1000.0	The maximum (rated) flow rate of dry air through the device when operating at full-speed.
3	Rated fan power	kJ/hr	2684.0	The rated fan power consumption when the fan is operating at full-speed.
4	Motor efficiency	0..1	0.8	The efficiency of the fan motor. This efficiency is used to calculate the amount of heat added to the air stream.
5	Motor heat loss fraction	0..1	0.0	The fraction of the motor heat loss transferred to the air stream. The motor heat loss is calculated by subtracting the efficiency of the motor from 1 and multiplying the resultant quantity by the power consumption. Typical values are 0 for motors mounted outside the air stream and 1 for motors mounted within the air stream.
6	Heater capacity	kJ/hr	16200	The gross capacity of the heating device in the unit heater.
7	Number of power coefficients	-	3	The number of polynomial multipliers that will be supplied relating the normalized fan power to the normalized fan flow rate (input control signal).
	Power coefficients	-	1.0	The value of each polynomial multiplier for the relationship between normalized fan power and normalized fan flow rate (input control signal).

INPUTS

Input Number	Name	Unit	Typical Value	Comment
1	Inlet air temperature	C	20.0	The dry-bulb temperature of the air entering the humidifier.
2	Inlet air humidity ratio	$kgH_2O/kgAir$	0.003	The absolute humidity ratio of the air entering the humidifier. This input is ignored if Humidity Mode (parameter 1) = 2
3	Inlet air relative humidity	%	50	The relative humidity of the air entering the humidifier. This input is ignored if Humidity Mode (parameter 1) = 1
4	Inlet air flow rate	kg/hr	2000.0	The rate at which dry air flows through the humidifier.
5	Inlet air pressure	atm	1.0	The absolute pressure of air entering the humidifier.
6	Air side pressure drop	atm	0.0	The pressure drop of the air stream as it flows through the device.
7	Heater control signal	0..1	1.0	1: the device is ON and operating 0: the device is OFF
8	Set point temperature	C	50.0	The desired outlet temperature of the air exiting the device.

9	Heater efficiency	0..1	1.0	The efficiency of the heating element in converting input power (fuel) into useful heat to the air stream.

OUTPUTS

Output Number	Name	Unit	Comment
1	Outlet air temperature	C	The average dry-bulb temperature of the air exiting the heater over the time step.
2	Outlet air humidity ratio	$kgH_2O/kgAir$	The average humidity ratio of the air exiting the heater over the time step.
3	Outlet air %RH	%	The average relative humidity of air exiting the heater over the time step.
4	Outlet air flow rate	kg/hr	The flow rate of dry air exiting the heater.
5	Outlet air pressure	atm	The absolute pressure of the air exiting the heater.
6	Fan power	kJ/hr	The power consumed by the fan portion of the device..
7	Fan to air heat transfer	kJ/hr	The rate at which heat is transferred to the air by the fan operation. This value may include motor heat loss if the motor is located within the air stream.
8	Fan to ambient heat transfer	kJ/hr	The rate at which energy is transferred to the environment from the fan. This value is calculated by subtracting the heat transfer to the air stream from the total fan power.
9	Heating rate	kJ/hr	The rate at which heat is transferred to the air stream from the heating section of the device.
10	Fuel consumption	kJ/hr	The rate at which fuel is consumed by the device in the heating section (the heat transfer to the air divided by the efficiency of the fuel conversion process).

TYPE 664: ELECTRIC UNIT HEATER WITH VARIABLE SPEED FAN, PROPORTIONAL CONTROL, AND DAMPER CONTROL (HEATING AND VENTILATING UNIT)

PARAMETERS

Parameter Number	Name	Unit	Typical Value	Comment
1	Humidity mode	-	1	This parameter indicates whether the calculation will be based on the inlet humidity ratio input (mode=1) or the inlet relative humidity input (mode=2).
2	Rated air flow rate	kg/hr	2000.0	The nominal flow rate of dry air through the unit heater when operating at its rated condition (typically the maximum air flow rate of the fan).
3	Rated fan power	kJ/hr	671.1	The nominal fan power consumption when the unit heater is operating at its rated condition (typically the fan power at the maximum fan flow rate).
4	Motor efficiency	0..1	0.80	The efficiency of the fan motor. This efficiency is used to calculate the amount of heat added to the air stream.
5	Motor heat loss fraction	0..1	0.30	The fraction of the motor heat loss transferred to the air stream. The motor heat loss is calculated by subtracting the efficiency of the motor from 1 and multiplying the resultant quantity by the power consumption. Typical values are 0 for motors mounted outside the air stream and 1 for motors mounted within the air stream.
6	Rated heater capacity	kJ/hr	20,000.0	The rated capacity of the unit heater electric heating element.
7	Number of power coefficients	-	3	The number of polynomial multipliers that will be supplied relating the normalized fan power to the normalized fan flow rate (input control signal).
Cycle	Power coefficients (1 to PAR 7)	-	0.0	The value of the 1st through nth polynomial multipliers for the relationship between normalized fan power and normalized fan flow rate.

INPUTS

Input Number	Name	Unit	Typical Value	Comment
1	Inlet air temperature	C	20.0	The dry-bulb temperature of the air entering the unit heater
2	Inlet air humidity ratio	-	0.008	The absolute humidity ratio of the air entering the unit heater. This input is ignored in humidity mode 2 (PAR 1=2)
3	Inlet air relative humidity	%	50	The relative humidity of the air entering the unit heater. This input is ignored in humidity mode 1 (PAR 1=1)
4	Inlet air pressure	atm	1.0	The absolute pressure of inlet air.
5	Fan control signal	-	1.0	The input control signal to the fan: = fan is full ON = fan is OFF A value between 0 and 1 signifies that the fan is operating at a variable speed condition.
6	Air side pressure rise	atm	0.0	The increase in air-side pressure across the device. This value should be set to zero when the fan is off.

7	Heater control signal	-	1.0	The control signal for the heating element in the unit heater. = heater is full ON = heater is OFF A value between 0 and 1 signifies that the heater is operating in a proportional control regime.
8	Desired delivery temperature	C	60.0	The desired temperature of the air exiting the unit heater. The unit heater will attempt to keep the outlet temperature at this set point provided that the inlet temperature (plus fan contribution) is lower than the set point, and provided that the available capacity is sufficient to meet this condition.
9	Heater efficiency	0..1	0.95	The efficiency of the heating element in converting input power (fuel) into useful heat to the air stream.
10	Ambient temperature	C	20.0	The dry-bulb temperature of the ambient air to be mixed with the return air before being heated by the unit heater.
11	Ambient humidity ratio	kgH_2O /kgAir	0.008	The absolute humidity ratio of the ambient air to be mixed with the return air before being heated by the unit heater. This input is ignored in humidity mode 2 (PAR 1=2)
12	Ambient relative humidity	%	50	The relative humidity of the ambient air to be mixed with the return air before being heated by the unit heater. This input is ignored in humidity mode 1 (PAR 1=1)
13	Damper position	0..1	0.5	The position of the outside air damper 1=Full Open (Use 100% Outside Air) 0=Full Closed (Use No Outside Air) A value between 0 and 1 indicates that the damper is partially open.

OUTPUTS

Output Number	Name	Unit	Comment
1	Outlet air temperature	C	The outlet air dry-bulb temperature from the unit heater.
2	Outlet air humidity ratio	-	The absolute humidity ratio of the air exiting the unit heater.
3	Outlet air relative humidity	%	The relative humidity of the air exiting the unit heater.
4	Outlet air flow rate	kg/hr	The flow rate of dry air exiting the unit heater.
5	Outlet air pressure	atm	The absolute pressure of air exiting the unit heater.
6	Fan power consumption	kJ/hr	The rate at which power is consumed by the fan during the time step.
7	Fan heat transfer to air	kJ/hr	The rate at which heat is transferred to the air by the fan operation. This value may include motor heat loss if the motor is located within the air stream.
8	Fan heat transfer to ambient	kJ/hr	The rate at which energy is transferred to the environment from the fan. This value is calculated by subtracting the heat transfer to the air stream from the total fan power.
9	Heating element power	kJ/hr	The rate at which heat is added to the air stream from the heating elements of the unit heater.
10	Fuel consumption rate	kJ/hr	The rate at which fuel is consumed by the device in the heating section (the heat transfer to the air divided by the efficiency of the fuel

			conversion process).
11	Condensate temperature	C	The temperature of condensate resulting from saturation during the mixing of the indoor air streams.
12	Condensate flow rate	kg/hr	The flow rate of condensate resulting from saturation during the mixing of the indoor air streams.

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

PARAMETERS

Parameter Number	Name	Unit	Typical Value	Comment
1	Humidity mode	-	1	This parameter indicates whether the calculation will be based on the inlet humidity ratio input (mode=1) or the inlet relative humidity input (mode=2).
2	Logical unit number for cooling data	-	12	The logical unit which is ASSIGNed to the data file which contains the heat pump cooling performance data.
3	Logical unit for heating data	-	13	The logical unit which is ASSIGNed to the data file containing the heat pump heating performance data.
4	Number of outdoor dry bulb steps – cooling	-	6	The number of outdoor ambient dry-bulb temperatures for which data is provided in the performance data files. (samp_c.dat)
5	Number of indoor dry bulb temperatures – cooling	-	5	The number of return air dry-bulb temperatures for which cooling performance data is provided in the associated data files. (samp_c.dat)
6	Number of indoor wet bulb temperatures – cooling	-	4	The number of return air wet-bulb temperatures for which heating data is provided in the associated cooling performance data file. (samp_c.dat)
7	Number of outdoor dry bulb temperatures – heating	-	16	The number of ambient air dry-bulb temperatures for which heating performance data is supplied in the associated data file. (samp_h.dat)
8	Number of indoor temperatures – heating	-	4	The number of return air dry-bulb temperatures for which heating performance data will be supplied in the associated data file. (samp_h.dat)
9	Number of airflow steps	-	3	The number of air flow rate steps for which heating and cooling performance data is supplied in the associated data file. (samp_c.dat and samp_h.dat)
10	Specific heat of air stream	kJ/kg-K	1.007	The specific heat of the air stream entering the heat pump
11	Scale factor for heat pump	-	1.0	The scale factor can be used to re-size the heat pump without changing the catalog data. This parameter simply multiplies the catalog heating and cooling power and capacity read from the performance data files by a constant.
12	Total air flow rate	l/s	300.0	The flow-rate on the air-side of the heat pump. This flow-rate is the total flow rate (return plus outside air).
13	Rated indoor fan power	kJ/hr	671.1	The rated power of the indoor fan of the air-source heat pump. Both the indoor and outdoor fan power should be included in the catalog value of total power.
14	Rated outdoor fan power	kJ/hr	671.1	The rated power of the outdoor fan of the air-source heat pump. Both the indoor and outdoor fan power should be included in the catalog value of total power.
15	Auxiliary heat mode	-		The method by which auxiliary heat may be provided to the indoor air stream.

				0 = no auxiliary heat available 1= two-stage electric heating elements 2 = gas heater used
Auxiliary Heat Mode (PARAMETER 15) = 0 (no auxiliary heat available) no additional PARAMETERS are required.				
Auxiliary Heat Mode (PARAMETER 15) = 1 (Two stage electric heating elements for auxiliary heat)				
16	First stage capacity	kJ/hr	16200	The capacity of the first stage auxiliary heating element.
17	Second stage capacity	kJ/hr	16200	The capacity of the second stage auxiliary heating element.
Auxiliary Heat Mode (PARAMETER 15) = 2 (Gas fired auxiliary heat)				
16	Heater capacity	kJ/hr	16200	The capacity of the supplemental heating device.
17	Heater efficiency	0..1	0.87	The efficiency with which the auxiliary heater converts fuel into an air stream temperature rise.

INPUTS

Input Number	Name	Unit	Typical Value	Comment
1	Return air temperature	C	20.0	The dry-bulb temperature of the air returning to the heat pump from the zone. This is typically the room air temperature. This air will be mixed with a user-controlled amount of outside air before entering the heat pump
2	Return air humidity ratio	kgH_2O /kgAir	0.008	The absolute humidity ratio of the air returning to the heat pump from the zone. This air is typically at room air conditions. This return air will be mixed with a user-specified amount of outside air before entering the heat pump. This parameter is ignored in humidity mode 2 (PAR 1 = 2)
3	Return air relative humidity	%	50	The relative humidity of the air returning to the heat pump from the zone. This air is typically at room air conditions. This return air will be mixed with a user-specified amount of outside air before entering the heat pump. This parameter is ignored in humidity mode 1 (PAR 1 = 1)
4	Return air flow rate	kg/hr	0	This input is not used by the model and is only included for connection purposes if the air source heat pump is part of a air-stream loop. This model sets the air flow rate.
5	Return air pressure	atm	1.0	The pressure of the air entering the heat pump. This pressure is typically the zone air pressure and the model assumes both the return air and outside air are at this pressure.
6	Fan pressure rise	atm	0.0	The net pressure rise (although it could be a net pressure drop) of the air across the heat pump due to the operation of the fan and the pressure drops of the coils and ducting.
7	Ambient air temperature	C	20.0	The temperature of the ambient air that is mixed with return air on the indoor side of the heat pump. NOTE: this is NOT necessarily the same temperature as the ambient sink to which the heat pump rejects or from which the heat pump absorbs energy.
8	Ambient humidity ratio	kgH_2O /kgAir	0.008	The absolute humidity ratio of the ambient air that is mixed with return air on the indoor side of the heat pump.
9	Ambient relative	%	0.008	The relative humidity of the ambient air that is mixed with

	humidity			return air on the indoor side of the heat pump.
10	Ambient sink temperature	C	20	The temperature to which the heat pump rejects energy in cooling or from which the heat pump absorbs energy in heating.
11	Cooling control signal	-	1.0	The control signal for cooling operation CTRL < 0.5 : cooling mode is OFF CTRL ≥ 0.5 : cooling mode is ON
12	Heating control signal	-	0.0	The control signal for heating operation CTRL < 0.5 : heating mode is OFF CTRL ≥ 0.5 : heating mode is ON
13	Fan control signal	-	0.0	The control signal for operation of the ventilation fan when the heat pump is not operating in heating or cooling mode CTRL < 0.5 : Fan is OFF if heat pump compressor is OFF CTRL ≥ 0.5 : Fan is ON regardless of compressor operation.
14	Outside air control signal	-	0.0	The control signal for mixing of the outside air CTRL < 0.5 : Do NOT mix any ambient air with the return air before sending it to the heat pump CTRL ≥ 0.5 : Mix the user-specified flow rate of ambient air with return air before sending it to the heat pump
Auxiliary Heat Mode (PARAMETER 15) = 0 (no auxiliary heat available) no additional INPUTS are required.				
Auxiliary Heat Mode (PARAMETER 15) = 1 (Two stage electric heating elements for auxiliary heat)				
15	Stage 1 auxiliary signal	0..1	0.0	The control signal for the 1st stage auxiliary heater CTRL < 0.5 : Auxiliary heating device 1 is OFF CTRL ≥ 0.5 : Auxiliary heating device 1 is ON
16	Stage 2 auxiliary signal	0..1	0.0	The control signal for the operation of the 2nd-stage auxiliary heater CTRL < 0.5 : Auxiliary heating device 2 is OFF CTRL ≥ 0.5 : Auxiliary heating device 2 is ON
Auxiliary Heat Mode (PARAMETER 15) = 2 (Gas fired auxiliary heat)				
15	Auxiliary heating signal	0..1	0.0	The control signal for the auxiliary heater CTRL < 0.5 : Auxiliary heating device is OFF CTRL ≥ 0.5 : Auxiliary heating device is ON

OUTPUTS

Output Number	Name	Unit	Comment
1	Exiting air temperature	C	The dry-bulb temperature of the air exiting the heat pump.
2	Exiting air humidity ratio	kgH_2O /kgAir	The absolute humidity ratio of the air exiting the heat pump.
3	Exiting air relative humidity	%	The relative humidity of the air exiting the heat pump.
4	Exiting air flow rate	kg/hr	The flow rate of dry air exiting the heat pump.
5	Exiting air pressure	atm	The absolute pressure of air exiting the heat pump.
6	Total cooling rate	kJ/hr	The rate at which energy (both sensible and latent) is removed from the conditioned air stream in cooling mode.
7	Sensible cooling rate	kJ/hr	The rate at which sensible heat is removed from the conditioned air stream in cooling mode.

8	Latent cooling rate	kJ/hr	The rate at which latent energy is removed from the conditioned air stream in cooling mode.
9	Total heating rate	kJ/hr	The rate at which heat is added to the conditioned air stream by the heat pump and auxiliary heating devices
10	Heat rejection rate	kJ/hr	The rate at which heat is rejected to the ambient during cooling operation.
11	Heat absorption rate	kJ/hr	The rate at which heat is removed from the ambient air stream in heating operation.
12	Auxiliary heating rate	kJ/hr	The rate at which auxiliary energy is added to the conditioned air stream.
13	Heat pump power	kJ/hr	The total power (compressor + controls + blower + auxiliary) consumed by the heat pump while operating.
14	C.O.P.	-	The Coefficient of Performance of the heat pump.
15	EER	-	The Energy Efficiency Rating of the heat pump during the time step.
16	Indoor fan power	kJ/hr	The rate at which the heat pump indoor fan is consuming energy.
17	Outdoor fan power	kJ/hr	The rate at which the heat pump outdoor fan is consuming energy.
18	Compressor power	kJ/hr	The rate at which the heat pump compressor is consuming energy.
19	Total power	kJ/hr	The rate at which the heat pump consumes power not including auxiliary energy. This output is the combination of the previous three outputs.
20	Condensate temperature	C	The temperature of condensate resulting from saturation during the mixing of the indoor air streams.
21	Condensate flow rate	kg/hr	The flow rate of condensate resulting from saturation during the mixing of the indoor air streams.

Sample Data Files

.\Tess Models\SampleCatalogData\AirSourceHeatPump\Samp_c.dat
.\Tess Models\SampleCatalogData\AirSourceHeatPump\Samp_h.dat

TYPE 666: WATER COOLED CHILLER

PARAMETERS

Parameter Number	Name	Unit	Typical Value	Comment
1	Rated capacity	kJ/hr	1,266,000	The capacity of the machine at its rated condition (typically 30 C (85F) inlet cooling water temperature and 7 C (44F) chilled water set point temperature). The data file associated with this model should be consistent with the rating conditions.
2	Rated C.O.P.	-	3.0	The COP of the chiller at its rated conditions (typically 30 C (85F) inlet cooling water temperature and 7 C (44F) chilled water set point temperature). Make sure that the associated file for this component is consistent with the rating conditions.
3	Logical unit number for performance data file	-	12	The logical unit which will be ASSIGNed to the user-supplied data file containing the capacity and COP ratios as a function of inlet cooling water temperature and chilled water set point temperatures.
4	Logical unit number for PLR data file	-	13	The logical unit which will be ASSIGNed to the user-supplied data file which contains the fraction of full-load power data as a function of the machine part load ratio.
5	CHW fluid specific heat	kJ/kg-K	4.190	The specific heat of the chilled water stream flowing through the chiller.
6	CW fluid specific heat	kJ/kg-K	4.190	The specific heat of the cooling water flow stream.
7	Number of CW temperatures in data file	-	6	The number of cooling water temperatures for which capacity and COP ratios will be provided in the user-supplied data file. (samp_c.dat)
8	Number of CHW set points in data file	-	6	The number of chilled water set point temperatures for which the capacity and COP ratio will be provided in the user-supplied data file. (samp_c.dat)
9	Number of PLR's in data file	-	5	The number of part-load ratios for which fraction of full-load power will be supplied in the user-provided data file. (samp_PLR.dat)

INPUTS

Input Number	Name	Unit	Typical Value	Comment
1	Chilled water inlet temperature	C	12.22	The temperature of the chilled water stream entering the chiller.
2	Chilled water flow rate	kg/hr	250,000.0	The mass flow rate at which chilled water enters the chiller.
3	Cooling water temperature	C	30.0	The temperature at which the cooling water flow stream enters the chiller.

4	Cooling water flow rate	kg/hr	350,000.0	The mass flow rate at which the cooling fluid (typically water) enters the chiller.
5	CHW set point	C	6.67	The set-point temperature for the chilled water stream. If the chiller has the capacity to meet the current load, the chiller will modulate to meet the load and chilled water stream will leave at this temperature.
6	Chiller control signal	-	1.0	The control signal for the operation of the chiller. CTRL < 0.5 : chiller is OFF CTRL ≥ 0.5 : chiller is ON

OUTPUTS

Output Number	Name	Unit	Comment
1	Chilled water temperature	C	The temperature of the chilled water stream exiting the chiller.
2	Chilled water flow rate	kg/hr	The flow rate of the chilled water stream exiting the chiller.
3	Cooling water temperature	C	The temperature of the cooling flow stream exiting the chiller.
4	Cooling water flow rate	kg/hr	The mass flow rate at which the cooling stream exits the chiller.
5	Chiller power	kJ/hr	The power requirement of the chiller. The power is read (and interpolated) from the user-supplied data file. The power in the data file should be for the chiller total power (compressor plus outdoor fan plus controls) and not just for the compressor.
6	Chiller heat rejection	kJ/hr	The rate at which heat is rejected to the cooling water flow stream by the chiller.
7	Chiller capacity	kJ/hr	The capacity of the chiller given the current cooling water inlet temperature and chilled water set-point temperature.
8	C.O.P.	-	The coefficient of performance (capacity divided by power) of the chiller given the current cooling water inlet temperature and chilled water set-point temperature.
9	Chiller load	kJ/hr	The load that the chiller must attempt to meet at the current timestep. The load is simply the chilled water mass flow rate multiplied by the fluid specific heat multiplied by the temperature difference between the chilled water inlet temperature and chilled water set-point. The machine may or may not be able to meet this load.
10	Chiller load met	kJ/hr	The load that the chiller was able to meet at the current timestep. If the chiller was unable to meet the entire load, the temperature of the exiting flow stream will be higher than the chilled water set-point temperature.
11	Chiller PLR	-	The chiller part load ratio at the current conditions. The part load ratio is defined as the load met by the chiller divided by the capacity of the chiller at the given conditions.
12	Fraction of full-load power	-	The fraction of full-load power is interpolated from the user-supplied data file as a function of the chiller part load ratio. The fraction of full-load power is a ratio of the chiller power at the current conditions at part-load to the chiller power at the current conditions at full-load.

Sample Data Files

.\Tess Models\SampleCatalogData\WaterCooledChiller\Samp_C.Dat
.\Tess Models\SampleCatalogData\WaterCooledChiller\Samp_PLR.Dat

TYPE 667: AIR-TO-AIR HEAT RECOVERY DEVICE

PARAMETERS

Parameter Number	Name	Unit	Typical Value	Comment
1	Humidity mode	kJ/kg-K	1	This parameter indicates whether the calculation will be based on the inlet humidity ratio input (mode=1) or the inlet relative humidity input (mode=2).
2	Rated power	kJ/hr	671.1	The nominal power consumption when the heat recovery device is operating. This is typically the fan power or motor power.

INPUTS

Input Number	Name	Unit	Typical Value	Comment
1	Exhaust air temperature	C	20.0	The dry-bulb temperature of exhaust air entering the heat recovery device.
2	Exhaust air humidity ratio	kgH_2O /kgAir	0.008	The absolute humidity ratio of exhaust air entering the heat recovery device. This parameter is ignored in humidity mode 2 (PAR 1 = 2)
3	Exhaust air relative humidity	%	50	The relative humidity of exhaust air entering the heat recovery device. This parameter is ignored in humidity mode 1 (PAR 1 = 1)
4	Exhaust air flow rate	kg/hr	0	The flow rate of exhaust air entering the heat recovery device.
5	Exhaust air pressure	atm	1.0	The absolute pressure of the exhaust air entering the heat recovery device.
6	Exhaust air pressure drop	atm	0.0	The pressure drop of the exhaust air as it flows through the heat recovery device.
7	Fresh air temperature	C	20.0	The dry-bulb temperature of fresh air entering the heat recovery device.
8	Fresh air humidity ratio	kgH_2O /kgAir	0.008	The absolute humidity ratio of fresh air entering the heat recovery device. This parameter is ignored in humidity mode 2 (PAR 1 = 2)
9	Fresh air relative humidity	%	50	The relative humidity of fresh air entering the heat recovery device. This parameter is ignored in humidity mode 1 (PAR 1 = 1)
10	Fresh air flow rate	kg/hr	0	The flow rate of fresh air entering the heat recovery device.
11	Fresh air pressure	atm	1.0	The absolute pressure of the fresh air entering the heat recovery device.
12	Fresh air pressure drop	atm	0.0	The pressure drop of the fresh air as it flows through the heat recovery device.
13	Sensible effectiveness	-	0.6	The effectiveness of the heat recovery device for sensible only heat transfer. Refer to the detailed description of this component or the TRNSYS Type 91 heat exchanger for a

				description of the effectiveness concept.
14	Latent effectiveness	-	0.3	The effectiveness of the device in transferring latent energy from one flow stream to another. Refer to the description of this component or the discussion of the effectiveness concept in the Type 91 description in the main TRNSYS manual for more information on the effectiveness concept.
15	On/Off control signal	-	1.0	The ON/OFF control signal for the heat recovery device. CTRL < 0.5 : the device will NOT transfer heat between the two flow streams and the power will be set to 0. CTRL > 0.5 : the device will transfer heat between the two flow streams and the power will be calculated.

OUTPUTS

Output Number	Name	Unit	Comment
1	Exhaust air temperature	C	The dry-bulb temperature of the exhaust air after its pass through the heat recovery device.
2	Exhaust air humidity ratio	$kgH_2O/kgAir$	The absolute humidity ratio of the exhaust air exiting the heat recovery device.
3	Exhaust air %RH	%	The percent relative humidity of the exhaust air upon exiting the heat recovery device.
4	Exhaust air flow rate	kg/hr	The exhaust air outlet flow rate from the heat recovery device.
5	Exhaust air pressure	atm	The absolute pressure of the exhaust air upon exiting the heat recovery device.
6	Ventilation air temperature	C	The dry-bulb temperature of the ventilation air after being pre-treated by the heat recovery device.
7	Ventilation air humidity ratio	$kgH_2O/kgAir$	The absolute humidity ratio of the ventilation air after being pre-treated by the heat recovery device.
8	Ventilation air %RH	%	The percent relative humidity of the ventilation air stream after being pre-treated by the heat recovery device.
9	Ventilation air flow rate	kg/hr	The dry air flow rate of the ventilation stream through the heat recovery device.
10	Ventilation air pressure	atm	The absolute pressure of the ventilation air upon exiting the heat recovery device.
11	Total heat transfer	kJ/hr	The rate at which heat (sensible plus latent) is transferred from the exhaust air stream to the ventilation intake stream.
12	Sensible heat transfer rate	kJ/hr	The rate at which sensible energy is transferred from the exhaust air stream to the ventilation air intake stream.
13	Latent heat transfer rate	kJ/hr	The rate at which latent energy is transferred from the exhaust air stream to the ventilation intake stream.
14	Power	kJ/hr	The power consumption rate of the heat recovery device.

TYPE 668: WATER TO WATER HEAT PUMP

PARAMETERS

Parameter Number	Name	Unit	Typical Value	Comment
1	Source fluid specific heat	kJ/kg-K	4.190	The specific heat of the source-side fluid.
2	Load fluid specific heat	kJ/kg-K	4.190	The specific heat of the load-side fluid.
3	Logical unit number for cooling data file	-	20	The logical unit which will be ASSIGNed to the user-supplied data file containing the cooling performance data.
4	Number of source temperatures - cooling	-	6	The number of source-side temperatures for which cooling performance data will be read from the user-supplied data file. (samp_c.dat)
5	Number of load temperatures - cooling	-	4	The number of load-side temperatures for which cooling performance data is supplied in the cooling data file. (samp_c.dat)
6	Logical unit number for heating data file	-	21	The logical unit which will be ASSIGNed to the user-supplied data file containing the heating performance data.
7	Number of source temperatures - heating	-	6	The number of source-side temperatures for which performance data is provided in the user-supplied heating performance data file. (samp_h.dat)
8	Number of load temperatures – heating	-	4	The number of load-side temperatures for which heating performance data is provided in the user-supplied heating performance data file. (samp_h.dat)
9	Number of identical heat pumps	-	1	The number of identical heat pumps to be modeled using this component. The capacity and power read from the data files will be multiplied by this factor to scale up the results without having to specify multiple uses of this component. The entering flow rates should be for the total flow (all heat pumps) and not just for 1 heat pump.

INPUTS

Input Number	Name	Unit	Typical Value	Comment
1	Inlet source temperature	C	40.0	The temperature of the source-side fluid entering the heat pump.
2	Source flow rate	kg/hr	12,000.0	The flow rate of source-side fluid through the heat pump.
3	Inlet load temperature	C	20.0	The temperature of the load-side flow entering the heat pump.
4	Load flow rate	kg/hr	12,000.0	The flow rate of the load-side fluid through the heat pump.
5	Cooling control signal	-	1.0	The control signal for cooling operation of the heat pump: CTRL < 0.5 : Cooling mode OFF CTRL ≥ 0.5 : Cooling mode ON
6	Heating control	-	0.0	The control signal for heating operation of the heat pump

	signal			CTRL < 0.5 : Heating mode OFF CTRL ≥ 0.5 : Heating mode ON

OUTPUTS

Output Number	Name	Unit	Comment
1	Outlet source temperature	C	The temperature of the source-side fluid exiting the heat pump.
2	Source flow rate	kg/hr	The flow rate of the source-side fluid exiting the heat pump.
3	Outlet load temperature	C	The temperature of the load-side fluid exiting the heat pump.
4	Load flow rate	kg/hr	The flow rate of the load-side fluid exiting the heat pump.
5	Heat transfer to load	kJ/hr	The rate at which heat is transferred to the load-side fluid by the heat pump (positive in heating negative in cooling mode).
6	Heat transfer from source	kJ/hr	The rate at which heat is transferred from the source fluid by the heat pump.
7	Heat pump power	kJ/hr	The rate at which the heat pump consumes energy for the given entering fluid conditions.
8	C.O.P.	-	The coefficient of performance (load met divided by power) for the heat pump given the current inlet fluid conditions.

Sample Data Files

.\Tess Models\SampleCatalogData\Water-to-WaterHeatPump\Samp_C.dat
.\Tess Models\SampleCatalogData\Water-to-WaterHeatPump\Samp_H.dat

TYPE 670: HEATING COIL WITH HOT-SIDE BYPASS TO KEEP AIR-SIDE OUTLET BELOW ITS SETPOINT

PARAMETERS

Parameter Number	Name	Unit	Typical Value	Comment
1	Humidity mode	-	1	This parameter indicates whether the calculation will be based on the inlet humidity ratio input (mode=1) or the inlet relative humidity input (mode=2).
2	Liquid specific heat	kJ/kg-K	4.190	The specific heat of the liquid stream flowing through the heating coil.

INPUTS

Input Number	Name	Unit	Typical Value	Comment
1	Fluid inlet temperature	C	40.0	The temperature of the liquid stream fluid flowing into the heating coil.
2	Fluid flow rate	kg/hr	1000.0	The flow rate of the liquid stream fluid flowing into the heating coil.
3	Air inlet temperature	C	20.0	The dry-bulb temperature of air entering the heating coil.
4	Air inlet humidity ratio	kgH_2O /kgAir	0.008	The absolute humidity ratio of air entering the heating coil. This parameter is ignored in humidity mode 2 (PAR 1 = 2)
5	Air inlet relative humidity	%	50	The relative humidity of air entering the heating coil. This parameter is ignored in humidity mode 1 (PAR 1 = 1)
6	Air inlet flow rate	kg/hr	0	The flow rate of air entering the heating coil.
7	Air inlet pressure	atm	1.0	The absolute pressure of air entering the heating coil.
8	Heat exchanger effectiveness	0..1	0.5	The effectiveness of the heating coil heat exchanger. The effectiveness is a dimensionless parameter that relates the heat transfer in the heat exchanger to the maximum possible heat transfer in the heat exchanger:
9	Air side pressure drop	atm	0.0	The pressure drop of the air stream as it passes across the heating coil.
10	Air set point temperature	C	35.0	The maximum desired temperature of the air exiting the heating coil.

OUTPUTS

Output Number	Name	Unit	Comment
1	Fluid outlet temperature	C	The temperature of the liquid stream exiting the heating coil.
2	Outlet fluid flow rate	kg/hr	The flow rate of the liquid stream exiting the heating coil.

3	Air outlet temperature	C	The dry-bulb temperature of the air exiting the heating coil.
4	Air outlet humidity ratio	kgH_2O /kgAir	The absolute humidity ratio of the air exiting the heating coil.
5	Outlet air %RH	%	The percent relative humidity of the air exiting the heating coil.
6	Air outlet flow rate	kg/hr	The flow rate of dry air exiting the heating coil.
7	Air outlet pressure	atm	The absolute pressure air exiting the heating coil.
8	Bypass fraction for liquid side	-	The calculated bypass fraction for the hot-side fluid: 1 = The entire liquid stream is bypassed around the heat exchanger 0 = The entire liquid stream flows through the heat exchanger
9	Heat exchanger heat transfer rate	kJ/hr	The rate at which heat is transferred from the liquid stream to the air stream.
10	Bypass fluid temperature	C	The temperature of the liquid that is bypassed around the heating coil for control purposes.
11	Bypass fluid flow rate	kg/hr	The flow rate of the liquid that is bypassed around the heating coil for control purposes.
12	Coil outlet fluid temperature	C	The outlet temperature of the liquid that passes through the heating coil (before the mix with the liquid that is bypassed around the coil for control purposes).
13	Coil outlet flow rate	kg/hr	The outlet flow rate of the liquid that passes through the heating coil (before the mix with the liquid that is bypassed around the coil for control purposes)

TYPE 673: TWO-PIPE CONSOLE UNIT IN ENERGY RATE CONTROL MODE

PARAMETERS

Parameter Number	Name	Unit	Typical Value	Comment
1	Number of identical units	-	100.0	The number of identical 2-pipe console units to be modeled by this component. Enter the fan power and rated heating and cooling capacities per unit, but input the TOTAL flow rate to all the unit being modeled by this component.
2	Rated unit fan power	kJ/hr	1000.0	The nominal fan power consumption of 1 console unit when the console unit is operating.
3	Rated cooling capacity	kJ/hr	12660	The total rated cooling capacity of 1 console unit. Do not set this parameter to a very large number just to avoid capacity-limited conditions as the fan power will be calculated incorrectly due to a incorrect fan run time fraction (load/capacity).
4	Rated heating capacity	kJ/hr	12660	The rated heating capacity of one 2-pipe console unit. Do not set this parameter to a very large number just to avoid capacity-limited conditions as the fan power will be calculated incorrectly due to an incorrect fan run-time fraction (load/capacity).
5	Fluid specific heat	kJ/kg-K	4.190	The specific heat of the working fluid (typically water) entering the console unit.
6	Number of power coefficients	-	0	The number of user-defined polynomial coefficients relating the normalized fan power to the normalized fan flow rate (fan part load ratio). For a constant speed fan, this parameter should be set to 1.
	Power coefficients	-	0.0	The value of the specified polynomial coefficient relating the fraction of fan full-load power to the fan part load ratio.

INPUTS

Input Number	Name	Unit	Typical Value	Comment
1	Inlet fluid temperature	C	20.0	The temperature of the working fluid entering the console unit.
2	TOTAL fluid flow rate	kg/hr	0	The TOTAL flow rate of working fluid entering the console units being modeled by this component - not the flow rate per unit heater.
3	Sensible load	kJ/hr	0	The sensible load to be met by the console units. Heating loads are negative and cooling loads are positive.
4	Latent load	kJ/hr	0	The latent load to be met by the console units. Dehumidification loads are positive – humidification loads are not processed by this component.
5	Fan control signal	-	1.0	The input control signal to the fan: 1=Full ON, 0=Completely OFF. Intermediate values are interpreted as

				the fan operating in proportional regime. The fan will modulate to meet the load given the capacity of the units even if the fan control is set off. The fan will run longer than required if the input fan control signal is greater than the calculated required run-time fraction of the fan (fan runs non-stop during occupied hours for example)
6	Cooling control signal	-	1.0	The control signal for cooling operation CTRL ≥ 0.5 cooling operation allowed CTRL < 0.5 cooling operation NOT allowed
7	Heating control signal	-	0	The control signal for heating operation CTRL ≥ 0.5 heating operation allowed CTRL < 0.5 heating operation NOT allowed

OUTPUTS

Output Number	Name	Unit	Comment
1	Outlet fluid temperature	C	The temperature of the working fluid exiting the console units.
2	Outlet flow rate	kg/hr	The TOTAL flow rate of working fluid exiting the console units.
3	Sensible load met	kJ/hr	The total sensible load met by the console units (heating = negative, cooling = positive).
4	Latent load met	kJ/hr	The total latent load met by the console units (dehumidification = positive).
5	Load not met	kJ/hr	The load not met by the console units. Regardless of heating or cooling, this output will always be a positive number.
6	Fan power	kJ/hr	The rate at which power is consumed by the fan during the time step.
7	Fan fraction of full-load power	-	The fraction of full-load power for the fan based on the current fan part-load ratio.

TYPE 676: DOUBLE-EFFECT STEAM-FIRED ABSORBTION CHILLER

PARAMETERS

Parameter Number	Name	Unit	Typical Value	Comment
1	Rated capacity	kJ/hr	13.9E+06	The capacity of the machine at its rated condition (typically 30 C (85F) inlet cooling water temperature and 7 C (44F) chilled water set point temperature). The data files associated with this model should be consistent with the rating conditions.
2	Rated C.O.P.	-	1.21	The coefficient of performance of the chiller at its rated conditions (typically 30 C (85F) inlet cooling water temperature and 7 C (44F) chilled water set point temperature). Make sure that the associated files for this component is consistent with the rating conditions.
3	Logical unit number for S1 data file	-	20	The logical unit which will be ASSIGNed to the user-supplied data file containing the fraction of full-load capacity as a function of the inlet steam gauge pressure.
4	Number of steam pressures in S1 data file	-	12	The number of steam gauge pressures for which fraction of full-load capacity data is provided in the first data file required by this model.
5	Logical unit number for S2 data file	-	21	The logical unit which will be ASSIGNed to the user-supplied data file containing the fraction of nominal capacity as a function of the chilled water set point temperature and the entering cooling water temperature.
6	Number of CW steps in S2 data file	-	5	The number of cooling water temperature steps contained in the second required catalog data file. Fraction of nominal capacity data must be provided in the second required data file (S2.dat) as a function of the cooling water temperature and chilled water set point.
7	Number of CHW set points in S2 data file	-	5	The number of chilled water set points for which fraction of nominal capacity is provided in the second required data file (S2.dat).
8	Logical unit number for S3 data file	-	22	The logical unit which will be ASSIGNed to the user-supplied data file which contains the fraction of design energy input as a function of the fraction of the design load and the inlet cooling water temperature.
9	Number of CW steps in S3 data file	-	4	The number of cooing water temperatures for which fraction of design energy input data is provided in the third required data file (S3.dat).
10	Number of load fractions in S3 data file	-	11	The number of fractions of design load for which the fraction of design energy input data is provided in the required data file (S3.dat).
11	Logical unit number for S4 data file	-	23	The logical unit which will be ASSIGNed to the user-supplied data file which contains the outlet steam condensate temperatures as a function of the inlet steam gauge pressure.
12	Number of steam pressures in S4 data file	-	7	The number of inlet steam gauge pressures for which outlet steam condensate temperature data will be provided in the fourth required data file for this component (S4.dat).

13	CHW fluid specific heat	kJ/kg-K	4.190	The specific heat of the chilled water stream flowing through the chiller.
14	CW fluid specific heat	kJ/kg-K	4.190	The specific heat of the cooling water flow stream.
15	Auxiliary electrical power	kJ/hr	40,000.0	The auxiliary electrical power required by the absorption chiller while its operating (solution pumps, refrigerant pumps etc.)

INPUTS

Input Number	Name	Unit	Typical Value	Comment
1	Chilled water inlet temperature	C	12.22	The temperature of the chilled water stream entering the chiller.
2	Chilled water flow rate	kg/hr	583,000.0	The mass flow rate at which chilled water enters the chiller.
3	Cooling water inlet temperature	C	30.0	The temperature at which the cooling water flow stream enters the chiller.
4	Cooling water flow rate	kg/hr	972,000.0	The mass flow rate at which the cooling fluid (typically water) enters the chiller.
5	Steam inlet temperature	C	162.0	The temperature of the steam provided for operating the absorption chiller.
6	Steam inlet gauge pressure	kPa	650.0	The gauge pressure of the steam provided to operate the absorption chiller.
7	CHW set point	C	6.67	The set-point temperature for the chilled water stream. If the chiller has the capacity to meet the current load, the chiller will modulate to meet the load and chilled water stream will leave at this temperature.
8	Chiller control signal	-	1.0	The control signal for the operation of the chiller. If the control signal is ≥ 0.5 = chiller is ON. If the control signal is < 0.5, chiller is OFF

OUTPUTS

Output Number	Name	Unit	Comment
1	Chilled water temperature	C	The temperature of the chilled water stream exiting the chiller.
2	Chilled water flow rate	kg/hr	The flow rate of the chilled water stream exiting the chiller.
3	Cooling water temperature	C	The temperature of the cooling flow stream exiting the chiller.
4	Cooling water flow rate	kg/hr	The mass flow rate at which the cooling stream exits the chiller.
5	Condensate temperature	C	The temperature of the steam condensate exiting the absorption chiller.
6	Condensate (steam)	kg/hr	The flow rate of condensate exiting the absorption chiller. This flow

	flow rate		rate is also the required flow rate of steam entering the absorption chiller.
7	Chilled water energy	kJ/hr	The rate at which energy was removed from the chilled water flow stream during the time step.
8	Cooling water energy	kJ/hr	The rate at which heat is rejected to the cooling water flow stream by the chiller.
9	Steam heat transfer	kJ/hr	The rate at which energy was removed from the inlet steam flow in order to operate the absorption chiller.
10	Electrical energy required	kJ/hr	The rate at which electrical energy was required in order to operate the absorption chiller (solution pumps, refrigerant pumps, etc.).
11	Fraction of full -load capacity	-	The fraction of full-load capacity available to the chiller this time step. This value is interpolated from the first required data file (S1.dat) as a function of the entering steam gauge pressure.
12	Fraction of nominal capacity	-	The fraction of nominal capacity (full-load capacity modified by the inlet steam conditions) available to the chiller at the current time step. The fraction of nominal capacity is interpolated from the second required data file for this component (S2.dat) as a function of the entering cooling water temperature and the chilled water set-point temperature.
13	Fraction of design energy input	-	The fraction of design energy input required by the chiller at the current time step. The fraction of the energy input as compared to design conditions is interpolated from the third required data file for this component (S3.dat) as a function of the entering cooling water temperature and the fraction of design load to be met by the chiller at the current time step.
14	C.O.P	-	The coefficient of performance (C.O.P.) of the chiller at current conditions. The C.O.P. for this model is defined as the energy transferred from the chilled water stream divided by the sum of the electrical energy required by the chiller and the energy provided to the chiller by the inlet steam flow

Sample Data File Set

.\Tess Models\SampleCatalogData\AbsorptionChiller\Double-Effect\Steam-Fired\S1.dat
.\Tess Models\SampleCatalogData\AbsorptionChiller\Double-Effect\Steam-Fired\S2.dat
.\Tess Models\SampleCatalogData\AbsorptionChiller\Double-Effect\Steam-Fired\S3.dat
.\Tess Models\SampleCatalogData\AbsorptionChiller\Double-Effect\Steam-Fired\S4.dat

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

PARAMETERS

Parameter Number	Name	Unit	Typical Value	Comment
1	Rated capacity	kJ/hr	13.9E+06	The capacity of the machine at its rated condition (typically 30 C (85F) inlet cooling water temperature and 7 C (44F) chilled water set point temperature). The data files associated with this model should be consistent with the rating conditions.
2	Rated C.O.P.	-	1.21	The C.O.P. of the chiller at its rated conditions (typically 30 C (85F) inlet cooling water temperature and 7 C (44F) chilled water set point temperature). Make sure that the associated files for this component is consistent with the rating conditions.
3	Logical unit number for S1 data file	-	20	The logical unit which will be ASSIGNed to the user-supplied data file containing the fraction of full-load capacity as a function of the inlet hot water temperature.
4	Number of HW temperatures in S1 data file	-	12	The number of hot water inlet temperatures for which fraction of full-load capacity data is provided in the first data file required by this model.
5	Logical unit number for S2 data file	-	21	The logical unit which will be ASSIGNed to the user-supplied data file containing the fraction of nominal capacity as a function of the chilled water set point temperature and the entering cooling water temperature.
6	Number of CW steps in S2 data file	-	5	The number of cooling water temperature steps contained in the second required catalog data file. Fraction of nominal capacity data must be provided in the second required data file (S2.dat) as a function of the cooling water temperature and chilled water set point.
7	Number of CHW set points in S2 data file	-	5	The number of chilled water set points for which fraction of nominal capacity is provided in the second required data file (S2.dat).
8	Logical Unit - S3	-	22	The logical unit which will be ASSIGNed to the user-supplied data file which contains the fraction of design energy input as a function of the fraction of the design load and the inlet cooling water temperature.
9	Number of CW steps in S3 data file	-	4	The number of cooing water temperatures for which fraction of design energy input data is provide in the third required data file (S3.dat).
10	Number of load fractions in S3 data file	-	11	The number of fractions of design load for which the fraction of design energy input data is provided in the required data file (S3.dat).
11	HW fluid specific heat	kJ/kg-K	4.190	The specific heat of the fluid (typically hot water) which will be used by the absorption chiller as the energy source for chiller operation.
12	CHW fluid specific heat	kJ/kg-K	4.190	The specific heat of the chilled water stream flowing through the chiller.

13	CW fluid specific heat	kJ/kg-K	4.190	The specific heat of the cooling water flow stream.
14	Auxiliary electrical power	kJ/hr	40,000.0	The auxiliary electrical power required by the absorption chiller while its operating (solution pumps, refrigerant pumps, etc.)

INPUTS

Input Number	Name	Unit	Typical Value	Comment
1	Chilled water inlet temperature	C	12.22	The temperature of the chilled water stream entering the chiller.
2	Chilled water flow rate	kg/hr	583,000.0	The mass flow rate at which chilled water enters the chiller.
3	Cooling water inlet temperature	C	30.0	The temperature at which the cooling water flow stream enters the chiller.
4	Cooling water flow rate	kg/hr	972,000.0	The mass flow rate at which the cooling fluid (typically water) enters the chiller.
5	Hot water inlet temperature	C	162.0	The temperature of the inlet stream (typically hot water) which will be used as the energy source for chiller operation.
6	Hot water flow rate	kg/hr	200,000.0	The flow rate of fluid (typically hot water) used as the energy source for chiller operation.
7	CHW set point	C	6.67	The set-point temperature for the chilled water stream. If the chiller has the capacity to meet the current load, the chiller will modulate to meet the load and chilled water stream will leave at this temperature.
8	Chiller control signal	-	1.0	The control signal for the operation of the chiller. If the control signal is ≥ 0.5 = chiller is ON. If the control signal is < 0.5, chiller is OFF

OUTPUTS

Output Number	Name	Unit	Comment
1	Chilled water temperature	C	The temperature of the chilled water stream exiting the chiller.
2	Chilled water flow rate	kg/hr	The flow rate of the chilled water stream exiting the chiller.
3	Cooling water temperature	C	The temperature of the cooling flow stream exiting the chiller.
4	Cooling water flow rate	kg/hr	The mass flow rate at which the cooling stream exits the chiller.
5	Hot water outlet temperature	C	The temperature of the hot water stream exiting the absorption chiller.
6	Hot water flow rate	kg/hr	The flow rate of fluid (typically hot water) exiting the chiller and used by the chiller for an energy source for chiller operation.
7	Chilled water energy	kJ/hr	The rate at which energy was removed from the chilled water flow

			stream during the time step.
8	Cooling water energy	kJ/hr	The rate at which heat is rejected to the cooling water flow stream by the chiller.
9	Hot water energy	kJ/hr	The rate at which energy was removed from the hot water flow in order to operate the absorption chiller.
10	Electrical energy required	kJ/hr	The rate at which electrical energy was required in order to operate the absorption chiller (solution pumps, refrigerant pumps, etc.).
11	Fraction of full-load capacity	-	The fraction of full-load capacity available to the chiller this time step. This value is interpolate from the first required data file (S1.dat) as a function of the entering hot water temperature.
12	Fraction of nominal capacity	-	The fraction of nominal capacity (full-load capacity modified by the inlet steam conditions) available to the chiller at the current time step. The fraction of nominal capacity is interpolated from the second required data file for this component (S2.dat) as a function of the entering cooling water temperature and the chilled water set-point temperature.
13	Fraction of design energy input	-	The fraction of design energy input required by the chiller at the current time step. The fraction of the energy input as compared to design conditions is interpolated from the third required data file for this component (S3.dat) as a function of the entering cooling water temperature and the fraction of design load to be met by the chiller at the current time step.
14	C.O.P	-	The coefficient of performance (C.O.P.) of the chiller at current conditions. The C.O.P. for this model is defined as the energy transferred from the chilled water stream divided by the sum of the electrical energy required by the chiller and the energy provided to the chiller by the inlet hot water flow stream

Sample Files

.\Tess Models\SampleCatalogData\AbsorptionChiller\Double-Effect\HotWater-Fired\S1.dat
.\Tess Models\SampleCatalogData\AbsorptionChiller\Double-Effect\HotWater-Fired\S2.dat
.\Tess Models\SampleCatalogData\AbsorptionChiller\Double-Effect\HotWater-Fired\S3.dat

TYPE 678: DOUBLE-EFFECT DIRECT-FIRED ABSORPTION CHILLER

PARAMETERS

Parameter Number	Name	Unit	Typical Value	Comment
1	Rated capacity	kJ/hr	13.9E+06	The capacity of the machine at its rated condition (typically 30 C (85F) inlet cooling water temperature and 7 C (44F) chilled water set point temperature). The data files associated with this model should be consistent with the rating conditions.
2	Rated C.O.P.	-	1.21	The C.O.P. of the chiller at its rated conditions (typically 30 C (85F) inlet cooling water temperature and 7 C (44F) chilled water set point temperature). Make sure that the associated files for this component is consistent with the rating conditions.
3	Logical unit number for S2 data file	-	20	The logical unit which will be ASSIGNed to the user-supplied data file containing the fraction of nominal capacity as a function of the chilled water set point temperature and the entering cooling water temperature.
4	Number of CW steps in S2 data file	-	5	The number of cooling water temperature steps contained in the second required catalog data file. Fraction of nominal capacity data must be provided in the second required data file (S2.dat) as a function of the cooling water temperature and chilled water set point.
5	Number of CHW set points in S2 data file	-	5	The number of chilled water set points for which fraction of nominal capacity is provided in the second required data file (S2.dat).
6	Logical unit number for S3 data file	-	21	The logical unit which will be ASSIGNed to the user-supplied data file which contains the fraction of design energy input as a function of the fraction of the design load and the inlet cooling water temperature.
7	Number of CW steps in S3 data file	-	4	The number of cooing water temperatures for which fraction of design energy input data is provided in the third required data file (S3.dat).
8	Number of load fractions in S3 data file	-	11	The number of fractions of design load for which the fraction of design energy input data is provided in the required data file (S3.dat).
9	CHW fluid specific heat	kJ/kg-K	4.190	The specific heat of the chilled water stream flowing through the chiller.
10	CW fluid specific heat	kJ/kg-K	4.190	The specific heat of the cooling water flow stream.
11	Auxiliary electrical power	kJ/hr	40,000.0	The auxiliary electrical power required by the absorption chiller while its operating (solution pumps, refrigerant pumps, etc.)

INPUTS

Input Number	Name	Unit	Typical Value	Comment
1	Chilled water inlet temperature	C	12.22	The temperature of the chilled water stream entering the chiller.
2	Chilled water flow rate	kg/hr	583,000.0	The mass flow rate at which chilled water enters the chiller.
3	Cooling water inlet temperature	C	30.0	The temperature at which the cooling water flow stream enters the chiller.
4	Cooling water flow rate	kg/hr	972,000.0	The mass flow rate at which the cooling fluid (typically water) enters the chiller.
5	CHW set point	C	6.67	The set-point temperature for the chilled water stream. If the chiller has the capacity to meet the current load, the chiller will modulate to meet the load and chilled water stream will leave at this temperature.
6	Chiller control signal	-	1.0	The control signal for the operation of the chiller. If the control signal is ≥ 0.5 = chiller is ON. If the control signal is < 0.5, chiller is OFF

OUTPUTS

Output Number	Name	Unit	Comment
1	Chilled water temperature	C	The temperature of the chilled water stream exiting the chiller.
2	Chilled water flow rate	kg/hr	The flow rate of the chilled water stream exiting the chiller.
3	Cooling water temperature	C	The temperature of the cooling flow stream exiting the chiller.
4	Cooling water flow rate	kg/hr	The mass flow rate at which the cooling stream exits the chiller.
5	Chilled water energy	kJ/hr	The rate at which energy was removed from the chilled water flow stream during the time step.
6	Cooling water energy	kJ/hr	The rate at which heat is rejected to the cooling water flow stream by the chiller.
7	Required source energy	kJ/hr	The rate at which energy needs to be supplied to the chiller (generator) in order to operate. This source energy output does not include thermal conversion or combustion efficiencies.
8	Electrical energy required	kJ/hr	The rate at which electrical energy was required in order to operate the absorption chiller (solution pumps, refrigerant pumps, etc.).
9	Fraction of nominal capacity	-	The fraction of nominal capacity (full-load capacity modified by the inlet steam conditions) available to the chiller at the current time step. The fraction of nominal capacity is interpolated from the second required data file for this component (S2.dat) as a function of the entering cooling water temperature and the chilled water set-point temperature.
10	Fraction of design energy input	-	The fraction of design energy input required by the chiller at the current time step. The fraction of the energy input as compared to design

			conditions is interpolated from the third required data file for this component (S3.dat) as a function of the entering cooling water temperature and the fraction of design load to be met by the chiller at the current time step.
11	C.O.P	-	The coefficient of performance (C.O.P.) of the chiller at current conditions. The C.O.P. for this model is defined as the energy transferred from the chilled water stream divided by the sum of the electrical energy required by the chiller and the source energy required by the chiller

Sample File Set

.\Tess Models\SampleCatalogData\AbsorptionChiller\Double-Effect\Direct-Fired\S2.dat
.\Tess Models\SampleCatalogData\AbsorptionChiller\Double-Effect\Direct-Fired\S3.dat

TYPE 679: SINGLE-EFFECT STEAM-FIRED ABSORPTION CHILLER

PARAMETERS

Parameter Number	Name	Unit	Typical Value	Comment
1	Rated capacity	kJ/hr	5.38E+06	The capacity of the machine at its rated condition (typically 30 C (85F) inlet cooling water temperature and 7 C (44F) chilled water set point temperature). The data files associated with this model should be consistent with the rating conditions.
2	Rated C.O.P.	-	0.53	The C.O.P. of the chiller at its rated conditions (typically 30 C (85F) inlet cooling water temperature and 7 C (44F) chilled water set point temperature). Make sure that the associated files for this component are consistent with the rating conditions.
3	Logical unit number for S1 data file	-	20	The logical unit which will be ASSIGNed to the user-supplied data file containing the fraction of full-load capacity and fraction of design energy input as a function of the inlet steam gauge pressure the inlet cooling water temperature, the chilled water set point temperature and the fraction of design load.
4	Number of steam pressures in S1 data file	-	5	The number of steam gauge pressures for which catalog data is provided in the first data file required by this model.
5	Number of CW steps in S1 data file	-	3	The number of cooling water temperature steps contained in the first required catalog data file (S1.dat).
6	Number of CHW set points in S1 data file	-	7	The number of chilled water set points for which catalog data is provided in the first required data file (S1.dat).
7	Number of load fractions in S1 data file	-	11	The number of fractions of design load for which catalog data is provided in the required data file (S1.dat).
8	Logical unit for S2 data file	-	21	The logical unit which will be ASSIGNed to the user-supplied data file which contains the outlet steam condensate temperatures as a function of the inlet steam gauge pressure.
9	Number of steam pressures in S2 data file	-	4	The number of inlet steam gauge pressures for which outlet steam condensate temperature data will be provided in the second required data file for this component (S2.dat).
10	CHW fluid specific heat	kJ/kg-K	4.190	The specific heat of the chilled water stream flowing through the chiller.
11	CW fluid specific heat	kJ/kg-K	4.190	The specific heat of the cooling water flow stream.
12	Auxiliary electrical power	kJ/hr	20,000.0	The auxiliary electrical power required by the absorption chiller while its operating (solution pumps, refrigerant pumps, etc.)

INPUTS

Input Number	Name	Unit	Typical Value	Comment
1	Chilled water inlet temperature	C	12.22	The temperature of the chilled water stream entering the chiller.
2	Chilled water flow rate	kg/hr	232,000.0	The mass flow rate at which chilled water enters the chiller.
3	Cooling water inlet temperature	C	30.0	The temperature at which the cooling water flow stream enters the chiller.
4	Cooling water flow rate	kg/hr	279,000.0	The mass flow rate at which the cooling fluid (typically water) enters the chiller.
5	Steam inlet temperature	C	120.0	The temperature of the steam provided for operating the absorption chiller.
6	Steam inlet gauge pressure	kPa	96.5	The gauge pressure of the steam provided to operate the absorption chiller.
7	CHW set point	C	6.67	The set-point temperature for the chilled water stream. If the chiller has the capacity to meet the current load, the chiller will modulate to meet the load and chilled water stream will leave at this temperature.
8	Chiller control signal	-	1	The control signal for the operation of the chiller. If the control signal is ≥ 0.5 = chiller is ON. If the control signal is < 0.5, chiller is OFF

OUTPUTS

Output Number	Name	Unit	Comment
1	Chilled water temperature	C	The temperature of the chilled water stream exiting the chiller.
2	Chilled water flow rate	kg/hr	The flow rate of the chilled water stream exiting the chiller.
3	Cooling water temperature	C	The temperature of the cooling flow stream exiting the chiller.
4	Cooling water flow rate	kg/hr	The mass flow rate at which the cooling stream exits the chiller.
5	Condensate temperature	C	The temperature of the steam condensate exiting the absorption chiller.
6	Condensate (steam) flow rate	kg/hr	The flow rate of condensate exiting the absorption chiller. This flow rate is also the required flow rate of steam entering the absorption chiller.
7	Chilled water energy	kJ/hr	The rate at which energy was removed from the chilled water flow stream during the time step.
8	Cooling water energy	kJ/hr	The rate at which heat is rejected to the cooling water flow stream by the chiller.
9	Steam heat transfer	kJ/hr	The rate at which energy was removed from the inlet steam flow in order to operate the absorption chiller.
10	Electrical energy required	kJ/hr	The rate at which electrical energy was required in order to operate the absorption chiller (solution pumps, refrigerant pumps, etc.).
11	Fraction of nominal	-	The fraction of nominal capacity available to the chiller at the current

	capacity		time step. The fraction of nominal capacity is interpolated from the first required data file for this component (S1.dat) as a function of the entering cooling water temperature, the chilled water set-point temperature, and the inlet steam gauge pressure.
12	Fraction of design energy input	-	The fraction of design energy input required by the chiller at the current time step. The fraction of the energy input as compared to design conditions is interpolated from the first required data file for this component (S1.dat) as a function of the entering cooling water temperature, the fraction of design load to be met by the chiller at the current time step, the entering steam gauge pressure, and the chilled water set point temperature.
13	C.O.P	-	The coefficient of performance (C.O.P.) of the chiller at current conditions. The C.O.P. for this model is defined as the energy transferred from the chilled water stream divided by the sum of the electrical energy required by the chiller and the energy provided to the chiller by the inlet steam flow.

Sample Files

.\Tess Models\SampleCatalogData\AbsorptionChiller\Single-Effect\Steam-Fired\S1.dat
.\Tess Models\SampleCatalogData\AbsorptionChiller\Single-Effect\Steam-Fired\S2.dat

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

PARAMETERS

Parameter Number	Name	Unit	Typical Value	Comment
1	Rated capacity	kJ/hr	5.38E+06	The capacity of the machine at its rated condition (typically 30 C (85F) inlet cooling water temperature and 7 C (44F) chilled water set point temperature). The data files associated with this model should be consistent with the rating conditions.
2	Rated C.O.P.	-	0.53	The C.O.P. of the chiller at its rated conditions (typically 30 C (85F) inlet cooling water temperature and 7 C (44F) chilled water set point temperature). Make sure that the associated files for this component is consistent with the rating conditions.
3	Logical unit number for S1 data file	-	20	The logical unit which will be ASSIGNed to the user-supplied data file containing the fraction of nominal capacity and fraction of design energy input data as a function of the inlet hot water temperature, the inlet cooling water temperature, the chilled water set point temperature, and the fraction of design load.
4	Number of HW temperatures in S1 data file	-	5	The number of hot water inlet temperatures for which catalog data is supplied in the data file.
5	Number of CW steps in S1 data file	-	3	The number of cooling water temperature steps contained in the required catalog data file
6	Number of CHW set points in S1 data file	-	7	The number of chilled water set points for which catalog data is provided in the required data file.
7	Number of load fractions in S1 data file	-	11	The number of fractions of design load for which catalog data is provided in the required data file.
8	HW fluid specific heat	kJ/kg-K	4.190	The specific heat of the fluid (typically hot water) which will be used by the absorption chiller and the energy source for chiller operation.
9	CHW fluid specific heat	kJ/kg-K	4.190	The specific heat of the chilled water stream flowing through the chiller.
10	CW fluid specific heat	kJ/kg-K	4.190	The specific heat of the cooling water flow stream.
11	Auxiliary electrical power	kJ/hr	20,000.0	The auxiliary electrical power required by the absorption chiller while its operating (solution pumps, refrigerant pumps, etc.)

INPUTS

Input Number	Name	Unit	Typical Value	Comment
1	Chilled water inlet temperature	C	12.22	The temperature of the chilled water stream entering the chiller.
2	Chilled water flow rate	kg/hr	232,000.0	The mass flow rate at which chilled water enters the chiller.
3	Cooling water inlet temperature	C	30.0	The temperature at which the cooling water flow stream enters the chiller.
4	Cooling water flow rate	kg/hr	279,000.0	The mass flow rate at which the cooling fluid (typically water) enters the chiller.
5	Hot water inlet temperature	C	142.0	The temperature of the inlet stream (typically hot water) which will be used as the energy source for chiller operation.
6	Hot water flow rate	kg/hr	58,000.0	The flow rate of fluid (typically hot water) used as the energy source for chiller operation.
7	CHW set point	C	6.67	The set-point temperature for the chilled water stream. If the chiller has the capacity to meet the current load, the chiller will modulate to meet the load and chilled water stream will leave at this temperature.
8	Chiller control signal	-	1.0	The control signal for the operation of the chiller. If the control signal is ≥ 0.5 = chiller is ON. If the control signal is < 0.5, chiller is OFF

OUTPUTS

Output Number	Name	Unit	Comment
1	Chilled water temperature	C	The temperature of the chilled water stream exiting the chiller.
2	Chilled water flow rate	kg/hr	The flow rate of the chilled water stream exiting the chiller.
3	Cooling water temperature	C	The temperature of the cooling flow stream exiting the chiller.
4	Cooling water flow rate	kg/hr	The mass flow rate at which the cooling stream exits the chiller.
5	Hot water outlet temperature	C	The temperature of the hot water stream exiting the absorption chiller.
6	Hot water flow rate	kg/hr	The flow rate of fluid (typically hot water) exiting the chiller and used by the chiller for an energy source for chiller operation.
7	Chilled water energy	kJ/hr	The rate at which energy was removed from the chilled water flow stream during the time step.
8	Cooling water energy	kJ/hr	The rate at which heat is rejected to the cooling water flow stream by the chiller.
9	Hot water energy	kJ/hr	The rate at which energy was removed from the hot water flow in order to operate the absorption chiller.
10	Electrical energy required	kJ/hr	The rate at which electrical energy was required in order to operate the absorption chiller (solution pumps, refrigerant pumps, etc.).
11	Fraction of nominal	-	The fraction of nominal capacity available to the chiller at the current

	capacity		time step. The fraction of nominal capacity is interpolated from the required data file for this component as a function of the entering cooling water temperature, the chilled water set-point temperature, the hot water inlet temperature, and the fraction of design load.
12	Fraction of design energy input	-	The fraction of design energy input required by the chiller at the current time step. The fraction of the energy input as compared to design conditions is interpolated from the required data file for this component as a function of the entering cooling water temperature, the fraction of design load to be met by the chiller at the current time step, the entering hot water temperature, and the chilled water set point temperature.
13	C.O.P	-	The coefficient of performance (C.O.P.) of the chiller at current conditions. The C.O.P. for this model is defined as the energy transferred from the chilled water stream divided by the sum of the electrical energy required by the chiller and the energy provided to the chiller by the inlet hot water flow stream

Sample File Set

.\Tess Models\SampleCatalogData\AbsorptionChiller\Single-Effect\HotWater-Fired\S1.dat

TYPE 681: SINGLE-EFFECT DIRECT-FIRED ABSORPTION CHILLER

PARAMETERS

Parameter Number	Name	Unit	Typical Value	Comment
1	Rated capacity	kJ/hr	5.38E+06	The capacity of the machine at its rated condition (typically 29 C (85F) inlet cooling water temperature and 7 C (44F) chilled water set point temperature). The data files associated with this model should be consistent with the rating conditions.
2	Rated C.O.P.	-	0.53	The C.O.P. of the chiller at its rated conditions (typically 29 C (85F) inlet cooling water temperature and 7 C (44F) chilled water set point temperature). Make sure that the associated files for this component is consistent with the rating conditions.
3	Logical unit number	-	20	The logical unit which will be ASSIGNed to the user-supplied data file containing the fraction of design energy input as a function of the chilled water set point temperature, the entering cooling water temperature, and the fraction of design load.
4	Number of CW steps in data file	-	3	The number of cooling water temperature steps contained in the required catalog data file.
5	Number of CHW set points in data file	-	7	The number of chilled water set points for which fraction of design energy input data is provided in the required data file.
6	Number of load fractions in data file	-	11	The number of fractions of design load for which the fraction of design energy input data is provided in the required data file.
7	CHW fluid specific heat	kJ/kg-K	4.190	The specific heat of the chilled water stream flowing through the chiller.
8	CW fluid specific heat	kJ/kg-K	4.190	The specific heat of the cooling water flow stream.
9	Auxiliary electrical power	kJ/hr	20,000.0	The auxiliary electrical power required by the absorption chiller while its operating (solution pumps, refrigerant pumps, etc.)

INPUTS

Input Number	Name	Unit	Typical Value	Comment
1	Chilled water inlet temperature	C	12.22	The temperature of the chilled water stream entering the chiller.
2	Chilled water flow rate	kg/hr	232,000.0	The mass flow rate at which chilled water enters the chiller.
3	Cooling water inlet temperature	C	30.0	The temperature at which the cooling water flow stream enters the chiller.
4	Cooling water flow	kg/hr	279,000.	The mass flow rate at which the cooling fluid (typically

	rate		0	water) enters the chiller.
5	CHW set point	C	6.67	The set-point temperature for the chilled water stream. If the chiller has the capacity to meet the current load, the chiller will modulate to meet the load and chilled water stream will leave at this temperature.
6	Chiller control signal	-	1	The control signal for the operation of the chiller. If the control signal is ≥ 0.5 = chiller is ON. If the control signal is < 0.5, chiller is OFF

OUTPUTS

Output Number	Name	Unit	Comment
1	Chilled water temperature	C	The temperature of the chilled water stream exiting the chiller.
2	Chilled water flow rate	kg/hr	The flow rate of the chilled water stream exiting the chiller.
3	Cooling water temperature	C	The temperature of the cooling flow stream exiting the chiller.
4	Cooling water flow rate	kg/hr	The mass flow rate at which the cooling stream exits the chiller.
5	Chilled water energy	kJ/hr	The rate at which energy was removed from the chilled water flow stream during the time step.
6	Cooling water energy	kJ/hr	The rate at which heat is rejected to the cooling water flow stream by the chiller.
7	Required source energy	kJ/hr	The rate at which energy must be supplied to the chiller (generator) in order to operate. This source energy output does not include thermal conversion or combustion efficiencies.
8	Electrical energy required	kJ/hr	The rate at which electrical energy was required in order to operate the absorption chiller (solution pumps, refrigerant pumps, etc.).
9	Fraction of design energy input	-	The fraction of design energy input required by the chiller at the current time step. The fraction of the energy input as compared to design conditions is interpolated from the required data file for this component (S1.dat) as a function of the entering cooling water temperature, the chilled water set point temperature, and the fraction of design load to be met by the chiller at the current time step.
10	C.O.P	-	The coefficient of performance (C.O.P.) of the chiller at current conditions. The C.O.P. for this model is defined as the energy transferred from the chilled water stream divided by the sum of the electrical energy required by the chiller and the source energy required by the chiller

Sample File Set

.\Tess Models\SampleCatalogData\AbsorptionChiller\Single-Effect\Direct-Fired\S1.dat

TYPE 683: ROTARY DESICCANT DEHUMIDIFER

PARAMETERS

Parameter Number	Name	Unit	Typical Value	Comment
1	Dehumidifier F1 effectiveness	-	0.08	The effectiveness of the dehumidifier's F1 potential line.
2	Dehumidifier F2 effectiveness	-	0.95	The effectiveness of the dehumidifier's F2 potential line.

INPUTS

Input Number	Name	Unit	Typical Value	Comment
1	Process air inlet temperature	C	15	The temperature of process air entering the dehumidifier. The process air is the cool, moist air that will be dehumidified and slightly heated by the dehumidifier.
2	Process air inlet humidity ratio	kgH2O/kgAir	0.008	The absolute humidity ratio of process air entering the dehumidifier.
3	Process air flow rate	kg/hr	450	The mass flow rate of process air entering the dehumidifier.
4	Regeneration air humidity ratio	kgH2O/kgAir	0.005	The absolute humidity ratio of regeneration air entering the dehumidifier.
5	Regeneration air flow rate	kg/hr	300	The flow rate of the warm air stream used to regenerate (dry) the desiccant matrix.
6	Humidity ratio set point	kgH2O/kgAir	0.0	The set point of the dehumidifier. This model does not capacity limit the dehumidifier's ability to get the process air stream to the desired set point. The model determines the temperature of regeneration air required to meet the set point.
7	Ambient temperature	C	10	The temperature of the dehumidifier's surroundings. When the dehumidifier is OFF, the regeneration air temperature is automatically set to the ambient temperature.
8	Control signal	-	1.0	The humidifier ON/OFF control signal CTRL < 0.5 : dehumidifier is OF CTRL >= 0.5 : dehumidifier is ON

OUTPUTS

Output Number	Name	Unit	Comment
1	Process air outlet temperature	C	The temperature of the process air stream exiting the dehumidifier.
2	Process air outlet humidity ratio	-	The humidity ratio of the process air stream exiting the dehumidifier. This value should be equal to the humidity ratio set point specified as

			INPUT 6 unless the dehumidifier control signal is set to 0 (OFF)
3	Process air outlet flowrate	kg/hr	The mass flow rate of the process air stream exiting the dehumidifier.
4	Regeneration air INLET temperature	C	The temperature of regeneration air required for the process air stream to exit the dehumidifier at the desired humidity set point.
5	Regeneration air outlet temperature	C	The temperature of the regeneration air stream exiting the dehumidifier.
6	Regeneration air humidity ratio	-	The humidity ratio of the regeneration air stream exiting the dehumidifier.
7	Regeneration air flowrate	kg/hr	The flow rate of the regeneration air stream exiting the dehumidifier

TYPE 684: AIR SIDE ECONOMIZER

PARAMETERS

Parameter Number	Name	Unit	Typical Value	Comment
1	Humidity mode	-	1	This parameter indicates whether the calculation will be based on the inlet humidity ratio input (mode=1) or the inlet relative humidity input (mode=2).
2	Economizer mode	-	1	The mode that the economizer will be operating in: 1= temperature mode 2 = enthalpy mode 3 = humidity mode

INPUTS

Input Number	Name	Unit	Typical Value	Comment
1	Ambient temperature	C	20.0	The dry-bulb temperature of ambient air
2	Ambient humidity ratio	kgH_2O /kgAir	0.008	The absolute humidity ratio of ambient air. This parameter is ignored in humidity mode 2 (PAR 1 = 2)
3	Ambient relative humidity	%	50	The relative humidity of ambient air. This parameter is ignored in humidity mode 1 (PAR 1 = 1)
4	Ambient pressure	Atm	1.0	The absolute pressure of ambient air.
5	Zone temperature	C	20.0	The dry-bulb temperature of zone air
6	Zone humidity ratio	kgH_2O /kgAir	0.008	The absolute humidity ratio of zone air. This parameter is ignored in humidity mode 2 (PAR 1 = 2)
7	Zone relative humidity	%	50	The relative humidity of zone air. This parameter is ignored in humidity mode 1 (PAR 1 = 1)
8	Zone pressure	atm	1.0	The absolute pressure of zone air.
9	Supply air flow rate	kg/hr	0.0	The total dry air flow rate after mixing the outside air and return air. This is the flow rate of air that will be delivered to the zone (or downstream conditioning equipment).
10	Minimum outside air fraction	0..1	0.15	The minimum allowable fraction of outside air at the current time step. At a minimum, the economizer will mix this fraction of outside air with the remaining fraction of return air to create the supply air flow rate.
11	Maximum outside air fraction	0..1	1.0	The maximum allowable fraction of outside air at the current time step. At ideal economizer conditions, the economizer will mix this fraction of outside air with the remaining fraction of return air to create the supply air flow rate.
12	Outside air damper pressure drop	atm	0.0	The pressure drop of the outside air (ambient air) as it passes across the outside air damper.
13	Exhaust air damper pressure drop	atm	0.0	The pressure drop of the exhaust air (zone air) as it passes across the exhaust air damper.
14	Return air damper pressure drop	atm	0.0	The pressure drop of the exhaust air (zone air) as it passes across the return air damper.

15	Control signal	0..1	1	The control signal for the operation of the economizer: >0.5 = ON and allowing the dampers to modulate the amount of outside air < 0.5 = allowing only the minimum specified amount of outside air
16	Zone set point temperature	C	26.0	The cooling set point of the zone. This value is used for control purposes by the economizer.
17	Cooling coil set point temperature	C	10.0	The set point temperature for the air leaving the cooling coil. This value is used for control purposes by the economizer.
18	Zone set point humidity	kgH_2O /kgAir	0.008	The desired absolute humidity of the zone during cooling season. This value is used for control purposes by the economizer.
19	Cooling coil set point humidity	kgH_2O /kgAir	0.004	The desired absolute humidity of the air leaving the cooling coil. This value is used for control purposes by the economizer.

OUTPUTS

Output Number	Name	Unit	Comment
1	Supply air outlet temperature	C	The temperature of supply air exiting economizer.
2	Supply air outlet humidity ratio	kgH_2O/kgAir	The humidity ratio of supply air exiting the economizer.
3	Supply air outlet relative humidity	%	The relative humidity of supply air exiting the economizer.
4	Supply air outlet flow rate	kg/hr	The mass flow rate of supply air exiting the economizer.
5	Supply air outlet pressure	atm	The absolute pressure of supply air exiting the economizer.
6	Exhaust air outlet temperature	C	The temperature of ex exhaust air exiting the economizer.
7	Exhaust air outlet humidity ratio	kgH_2O/kgAir	The humidity ratio of exhaust air exiting the economizer.
8	Exhaust air outlet relative humidity	%	The relative humidity of exhaust air exiting the economizer.
9	Exhaust air outlet flow rate	kg/hr	The mass flow rate of exhaust air exiting the economizer.
10	Exhaust air outlet pressure	atm	The absolute pressure of exhaust air exiting the economizer.
11	Outside air fraction	0..1	The fraction of outside air in the supply air flow stream.
12	Energy from outside air	kJ/hr	The rate at which energy is added to the supply air stream due to the introduction of the outside air into the system.
13	Cooling energy reduction	kJ/hr	The rate at which cooling energy is saved by the economizer due to an increase in the outside air flow rate beyond the minimum outside air flow rate for the current time step.

TYPE 688: UNITARY DEHUMIDIFIER

PARAMETERS

Parameter Number	Name	Unit	Typical Value	Comment
1	Humidity mode	-	1	This parameter indicates whether the calculation will be based on the inlet humidity ratio input (mode=1) or the inlet relative humidity input (mode=2).
2	Logical unit for data file	-	10	The logical unit which is ASSIGNed to the user-supplied data file containing the catalog performance data. Logical units must be unique integers for every file used in a simulation.
3	Number of temperatures	-	3	The number of air dry-bulb temperature points for which catalog performance is provided in the user-supplied data file.
4	Number of relative humidities	-	6	The number of air percent relative humidity points for which catalog performance is provided in the user-supplied data file.
5	Number of flow ratios	-	2	The number of fractional air flow rate points for which catalog performance is provided in the user-supplied data file.
6	Rated fan power	kJ/hr	335.0	The rated fan power at full-speed operation.
7	Rated air flow rate	kg/hr	400.0	The rated fan dry air flow rate at full-speed operation.
8	Number of fan coefficients	-	1	The number of fan power coefficients that will be provided that relate the fraction of full-load fan power to the fraction of rated flow rate. Refer to the technical documentation for help on setting these coefficients.
9	Fan coefficients	-	1.0	The value of the polynomial multiplier for the relationship between normalized fan power and normalized fan flow rate.

INPUTS

Input Number	Name	Unit	Typical Value	Comment
1	Air inlet temperature	C	20.0	The dry-bulb temperature of air entering the dehumidifier
2	Air inlet humidity ratio	kgH_2O /kgAir	0.008	The absolute humidity ratio of air entering the dehumidifier. This parameter is ignored in humidity mode 2 (PAR 1 = 2)
3	Air inlet relative humidity	%	50	The relative humidity of air entering the dehumidifier. This parameter is ignored in humidity mode 1 (PAR 1 = 1)
4	Air flow rate	kg/hr	0.0	The flow rate of dry air entering the dehumidifier
5	Air inlet pressure	atm	1.0	The absolute pressure of air entering the dehumidifier.
6	Air side pressure drop	atm	20.0	The pressure rise of the air stream as it flows through the device.
7	Dehumidifier control signal	0..1	1.0	The control signal for the operation of the dehumidifier; 0 = OFF >0.5 = ON

8	Fan control signal	0..1	1.0	The control signal for the operation of the dehumidifier fan: 0 = OFF >0 = ON at the provided fraction of rated flow rate
9	Heat rejection indicator	0..1	1.0	This input tells the model how to handle the waste heat generated by the device (compressor heat, fan heat, and cooling energy removed from the air), 0 = the waste heat will be rejected to the surroundings, 1=the waste heat is added to the outlet air stream

OUTPUTS

Output Number	Name	Unit	Comment
1	Air outlet temperature	C	The temperature of the air stream exiting the dehumidifier.
2	Air outlet humidity ratio	kgH_2O /kgAir	The humidity ratio of the air stream exiting the dehumidifier.
3	Air outlet relative humidity	%	The percent relative humidity of the air exiting the device.
4	Dry air flow rate	kg/hr	The flow rate of dry air exiting the device.
5	Outlet air pressure	atm	The absolute pressure of the air exiting the device.
6	Energy to surroundings	kJ/hr	The rate at which waste heat from the dehumidifier is dumped to the environment (and therefore not added to the outlet air flow stream).
7	Cooling capacity	kJ/hr	The cooling capacity of the dehumidifier at the current conditions.
8	Fan power	kJ/hr	The rate at which the fan is consuming energy.
9	Compressor power	kJ/hr	The rate at which the compressor of the dehumidifier refrigerant cycle is consuming energy.
10	Total power	kJ/hr	The rate at which the device is consuming energy (fan plus compressor).
11	Air side heat transfer	kJ/hr	The rate at which energy is added to the air stream (sensible plus latent) as it flows through the device.
12	Condensate temperature	C	The temperature of the condensed water exiting the dehumidifier.
13	Condensate flow rate	kg/hr	The flow rate of condensed water exiting the dehumidifier.

TYPE 689: HEAT PIPE

PARAMETERS

Parameter Number	Name	Unit	Typical Value	Comment
1	Humidity mode	-	1	This parameter indicates whether the calculation will be based on the inlet humidity ratio input (mode=1) or the inlet relative humidity input (mode=2).

INPUTS

Input Number	Name	Unit	Typical Value	Comment
1	Inlet 1 air temperature	C	20.0	The dry-bulb temperature of air entering the hot side of the heat pipe.
2	Inlet 1air humidity ratio	kgH_2O /kgAir	0.008	The absolute humidity ratio of air entering the hot side of the heat pipe. This parameter is ignored in humidity mode 2 (PAR 1 = 2)
3	Inlet 1air relative humidity	%	50	The relative humidity of air entering the hot side of the heat pipe. This parameter is ignored in humidity mode 1 (PAR 1 = 1)
4	Inlet 1air flow rate	kg/hr	0.0	The flow rate of air entering the hot side of the heat pipe.
5	Inlet 1air inlet pressure	atm	1.0	The absolute pressure of air entering the hot side of the heat pipe.
6	Inlet 1 pressure drop	atm	0.0	The pressure drop of the air as it flows across the hot-side of the heat pipe.
7	Inlet 2 air temperature	C	20.0	The dry-bulb temperature of air entering the cold side of the heat pipe.
8	Inlet 2 air humidity ratio	kgH_2O /kgAir	0.008	The absolute humidity ratio of air entering the cold side of the heat pipe. This parameter is ignored in humidity mode 2 (PAR 1 = 2)
9	Inlet 2air relative humidity	%	50	The relative humidity of air entering the cold side of the heat pipe. This parameter is ignored in humidity mode 1 (PAR 1 = 1)
10	Inlet 2 air flow rate	kg/hr	0.0	The flow rate of air entering the cold side of the heat pipe.
11	Inlet 2 air inlet pressure	atm	1.0	The absolute pressure of air entering the cold side of the heat pipe.
12	Inlet 2 pressure drop	atm	0.0	The pressure drop of the air as it flows across the cold side of the heat pipe.
13	Effectiveness	0..1	0.7	The effectiveness of the heat pipe as a heat exchanger.

OUTPUTS

Output Number	Name	Unit	Comment
1	Outlet 1 air temperature	C	The temperature of the air stream exiting the hot side of the heat pipe.
2	Outlet 1 air humidity ratio	kgH_2O /kgAir	The humidity ratio of the air stream exiting the hot side of the heat pipe..
3	Outlet 1 air relative humidity	%	The percent relative humidity of the air exiting the hot side of the heat pipe..
4	Outlet 1 air dry air flow rate	kg/hr	The flow rate of dry air exiting the hot side of the heat pipe..
5	Outlet 1 air pressure	atm	The absolute pressure of the air exiting the hot side of the heat pipe..
6	Outlet 2 air temperature	C	The temperature of the air stream exiting the cold side of the heat pipe.
7	Outlet 2 air humidity ratio	kgH_2O /kgAir	The humidity ratio of the air stream exiting the cold side of the heat pipe..
8	Outlet 2 air relative humidity	%	The percent relative humidity of the air exiting the cold side of the heat pipe..
9	Outlet 2 air dry air flow rate	kg/hr	The flow rate of dry air exiting the cold side of the heat pipe..
10	Outlet 2 air pressure	atm	The absolute pressure of the air exiting the cold side of the heat pipe..
11	Heat transfer rate	kJ/hr	The rate at which heat is removed from the inlet 1 air stream (hot-side) and added to air stream 2 (the cold-side).

TYPE 692: PERFORMANCE MAP FLUID COOLER

PARAMETERS

Parameter Number	Name	Unit	Typical Value	Comment
1	Logical unit of performance data	-	10	The logical unit number which will be ASSIGNed to the user-supplied data file containing the capacity and COP as a function of inlet fluid temperature and sink temperature.
2	Number of sink temperatures	-	6	The number of sink temperatures for which capacity and COP data will be provided in the user-supplied external data file.
3	Number of inlet fluid temperatures	-	6	The number of inlet fluid temperatures for which capacity and COP data will be provided in the user-supplied external data file.
4	Fluid specific heat	kJ/kg-K	4.19	The specific heat of the fluid flowing into the fluid cooler.

INPUTS

Input Number	Name	Unit	Typical Value	Comment
1	Inlet fluid temperature	C	12.22	The temperature of the fluid entering the device.
2	Inlet fluid flow rate	kg/hr	0.0	The mass flow rate of the fluid entering the device.
3	Sink temperature	C	30.0	The temperature of the thermal sink for the device (the temperature to which the rejected energy will be transferred).
4	Set point temperature	C	6.67	The set-point temperature for the fluid stream. If the fluid cooler has the capacity to meet the load, the device will modulate to meet the load and the outlet flow stream will leave at this temperature.
5	Control signal	0..1	1.0	The control signal for the operation of the device CTRL < 0.5 : device is OFF CTRL >= 0.5 : device is ON

OUTPUTS

Output Number	Name	Unit	Comment
1	Outlet fluid temperature	C	The temperature of fluid exiting the device.
2	Outlet fluid flow rate	kg/hr	The flow rate of fluid exiting the device.
3	Load met	kJ/hr	The load (energy removed from the flow stream) that the fluid cooler was able to meet at the current time step. If the fluid cooler was unable to meet the entire load, the temperature of the exiting flow stream will be higher than the set-point temperature.

4	Power	kJ/hr	The power requirement of the device. The power is read (and interpolated) from the user-supplied data file.
5	Capacity	kJ/hr	The capacity of the device given the current fluid inlet temperature and sink temperature.
6	Heat rejection rate	kJ/hr	The rate at which heat is rejected to the thermal sink by the device.
7	C.O.P.	-	The coefficient of performance (capacity divided by power) of the fluid cooler given the current conditions.

Sample File Set

.\Tess Models\SampleCatalogData\FluidCooler\Fluid_Cooler.dat

TYPE 696: AIR STREAM CONDITIONING DEVICE

PARAMETERS

Parameter Number	Name	Unit	Typical Value	Comment
1	Humidity mode	-	1	This parameter indicates whether the calculation will be based on the inlet humidity ratio input (mode=1) or the inlet relative humidity input (mode=2).
2	Leaving cooling air relative humidity	%	90.0	The percent relative humidity of the air exiting the device in cooling mode. If the user believes the air dew point is below the coil fluid temperature, this value should be set near 100% (somewhat less to account for not all of the air coming to equilibrium with the coil).
3	Reheat mode	-	1	Setting this value to 1 will allow the air to be reheated to its cooling set point condition if the air has to be cooled below its set point for dehumidification purposes.
4	Dehumidification mode	-	1	Setting this parameter to 1 will only dehumidify the air when the air is being actively cooled by this device.
5	Humidification mode	-	1	Setting this parameter to 1 will only humidify the air when the air is being actively heated by this device.

INPUTS

Input Number	Name	Unit	Typical Value	Comment
1	Inlet air temperature	C	20.0	The dry-bulb temperature of air entering the coil.
2	Inlet air humidity ratio	kgH_2O /kgAir	0.008	The absolute humidity ratio of air entering the coil. This parameter is ignored in humidity mode 2 (PAR 1 = 2)
3	Inlet air relative humidity	%	50	The relative humidity of air entering the hot side of the coil. This parameter is ignored in humidity mode 1 (PAR 1 = 1)
4	Inlet air flow rate	kg/hr	0.0	The flow rate of air entering the coil.
5	Inlet air pressure	atm	1.0	The absolute pressure of air entering the coil.
6	Air side pressure drop	atm	0.0	The pressure drop of the air as it flows through the coil.
7	Heating temperature set point	C	20.0	The desired outlet air temperature from the device in heating mode.
8	Cooling temperature set point	C	10.0	The desired outlet air temperature from the device in cooling mode.
9	Minimum outlet air relative humidity	%	20.0	The minimum relative humidity of the air exiting the device. If enabled, humidification will occur to keep the air at or above this set point.
10	Maximum outlet air relative humidity	%	70.0	The maximum percent relative humidity of the air exiting the device. If enabled, dehumidification will occur to keep the air at or below this set point.

9	Minimum outlet air humidity ratio	kgH2O/kgAir	0.005	The minimum absolute humidity ratio of the air exiting the device. If enabled, humidification will occur to keep the air at or above this set point.
10	Maximum outlet air humidity ratio	kgH2O/kgAir	0.01	The maximum absolute humidity ratio of the air exiting the device. If enabled, dehumidification will occur to keep the air at or below this set point.

OUTPUTS

Output Number	Name	Unit	Comment
1	Air outlet temperature	C	The temperature of the air stream exiting the cooling coil
2	Air outlet humidity ratio	kgH_2O /kgAir	The humidity ratio of the air stream exiting the cooling coil
3	Air outlet relative humidity	%	The percent relative humidity of the air exiting the cooling coil
4	Air outlet flow rate	kg/hr	The flow rate of dry air exiting the cooling coil
5	Air outlet pressure	atm	The absolute pressure of the air exiting the cooling coil
6	Heating energy	kJ/hr	The rate at which energy is supplied to the air stream in order to raise its temperature to the provided set point.
7	Humidification energy	kJ/hr	The rate at which energy is supplied to the air stream in order to raise its humidity to the provided set point.
8	Cooling energy	kJ/hr	The rate (sensible + latent) at which energy is removed from the air stream in order to lower its temperature and humidity to the provided set points.
9	Sensible cooling energy	kJ/hr	The rate at which energy is removed from the air stream in order to lower its temperature to the provided set point.
10	Latent cooling energy	kJ/hr	The rate at which energy is removed from the air stream in order to lower its humidity to the provided set point.
11	Reheat energy	kJ/hr	The rate at which energy is added to the air stream by the reheating device.

TYPE 699: HEAT EXCHANGER WITH COLD-SIDE BYPASS TO KEEP HOT-SIDE OUTLET ABOVE ITS SETPOINT

PARAMETERS

Parameter Number	Name	Unit	Typical Value	Comment
1	Effectiveness of heat exchanger	-	0.65	The effectiveness of the heat exchanger. The effectiveness is a dimensionless parameter that relates the heat transfer in the heat exchanger to the maximum possible heat transfer in the heat exchanger given the inlet temperatures.
2	Specific heat of hot-side fluid	kJ/kg-K	4.190	The specific heat of the fluid flowing through the hot side of the heat exchanger.
3	Specific heat of cold-side fluid	kJ/kg-K	4.190	The specific heat of the fluid flowing through the cold side of the heat exchanger.
4	Number of possible steps	-	1000	The number of possible diverter valve setting steps for diverting cold side fluid past the heat exchanger. If the flow is continuously variable, this parameter should be set to a large number. Doing so, however, can have negative effects on simulation speed.

INPUTS

Input Number	Name	Unit	Typical Value	Comment
1	Hot-side inlet temperature	C	20.0	The temperature of the hot-side fluid flowing into the heat exchanger
2	Hot-side flow rate	kg/hr	200.0	The flow rate of the hot-side fluid flowing into the heat exchanger.
3	Cold-side inlet temperature	C	10.0	The temperature of the cold-side fluid flowing into the heat exchanger.
4	Cold-side flow rate	kg/hr	200.0	The flow rate of the cold-side fluid flowing into the heat exchanger
5	Hot-side set temperature	C	14.0	The minimum desired temperature of the fluid exiting the hot side of the heat exchanger.
6	Modulation control	-	0	When this control function is greater than 0.5, the cold-side flow will not modulate and instead pass completely through the heat exchanger; possibly resulting in temperatures lower than the specified set temperature for the exiting hot-side flow.

OUTPUTS

Output	Name	Unit	Comment

Number			
1	Hot-side outlet temperature	C	The temperature of the fluid leaving the hot side of the heat exchanger.
2	Hot-side outlet flow rate	kg/hr	The flow rate of fluid leaving the hot-side of the heat exchanger.
3	Cold-side HX outlet temperature	C	The temperature of the cold-side fluid exiting the heat exchanger *before* the bypass is mixed back in.
4	Cold-side HX outlet flow rate	kg/hr	The flow rate of the cold-side fluid exiting the heat exchanger *before* the bypass is mixed back in.
5	Cold-side bypass temperature	C	The temperature of the cold-side fluid bypassing the heat exchanger.
6	Cold-side bypass flow rate	kg/hr	The flow rate of the cold-side fluid bypassing the heat exchanger.
7	Cold-side outlet temperature	C	The temperature of the cold-side fluid exiting the heat exchanger *after* the bypass is mixed back in.
6	Cold-side outlet flow rate	kg/hr	The flow rate of the cold-side fluid exiting the heat exchanger *after* the bypass is mixed back in.
9	Bypass fraction for cold-side	-	The calculated bypass fraction for the cold-side fluid: 1 = The entire cold-side stream is bypassed around the heat exchanger 0 = The entire stream flows through the heat exchanger
10	Heat transfer rate	kJ/hr	The rate at which heat is transferred from the hot-side fluid to the cold-side fluid.

TYPE 700: BOILER WITH EFFICIENCY AS AN INPUT

PARAMETERS

Parameter Number	Name	Unit	Typical Value	Comment
1	Rated capacity	kJ/hr	30000.0	The rated capacity of the boiler. The available capacity is simply this parameter multiplied by the input control signal. The capacity for this parameter refers to the energy input to the fluid and not the gross capacity of the device.
2	Fluid specific heat	kJ/kg-K	4.19	The specific heat of the fluid flowing through the device.

INPUTS

Input Number	Name	Unit	Typical Value	Comment
1	Inlet fluid temperature	C	50.0	The temperature of fluid entering the boiler
2	Inlet fluid flow rate	kg/hr	1000.0	The mass flow rate of fluid entering the boiler
3	Control signal	0..1	0.0	ON/OFF control switch CTRL < 0.5 – the boiler is OFF CTRL > 0.5 – the boiler is ON
4	Set point temperature	C	70.0	The desired temperature of the fluid exiting the device.
5	Boiler efficiency	0..1	0.78	The overall efficiency of the boiler. The fuel input energy will be calculated by dividing the energy delivered to the fluid by this boiler efficiency.
6	Combustion efficiency	0..1	0.85	The combustion efficiency for the boiler. The combustion efficiency is defined as (input energy - stack energy) /input energy and accounts for the losses from the boiler.

OUTPUTS

Output Number	Name	Unit	Comment
1	Outlet fluid temperature	C	The temperature of fluid exiting the boiler
2	Outlet fluid flow rate	kg/hr	The mass flow rate of fluid exiting the boiler
3	Fluid energy	kJ/hr	The rate at which heat is transferred to the fluid.
4	Losses to surroundings	kJ/hr	The rate at which energy is lost from the boiler shell to the environment.
5	Exhaust energy	kJ/hr	The rate at which energy is exhausted from the boiler stack. This term is calculated by first determining the required fuel input and then using the combustion efficiency to calculate the stack losses.
6	Required boil energy input	kJ/hr	The rate at which fuel is being consumed by the boiler to heat the fluid. This term is calculated by dividing the energy provided to the fluid by the boiler efficiency.
7	Part load ratio	0..1	The ratio of delivered fluid energy to available energy input (capacity).

TYPE 751: BOILER WITH EFFICIENCY READ FROM A DATA FILE

PARAMETERS

Parameter Number	Name	Unit	Typical Value	Comment
1	Rated capacity	kJ/hr	30000.0	The rated capacity of the boiler. The available capacity is simply this parameter multiplied by the input control signal. The capacity for this parameter refers to the energy input to the fluid and not the gross capacity of the device.
2	Fluid specific heat	kJ/kg-K	4.19	The specific heat of the fluid flowing through the device.
3	Logical unit for data file	-	10	The logical unit which will be ASIGNed to the external data file containing the boiler and combustion efficiencies as a function of the inlet fluid temperature and the boiler part-load ratio. Logical units must be unique integers in TRNSYS.
4	Number of inlet temperatures	-	11	The number of inlet fluid temperatures for which the boiler and combustion efficiency will be provided in the external data file.
5	Number of PLRs	-	2	The number of part-load ratios for which the boiler and combustion efficiency will be provided in the external data file.

INPUTS

Input Number	Name	Unit	Typical Value	Comment
1	Inlet fluid temperature	C	50.0	The temperature of fluid entering the boiler
2	Inlet fluid flow rate	kg/hr	1000.0	The mass flow rate of fluid entering the boiler
3	Control signal	0..1	0.0	ON/OFF control switch CTRL < 0.5 – the boiler is OFF CTRL > 0.5 – the boiler is ON
4	Set point temperature	C	70.0	The desired temperature of the fluid exiting the device.

OUTPUTS

Output Number	Name	Unit	Comment
1	Outlet fluid temperature	C	The temperature of fluid exiting the boiler
2	Outlet fluid flow rate	kg/hr	The mass flow rate of fluid exiting the boiler
3	Fluid energy	kJ/hr	The rate at which heat is transferred to the fluid.
4	Losses to surroundings	kJ/hr	The rate at which energy is lost from the boiler shell to the environment.
5	Exhaust energy	kJ/hr	The rate at which energy is exhausted from the boiler stack. This term is calculated by first determining the required fuel input and then using the

			combustion efficiency to calculate the stack losses.
6	Required boil energy input	kJ/hr	The rate at which fuel is being consumed by the boiler to heat the fluid. This term is calculated by dividing the energy provided to the fluid by the boiler efficiency.
7	Part load ratio	0..1	The ratio of delivered fluid energy to available energy input (capacity).
8	Boiler efficiency	0..1	The overall efficiency of the boiler. The fuel input energy will be calculated by dividing the energy delivered to the fluid by this boiler efficiency.
9	Combustion efficiency	0..1	The combustion efficiency for the boiler. The combustion efficiency is defined as (input energy - stack energy) /input energy and accounts for the losses from the boiler.

Sample File Set

.\Tess Models\SampleCatalogData\Boilers\Fluid Boiler\Efficiency.dat

TYPE 752: SIMPLE COOLING COIL

PARAMETERS

Parameter Number	Name	Unit	Typical Value	Comment
1	Control mode	-	1	This parameter tells the cooling coil model the mode of operation for the coil: 1 = the outlet air temperature will be controlled, 2 = the outlet air temperature and absolute humidity ratio will be controlled, 3 = the outlet air temperature and relative humidity will be controlled, 4 = the outlet air humidity ratio will be controlled
2	Humidity mode	-	1	This parameter indicates whether the calculation will be based on the inlet humidity ratio input (mode=1) or the inlet relative humidity input (mode=2).

INPUTS

Input Number	Name	Unit	Typical Value	Comment
1	Inlet air temperature	C	20.0	The dry-bulb temperature of air entering the coil.
2	Inlet air humidity ratio	kgH_2O /kgAir	0.008	The absolute humidity ratio of air entering the coil. This parameter is ignored in humidity mode 2 (PAR 1 = 2)
3	Inlet air relative humidity	%	50	The relative humidity of air entering the coil. This parameter is ignored in humidity mode 1 (PAR 1 = 1)
4	Inlet air flow rate	kg/hr	0.0	The flow rate of air entering the coil.
5	Inlet air pressure	atm	1.0	The absolute pressure of air entering the coil.
6	Air side pressure drop	atm	0.0	The pressure drop of the air as it flows through the coil.
7	Coil bypass fraction	0..1	0.15	The fraction of the air flow through the coil that is assumed to be unaffected by the coil. The remaining air will come to the equilibrium temperature with the average fluid temperature (water) in the coil. These two air streams will then mix to form the air outlet conditions.
8	Control signal	0..1	1.0	CTRL < 0.5 – the coil is OFF. CTRL > 0.5 – the coil is ON and conditioning the air stream
Control Mode 1 Inputs:				
9	Temperature set point	C	10.0	The desired outlet temperature of the air.
Control Mode 2 Inputs				
9	Temperature set point	C	10.0	The desired outlet temperature of the air.
10	Humidity set point	kgAir/kg H_2O	0.005	The desired outlet humidity ratio of the air
Control Mode 3 Inputs				
9	Temperature set point	C	10.0	The desired outlet temperature of the air.
10	Humidity set point	kgAir/kg	20.0	The desired outlet relative humidity of the air

		H_2O		
Control Mode 4 Inputs:				
9	Humidity set point	%	0.005	The desired outlet humidity ratio of the air.

OUTPUTS

Output Number	Name	Unit	Comment
1	Air outlet temperature	C	The temperature of the air stream exiting the cooling coil
2	Air outlet humidity ratio	kgH_2O /kgAir	The humidity ratio of the air stream exiting the cooling coil
3	Air outlet relative humidity	%	The percent relative humidity of the air exiting the cooling coil
4	Air outlet flow rate	kg/hr	The flow rate of dry air exiting the cooling coil
5	Air outlet pressure	atm	The absolute pressure of the air exiting the cooling coil
6	Air side heat transfer	kJ/hr	The rate at which energy is removed from the air stream (sensible plus latent).
7	Reheat energy	kJ/hr	The rate at which energy is added to the air stream by the reheating device.
8	Condensate temperature	C	The temperature at which condensed water from the air stream exits the cooling coil.
9	Condensate flow rate	kg/hr	The rate at which condensed water from the air stream exits the cooling coil.

TYPE 753: HEATING COIL WITH VARIOUS CONTROL MODES

PARAMETERS

Parameter Number	Name	Unit	Typical Value	Comment
1	Control mode	-	1	This parameter tells the heating coil model the mode of operation for the coil: 0 = free float mode 1 = the outlet air temperature will be controlled, 2 = the outlet liquid temperature will be controlled,
2	Humidity mode	-	1	This parameter indicates whether the calculation will be based on the inlet humidity ratio input (mode=1) or the inlet relative humidity input (mode=2).
3	Liquid specific heat	kJ/kg-K	4.19	The specific heat of the fluid on the liquid side of the coil

INPUTS

Input Number	Name	Unit	Typical Value	Comment
1	Inlet liquid temperature	C	10.0	The temperature of liquid entering the coil
2	Inlet liquid flow rate	kg/hr	0.0	The flow rate of liquid entering the coil
3	Inlet air temperature	C	20.0	The dry-bulb temperature of air entering the coil.
4	Inlet air humidity ratio	kgH_2O /kgAir	0.008	The absolute humidity ratio of air entering the coil. This parameter is ignored in humidity mode 2 (PAR 1 = 2)
5	Inlet air relative humidity	%	50	The relative humidity of air entering the coil. This parameter is ignored in humidity mode 1 (PAR 1 = 1)
6	Inlet air flow rate	kg/hr	0.0	The flow rate of air entering the coil.
7	Inlet air pressure	atm	1.0	The absolute pressure of air entering the coil.
8	Air side pressure drop	atm	0.0	The pressure drop of the air as it flows through the coil.
9	Coil bypass fraction	0..1	0.15	The fraction of the air flow through the heating coil that is assumed to be unaffected by the coil. The remaining air will come to the equilibrium temperature with the average fluid temperature (water) in the coil. These two air streams will then mix to form the air outlet conditions.
Control Mode 0 Inputs: (there are no more inputs for control mode 0)				
Control Mode 1 Inputs:				
10	Temperature set point	C	10.0	The desired outlet temperature of the air.
Control Mode 2 Inputs				
10	Temperature set point	C	10.0	The desired outlet temperature of the liquid.

OUTPUTS

Output Number	Name	Unit	Comment
1	Liquid outlet temperature	C	The temperature of liquid exiting the coil
2	Liquid outlet flow rate	kg/hr	The mass flow rate of liquid exiting the coil
3	Air outlet temperature	C	The temperature of the air stream exiting the coil
4	Air outlet humidity ratio	kgH_2O /kgAir	The humidity ratio of the air stream exiting the coil
5	Air outlet relative humidity	%	The percent relative humidity of the air exiting the coil
6	Air outlet flow rate	kg/hr	The flow rate of dry air exiting the coil
7	Air outlet pressure	atm	The absolute pressure of the air exiting the coil
8	Air side heat transfer	kJ/hr	The rate at which energy is removed from the air stream (sensible plus latent).
9	Liquid heat transfer	kJ/hr	The rate at which energy is transferred from the coil fluid to the air stream.
10	Coil liquid outlet temperature	C	The temperature of the fluid stream exiting the heating coil BEFORE the controlled bypass fluid is mixed back in.
11	Coil liquid flow rate	kg/hr	The rate at which liquid passes through the coil (does not include the liquid that is bypassed around the coil and later mixed back in).
12	Bypass liquid outlet temperature	C	The temperature of the liquid stream that is bypassed around the heating coil for control purposes (before the mixing process).
13	Bypass liquid flow rate	kg/hr	The flow rate of the liquid stream that is bypassed around the heating coil for control purposes (before the mixing process).
14	Bypass fraction for liquid side	0..1	The calculated bypass fraction for the liquid-side fluid. The heating coil fluid (typically water) is bypassed around the heating coil in order to control the temperature of the coil outlet fluids: 1 = the entire liquid stream is bypassed around the heating coil and no heat or mass transfer takes place, 0 = the entire liquid stream flows through the heating coil.

TYPE 754: SIMPLE HEATING COIL

PARAMETERS

Parameter Number	Name	Unit	Typical Value	Comment
1	Control mode	-	1	This parameter tells the heating coil model the mode of operation for the coil: 1 = the outlet air temperature will be controlled, 2 = the outlet air temperature and absolute humidity ratio will be controlled, 3 = the outlet air temperature and relative humidity will be controlled, 4 = the outlet air humidity ratio will be controlled
2	Humidity mode	-	1	This parameter indicates whether the calculation will be based on the inlet humidity ratio input (mode=1) or the inlet relative humidity input (mode=2).

INPUTS

Input Number	Name	Unit	Typical Value	Comment
1	Inlet air temperature	C	20.0	The dry-bulb temperature of air entering the coil.
2	Inlet air humidity ratio	kgH_2O /kgAir	0.008	The absolute humidity ratio of air entering the coil. This parameter is ignored in humidity mode 2 (PAR 1 = 2)
3	Inlet air relative humidity	%	50	The relative humidity of air entering the coil. This parameter is ignored in humidity mode 1 (PAR 1 = 1)
4	Inlet air flow rate	kg/hr	0.0	The flow rate of air entering the coil.
5	Inlet air pressure	atm	1.0	The absolute pressure of air entering the coil.
6	Air side pressure drop	atm	0.0	The pressure drop of the air as it flows through the coil.
7	Coil bypass fraction	0..1	0.15	The fraction of the air flow through the coil that is assumed to be unaffected by the coil. The remaining air will come to the equilibrium temperature with the average fluid temperature (water) in the coil. These two air streams will then mix to form the air outlet conditions.
8	Control signal	0..1	1.0	CTRL < 0.5 – the coil is OFF. CTRL > 0.5 – the coil is ON and conditioning the air stream
Control Mode 1 Inputs:				
9	Temperature set point	C	10.0	The desired outlet temperature of the air.
Control Mode 2 Inputs				
9	Temperature set point	C	10.0	The desired outlet temperature of the air.
10	Humidity set point	kgAir/kg H_2O	0.005	The desired outlet humidity ratio of the air
Control Mode 3 Inputs				
9	Temperature set point	C	10.0	The desired outlet temperature of the air.
10	Humidity set point	kgAir/kg	20.0	The desired outlet relative humidity of the air

		H_2O		
Control Mode 4 Inputs:				
9	Humidity set point	%	0.005	The desired outlet humidity ratio of the air.

OUTPUTS

Output Number	Name	Unit	Comment
1	Air outlet temperature	C	The temperature of the air stream exiting the coil
2	Air outlet humidity ratio	kgH_2O /kgAir	The humidity ratio of the air stream exiting the coil
3	Air outlet relative humidity	%	The percent relative humidity of the air exiting the coil
4	Air outlet flow rate	kg/hr	The flow rate of dry air exiting the coil
5	Air outlet pressure	atm	The absolute pressure of the air exiting the coil
6	Air side heat transfer	kJ/hr	The rate at which energy is added to the air stream (sensible plus latent).
7	Humidification energy	kJ/hr	The rate at which latent energy is transferred to the air stream from the device.
8	Condensate temperature	C	The temperature at which condensed water from the air stream exits the coil.
9	Condensate flow rate	kg/hr	The rate at which condensed water from the air stream exits the coil.

TYPE 756: RESIDENTIAL COOLING COIL (SINGLE DATA FILE FORMAT)

PARAMETERS

Parameter Number	Name	Unit	Typical Value	Comment
1	Humidity mode	-	1	A switch to specify how inlet air humidity will be specified. 1: humidity ratio of inlet air will be used. 2: relative humidity of inlet air will be used.
2	Logical unit for performance data	-	11	The logical unit number ASSIGNed to the data file that contains the cooling coil performance data (the total cooling capacity and power draw as a function of the ambient dry-bulb temperature, indoor wet-bulb temperature, and the evaporator flow rate.
3	Number of condenser temperatures	-	4	The number of ambient dry-bulb temperature data points for which the cooling coil capacity and power draw are given in the performance data file.
4	Number of evaporator flows	-	3	The number of evaporator flow rate data points for which the cooling coil capacity and power draw are given in the performance data file.
5	Number of wet bulb temperatures	-	3	The number of indoor wet-bulb temperature data points for which the cooling coil capacity and power draw are given in the performance data file.
6	Number of dry bulb temperatures	-	3	The number of indoor dry-bulb temperature data points for which the sensible heat ratio of the cooling coil is given in the sensible heat ratio data file.
7	Blower power draw	kJ/hr	671.1	The power draw of the indoor blower for the cooling coil while operating.

INPUTS

Input Number	Name	Unit	Typical Value	Comment
1	Ambient temperature	C	30.0	The ambient dry-bulb temperature (the temperature of the air flowing across the outdoor coil (the condenser)).
2	Indoor air temperature	C	20.0	The indoor dry-bulb temperature (the temperature of the air flowing across the indoor coil (the evaporator))
3	Indoor air humidity ratio	$kgH_2O/kgAir$	0.003	The absolute humidity ratio of the air flowing across the indoor coil (the evaporator). This input is ignored if Humidity Mode (parameter 1) = 2
4	Indoor air relative humidity	%	50	The relative humidity of the air flowing across the indoor coil (the evaporator). This input is ignored if Humidity Mode (parameter 1) = 1
5	Evaporator air flow rate	kg/hr	2000.0	The rate at which dry air flows across the evaporator.
6	Indoor air pressure	atm	1.0	The absolute pressure of the indoor air (the air flowing across the indoor coil (the evaporator))

7	Air side pressure drop	atm	0.0	The pressure drop of the indoor air as it flows across the indoor coil (the evaporator).
8	Control signal	-	1	The on/off control signal for the cooling coil ≥ 0.5: ON < 0.5: OFF

OUTPUTS

Output Number	Name	Unit	Comment
1	Return air temperature	C	The dry-bulb temperature of the indoor air after it has passed across the cooling coil.
2	Return air humidity ratio	-	The absolute humidity ratio of the indoor air after it has passed across the cooling coil.
3	Return air %RH	%	The relative humidity of the indoor air after it has passed across the cooling coil.
4	Return air flow rate	kg/hr	The flow rate of dry air flowing across the indoor coil (evaporator).
5	Return air pressure	atm	The absolute pressure of the indoor air after it has passed through the air conditioner (across the evaporator section).
6	Total energy removal	kJ/hr	The total (sensible + latent) energy removal rate from the indoor air stream across the cooling coil.
7	Sensible energy removal	kJ/hr	The rate at which sensible energy is removed from the air stream as it passes across the indoor coil (evaporator).
8	Heat rejection	kJ/hr	The rate at which heat is rejected to the ambient by the outdoor coil (condenser).
9	Power	kJ/hr	The rate at which power is consumed by the cooling coil (compressor + blower + controls).
10	Compressor power	kJ/hr	The rate at which the cooling coil compressor consumes power.
11	C.O.P	-	The coefficient of performance of the cooling coil.
12	EER	-	The energy efficiency ratio of the cooling coil.
13	Condensate temperature	C	The temperature of the condensate being drained from the air conditioner.
14	Condensate flow rate	kg/hr	The flow rate of condensate being drained from the device.

Sample Data Files

.\Tess Models\SampleCatalogData\UnitaryAirConditioner\UnifiedFileFormat\Perf_Unitary.dat

TYPE 757: INDIRECT EVAPORATIVE COOLER

PARAMETERS

Parameter Number	Name	Unit	Typical Value	Comment
1	Humidity mode	-	1	A switch to specify how inlet air humidity will be specified. 1: humidity ratio of inlet air will be used. 2: relative humidity of inlet air will be used.
2	Logical unit for performance data	-	11	The logical unit which will be ASSIGNed to the data file containing the effectiveness of the device as a function of the entering air conditions.
3	Number of primary dry bulb temperatures	-	4	The number of primary stream air inlet dry-bulb temperatures for which the effectiveness of the device is provided.
4	Number of secondary wet bulb temperatures	-	3	The number of secondary stream air inlet wet-bulb temperatures for which the effectiveness of the device is provided.

INPUTS

Input Number	Name	Unit	Typical Value	Comment
1	Inlet air temperature – primary stream	C	20.0	The temperature of the primary air stream entering the indirect evaporative cooler.
2	Inlet air humidity ratio – primary stream	kgH_2O/kgAir	0.003	The absolute humidity ratio of the primary air stream entering the indirect evaporative cooler. This input is ignored if Humidity Mode (parameter 1) = 2
3	Inlet air relative humidity – primary stream	%	50	The percent relative humidity of the primary air stream entering the indirect evaporative cooler. This input is ignored if Humidity Mode (parameter 1) = 1
4	Inlet air flow rate – primary stream	kg/hr	2000.0	The dry air flow rate of the primary air stream entering the indirect evaporative cooler.
5	Inlet air pressure – primary stream	atm	1.0	The absolute pressure of the primary air stream entering the indirect evaporative cooler.
6	Inlet air pressure drop – primary stream	atm	0.0	The pressure drop of the primary air stream as it flows through the indirect evaporative cooler.
7	Inlet air temperature – secondary stream	C	20.0	The temperature of the secondary air stream entering the indirect evaporative cooler.
8	Inlet air humidity ratio – secondary stream	kgH_2O/kgAir	0.003	The absolute humidity ratio of the secondary air stream entering the indirect evaporative cooler. This input is ignored if Humidity Mode (parameter 1) = 2
9	Inlet air relative humidity – secondary stream	%	50	The percent relative humidity of the secondary air stream entering the indirect evaporative cooler. This input is ignored if Humidity Mode (parameter 1) = 1
10	Inlet air flow rate – secondary stream	kg/hr	2000.0	The dry air flow rate of the secondary air stream entering the indirect evaporative cooler.

11	Inlet air pressure – secondary stream	atm	1.0	The absolute pressure of the secondary air stream entering the indirect evaporative cooler.
12	Inlet air pressure drop – secondary stream	atm	0.0	The pressure drop of the secondary air stream as it flows through the indirect evaporative cooler.

OUTPUTS

Output Number	Name	Unit	Comment
1	Outlet air temperature – primary stream	C	The dry-bulb temperature of air exiting the primary stream of the evaporative cooler.
2	Outlet air humidity ratio– primary stream	-	The absolute humidity ratio of air exiting the primary stream of the evaporative cooler.
3	Outlet air %RH – primary stream	%	The relative humidity of air exiting the primary stream of the evaporative cooler.
4	Outlet air flow rate– primary stream	kg/hr	The flow rate of air exiting the primary stream of the evaporative cooler.
5	Outlet air pressure– primary stream	atm	The absolute pressure of air exiting the primary stream of the evaporative cooler.
6	Outlet air temperature – secondary stream	C	The dry-bulb temperature of air exiting the secondary stream of the evaporative cooler.
7	Outlet air humidity ratio– secondary stream	-	The absolute humidity ratio of air exiting the secondary stream of the evaporative cooler.
8	Outlet air %RH – secondary stream	%	The relative humidity of air exiting the secondary stream of the evaporative cooler.
9	Outlet air flow rate– secondary stream	kg/hr	The flow rate of air exiting the secondary stream of the evaporative cooler.
10	Outlet air pressure– secondary stream	atm	The absolute pressure of air exiting the secondary stream of the evaporative cooler.
11	Heat transfer rate	kJ/hr	The rate at which heat is transferred from the primary air stream to the secondary air stream.
12	Condensate temperature	C	The temperature of the condensate being drained from the primary stream of the evaporative cooler.
13	Condensate flow rate	kg/hr	The flow rate of condensate being drained from the primary stream of the evaporative cooler.
14	Effectiveness	0..1	The effectiveness of the device in transferring heat from the primary air stream to the secondary air stream. The effectiveness is defined as the inlet dry bulb temperature of the primary air stream minus the outlet dry bulb temperature of the primary air stream divided by the inlet dry-bulb temperature of the primary air stream minus the wet-bulb temperature of the secondary air stream.

Sample Data Files

.\Tess Models\SampleCatalogData\IndirectEvaporativeCooler\Indirect.dat

TYPE 760: SENSIBLE ONLY AIR TO AIR HEAT EXCHANGER (HEAT WHEEL)

PARAMETERS

Parameter Number	Name	Unit	Typical Value	Comment
1	Humidity mode	-	1	This parameter indicates whether the calculation will be based on the inlet humidity ratio input (mode=1) or the inlet relative humidity input (mode=2).
2	Rated power	kJ/hr	671.1	The nominal power consumption when the heat recovery device is operating. This is typically the fan power or motor power. The heat from the fan or motor is assumed to be contained in the sensible effectiveness term.
3	Control mode	-	0	The control method for the device: 0 = outlet temperatures are not controlled, 1 = Keep the fresh air outlet temperature below the user-specified temperature, 2 = Keep the fresh air outlet temperature above the user-specified temperature, 3 = Keep the exhaust air outlet temperature below the user-specified temperature, 4 = Keep the exhaust air outlet temperature above the user-specified temperature

INPUTS

Input Number	Name	Unit	Typical Value	Comment
1	Exhaust air temperature	C	20.0	The dry-bulb temperature of exhaust air entering the heat exchanger
2	Exhaust air humidity ratio	kgH_2O /kgAir	0.008	The absolute humidity ratio of exhaust air entering the heat exchanger. This parameter is ignored in humidity mode 2 (PAR 1 = 2)
3	Exhaust air relative humidity	%	50	The relative humidity of exhaust air entering the heat exchanger. This parameter is ignored in humidity mode 1 (PAR 1 = 1)
4	Exhaust air flow rate	kg/hr	0.0	The flow rate of the exhaust air entering the heat exchanger
5	Exhaust air pressure	atm	1.0	The absolute pressure of exhaust air entering the heat exchanger
6	Exhaust side pressure drop	atm	0.0	The pressure drop of exhaust air in the heat exchanger.
7	Fresh air temperature	C	20.0	The dry-bulb temperature of exhaust air entering the heat exchanger
8	Fresh air humidity ratio	kgH_2O /kgAir	0.008	The absolute humidity ratio of fresh air entering the heat exchanger. This parameter is ignored in humidity mode 2 (PAR 1 = 2)
9	Fresh air relative	%	50	The relative humidity of fresh air entering the heat

	humidity			exchanger. This parameter is ignored in humidity mode 1 (PAR 1 = 1)
10	Fresh air flow rate	kg/hr	0.0	The flow rate of the fresh air entering the heat exchanger
11	Fresh air pressure	atm	1.0	The absolute pressure of fresh air entering the heat exchanger
12	Fresh side pressure drop	atm	0.0	The pressure drop of fresh air in the heat exchanger
13	Sensible effectiveness	0..1	0.6	The effectiveness of the heat recovery device for sensible heat transfer.
14	Control signal	0..1	1.0	The ON/OFF control signal for the heat recovery device. CTRL < 0.5 : the device will NOT transfer heat between the two flow streams and the power will be set to 0. CTRL >= 0.5 : the device WILL transfer heat between the two flow streams and the power will be calculated.
15	Control temperature	C	20.0	The desired outlet temperature of the air stream (which air stream depends on the control mode parameter).

OUTPUTS

Output Number	Name	Unit	Comment
1	Exhaust air outlet temperature	C	The temperature of exhaust air exiting the heat exchanger.
2	Exhaust air outlet humidity ratio	$kgH_2O/kgAir$	The humidity ratio of exhaust air exiting the heat exchanger.
3	Exhaust air outlet relative humidity	%	The relative humidity of exhaust air exiting the heat exchanger.
4	Exhaust air outlet flow rate	kg/hr	The mass flow rate of exhaust air exiting the heat exchanger.
5	Exhaust air outlet pressure	atm	The absolute pressure of exhaust air exiting the heat exchanger.
6	Fresh air outlet temperature	C	The temperature of ex fresh air exiting the heat exchanger.
7	Fresh air outlet humidity ratio	$kgH_2O/kgAir$	The humidity ratio of fresh air exiting the heat exchanger.
8	Fresh air outlet relative humidity	%	The relative humidity of fresh air exiting the heat exchanger.
9	Fresh air outlet flow rate	kg/hr	The mass flow rate of fresh air exiting the heat exchanger.
10	Fresh air outlet pressure	atm	The absolute pressure of fresh air exiting the heat exchanger.
11	Heat transfer rate	kJ/hr	The rate at which heat is transferred from the exhaust air stream to the fresh air stream.
12	Power	kJ/hr	The power consumption rate of the heat exchanger
13	Condensate temperature (exhaust stream)	C	The temperature of the condensate from the exhaust stream.
14	Condensate flow rate (exhaust stream)	kg/hr	The mass flow rate of the condensate from the exhaust stream.

15	Condensate temperature (fresh air stream)	C	The temperature of the condensate from the fresh air stream.
16	Condensate flow rate (fresh air stream)	kg/hr	The mass flow rate of the condensate from the fresh air stream.

HYDRONIC COMPONENTS

Hydronic Components

TYPE 642: SINGLE-SPEED FAN/BLOWER

PARAMETERS

Parameter Number	Name	Unit	Typical Value	Comment
1	Humidity input mode	-	1	This parameter indicates whether the calculation will be based on the inlet humidity ratio input (mode=1) or the inlet relative humidity input (mode=2).
2	Rated flow rate	kg/hr	1000.0	The flow rate of dry air through the fan when operating at the low-speed setting.
3	Rated power	kJ/hr	1342.0	The rated fan power consumption at the low speed setting.
4	Motor efficiency	0..1	0.80	The efficiency of the fan motor. This efficiency is used to calculate the amount of heat added to the air stream.
5	Motor heat loss fraction	0..1	0.0	The fraction of the motor heat loss transferred to the air stream. The motor heat loss is calculated by subtracting the efficiency of the motor from 1 and multiplying the resultant quantity by the power consumption. Typical values are 0 for motors mounted outside the air stream and 1 for motors mounted within the air stream.

INPUTS

Input Number	Name	Unit	Typical Value	Comment
1	Inlet air temperature	C	20.0	The dry-bulb temperature of air entering the fan.
2	Inlet air humidity ratio	-	0.008	The absolute humidity ratio of the air entering the humidifier. This input is ignored if Humidity Mode (parameter 1) = 2
3	Inlet air relative humidity	%	50	The relative humidity of the air entering the humidifier. This input is ignored if Humidity Mode (parameter 1) = 1
4	Dry air flow rate	kg/hr	1000.0	The flow rate of the air (dry) entering the fan. This input is not used by this component except for convergence checking.
5	Inlet air pressure	atm	1.0	The absolute pressure of the air entering the fan
6	Low-speed control signal	-	1.0	The control signal to the fan. Control function ≥ 0.5 : Fan is ON Control function < 0.5 : Fan is OFF
7	Air stream pressure rise	atm	0.0	The increase in air-side pressure for the fan. This value should be set to zero when the fan is off.

OUTPUTS

Output Number	Name	Unit	Comment
1	Outlet air temperature	C	The outlet air dry-bulb temperature from the fan.
2	Outlet air humidity ratio	-	The humidity ratio of the air exiting the fan. In all cases, the exiting humidity ratio is set to the inlet air humidity ratio.
3	Outlet air relative humidity	%	The relative humidity of the air exiting the fan.
4	Outlet air flow rate	kg/hr	The flow rate of dry air exiting the fan.
5	Outlet air pressure	atm	The absolute pressure of air exiting the fan.
6	Power consumption	kJ/hr	The power consumed by the fan.
7	Air heat transfer	kJ/hr	The rate at which heat is transferred to the air stream by the fan.
8	Ambient heat transfer	kJ/hr	The rate at which heat is transferred to the ambient by the fan.

TYPE 644: TWO-SPEED FAN/BLOWER

PARAMETERS

Parameter Number	Name	Unit	Typical Value	Comment
1	Humidity input mode	-	1	This parameter indicates whether the calculation will be based on the inlet humidity ratio input (mode=1) or the inlet relative humidity input (mode=2).
2	Rated flow rate at low speed	kg/hr	1000.0	The flow rate of dry air through the fan when operating at the low-speed setting.
3	Rated flow rate at high speed	kg/hr	2000.0	The flow rate of dry air through the fan when operating at the high-speed setting.
4	Rated power at low speed	kJ/hr	1342.0	The rated fan power consumption at the low speed setting.
5	Rated power at high speed	kJ/hr	2684.0	The rated fan power consumption at the high speed fan setting.
6	Motor efficiency	0..1	0.80	The efficiency of the fan motor. This efficiency is used to calculate the amount of heat added to the air stream.
7	Motor heat loss fraction	0..1	0.0	The fraction of the motor heat loss transferred to the air stream. The motor heat loss is calculated by subtracting the efficiency of the motor from 1 and multiplying the resultant quantity by the power consumption. Typical values are 0 for motors mounted outside the air stream and 1 for motors mounted within the air stream.

INPUTS

Input Number	Name	Unit	Typical Value	Comment
1	Inlet air temperature	C	20.0	The dry-bulb temperature of air entering the fan.
2	Inlet air humidity ratio	-	0.008	The absolute humidity ratio of the air entering the humidifier. This input is ignored if Humidity Mode (parameter 1) = 2
3	Inlet air relative humidity	%	50	The relative humidity of the air entering the humidifier. This input is ignored if Humidity Mode (parameter 1) = 1
4	Dry air flow rate	kg/hr	1000.0	The flow rate of the air (dry) entering the fan. This input is not used by this component except for convergence checking.
5	Inlet air pressure	atm	1.0	The absolute pressure of the air entering the fan
6	Low-speed control signal	-	1.0	The low-speed input control signal to the fan. Low-speed control function ≥ 0.5: Fan is on low speed. Low-speed control function < 0.5: Fan is off. This control signal is overridden by the high-speed fan control signal being set to 'on'.
7	High speed control signal	-	0.0	The high speed input control signal to the fan. High-speed control function ≥ 0.5: Fan is on high speed.

				High-speed control function < 0.5: Fan is controlled by the low-speed control signal.
8	Air stream pressure rise	atm	0.0	The increase in air-side pressure for the fan. This value should be set to zero when the fan is off and should probably be set differently for high-speed and low-speed operation.

OUTPUTS

Output Number	Name	Unit	Comment
1	Outlet air temperature	C	The outlet air dry-bulb temperature from the fan.
2	Outlet air humidity ratio	-	The humidity ratio of the air exiting the fan. In all cases, the exiting humidity ratio is set to the inlet air humidity ratio.
3	Outlet air relative humidity	%	The relative humidity of the air exiting the fan.
4	Outlet air flow rate	kg/hr	The flow rate of dry air exiting the fan.
5	Outlet air pressure	atm	The absolute pressure of air exiting the fan.
6	Power consumption	kJ/hr	The power consumed by the fan.
7	Air heat transfer	kJ/hr	The rate at which heat is transferred to the air stream by the fan.
8	Ambient heat transfer	kJ/hr	The rate at which heat is transferred to the ambient by the fan.

TYPE 646: AIR SUPPLY PLENUM WITH UP TO 100 PORTS

PARAMETERS

Parameter Number	Name	Unit	Typical Value	Comment
1	Humidity input mode	-	1	This parameter indicates whether the calculation will be based on the inlet humidity ratio input (mode=1) or the inlet relative humidity input (mode=2).
2	Number of outlet ports (n)	-	2	The number of outlet ports (ducts) from the supply plenum. The outlet temperature and humidity ratio for each port are set equal to the inlet values. The outlet flow rate for the port is the inlet flow rate multiplied by the given input fraction for that port.

INPUTS

Input Number	Name	Unit	Typical Value	Comment
1	Inlet air temperature	C	20.0	The dry-bulb temperature of the air entering the supply plenum.
2	Inlet air humidity ratio	-	0.008	The absolute humidity ratio of the air entering the supply plenum. This input is ignored if Humidity Mode (parameter 1) = 2
3	Inlet air relative humidity	%	50	The relative humidity of the air entering the supply plenum. This input is ignored if Humidity Mode (parameter 1) = 1
4	Inlet air flow rate	kg/hr	2000.0	The flow rate of dry air entering the supply plenum.
5	Inlet air pressure	atm	1.0	The absolute pressure of the air entering the supply plenum.
6	Air stream pressure drop	atm	0.0	The pressure drop of the air as it flows through the device.
Cycle	Fraction of flow to each outlet	0..1	0.5	The mass flow rate fraction of air that exits the supply plenum at each outlet port, starting with outlet port 1. The sum of the fractions must be equal to 1.0 or the last input fraction will be ignored and instead calculated from conservation of mass.

OUTPUTS

Output Number	Name	Unit	Comment
Cycle	Air temperature at each outlet	C	The outlet air dry-bulb temperature at each outlet port, starting with port 1
	Air humidity ratio at each outlet	-	The humidity ratio of the air at each outlet port, starting with port 1

	Air relative humidity at each outlet	%	The relative humidity of the air at each outlet port, starting with port 1
	Air flow rate at each outlet	kg/hr	The flow rate of dry air at each outlet port, starting with port 1
	Air pressure at each outlet	atm	The absolute pressure of the air exiting the device at each outlet port, starting with port 1.
5*PAR(2)+1	Condensate temperature	C	The temperature of condensate draining from the supply plenum
5*PAR(2)+2	Condensate flow rate	kg/hr	The flow rate of condensate draining from the supply plenum.

TYPE 647: 100 PORT FLOW DIVERTER

PARAMETERS

Parameter Number	Name	Unit	Default	Comment
1	Number of outlets (n)	-	2	The number of outlet ports from the diverting valve. The outlet temperature for each port is set equal to the inlet temperature. The outlet flow rate is the inlet flow rate multiplied by the given inlet fraction for the port.

INPUTS

Input Number	Name	Unit	Default	Comment
1	Inlet temperature	C	20.0	The temperature of the fluid entering the diverting valve.
2	Inlet flow rate	kg/hr	2000.0	The flow rate of fluid entering the diverting valve
Cycle based on PAR 1	Fraction of flow to each outlet	-	0.5	The fraction of fluid that exits the diverting valve at each outlet, starting with port 1. The sum of the fractions must be equal to 1.0 or the last input fraction will be ignored and instead calculated from conservation of mass.

OUTPUTS

Output Number	Name	Unit	Comment
Cycle based on PAR 1	Temperature at each outlet	C	The temperature of the fluid at each outlet port, starting with port 1.
	Flow rate at each outlet	kg/hr	The flow rate of fluid at each outlet port, starting with port 1.

TYPE 648: AIR RETURN PLENUM WITH UP TO 100 PORTS

PARAMETERS

Parameter Number	Name	Unit	Typical Value	Comment
1	Humidity input mode	-	1	This parameter indicates whether the calculation will be based on the inlet humidity ratio input (mode=1) or the inlet relative humidity input (mode=2).
2	Number of inlets (n)	-	2	The number of inlet ports to the return plenum (mixing valve).

INPUTS

Input Number	Name	Unit	Typical Value	Comment
Cycle based on PAR 2	Air temperature at each inlet	C	20.0	The dry-bulb temperature of the air entering the return plenum.
	Air humidity ratio at each inlet	$kgH_2O/kgAir$	0.008	The absolute humidity ratio of the air entering the return plenum. This input is ignored if Humidity Mode (parameter 1) = 2
	Air relative humidity at each inlet	%	50.0	The relative humidity of the air entering the return plenum. This input is ignored if Humidity Mode (parameter 1) = 1
	Dry air flow rate at each inlet	kg/hr	1000.0	The flow rate of dry air entering the return plenum.
	Air pressure at each inlet	atm	1.0	The absolute pressure of the air entering the return plenum.
5*PAR(2)+1	Air pressure drop	atm	0.0	The pressure drop across the return plenum (calculated from the lowest air pressure of the active ports).

OUTPUTS

Output Number	Name	Unit	Comment
1	Air temperature at outlet	C	The temperature of the air at the outlet of the return plenum
2	Air humidity ratio at outlet	$kgH_2O/kgAir$	The humidity ratio of the air at the outlet of the return plenum
3	Air relative humidity at outlet	%	The relative humidity of the air at the outlet of the return plenum
4	Dry air flow rate at outlet	kg/hr	The flow rate of dry air at the outlet of the return plenum
5	Air pressure at outlet	atm	The absolute pressure of air at the outlet of the return plenum
6	Condensate temperature	C	The temperature of condensate draining from the return plenum

7	Condensate flow rate	kg/hr	The flow rate of condensate draining from the return plenum.

TYPE 649: FLOW MIXER WITH UP TO 100 PORTS

PARAMETERS

Parameter Number	Name	Unit	Typical Value	Comment
1	Number of inlets (n)	-	2	The number of inlet ports to the mixing valve.

INPUTS

Input Number	Name	Unit	Typical Value	Comment
 based on PAR 1	Temperature at each inlet	C	20.0	The temperature of the fluid entering the mixing valve at each inlet, starting with inlet 1.
	Flow rate at each inlet	kg/hr	200.0	The fluid flow rate entering the mixing valve at each inlet, starting with inlet 1.

OUTPUTS

Output Number	Name	Unit	Comment
1	Temperature at outlet	C	The temperature of the fluid exiting the mixing valve.
2	Flow rate at outlet	kg/hr	The flow rate of fluid exiting the mixing valve.

TYPE 654: CONSTANT SPEED PUMP

PARAMETERS

Parameter Number	Name	Unit	Typical Value	Comment
1	Rated flow rate	-	2	The flow rate of fluid through the pump when operating.
2	Fluid specific heat	kJ/kg-K	4.19	The specific heat of the fluid flowing through the device.
3	Rated power	kJ/hr	2684	The pump power consumption during operation.
4	Motor heat loss fraction	0..1	0.0	The fraction of the motor heat loss transferred to the fluid stream. The motor heat loss is calculated by subtracting the efficiency of the motor from 1 and multiplying the resultant quantity by the power consumption. Typical values for this parameter are 0 for motors mounted outside the fluid stream and 1 for motors mounted within the fluid stream.

INPUTS

Input Number	Name	Unit	Typical Value	Comment
1	Inlet fluid temperature	C	20.0	The temperature of the fluid entering the device
2	Inlet fluid flow rate	kg/hr	200.0	The flow rate of fluid entering the device. This input is not used by this component except for convergence checking.
3	Control signal	0..1	1.0	The input control signal to the pump: CTRL < 0.5: the pump is OFF CTRL >= 0.5: the pump is ON
4	Overall pump efficiency	0..1	0.6	The overall efficiency of the pump. The overall pump efficiency includes the inefficiencies due to the motor and shaft friction. The overall pump efficiency must be less than the motor efficiency. The lower the efficiency the greater the amount of power consumed and the greater the heat transfer to the fluid and/or ambient.
5	Pump motor efficiency	0..1	0.9	The efficiency of the pump motor. The motor efficiency must be greater than the overall pump efficiency. The lower the motor efficiency the greater the amount of power consumed and the greater the heat transfer to the fluid and/or ambient.

OUTPUTS

Output Number	Name	Unit	Comment
1	Outlet fluid temperature	C	The temperature of the fluid exiting the device.

2	Outlet fluid flow rate	kg/hr	The flow rate of fluid exiting the device.
3	Power consumption	kJ/hr	The power consumed by the pump.
4	Fluid heat transfer	kJ/hr	The rate at which heat is transferred to the fluid by the pump operation.
5	Environment heat transfer	kJ/hr	The rate at which heat is transferred from the pump to the environment. This value is simply the pump power minus the heat transfer directly to the fluid.

TYPE 656: VARIABLE SPEED PUMP

PARAMETERS

Parameter Number	Name	Unit	Typical Value	Comment
1	Rated flow rate	-	2	The flow rate of fluid through the pump when operating.
2	Fluid specific heat	kJ/kg-K	4.19	The specific heat of the fluid flowing through the device.
3	Rated power	kJ/hr	2684	The pump power consumption during operation.
4	Motor heat loss fraction	0..1	0.0	The fraction of the motor heat loss transferred to the fluid stream. The motor heat loss is calculated by subtracting the efficiency of the motor from 1 and multiplying the resultant quantity by the power consumption. Typical values for this parameter are 0 for motors mounted outside the fluid stream and 1 for motors mounted within the fluid stream.
5	Number power coefficients	-	1	The number of polynomial multipliers that will be supplied relating the normalized pump power to the normalized pump flow rate (input control signal).
	Power coefficient	-	1.0	The value of the polynomial multiplier for the relationship between normalized pump power and normalized pump flow rate (input control signal).

INPUTS

Input Number	Name	Unit	Typical Value	Comment
1	Inlet fluid temperature	C	20.0	The temperature of the fluid entering the device
2	Inlet fluid flow rate	kg/hr	200.0	The flow rate of fluid entering the device. This input is not used by this component except for convergence checking.
3	Control signal	0..1	1.0	The input control signal to the pump: CTRL < 0.5: the pump is OFF CTRL >= 0.5: the pump is ON
4	Overall pump efficiency	0..1	0.6	The overall efficiency of the pump. The overall pump efficiency includes the inefficiencies due to the motor and shaft friction. The overall pump efficiency must be less than the motor efficiency. The lower the efficiency the greater the amount of power consumed and the greater the heat transfer to the fluid and/or ambient.
5	Pump motor efficiency	0..1	0.9	The efficiency of the pump motor. The motor efficiency must be greater than the overall pump efficiency. The lower the motor efficiency the greater the amount of power consumed and the greater the heat transfer to the fluid and/or ambient.

OUTPUTS

Output Number	Name	Unit	Comment
1	Outlet fluid temperature	C	The temperature of the fluid exiting the device.
2	Outlet fluid flow rate	kg/hr	The flow rate of fluid exiting the device.
3	Power consumption	kJ/hr	The power consumed by the pump.
4	Fluid heat transfer	kJ/hr	The rate at which heat is transferred to the fluid by the pump operation.
5	Environment heat transfer	kJ/hr	The rate at which heat is transferred from the pump to the environment. This value is simply the pump power minus the heat transfer directly to the fluid.

TYPE 662: VARIABLE SPEED FAN/BLOWER

PARAMETERS

Parameter Number	Name	Unit	Typical Value	Comment
1	Humidity input mode	-	1	This parameter indicates whether the calculation will be based on the inlet humidity ratio input (mode=1) or the inlet relative humidity input (mode=2).
2	Rated flow rate	kg/hr	1000.0	The flow rate of dry air through the fan when operating at rated conditions
3	Rated power	kJ/hr	1342.0	The fan power consumption at rated conditions.
4	Motor efficiency	0..1	0.80	The efficiency of the fan motor. This efficiency is used to calculate the amount of heat added to the air stream.
5	Motor heat loss fraction	0..1	0.0	The fraction of the motor heat loss transferred to the air stream. The motor heat loss is calculated by subtracting the efficiency of the motor from 1 and multiplying the resultant quantity by the power consumption. Typical values are 0 for motors mounted outside the air stream and 1 for motors mounted within the air stream.
6	Number power coefficients	-	1	The number of polynomial multipliers that will be supplied relating the normalized fan power to the normalized fan flow rate (input control signal).
Cycle	Power coefficient	-	1.0	The value of the polynomial multiplier for the relationship between normalized fan power and normalized fan flow rate (input control signal).

INPUTS

Input Number	Name	Unit	Typical Value	Comment
1	Inlet air temperature	C	20.0	The dry-bulb temperature of air entering the fan.
2	Inlet air humidity ratio	-	0.008	The absolute humidity ratio of the air entering the humidifier. This input is ignored if Humidity Mode (parameter 1) = 2
3	Inlet air relative humidity	%	50	The relative humidity of the air entering the humidifier. This input is ignored if Humidity Mode (parameter 1) = 1
4	Dry air flow rate	kg/hr	1000.0	The flow rate of the air (dry) entering the fan. This input is not used by this component except for convergence checking.
5	Inlet air pressure	atm	1.0	The absolute pressure of the air entering the fan
6	Control signal	-	1.0	The input control signal to the fan. CTRL = 0.0: Fan is OFF CTRL = 1.0: Fan is ON at full speed. 0.0 < CTRL < 1.0 Modulating operation.
7	Air stream pressure rise	atm	0.0	The increase in air-side pressure for the fan. This value should be set to zero when the fan is off and should probably

				be set differently for high-speed and low-speed operation.

OUTPUTS

Output Number	Name	Unit	Comment
1	Outlet air temperature	C	The outlet air dry-bulb temperature from the fan.
2	Outlet air humidity ratio	-	The humidity ratio of the air exiting the fan. In all cases, the exiting humidity ratio is set to the inlet air humidity ratio.
3	Outlet air relative humidity	%	The relative humidity of the air exiting the fan.
4	Outlet air flow rate	kg/hr	The flow rate of dry air exiting the fan.
5	Outlet air pressure	atm	The absolute pressure of air exiting the fan.
6	Power consumption	kJ/hr	The power consumed by the fan.
7	Air heat transfer	kJ/hr	The rate at which heat is transferred to the air stream by the fan.
8	Ambient heat transfer	kJ/hr	The rate at which heat is transferred to the ambient by the fan.

TYPE 674: AIR SUPPLY PLENUM WITH UP TO 100 PORTS AND RELATIVE HUMIDITY INPUT

In Version 1.x of the TESS Libraries, this component differed from Type646 in that its calculations were based on inlet air relative humidity as opposed to inlet air humidity ratio. In version 2.x of the TESS Libraries, Type646 has been modified to accept either humidity ratio or relative humidity as an input. Type674 has been retained for backwards compatibility but will not be available in version 3.x of the TESS Libraries when they are released. Please refer to the component description of Type646 if you would like to continue using Type674 but please consider replacing Type674 with Type646 in your projects.

TYPE 675: AIR RETURN PLENUM WITH UP TO 100 PORTS AND RELATIVE HUMIDITY INPUT

In Version 1.x of the TESS Libraries, this component differed from Type648 in that its calculations were based on inlet air relative humidity as opposed to inlet air humidity ratio. In version 2.x of the TESS Libraries, Type648 has been modified to accept either humidity ratio or relative humidity as an input. Type675 has been retained for backwards compatibility but will not be available in version 3.x of the TESS Libraries when they are released. Please refer to the component description of Type648 if you would like to continue using Type675 but please consider replacing Type675 with Type648 in your projects.

TYPE 695: VARIABLE SPEED PUMP – USER DEFINED CONTROL SIGNAL, CALCULATE POWER FROM HEAD AND DESIRED FLOW RATE

PARAMETERS

Parameter Number	Name	Unit	Typical Value	Comment
1	Rated flow rate	-	2	The flow rate of fluid through the pump when operating.
2	Fluid specific heat	kJ/kg-K	4.19	The specific heat of the fluid flowing through the device.
3	Fluid density	kg/m^3	2684	The density of the fluid flowing through the device.
4	Motor heat loss fraction	0..1	0.0	The fraction of the motor heat loss transferred to the fluid stream. The motor heat loss is calculated by subtracting the efficiency of the motor from 1 and multiplying the resultant quantity by the power consumption. Typical values for this parameter are 0 for motors mounted outside the fluid stream and 1 for motors mounted within the fluid stream.
5	Number efficiency coefficients	-	1	The number of polynomial multipliers that will be supplied relating the pump efficiency to the normalized pump flow rate (input control signal).
Cycle	Efficiency coefficient	-	1.0	The value of the polynomial multiplier for the relationship between pump efficiency and normalized pump flow rate (input control signal).

INPUTS

Input Number	Name	Unit	Typical Value	Comment
1	Inlet fluid temperature	C	20.0	The temperature of the fluid entering the device
2	Inlet fluid flow rate	kg/hr	200.0	The flow rate of fluid entering the device. This input is not used by this component except for convergence checking.
3	Control signal	0..1	1.0	The input control signal to the pump: CTRL < 0.5: the pump is OFF CTRL >= 0.5: the pump is ON
4	Pressure drop	kPa	10.0	The pressure drop that the pump must overcome in order to pump the specified amount of fluid.
5	Pump motor efficiency	0..1	0.9	The efficiency of the pump motor. The motor efficiency must be greater than the overall pump efficiency. The lower the motor efficiency the greater the amount of power consumed and the greater the heat transfer to the fluid and/or ambient.

OUTPUTS

Output Number	Name	Unit	Comment
1	Outlet fluid temperature	C	The temperature of the fluid exiting the device.
2	Outlet fluid flow rate	kg/hr	The flow rate of fluid exiting the device.
3	Power consumption	kJ/hr	The power consumed by the pump.
4	Fluid heat transfer	kJ/hr	The rate at which heat is transferred to the fluid by the pump operation.
5	Pump efficiency	0..1	The overall efficiency of the pump. This efficiency includes the motor efficiency and losses due to friction etc.
6	Environment heat transfer	kJ/hr	The rate at which heat is transferred from the pump to the environment. This value is simply the pump power minus the heat transfer directly to the fluid.

TYPE 709: CIRCULAR CROSS SECTION PIPE (CALCULATES U VALUE)

PARAMETERS

Parameter Number	Name	Unit	Typical Value	Comment
1	Inside diameter	m	0.0508	The inside diameter of the pipe
2	Outside diameter	m	0.06	The outside diameter of the pipe
3	Pipe length	m	1.0	The length of the pipe
4	Pipe material thermal conductivity	kJ/hr-m.K	3.0	The thermal conductivity of the pipe material
5	Fluid density	kg/m^3	1000.0	The density of the fluid flowing in the pipe
6	Fluid specific heat	kJ/kg-K	4.190	The specific heat of the fluid flowing in the pipe
7	Fluid thermal conductivity	kJ/hr-m.K	2.2068	The thermal conductivity of the fluid flowing in the pipe
8	Fluid viscosity	kg/m-hr	3.078	The dynamic viscosity of the fluid flowing in the pipe
9	Initial fluid temperature	C	10.0	The temperature of fluid in the pipe at the start of the simulation
10	Number of nodes	-	1	The number of isothermal nodes into which the overall pipe length will be broken
11	Insulation thickness	m	0.0254	The thickness of insulation surrounding the pipe
12	Insulation material thermal conductivity	kJ/hr-m.K	0.1	The thermal conductivity of the pipe insulating material.

INPUTS

Input Number	Name	Unit	Typical Value	Comment
1	Inlet fluid temperature	C	10.0	The temperature of the fluid entering the device
2	Inlet fluid flow rate	kg/hr	100.0	The flow rate of fluid entering the device. This input is not used by this component except for convergence checking.
3	Outer surface convection coefficient	$kJ/hr\text{-}m^2\text{-}K$	10.0	The heat transfer coefficient for thermal losses from the outside of the pipe to the environment. If the outside of the pipe is in direct contact with the loss temperature (as in a buried pipe application) this parameter should be set to a negative value.
Cycle	Loss temperature for node	C	10.0	The temperature of the environment from which thermal losses from this pipe node are calculated.

OUTPUTS

Output Number	Name	Unit	Comment
1	Outlet fluid temperature	C	The temperature of the fluid exiting the device.
2	Outlet fluid flow rate	kg/hr	The flow rate of fluid exiting the device.
3	Environment losses	kJ/hr	The rate at which energy is lost to the environment from the pipe.
4	Energy to pipe	kJ/hr	The net rate at which energy is transferred to the pipe by the flow stream.
5	Change in internal energy	kJ	The change in internal energy of the pipe since the beginning of the simulation. This output should not be integrated as it is an energy term and not an energy rate term.
6	Average temperature	C	The average temperature of the fluid in the pipe at the END of the time step.
7	Inner surface loss coefficient	kJ/hr-m^2-K	The calculated heat transfer coefficient from the fluid in the pipe to the environment temperature based on the inside surface area of the pipe. This value is constant over the length of the pipe as the fluid properties are not temperature dependent.
8	Outer surface loss coefficient	kJ/hr-m^2-K	The calculated heat transfer coefficient from the fluid in the pipe to the environment temperature based on the outside surface area of the pipe. This value is constant over the length of the pipe as the fluid properties are not temperature dependent.

TYPE 740: SINGLE SPEED PUMP – SETS FLOW RATE, CALCULATES POWER FROM PRESSURE DROP AND EFFICIENCY

PARAMETERS

Parameter Number	Name	Unit	Typical Value	Comment
1	Rated flow rate	kg/hr	1000.0	The flow rate of fluid through the pump when operating.
2	Fluid specific heat	kJ/kg-K	4.19	The specific heat of the fluid flowing through the device.
3	Fluid density	kg/m^3	1000.0	The density of the fluid flowing through the device.
4	Motor heat loss fraction	0..1	0.0	The fraction of the motor heat loss transferred to the fluid stream. The motor heat loss is calculated by subtracting the efficiency of the motor from 1 and multiplying the resultant quantity by the power consumption. Typical values for this parameter are 0 for motors mounted outside the fluid stream and 1 for motors mounted within the fluid stream.

INPUTS

Input Number	Name	Unit	Typical Value	Comment
1	Inlet fluid temperature	C	20.0	The temperature of the fluid entering the device
2	Inlet fluid flow rate	kg	0.0	The flow rate of fluid entering the device. This input is not used by this component except for convergence checking.
3	Control signal	0..1	1.0	The input control signal to the pump: < 0.5 - the pump is OFF, >= 0.5 - the pump is ON
4	Overall efficiency	0..1	0.6	The overall efficiency of the pump. The overall pump efficiency includes the inefficiencies due to the motor and shaft friction. The overall pump efficiency must be less than the motor efficiency. The lower the efficiency the greater the amount of power consumed and the greater the heat transfer to the fluid and/or ambient.
5	Motor efficiency	0..1	0.9	The efficiency of the pump motor. The motor efficiency must be greater than the overall pump efficiency. The lower the motor efficiency the greater the amount of power consumed and the greater the heat transfer to the fluid and/or ambient.
6	Pressure rise	kPa	10.0	The pressure rise across the pump or the pressure drop around the fluid loop.

OUTPUTS

Output Number	Name	Unit	Comment
1	Outlet fluid	C	The temperature of fluid exiting the pump.

	temperature		
2	Outlet fluid flow rate	kg/hr	The flow rate of fluid passing through the pump.
3	Power consumption	kJ/hr	The power consumed by the pump.
4	Fluid heat transfer	kJ/hr	The amount of energy transferred from the pump motor to the fluid stream passing through the pump.
5	Ambient heat transfer	kJ/hr	The amount of energy transferred from the pump motor to the ambient.

TYPE 741: VARIABLE SPEED PUMP – SETS FLOW RATE, CALCULATES POWER FROM PRESSURE DROP AND EFFICIENCY

PARAMETERS

Parameter Number	Name	Unit	Typical Value	Comment
1	Rated flow rate	kg/hr	1000.0	The flow rate of fluid through the pump when operating.
2	Fluid specific heat	kJ/kg-K	4.19	The specific heat of the fluid flowing through the device.
3	Fluid density	kg/m^3	1000.0	The density of the fluid flowing through the device.
4	Motor heat loss fraction	0..1	0.0	The fraction of the motor heat loss transferred to the fluid stream. The motor heat loss is calculated by subtracting the efficiency of the motor from 1 and multiplying the resultant quantity by the power consumption. Typical values for this parameter are 0 for motors mounted outside the fluid stream and 1 for motors mounted within the fluid stream.

INPUTS

Input Number	Name	Unit	Typical Value	Comment
1	Inlet fluid temperature	C	20.0	The temperature of the fluid entering the device
2	Inlet fluid flow rate	kg	0.0	The flow rate of fluid entering the device. This input is not used by this component except for convergence checking.
3	Control signal	0..1	1.0	The input control signal to the pump: 0 = Pump is Off, >0 = Pump is operating
4	Overall efficiency	0..1	0.6	The overall efficiency of the pump. The overall pump efficiency includes the inefficiencies due to the motor and shaft friction. The overall pump efficiency must be less than the motor efficiency. The lower the efficiency the greater the amount of power consumed and the greater the heat transfer to the fluid and/or ambient.
5	Motor efficiency	0..1	0.9	The efficiency of the pump motor. The motor efficiency must be greater than the overall pump efficiency. The lower the motor efficiency the greater the amount of power consumed and the greater the heat transfer to the fluid and/or ambient.
6	Pressure rise	kPa	10.0	The pressure rise across the pump or the pressure drop around the fluid loop.

OUTPUTS

Output Number	Name	Unit	Comment
1	Outlet fluid	C	The temperature of fluid exiting the pump.

	temperature		
2	Outlet fluid flow rate	kg/hr	The flow rate of fluid passing through the pump.
3	Power consumption	kJ/hr	The power consumed by the pump.
4	Fluid heat transfer	kJ/hr	The amount of energy transferred from the pump motor to the fluid stream passing through the pump.
5	Ambient heat transfer	kJ/hr	The amount of energy transferred from the pump motor to the ambient.

TYPE 742: VARIABLE SPEED PUMP - USER SPECIFIED FLOW RATE, CALCULATES POWER FROM PRESSURE DROP AND EFFICIENCY

PARAMETERS

Parameter Number	Name	Unit	Typical Value	Comment
1	Fluid specific heat	kJ/kg-K	4.19	The specific heat of the fluid flowing through the device.
2	Fluid density	kg/m^3	1000.0	The density of the fluid flowing through the device.
3	Motor heat loss fraction	0..1	0.0	The fraction of the motor heat loss transferred to the fluid stream. The motor heat loss is calculated by subtracting the efficiency of the motor from 1 and multiplying the resultant quantity by the power consumption. Typical values for this parameter are 0 for motors mounted outside the fluid stream and 1 for motors mounted within the fluid stream.

INPUTS

Input Number	Name	Unit	Typical Value	Comment
1	Inlet fluid temperature	C	20.0	The temperature of the fluid entering the device
2	Inlet fluid flow rate	kg	0.0	The flow rate of fluid entering the device. This input is not used by this component except for convergence checking.
3	Overall efficiency	0..1	0.6	The overall efficiency of the pump. The overall pump efficiency includes the inefficiencies due to the motor and shaft friction. The overall pump efficiency must be less than the motor efficiency. The lower the efficiency the greater the amount of power consumed and the greater the heat transfer to the fluid and/or ambient.
4	Motor efficiency	0..1	0.9	The efficiency of the pump motor. The motor efficiency must be greater than the overall pump efficiency. The lower the motor efficiency the greater the amount of power consumed and the greater the heat transfer to the fluid and/or ambient.
5	Pressure rise	kPa	10.0	The pressure rise across the pump or the pressure drop around the fluid loop.

OUTPUTS

Output Number	Name	Unit	Comment
1	Outlet fluid temperature	C	The temperature of fluid exiting the pump.
2	Outlet fluid flow rate	kg/hr	The flow rate of fluid passing through the pump.
3	Power consumption	kJ/hr	The power consumed by the pump.

4	Fluid heat transfer	kJ/hr	The amount of energy transferred from the pump motor to the fluid stream passing through the pump.
5	Ambient heat transfer	kJ/hr	The amount of energy transferred from the pump motor to the ambient.

TYPE 743: VARIABLE SPEED PUMP - USER SPECIFIED FLOW RATE, CALCULATES POWER FROM POLYNOMIAL

PARAMETERS

Parameter Number	Name	Unit	Typical Value	Comment
1	Rated flow rate	kg/hr	1000.	The rated (maximum) flow rate of fluid through the pump.
2	Fluid specific heat	kJ/kg-K	4.19	The specific heat of the fluid flowing through the device.
3	Rated power	kJ/hr	2684.	The rated (nominal) pump power consumption. This value should correspond to the flow rate provided as parameter 1.
4	Motor heat loss fraction	0..1	0.0	The fraction of the motor heat loss transferred to the fluid stream. The motor heat loss is calculated by subtracting the efficiency of the motor from 1 and multiplying the resultant quantity by the power consumption. Typical values for this parameter are 0 for motors mounted outside the fluid stream and 1 for motors mounted within the fluid stream.
5	Number of power coefficients	-	1	The number of polynomial multipliers that will be supplied relating the normalized pump power to the normalized pump flow rate.
Cycle	Polynomial coefficients	-	1.0	The values of the polynomial multipliers for the relationship between normalized pump power and normalized pump flow rate.

INPUTS

Input Number	Name	Unit	Typical Value	Comment
1	Inlet fluid temperature	C	20.0	The temperature of the fluid entering the device
2	Inlet fluid flow rate	kg	0.0	The flow rate of fluid entering the device. This input is not used by this component except for convergence checking.
3	Overall efficiency	0..1	0.6	The overall efficiency of the pump. The overall pump efficiency includes the inefficiencies due to the motor and shaft friction. The overall pump efficiency must be less than the motor efficiency. The lower the efficiency the greater the amount of power consumed and the greater the heat transfer to the fluid and/or ambient.
4	Motor efficiency	0..1	0.9	The efficiency of the pump motor. The motor efficiency must be greater than the overall pump efficiency. The lower the motor efficiency the greater the amount of power consumed and the greater the heat transfer to the fluid and/or ambient.

OUTPUTS

Output Number	Name	Unit	Comment
1	Outlet fluid temperature	C	The temperature of fluid exiting the pump.
2	Outlet fluid flow rate	kg/hr	The flow rate of fluid passing through the pump.
3	Power consumption	kJ/hr	The power consumed by the pump.
4	Fluid heat transfer	kJ/hr	The amount of energy transferred from the pump motor to the fluid stream passing through the pump.
5	Ambient heat transfer	kJ/hr	The amount of energy transferred from the pump motor to the ambient.

TYPE 744: VARIABLE SPEED FAN/BLOWER – USER SPECIFIED FLOW RATE

PARAMETERS

Parameter Number	Name	Unit	Typical Value	Comment
1	Humidity mode	-	1	This parameter indicates whether the calculation will be based on the inlet humidity ratio input (mode=1) or the inlet relative humidity input (mode=2).
2	Rated flow rate	kg/hr	1000.	The rated (maximum) flow rate of fluid through the fan.
3	Rated power	kJ/kg-K	2684.	The rated fan power consumption when the fan is operating at full-speed.
4	Motor efficiency	0..1	0.8	The efficiency of the fan motor. This efficiency is used to calculate the amount of heat added to the air stream.
5	Motor heat loss fraction	0..1	0.0	The fraction of the motor heat loss transferred to the air stream. The motor heat loss is calculated by subtracting the efficiency of the motor from 1 and multiplying the resultant quantity by the power consumption. Typical values for this parameter are 0 for motors mounted outside the air stream and 1 for motors mounted within the air stream.
6	Number of power coefficients	-	1	The number of polynomial multipliers that will be supplied relating the normalized fan power to the normalized fan flow rate.
Cycle	Polynomial coefficients	-	1.0	The values of the polynomial multipliers for the relationship between normalized fan power and normalized fan flow rate.

INPUTS

Input Number	Name	Unit	Typical Value	Comment
1	Inlet air temperature	C	20.0	The dry-bulb temperature of air entering the fan.
2	Inlet air humidity ratio	-	0.008	The absolute humidity ratio of the air entering the humidifier. This input is ignored if Humidity Mode (parameter 1) = 2
3	Inlet air relative humidity	%	50	The relative humidity of the air entering the humidifier. This input is ignored if Humidity Mode (parameter 1) = 1
4	Dry air flow rate	kg/hr	1000.0	The flow rate of the air (dry) entering the fan. This input is not used by this component except for convergence checking.
5	Inlet air pressure	atm	1.0	The absolute pressure of the air entering the fan
6	Pressure rise	atm	0.0	The pressure rise of air passing through the fan (or the pressure drop of the air loop). This value should be set to zero when the fan is OFF.

OUTPUTS

Output Number	Name	Unit	Comment
1	Outlet air temperature	C	The outlet air dry-bulb temperature from the fan.
2	Outlet air humidity ratio	-	The humidity ratio of the air exiting the fan. In all cases, the exiting humidity ratio is set to the inlet air humidity ratio.
3	Outlet air relative humidity	%	The relative humidity of the air exiting the fan.
4	Outlet air flow rate	kg/hr	The flow rate of dry air exiting the fan.
5	Outlet air pressure	atm	The absolute pressure of air exiting the fan.
6	Power consumption	kJ/hr	The power consumed by the fan.
7	Air heat transfer	kJ/hr	The rate at which heat is transferred to the air stream by the fan.
8	Ambient heat transfer	kJ/hr	The rate at which heat is transferred to the ambient by the fan.

TYPE 745: VARIABLE SPEED PUMP – USER SPECIFIED FLOW RATE, POWER CALCULATED FROM PRESSURE DROP AND EFFICIENCY

PARAMETERS

Parameter Number	Name	Unit	Typical Value	Comment
1	Rated flow rate	kg/hr	1000.	The rated (maximum) flow rate of fluid through the pump.
2	Fluid specific heat	kJ/kg-K	4.19	The specific heat of fluid flowing though the pump.
3	Fluid density	kg/m^3	1000.	The density of fluid flowing through the pump.
4	Motor heat loss fraction	0..1	0.0	The fraction of the motor heat loss transferred to the air stream. The motor heat loss is calculated by subtracting the efficiency of the motor from 1 and multiplying the resultant quantity by the power consumption. Typical values are 0 for motors mounted outside the air stream and 1 for motors mounted within the air stream.
5	Minimum operating power	kJ/hr	0.0	The power input below which there is no flow rate provided by the pump.

INPUTS

Input Number	Name	Unit	Typical Value	Comment
1	Inlet fluid temperature	C	20.0	The temperature of fluid entering the pump.
2	Inlet fluid flow rate	kg/hr	0.0	The flow rate of fluid entering the pump.
3	Overall efficiency	0..1	0.6	The overall efficiency of the pump. The overall pump efficiency includes the inefficiencies due to the motor and shaft friction. The overall pump efficiency must be less than the motor efficiency. The lower the efficiency the greater the amount of power consumed and the greater the heat transfer to the fluid and/or ambient.
4	Motor efficiency	0..1	0.9	The efficiency of the pump motor. The motor efficiency must be greater than the overall pump efficiency. The lower the motor efficiency the greater the amount of power consumed and the greater the heat transfer to the fluid and/or ambient.
5	Pressure rise	kPa	0.0	The pressure rise across the pump (equal to the pressure drop around the fluid loop)
6	Power available	kJ/hr	745.7	The power available to the pump.

OUTPUTS

Output Number	Name	Unit	Comment
1	Outlet temperature	C	The outlet fluid temperature from the pump.

2	Outlet flow rate	kg/hr	The flow rate of fluid exiting the fan.
3	Power consumption	kJ/hr	The power consumed by the pump.
4	Fluid heat transfer	kJ/hr	The rate at which heat is transferred to the fluid stream by the pump.
5	Ambient heat transfer	kJ/hr	The rate at which heat is transferred to the ambient by the pump.

TYPE 746: VARIABLE SPEED PUMP – USER SPECIFIED POWER, FLOW RATE CALCULATED FROM A POLYNOMIAL

PARAMETERS

Parameter Number	Name	Unit	Typical Value	Comment
1	Rated flow rate	kg/hr	1000.	The rated (maximum) flow rate of fluid through the pump.
2	Fluid specific heat	kJ/kg-K	4.19	The specific heat of fluid flowing though the pump.
3	Rated power	kJ/hr	2684.	The pump power consumption at full-speed operation.
4	Motor heat loss fraction	0..1	0.0	The fraction of the motor heat loss transferred to the air stream. The motor heat loss is calculated by subtracting the efficiency of the motor from 1 and multiplying the resultant quantity by the power consumption. Typical values are 0 for motors mounted outside the air stream and 1 for motors mounted within the air stream.
5	Number of power coefficients	-	1	The number of polynomial multipliers that will be supplied relating the normalized pump power to the normalized pump flow rate.
Cycle	Polynomial coefficients	-	1.0	The values of the polynomial multipliers for the relationship between normalized pump power and normalized pump flow rate.

INPUTS

Input Number	Name	Unit	Typical Value	Comment
1	Inlet fluid temperature	C	20.0	The temperature of fluid entering the pump.
2	Inlet fluid flow rate	kg/hr	0.0	The flow rate of fluid entering the pump.
3	Overall efficiency	0..1	0.6	The overall efficiency of the pump. The overall pump efficiency includes the inefficiencies due to the motor and shaft friction. The overall pump efficiency must be less than the motor efficiency. The lower the efficiency the greater the amount of power consumed and the greater the heat transfer to the fluid and/or ambient.
4	Motor efficiency	0..1	0.9	The efficiency of the pump motor. The motor efficiency must be greater than the overall pump efficiency. The lower the motor efficiency the greater the amount of power consumed and the greater the heat transfer to the fluid and/or ambient.
5	Power available	kJ/hr	745.7	The power available to the pump.

OUTPUTS

Output Number	Name	Unit	Comment
1	Outlet temperature	C	The outlet fluid temperature from the pump.
2	Outlet flow rate	kg/hr	The flow rate of fluid exiting the fan.
3	Power consumption	kJ/hr	The power consumed by the pump.
4	Fluid heat transfer	kJ/hr	The rate at which heat is transferred to the fluid stream by the pump.
5	Ambient heat transfer	kJ/hr	The rate at which heat is transferred to the ambient by the pump.

TYPE 747: CONSTANT SPEED PUMP – SETS THE FLOW RATE AND OPERATES AT INTERSECTION OF PUMP CURVE AND SYSTEM CURVE

PARAMETERS

Parameter Number	Name	Unit	Typical Value	Comment
1	Design flow rate	kg/hr	10000.	The design flow rate for the system that was used to choose this model of pump.
2	Design head	m	40.0	The pressure drop of the system when operating at its design flow rate.
3	Fluid specific heat	kJ/kg-K	4.19	The specific heat of the fluid flowing through the device.
4	Fluid density	kg/m^3	1000.	The density of the fluid flowing through the device.
5	Motor heat loss fraction	0..1	0.0	The fraction of the motor heat loss transferred to the air stream. The motor heat loss is calculated by subtracting the efficiency of the motor from 1 and multiplying the resultant quantity by the power consumption. Typical values are 0 for motors mounted outside the air stream and 1 for motors mounted within the air stream.
6	Logical unit for pump data	-	10	The logical unit number which will be ASSIGNed to the external file containing the pump performance data (pump head in meters and efficiency (-) as a function of the pump flow rate (l/s). Logical unit numbers must be unique integers greater than 10 in a TRNSYS input file.
7	Number of pump data points		12	The number of pump flow rates for which pump head (m) and efficiency (-) data are provided in the external data file.
8	Number of system curve coefficients	-	1	The number of coefficients that will be used to relate the normalized system head pressure drop to the normalized flow rate: 1 = head pressure drop is constant, 2=head pressure drop is linear with flow rate, 3=head pressure drop is quadratic with flow rate etc.
Cycle	Polynomial coefficients	-	1.0	The coefficients for the relationship of normalized system pressure drop to normalized system flow rate: Z=A1+A2*Y+A3*Y^2 etc. where Z is the normalized system pressure drop and Y is the normalized flow rate.

INPUTS

Input Number	Name	Unit	Typical Value	Comment
1	Inlet fluid temperature	C	20.0	The temperature of fluid entering the pump.
2	Inlet fluid flow rate	kg/hr	0.0	The flow rate of fluid entering the pump.
3	Control signal	0..1	1.0	The input control signal to the pump: < 0.5 = Pump is Off, >0.5 = Pump is operating
4	Motor efficiency	0..1	0.6	The efficiency of the pump motor. The motor efficiency must be greater than the overall pump efficiency. The lower the motor efficiency the greater the amount of power

				consumed and the greater the heat transfer to the fluid and/or ambient.

OUTPUTS

Output Number	Name	Unit	Comment
1	Outlet temperature	C	The outlet fluid temperature from the pump.
2	Outlet flow rate	kg/hr	The flow rate of fluid exiting the fan.
3	Power consumption	kJ/hr	The power consumed by the pump.
4	Efficiency	0..1	The efficiency of the pump
5	Pumpable head	m	The pressure drop through the system at the current flow rate - which is also the pumpable head for the pump at the current conditions.
6	Fluid heat transfer	kJ/hr	The rate at which heat is transferred to the fluid stream by the pump.
7	Ambient heat transfer	kJ/hr	The rate at which heat is transferred to the ambient by the pump.

TYPE 748: VARIABLE SPEED PUMP – USER SPECIFIED FLOW RATE, OPERATES AT INTERSECTION OF PUMP CURVE AND SYSTEM CURVE

PARAMETERS

Parameter Number	Name	Unit	Typical Value	Comment
1	Design flow rate	kg/hr	10000.	The design flow rate for the system that was used to choose this model of pump.
2	Design head	m	40.0	The pressure drop of the system when operating at its design flow rate.
3	Fluid specific heat	kJ/kg-K	4.19	The specific heat of the fluid flowing through the device.
4	Fluid density	kg/m^3	1000.	The density of the fluid flowing through the device.
5	Motor heat loss fraction	0..1	0.0	The fraction of the motor heat loss transferred to the air stream. The motor heat loss is calculated by subtracting the efficiency of the motor from 1 and multiplying the resultant quantity by the power consumption. Typical values are 0 for motors mounted outside the air stream and 1 for motors mounted within the air stream.
6	Logical unit for pump data	-	10	The logical unit number which will be ASSIGNed to the external file containing the pump performance data (pump head in meters and efficiency (-) as a function of the pump flow rate (l/s). Logical unit numbers must be unique integers greater than 10 in a TRNSYS input file.
7	Number of pump data points	-	12	The number of pump flow rates for which pump head (m) and efficiency (-) data are provided in the external data file.
8	Number of pump speeds	-	7	The number of pump speeds for which pump head (m) and efficiency (-) data are provided in the external data file.
9	Number of system curve coefficients	-	1	The number of coefficients that will be used to relate the normalized system head pressure drop to the normalized flow rate: 1 = head pressure drop is constant, 2=head pressure drop is linear with flow rate, 3=head pressure drop is quadratic with flow rate etc.
Cycle	Polynomial coefficients	-	1.0	The coefficients for the relationship of normalized system pressure drop to normalized system flow rate: Z=A1+A2*Y+A3*Y^2 etc. where Z is the normalized system pressure drop and Y is the normalized flow rate.

INPUTS

Input Number	Name	Unit	Typical Value	Comment
1	Inlet fluid temperature	C	20.0	The temperature of fluid entering the pump.
2	Inlet fluid flow rate	kg/hr	0.0	The flow rate of fluid entering the pump.
3	Desired outlet flow rate	kg/hr	1000.	The desired mass flow rate of fluid exiting the pump.

4	Motor efficiency	0..1	0.6	The efficiency of the pump motor. The motor efficiency must be greater than the overall pump efficiency. The lower the motor efficiency the greater the amount of power consumed and the greater the heat transfer to the fluid and/or ambient.

OUTPUTS

Output Number	Name	Unit	Comment
1	Outlet temperature	C	The outlet fluid temperature from the pump.
2	Outlet flow rate	kg/hr	The flow rate of fluid exiting the fan.
3	Power consumption	kJ/hr	The power consumed by the pump.
4	Efficiency	0..1	The efficiency of the pump
5	Pumpable head	m	The pressure drop through the system at the current flow rate - which is also the pumpable head for the pump at the current conditions.
6	Fluid heat transfer	kJ/hr	The rate at which heat is transferred to the fluid stream by the pump.
7	Ambient heat transfer	kJ/hr	The rate at which heat is transferred to the ambient by the pump.
8	Fraction of rated speed	0..1	The fraction of rated speed that the pump must be operated at in order to match the system curve and the pump curve pressure drops at the desired flow rate.

TYPE 749: VARIABLE SPEED PUMP – USER SPECIFIED POWER, OPERATES AT INTERSECTION OF PUMP CURVE AND SYSTEM CURVE

PARAMETERS

Parameter Number	Name	Unit	Typical Value	Comment
1	Design flow rate	kg/hr	10000.	The design flow rate for the system that was used to choose this model of pump.
2	Design head	m	40.0	The pressure drop of the system when operating at its design flow rate.
3	Fluid specific heat	kJ/kg-K	4.19	The specific heat of the fluid flowing through the device.
4	Fluid density	kg/m^3	1000.	The density of the fluid flowing through the device.
5	Motor heat loss fraction	0..1	0.0	The fraction of the motor heat loss transferred to the air stream. The motor heat loss is calculated by subtracting the efficiency of the motor from 1 and multiplying the resultant quantity by the power consumption. Typical values are 0 for motors mounted outside the air stream and 1 for motors mounted within the air stream.
6	Logical unit for pump data	-	10	The logical unit number which will be ASSIGNed to the external file containing the pump performance data (pump head in meters and efficiency (-) as a function of the pump flow rate (l/s). Logical unit numbers must be unique integers greater than 10 in a TRNSYS input file.
7	Number of pump data points	-	12	The number of pump flow rates for which pump head (m) and efficiency (-) data are provided in the external data file.
8	Number of pump speeds	-	7	The number of pump speeds for which pump head (m) and efficiency (-) data are provided in the external data file.
9	Number of system curve coefficients	-	1	The number of coefficients that will be used to relate the normalized system head pressure drop to the normalized flow rate: 1 = head pressure drop is constant, 2=head pressure drop is linear with flow rate, 3=head pressure drop is quadratic with flow rate etc.
Cycle	Polynomial coefficients	-	1.0	The coefficients for the relationship of normalized system pressure drop to normalized system flow rate: Z=A1+A2*Y+A3*Y^2 etc. where Z is the normalized system pressure drop and Y is the normalized flow rate.

INPUTS

Input Number	Name	Unit	Typical Value	Comment
1	Inlet fluid temperature	C	20.0	The temperature of fluid entering the pump.
2	Inlet fluid flow rate	kg/hr	0.0	The flow rate of fluid entering the pump.
3	Available power	kJ/hr	8500	The power available to the pump. This power will be used to find the maximum flow rate that can be pumped while matching the pressure drops of the system curve and pump

				curve.
4	Motor efficiency	0..1	0.6	The efficiency of the pump motor. The motor efficiency must be greater than the overall pump efficiency. The lower the motor efficiency the greater the amount of power consumed and the greater the heat transfer to the fluid and/or ambient.

OUTPUTS

Output Number	Name	Unit	Comment
1	Outlet temperature	C	The outlet fluid temperature from the pump.
2	Outlet flow rate	kg/hr	The flow rate of fluid exiting the fan.
3	Power consumption	kJ/hr	The power consumed by the pump.
4	Efficiency	0..1	The efficiency of the pump
5	Pumpable head	m	The pressure drop through the system at the current flow rate - which is also the pumpable head for the pump at the current conditions.
6	Fluid heat transfer	kJ/hr	The rate at which heat is transferred to the fluid stream by the pump.
7	Ambient heat transfer	kJ/hr	The rate at which heat is transferred to the ambient by the pump.
8	Fraction of rated speed	0..1	The fraction of rated speed that the pump must be operated at in order to match the system curve and the pump curve pressure drops at the desired flow rate.

TYPE 750: VARIABLE SPEED PUMP - OPERATES AT INTERSECTION OF PUMP CURVE AND SYSTEM CURVE (SETS FLOW RATE)

PARAMETERS

Parameter Number	Name	Unit	Typical Value	Comment
1	Design flow rate	kg/hr	10000.	The design flow rate for the system that was used to choose this model of pump.
2	Design head	m	40.0	The pressure drop of the system when operating at its design flow rate.
3	Fluid specific heat	kJ/kg-K	4.19	The specific heat of the fluid flowing through the device.
4	Fluid density	kg/m^3	1000.	The density of the fluid flowing through the device.
5	Motor heat loss fraction	0..1	0.0	The fraction of the motor heat loss transferred to the air stream. The motor heat loss is calculated by subtracting the efficiency of the motor from 1 and multiplying the resultant quantity by the power consumption. Typical values are 0 for motors mounted outside the air stream and 1 for motors mounted within the air stream.
6	Logical unit for pump data	-	10	The logical unit number which will be ASSIGNed to the external file containing the pump performance data (pump head in meters and efficiency (-) as a function of the pump flow rate (l/s). Logical unit numbers must be unique integers greater than 10 in a TRNSYS input file.
7	Number of pump data points	-	12	The number of pump flow rates for which pump head (m) and efficiency (-) data are provided in the external data file.
8	Number of pump speeds	-	7	The number of pump speeds for which pump head (m) and efficiency (-) data are provided in the external data file.
9	Number of system curve coefficients	-	1	The number of coefficients that will be used to relate the normalized system head pressure drop to the normalized flow rate: 1 = head pressure drop is constant, 2=head pressure drop is linear with flow rate, 3=head pressure drop is quadratic with flow rate etc.
Cycle	Polynomial coefficients	-	1.0	The coefficients for the relationship of normalized system pressure drop to normalized system flow rate: Z=A1+A2*Y+A3*Y^2 etc. where Z is the normalized system pressure drop and Y is the normalized flow rate.

INPUTS

Input Number	Name	Unit	Typical Value	Comment
1	Inlet fluid temperature	C	20.0	The temperature of fluid entering the pump.
2	Inlet fluid flow rate	kg/hr	0.0	The flow rate of fluid entering the pump.
3	Fraction of rated speed	kJ/hr	8500	The desired fraction of rated pump speed. This pump speed will be used to find the flow rate that can be pumped that matches the pressure drops of the system curve and pump

				curve.
4	Motor efficiency	0..1	0.6	The efficiency of the pump motor. The motor efficiency must be greater than the overall pump efficiency. The lower the motor efficiency the greater the amount of power consumed and the greater the heat transfer to the fluid and/or ambient.

OUTPUTS

Output Number	Name	Unit	Comment
1	Outlet temperature	C	The outlet fluid temperature from the pump.
2	Outlet flow rate	kg/hr	The flow rate of fluid exiting the fan.
3	Power consumption	kJ/hr	The power consumed by the pump.
4	Efficiency	0..1	The efficiency of the pump
5	Pumpable head	m	The pressure drop through the system at the current flow rate - which is also the pumpable head for the pump at the current conditions.
6	Fluid heat transfer	kJ/hr	The rate at which heat is transferred to the fluid stream by the pump.
7	Ambient heat transfer	kJ/hr	The rate at which heat is transferred to the ambient by the pump.
8	Fraction of rated speed	0..1	The fraction of rated speed that the pump must be operated at in order to match the system curve and the pump curve pressure drops at the desired flow rate.

LOADS AND STRUCTURES COMPONENTS

Loads and Structures Components

TYPE 660: LUMPED CAPACITANCE MULTI-ZONE BUILDING MODEL

PARAMETERS

Parameter Number	Name	Unit	Typical Value	Comment
1	Humidity mode	-	1	1: humidity ratio will be provided as an input 2: relative humidity will be provided as an input
2	Total heat loss coefficient	kJ/hr-K	1000.0	The overall heat transfer coefficient (UA-value) of this zone to the ambient. This UA-value will be used to calculate the skin losses (gains) from the zone.
3	Capacitance of zone	kJ/K	24,000.0	The thermal capacitance of the zone. This capacitance should include the capacitances of the building materials, furnishings and conditioned air.
4	Volume of zone	m^3	250.0	The volume of conditioned air in this zone
5	Moisture capacitance multiplier	-	4.0	The multiplier for the moisture capacitance of the zone air. If this multiplier is set to 1.0, the moisture capacitance will be the capacitance of the conditioned air only. Setting this multiplier higher than 1.0 will account for the moisture capacitance of furnishings, carpeting, etc. Typical values range from 1 to 10
6	Initial temperature	C	20.0	The initial dry-bulb temperature of the conditioned air in the zone.
7	Initial humidity ratio	-	0.008	The initial humidity ratio of the conditioned air in the zone. NOTE: the value of this parameter is ignored in humidity mode 2.
8	Initial relative humidity	%	50	The initial relative humidity of the conditioned air in the zone. NOTE: the value of this parameter is ignored in humidity mode 1.
9	Number of Misc. Heat Flows	-	1	The number of miscellaneous heat flows that will be added to or removed from the zone by specifying the heat transfer rate as an input to the model.
10	Number of adjacent zones	-	1	The number of zones adjacent to this zone. For each adjacent zone, the temperature, overall heat transfer coefficient, humidity ratio and air flow rate from that zone into this zone must be specified.
Cycle	Conductance between this zone and each adjacent zone	kJ/hr-K	100.0	The overall heat transfer coefficient between this zone and each adjacent zone.

INPUTS

Input Number	Name	Unit	Typical	Comment

			Value	
1	Ventilation temperature	C	20.0	The dry-bulb temperature of the ventilation air stream into the zone.
2	Ventilation humidity ratio	-	0.008	The absolute humidity ratio of the ventilation air stream into the zone. NOTE: the value of this parameter is ignored in humidity mode 2.
3	Ventilation relative humidity	%	50.0	The relative humidity of the ventilation air stream into the zone. NOTE: the value of this parameter is ignored in humidity mode 1.
4	Ventilation flow rate	kg/hr	2000.0	The dry-air flow rate of the ventilation air stream.
5	Ventilation air pressure	atm	1.0	The absolute air pressure of the ventilation air entering the zone.
6	Ambient temperature	C	10.0	The ambient air dry-bulb temperature.
7	Ambient humidity ratio	-	0.006	The absolute humidity ratio of the ambient air. NOTE: the value of this parameter is ignored in humidity mode 2.
8	Ambient relative humidity	%	50.0	The relative humidity of the ambient air. NOTE: the value of this parameter is ignored in humidity mode 1.
9	Infiltration flow rate	kg/hr	75.0	The infiltration flow rate of ambient air into the zone
10	Ambient air pressure	atm	1.0	The absolute pressure of the ambient air. Note: the building (zone) air pressure will be set to the ambient air pressure.
11	Energy gain due to lights	kJ/hr	3600.0	The rate of sensible energy gain to the zone due to lights.
12	Energy gain due to equipment	kJ/hr	1800.0	The rate of sensible energy gain to the building due to equipment/appliances
13	Occupancy sensible loads	kJ/hr	900.0	The sensible load imposed on the zone due to occupancy.
14	Occupancy latent gains	kJ/hr	1200.0	The latent load imposed on the zone due to occupancy.
15	Moisture gains	kg/hr	0.0	The rate at which moisture is generated inside the building due to equipment and other means.
16	Cooling set point temperature	C	25.56	The set point temperature for cooling in the zone if the energy rate control loads are to be calculated by the model.
17	Heating set point temperature	C	20.0	The set point temperature for heating in the zone if the energy rate control loads are to be calculated by the model.
18	Available cooling capacity	kJ/hr	0	The maximum sensible cooling rate of the ideal cooling equipment in the zone. Setting this input to a non-zero value will cause the energy rate control loads to be calculated by the model.
19	Available heating capacity	kJ/hr	0	The maximum heating rate of the heating equipment in the zone. Setting this input to a non-zero value will cause the energy rate control loads to be calculated for the zone.
20	Dehumidification set point	-	0.010	The set point zone absolute humidity ratio for the ideal dehumidification equipment in the zone if the energy rate control loads are to be calculated by this model.
21	Humidification set point	-	0.000	The humidification set point for the ideal humidifying equipment in the zone if the energy rate control loads are to be calculated by the model.
22	Dehumidification capacity	kJ/hr	0.0	The maximum dehumidification rate of the ideal dehumidifying equipment in the zone. Setting this input to a

				non-zero value will cause the energy rate control loads to be calculated by the model.
23	Humidification capacity	kJ/hr	0.0	The maximum humidification rate of the ideal humidifying equipment in the zone. Setting this input to a non-zero value will cause the energy rate control loads to be calculated by the model.
	Temperature of each adjacent zone	C	20.0	The dry-bulb temperature of each adjacent zone for convective and conductive heat transfer calculations.
	Absolute humidity ratio of each adjacent zone	-	0.008	The absolute humidity ratio of each adjacent zone for convective heat transfer calculations. NOTE: the value of this parameter is ignored in humidity mode 2.
	Relative humidity of each adjacent zone	%	50.0	The relative humidity of each adjacent zone for convective heat transfer calculations. NOTE: the value of this parameter is ignored in humidity mode 1.
	Air flow rate from each adjacent zone	kg/hr	0.0	The flow rate of air from each adjacent zone into this zone. Make sure that the flow rate of air is balanced into and out of the zone - the model assumes that an equal amount of zone air is exiting the zone.
	Pressure of each adjacent zone	atm	1.0	The absolute pressure of the air in each adjacent zone.
	Miscellaneous energy gains	kJ/hr	1000.0	The rate at which energy is added to the zone from each of the external miscellaneous sources specified in parameter 9

OUTPUTS

Output Number	Name	Unit	Comment
1	Zone temperature	C	The dry-bulb temperature of the conditioned air in the zone.
2	Zone humidity ratio	-	The absolute humidity ratio of the conditioned air in the zone.
3	Zone relative humidity	%	The relative humidity of the conditioned air in the zone.
4	Zone ventilation flow rate	kg/hr	The ventilation air flow rate into (and out of) the zone.
5	Zone infiltration flow rate	kg/hr	The infiltration air flow rate into (and out of) the zone.
6	Zone pressure	atm	The absolute pressure of air in the zone.
7	Sensible infiltration gain	kJ/hr	The rate of sensible energy gain to the zone due to infiltration.
8	Sensible ventilation gain	kJ/hr	The rate of sensible energy gain to the zone due to ventilation.
9	Shell losses	kJ/hr	The heat transfer from the zone to the ambient from the shell or skin of the building (UA losses).
10	Internal gains	kJ/hr	The rate at which sensible energy is added to the zone from people, lights and equipment.
11	Adjacent zone convective heat transfer	kJ/hr	The net heat transfer (sensible and latent) to this zone due to the convective exchanges between this zone and the adjacent zones.
12	Adjacent zone conductive heat	kJ/hr	The net heat transfer (sensible and latent) to this zone due to heat exchange with the adjacent zones through the walls (UA).

	transfer		
13	Energy storage rate	kJ/hr	The rate at which energy is being stored in the air, walls, furnishings, etc. in the zone.
14	Required heating energy	kJ/hr	The rate at which heat was supplied to the zone by the ideal internal heating device in order to keep the zone at or above its set point temperature
15	Required sensible cooling rate	kJ/hr	The rate at which sensible cooling was supplied to the zone by the ideal internal cooling device in order to keep the zone at or below its set point condition.
16	Total sensible energy delivery rate	kJ/hr	The sum of the required heating and sensible cooling energy rates for the ideal internal heating and cooling equipment for the current timestep. This output is simply the sum of the two previous outputs and is sometimes required for demand calculations.
17	Latent infiltration gains	kJ/hr	The rate at which latent energy is added to the zone due to the infiltration flow.
18	Latent ventilation gains	kJ/hr	The rate at which latent energy is added to the space due to the ventilation stream.
19	Internal latent gain	kJ/hr	The rate at which latent energy is added to the zone due to people and other internal latent sources.
20	Latent energy storage rate	kJ/hr	The rate at which latent energy is stored in the room air, walls, and furnishings.
21	Required humidification rate	kJ/hr	The rate at which humidification energy was delivered to the zone by the ideal internal humidifier in order to keep the zone at or above its humidification set point.
22	Required dehumidification rate	kJ/hr	The rate at which dehumidification energy was removed from the space by the ideal internal dehumidifier in order to keep the zone humidity at or below the dehumidification set point.
23	Total latent energy delivery rate.	kJ/hr	The total latent energy delivered/removed from the zone by the ideal internal humidifying and dehumidifying devices. This output is simply the sum of the previous two outputs and is sometimes used for demand purposes.
24	Condensation energy rate	kJ/hr	The rate at which latent energy is removed from the zone through condensation in the zone.
25	Sensible energy rate	kJ/hr	The net sensible loads on the zone that the heating and cooling equipment met. The rate at which sensible energy must be added to the space in order to keep the zone between its temperature set points. This output is simply the required sensible cooling rate minus the required heating rate and is referred to as the energy rate control sensible load. A positive value implies that net cooling was required.
26	Latent energy rate	kJ/hr	The net humidification loads on the zone met by the ideal internal humidifier and dehumidifier. This output is simply the dehumidification energy rate required minus the humidification energy rate required. A positive number implies that dehumidification is required. This is often termed the energy rate control latent load.

TYPE 682: LOAD IMPOSED ON A LIQUID STREAM

PARAMETERS

Parameter Number	Name	Unit	Typical Value	Comment
1	Fluid specific heat	kJ/kg-K	4.19	The specific heat of the fluid stream.

INPUTS

Input Number	Name	Unit	Typical Value	Comment
1	Inlet temperature	C	10.0	The temperature of fluid entering the load device.
2	Inlet flow rate	kg/hr	100.0	The mass flow rate of fluid entering the load device.
3	Load	kJ/hr	10000.0	The load imposed on the fluid stream.

OUTPUTS

Output Number	Name	Unit	Comment
1	Outlet temperature	C	The temperature of fluid exiting the load device.
2	Outlet flow rate	kg/hr	The mass flow rate of fluid exiting the load device.
3	Heat transfer	kJ/hr	The rate at which energy is transferred to the fluid flow stream.

TYPE 686: SYNTHETIC BUILDING LOADS CALCULATOR

PARAMETERS

Parameter Number	Name	Unit	Typical Value	Comment
1	Which day of the week is Sunday?	-	7	The day of the week in which the first Sunday of the simulation occurs.
2	Peak cooling load hour	hr	12.0	The hour of each day at which the peak cooling load occurs.
3	Peak heating load hour	hr	3.0	The hour of the day at which the peak heating load occurs.
4	Start of cooling season	hr	2160.0	The hour of the year that begins the cooling season.
5	End of cooling season	hr	6552.0	The hour of the year that ends the cooling season.
6	Start of heating season	hr	6552.0	The hour of the year that starts the heating season.
7	End of heating season	hr	2160.0	The hour of the year that ends the heating season.
8	Weekday offset for cooling	-	0.5	The offset for the SIN function which controls the hourly variation of the weekday cooling load.
9	Weekday multiplier for cooling	-	0.5	The multiplier for the SIN function which controls the hourly variation of the weekday cooling load.
10	Weekend offset for cooling	-	0.4	The offset for the SIN function which controls the hourly variation of the weekend cooling load.
11	Weekend multiplier for cooling	-	0.4	The multiplier for the SIN function which controls the hourly variation of the weekend cooling load.
12	Weekday offset for heating	-	0.5	The offset for the SIN function which controls the hourly variation of the weekday heating load.
13	Weekday multiplier for heating	-	0.5	The multiplier for the SIN function which controls the hourly variation of the weekday heating load.
14	Weekend offset for heating	-	0.4	The offset for the SIN function which controls the hourly variation of the weekend heating load.
15	Weekend multiplier for heating	-	0.4	The multiplier for the SIN function which controls the hourly variation of the weekend heating load.
16	Seasonal offset for cooling	-	0.0	The offset for the SIN function which controls the seasonal variation of the cooling load.
17	Seasonal multiplier for cooling	-	1.0	The multiplier for the SIN function which controls the seasonal variation of the cooling load.
18	Seasonal offset for heating	-	0.0	The offset for the SIN function which controls the seasonal variation of the heating load.
19	Seasonal multiplier for heating	-	1.0	The multiplier for the SIN function which controls the seasonal variation of the heating load.
20	Standard deviation for daily noise	-	0.2	The standard deviation of the noise to be imposed on the calculated daily normalized heating and cooling loads.
21	Standard deviation for hourly noise	-	0.1	The standard deviation of the noise to be imposed on the calculated hourly values of normalized heating and cooling

				loads.
22	Peak cooling load	kJ/h	10,000.0	The nominal peak cooling load for this building. The actual peak may be higher due to noise, or multiplier and offset parameters
23	Peak heating load	kJ/h	10,000.0	The nominal peak heating load for this building. The actual peak heating load may be higher due to noise or multiplier and offset parameters

OUTPUTS

Output Number	Name	Unit	Comment
1	Cooling load	kJ/h	The calculated cooling load for the synthetic building.
2	Heating load	kJ/h	The calculated heating load for the synthetic building.
3	Multiplier for seasonal cooling	-	The multiplier used to calculate the seasonal variation of the cooling load.
4	Multiplier for seasonal heating	-	The multiplier used to calculate the seasonal variation of the heating load.
5	Multiplier for daily cooling load	-	The multiplier used to calculate the hourly variation of the cooling load.
6	Multiplier for daily heating	-	The multiplier used to calculate the hourly variation of the heating load.
7	Daily noise multiplier	-	The normalized value of the daily "noise" for the heating and cooling loads.
8	Hourly noise multiplier	-	The normalized value of the hourly "noise" for the calculated heating and cooling loads.

TYPE 687: NATIONAL FENESTRATION RATINGS COUNCIL (NFRC) WINDOW

PARAMETERS

Parameter Number	Name	Unit	Typical Value	Comment
1	Area	m^2	0.5	The overall area of the window. Since the u-value given for the NFRC window includes frame effects, so too should this area parameter.
2	Number of units	-	1	The number of identical windows modeled by this component and subject to the same incident radiation levels.
3	Loss coefficient	W/m^2		The overall (glazing and frame) thermal energy loss coefficient for the window per unit area.
4	SHGC	-		The solar heat gain factor for window
5	Visible transmittance	0..1	0.7	The transmittance of the window to visible light.

INPUTS

Input Number	Name	Unit	Typical Value	Comment
1	Ambient temperature	C	10.0	The outdoor environmental temperature
2	Zone temperature	C	20.0	The indoor zone temperature
3	Incident radiation	$kJ/hr\text{-}m^2$	0.0	The total amount of radiation incident on the window.
4	Beam radiation	$kJ/hr\text{-}m^2$	0.0	The beam radiation incident on the window.
5	Incidence angle	degrees	90.0	The angle of incidence of beam radiation on the window. The angle between the beam radiation and the line normal to the glazing surface.

OUTPUTS

Output Number	Name	Unit	Comment
1	Solar gains	kJ/h	The energy gain to the zone from solar.
2	Thermal gains	kJ/h	The energy gain to the zone from the indoor/outdoor temperature difference.
3	Net gains	kJ/h	The combined solar and thermal gains to the zone.
4	Luminous flux	Lumens	The luminous flux coming through the window(s)
5	Luminous efficacy	Lumens/ W	The efficacy of the visible light coming through the window(s)
6	Ratio	0..1	The ratio of luminous flux from beam radiation to total luminous flux.

TYPE 690: ENERGY RATE LOADS CONVERSION

PARAMETERS

Parameter Number	Name	Unit	Typical Value	Comment
1	Humidity mode	-	1	This parameter indicates how the model will calculate the humidity effects in the model: 1 = the user-provided humidity ratio input will be used 2 = the user-provided relative humidity input will be used
2	Zone thermal capacitance	kJ/K	24000	The thermal capacitance of the zone. This capacitance should include the capacitances of the building materials, furnishings and conditioned air.
3	Zone moisture capacitance	kg	200	The moisture capacitance of the zone. This capacitance should include the capacitances of the building materials, furnishings and conditioned air.
4	Initial zone temperature	C	20.0	The initial dry-bulb temperature of the conditioned air in the zone.
5	Initial zone humidity ratio	-	0.005	The initial absolute humidity ratio of the conditioned air in the zone.
6	Number of loads	-	1	The number of energy rate control loads that will be provided to the model. For each load specified, the user must supply the sensible and latent load on the space.

INPUTS

Input Number	Name	Unit	Typical Value	Comment
	Sensible load	kJ/hr	0.0	The sensible energy load on the space. Cooling loads should be specified as positive numbers and will tend to increase the temperature of the space.
	Latent load	kJ/hr	0.0	The latent load on the space. Dehumidification loads should be specified as positive numbers and will tend to increase the humidity of the space.
3	Ventilation temperature	C	20.0	The dry-bulb temperature of the ventilation air stream into the zone.
4	Ventilation humidity ratio	kgH2O/kgAir	0.008	The absolute humidity ratio of the ventilation air stream into the zone. NOTE: this input is ignored in Humidity Mode 2
5	Ventilation relative humidity	%	50	The percent relative humidity of the ventilation air entering the zone. NOTE: this input is ignored in Humidity Mode 1
6	Ventilation flow rate	kg/hr	2000.0	The dry-air flow rate of the ventilation air stream.
7	Building air pressure	atm	1.0	The absolute air pressure of the ventilation air entering the zone. This pressure will also be used to set the pressure of the air in the zone.

OUTPUTS

Output Number	Name	Unit	Comment
1	Zone temperature	C	The dry-bulb temperature of the air in the zone.
2	Zone humidity ratio	kgH2O/kgAir	The absolute humidity ratio of the air in the zone.
3	Zone relative humidity	%	The percent relative humidity of the zone air.

TYPE 693: LOAD IMPOSED ON AN AIR STREAM

PARAMETERS

Parameter Number	Name	Unit	Typical Value	Comment
1	Humidity mode	-	1	This parameter indicates how the model will calculate the humidity effects in the model: 1 = the user-provided humidity ratio input will be used 2 = the user-provided relative humidity input will be used

INPUTS

Input Number	Name	Unit	Typical Value	Comment
1	Inlet temperature	C	20.0	The dry bulb temperature of air entering the load device.
2	Inlet humidity ratio	kgH2O/kgAir	0.008	The absolute humidity ratio of air entering the load device. NOTE: this input is ignored in Humidity Mode 2
3	Inlet relative humidity	%	50	The percent relative humidity of air entering the load device. NOTE: this input is ignored in Humidity Mode 1
4	Inlet flow rate	kg/hr	2000.0	The dry-air flow rate of air entering the load device.
5	Inlet air pressure	atm	1.0	The absolute air pressure of air entering the load device.
6	Air pressure drop	atm	0.0	The pressure drop of the air stream as it flows through the device.
7	Total load	kJ/hr	0.	The total energy load (sensible plus latent) that will be imposed on the air stream. Positive loads will tend to increase the temperature of the air stream.
8	Latent load	kJ/hr	0.	The latent energy load that will be imposed on the air stream. Positive loads will tend to increase the humidity of the air stream.

OUTPUTS

Output Number	Name	Unit	Comment
1	Outlet air temperature	C	The dry bulb temperature of air exiting the load device.
2	Outlet air humidity ratio	kgH2O/kgAir	The absolute humidity ratio of air exiting the load device.
3	Outlet air relative humidity	%	The percent relative humidity of air exiting the load device.
4	Outlet air flow rate	kg/hr	The dry-air flow rate of air exiting the load device.
5	Outlet air pressure	atm	The absolute air pressure of air exiting the load device.
6	Total imposed load	kJ/hr	The rate at which sensible plus latent energy was able to be added to the air stream.

7	Latent imposed load	kJ/hr	The rate at which latent energy was able to be added to the air stream.

TYPE 759: LUMPED CAPACITANCE MULTI-ZONE BUILDING MODEL (NO CONTROLLERS)

PARAMETERS

Parameter Number	Name	Unit	Typical Value	Comment
1	Humidity mode	-	1	1: humidity ratio will be provided as an input 2: relative humidity will be provided as an input
2	Total heat loss coefficient	kJ/hr-K	1000.0	The overall heat transfer coefficient (UA-value) of this zone to the ambient. This UA-value will be used to calculate the skin losses (gains) from the zone.
3	Capacitance of zone	kJ/K	24,000.0	The thermal capacitance of the zone. This capacitance should include the capacitances of the building materials, furnishings and conditioned air.
4	Volume of zone	m^3	250.0	The volume of conditioned air in this zone
5	Moisture capacitance multiplier	-	4.0	The multiplier for the moisture capacitance of the zone air. If this multiplier is set to 1.0, the moisture capacitance will be the capacitance of the conditioned air only. Setting this multiplier higher than 1.0 will account for the moisture capacitance of furnishings, carpeting, etc. Typical values range from 1 to 10
6	Initial temperature	C	20.0	The initial dry-bulb temperature of the conditioned air in the zone.
7	Initial humidity ratio	-	0.008	The initial humidity ratio of the conditioned air in the zone. NOTE: the value of this parameter is ignored in humidity mode 2.
8	Initial relative humidity	%	50	The initial relative humidity of the conditioned air in the zone. NOTE: the value of this parameter is ignored in humidity mode 1.
9	Number of Misc. Heat Flows	-	1	The number of miscellaneous heat flows that will be added to or removed from the zone by specifying the heat transfer rate as an input to the model.
10	Number of adjacent zones	-	1	The number of zones adjacent to this zone. For each adjacent zone, the temperature, overall heat transfer coefficient, humidity ratio and air flow rate from that zone into this zone must be specified.
Cycle	Conductance between this zone and each adjacent zone	kJ/hr-K	100.0	The overall heat transfer coefficient between this zone and each adjacent zone.

INPUTS

Input Number	Name	Unit	Typical Value	Comment
1	Ventilation	C	20.0	The dry-bulb temperature of the ventilation air stream into

	temperature			the zone.
2	Ventilation humidity ratio	-	0.008	The absolute humidity ratio of the ventilation air stream into the zone. NOTE: the value of this parameter is ignored in humidity mode 2.
3	Ventilation relative humidity	%	50.0	The relative humidity of the ventilation air stream into the zone. NOTE: the value of this parameter is ignored in humidity mode 1.
4	Ventilation flow rate	kg/hr	2000.0	The dry-air flow rate of the ventilation air stream.
5	Ventilation air pressure	atm	1.0	The absolute air pressure of the ventilation air entering the zone.
6	Ambient temperature	C	10.0	The ambient air dry-bulb temperature.
7	Ambient humidity ratio	-	0.006	The absolute humidity ratio of the ambient air. NOTE: the value of this parameter is ignored in humidity mode 2.
8	Ambient relative humidity	%	50.0	The relative humidity of the ambient air. NOTE: the value of this parameter is ignored in humidity mode 1.
9	Infiltration flow rate	kg/hr	75.0	The infiltration flow rate of ambient air into the zone
10	Ambient air pressure	atm	1.0	The absolute pressure of the ambient air. Note: the building (zone) air pressure will be set to the ambient air pressure.
11	Energy gain due to lights	kJ/hr	3600.0	The rate of sensible energy gain to the zone due to lights.
12	Energy gain due to equipment	kJ/hr	1800.0	The rate of sensible energy gain to the building due to equipment/appliances
13	Occupancy sensible loads	kJ/hr	900.0	The sensible load imposed on the zone due to occupancy.
14	Occupancy latent gains	kJ/hr	1200.0	The latent load imposed on the zone due to occupancy.
15	Moisture gains	kg/hr	0.0	The rate at which moisture is generated inside the building due to equipment and other means.
	Temperature of each adjacent zone	C	20.0	The dry-bulb temperature of each adjacent zone for convective and conductive heat transfer calculations.
	Absolute humidity ratio of each adjacent zone	-	0.008	The absolute humidity ratio of each adjacent zone for convective heat transfer calculations. NOTE: the value of this parameter is ignored in humidity mode 2.
	Relative humidity of each adjacent zone	%	50.0	The relative humidity of each adjacent zone for convective heat transfer calculations. NOTE: the value of this parameter is ignored in humidity mode 1.
	Air flow rate from each adjacent zone	kg/hr	0.0	The flow rate of air from each adjacent zone into this zone. Make sure that the flow rate of air is balanced into and out of the zone - the model assumes that an equal amount of zone air is exiting the zone.
	Pressure of each adjacent zone	atm	1.0	The absolute pressure of the air in each adjacent zone.
	Miscellaneous energy gains	kJ/hr	1000.0	The rate at which energy is added to the zone from each of the external miscellaneous sources specified in parameter 9

OUTPUTS

Output Number	Name	Unit	Comment
1	Zone temperature	C	The dry-bulb temperature of the conditioned air in the zone.
2	Zone humidity ratio	-	The absolute humidity ratio of the conditioned air in the zone.
3	Zone relative humidity	%	The relative humidity of the conditioned air in the zone.
4	Zone ventilation flow rate	kg/hr	The ventilation air flow rate into (and out of) the zone.
5	Zone infiltration flow rate	kg/hr	The infiltration air flow rate into (and out of) the zone.
6	Zone air pressure	atm	The absolute pressure of air in the zone.
7	Sensible infiltration gain	kJ/hr	The rate of sensible energy gain to the zone due to infiltration.
8	Sensible ventilation gain	kJ/hr	The rate of sensible energy gain to the zone due to ventilation.
9	Shell losses	kJ/hr	The heat transfer from the zone to the ambient from the shell or skin of the building (UA losses).
10	Internal gains	kJ/hr	The rate at which sensible energy is added to the zone from people, lights and equipment.
11	Adjacent zone convective heat transfer	kJ/hr	The net heat transfer (sensible and latent) to this zone due to the convective exchanges between this zone and the adjacent zones.
12	Adjacent zone conductive heat transfer	kJ/hr	The net heat transfer (sensible and latent) to this zone due to heat exchange with the adjacent zones through the walls (UA).
13	Energy storage rate	kJ/hr	The rate at which energy is being stored in the air, walls, furnishings, etc. in the zone.
14	Latent infiltration gains	kJ/hr	The rate at which latent energy is added to the zone due to the infiltration flow.
15	Latent ventilation gains	kJ/hr	The rate at which latent energy is added to the space due to the ventilation stream.
16	Internal latent gain	kJ/hr	The rate at which latent energy is added to the zone due to people and other internal latent sources.
17	Latent energy storage rate	kJ/hr	The rate at which latent energy is stored in the room air, walls, and furnishings.
18	Condensation energy rate	kJ/hr	The rate at which latent energy is removed from the zone through condensation in the zone.

OPTIMIZATION COMPONENTS

Optimization Components

TYPE 758: TRNOPT PRINTER

PARAMETERS

Parameter Number	Name	Unit	Typical Value	Comment
1	Number of collectors in series	-	1	The number of LPC's hooked up in series per parallel loop.
2	Number of collectors in parallel	-	1	The number of identical parallel collector loops where each collector loop has PAR(1) collectors in series. The flow rate through each collector is the total array flow rate divided by this parameter.
3	Aperture area	m^2	10.0	The aperture (reflector) area of one of the LPCs.
4	Concentration ratio	-	35.0	The concentration ratio of the LPC. The concentration ratio is defined as the aperture area divided by the receiver area.
5	Intercept efficiency ($F_R\tau\alpha_N$)	-	0.7	The intercept of the collector efficiency curve.
6	Efficiency slope (F_RU_L)	kJ/hr-m2-K	15.0	The loss coefficient of the collector efficiency curve.
7	Fluid specific heat	kJ/kg-K	4.190	The specific heat of the fluid entering the LPC.
8	Logical unit	-	26	The logical unit through which the collector incidence angle modifiers (IAM) data file will be read.
9	Number of IAM points	-	10	The number of incidence angles and incidence angle modifiers contained in the external data file.
10	Tested flow rate	kg/hr-m^2	50.0	The flow rate per unit area at which the collector efficiency was obtained.

INPUTS

Input Number	Name	Unit	Typical Value	Comment
1	Inlet temperature	C	10.	The temperature of the fluid flowing into the solar collector array.
2	Inlet flow rate	kg/hr	0.	The flow rate of fluid flowing into the solar collector array. The flow rate flowing through each collector is this flow rate divided by the number of collectors loops in parallel.
3	Ambient temperature	C	10.	The ambient temperature.
4	Incident beam radiation	kJ/hr-m^2	0.	The beam radiation incident upon the collector aperture (reflector).
5	Incidence angle	degrees	45.	The angle of incidence of beam radiation on the solar collector.
6	Maximum outlet temperature	C	100.	The maximum outlet temperature from the collector array. If the calculated outlet temperature is higher than the maximum temperature, a section of the collector array will be defocused to keep the temperature at the maximum

				temperature.

OUTPUTS

Output Number	Name	Unit	Comment
1	Outlet temperature	C	The temperature of the fluid leaving the solar collector array.
2	Outlet flow rate	kg/hr	The flow rate of fluid exiting the solar collector array.
3	Useful energy gain	kJ/hr	The rate of useful energy gain by the solar collector array.
4	Dumped energy	kJ/hr	The rate at which the collector energy is dumped to avoid an over-temperature condition.
5	Theoretical temperature	C	The temperature of the fluid exiting the solar collector array if the maximum collector temperature limit were removed.

SOLAR ENERGY COMPONENTS

Solar Energy Components

TYPE 536: LINEAR PARABOLIC CONCENTRATING COLLECTOR

PARAMETERS

Parameter Number	Name	Unit	Typical Value	Comment
1	Number of collectors in series	-	1	The number of LPC's hooked up in series per parallel loop.
2	Number of collectors in parallel	-	1	The number of identical parallel collector loops where each collector loop has PAR(1) collectors in series. The flow rate through each collector is the total array flow rate divided by this parameter.
3	Aperture area	m^2	10.0	The aperture (reflector) area of one of the LPCs.
4	Concentration ratio	-	35.0	The concentration ratio of the LPC. The concentration ratio is defined as the aperture area divided by the receiver area.
5	Intercept efficiency ($F_R\tau\alpha_N$)	-	0.7	The intercept of the collector efficiency curve.
6	Efficiency slope (F_RU_L)	kJ/hr-m2-K	15.0	The loss coefficient of the collector efficiency curve.
7	Fluid specific heat	kJ/kg-K	4.190	The specific heat of the fluid entering the LPC.
8	Logical unit	-	26	The logical unit through which the collector incidence angle modifiers (IAM) data file will be read.
9	Number of IAM points	-	10	The number of incidence angles and incidence angle modifiers contained in the external data file.
10	Tested flow rate	kg/hr-m^2	50.0	The flow rate per unit area at which the collector efficiency was obtained.

INPUTS

Input Number	Name	Unit	Typical Value	Comment
1	Inlet temperature	C	10.	The temperature of the fluid flowing into the solar collector array.
2	Inlet flow rate	kg/hr	0.	The flow rate of fluid flowing into the solar collector array. The flow rate flowing through each collector is this flow rate divided by the number of collectors loops in parallel.
3	Ambient temperature	C	10.	The ambient temperature.
4	Incident beam radiation	kJ/hr-m^2	0.	The beam radiation incident upon the collector aperture (reflector).
5	Incidence angle	degrees	45.	The angle of incidence of beam radiation on the solar collector.
6	Maximum outlet temperature	C	100.	The maximum outlet temperature from the collector array. If the calculated outlet temperature is higher than the maximum temperature, a section of the collector array will be defocused to keep the temperature at the maximum

				temperature.

OUTPUTS

Output Number	Name	Unit	Comment
1	Outlet temperature	C	The temperature of the fluid leaving the solar collector array.
2	Outlet flow rate	kg/hr	The flow rate of fluid exiting the solar collector array.
3	Useful energy gain	kJ/hr	The rate of useful energy gain by the solar collector array.
4	Dumped energy	kJ/hr	The rate at which the collector energy is dumped to avoid an over-temperature condition.
5	Theoretical temperature	C	The temperature of the fluid exiting the solar collector array if the maximum collector temperature limit were removed.

TYPE 537: FLAT PLATE SOLAR COLLECTOR WITH SPECIFIED OUTLET TEMPERATURE (EFFICIENCY:$f(T_{IN}-T_{AMB})$) – CAPACITANCE EFFECTS IGNORED

PARAMETERS

Parameter Number	Name	Unit	Typical Value	Comment
1	Number in series	-	1	This parameter is used to specify how many collectors are hooked up in a series arrangement.
2	Collector area	m^2	2.0	The total area of the solar collector array consistent with the supplied efficiency parameters.
3	Fluid specific heat	kJ/kg-K	4.190	The specific heat of the fluid flowing through the solar collector array.
4	Tested flow rate	kg/hr.m^2	50.0	The flow rate per unit area at which the collector was tested in order to determine the collector efficiency parameters.
5	Intercept efficiency	-	0.7	This parameter is the y-intercept of the collector efficiency vs. the temperature difference/radiation ratio curve.
6	Efficiency slope	kJ/hr-m^2-K	15	The slope of the efficiency curve.
7	Efficiency curvature	kJ/hr-m^2-K^2	0.0	The curvature of the efficiency curve.
8	1st-order IAM	-	0.1	This parameter is b0 in the Incidence Angle Modifier equation.
9	2nd-order IAM	-	0.0	This parameter is b1 in the Incidence Angle Modifier equation.
10	Minimum flow rate	kg/hr	0	The minimum flow rate through the solar collector that can be achieved when the pump is operating.
11	Maximum flow rate	kg/hr	0	The maximum flow rate through the collector that the pump can deliver.

INPUTS

Input Number	Name	Unit	Typical Value	Comment
1	Inlet temperature	C	20.0	The temperature of the fluid entering the solar collector.
2	Inlet flow rate	kg/hr	100.0	The flow rate of the fluid entering the solar collector.
3	Ambient temperature	C	10.0	The temperature of the environment in which the solar collector is located.
4	Incident radiation	kJ/hr-m^2	0.0	The total radiation incident on the plane of the solar collector per unit area.
5	Total horizontal radiation	kJ/hr-m^2	0.0	The total horizontal radiation per unit area.
6	Horizontal diffuse radiation	kJ/hr-m^2	0.0	The horizontal diffuse radiation.
7	Ground reflectance	-	0.2	The reflectance of the surface above which the solar collector is positioned.

8	Incidence angle	degrees	45.0	Angle of incidence of beam radiation on collector surface
9	Collector slope	degrees	45.0	The slope of the collector surface.
10	Pump control specification	-	0	The type of control that will be utilized by the solar collector. 0=Run at specified inlet flow and calculate the outlet temperature 1=Attempt to keep the collector outlet at the user-specified condition by varying the flow rate. The outlet flow rate is then set by this component.
11	Outlet temperature set point	C	60.	The desired outlet temperature from the collector.

OUTPUTS

Output Number	Name	Unit	Comment
1	Outlet temperature	C	The temperature of the fluid exiting the solar collector array.
2	Outlet flow rate	kg/hr	The flow rate of the fluid exiting the solar collector array.
3	Useful energy gain	kJ/hr	The rate of useful energy gain by the solar collector fluid.
4	Fraction of maximum flow	-	The fraction of the user-specified maximum flow rate that the collector requires in order to meet the user-specified outlet temperature.

TYPE 538: EVACUATED TUBE SOLAR COLLECTOR WITH SPECIFIED OUTLET TEMPERATURE

PARAMETERS

Parameter Number	Name	Unit	Typical Value	Comment
1	Number in series	-	1	The number of collectors hooked up in a series arrangement.
2	Collector area	m^2	2.0	The total area of the solar collector array consistent with the supplied efficiency parameters (typically gross area and not net area).
3	Fluid specific heat	kJ/kg-K	4.190	The specific heat of the fluid flowing through the solar collector array.
4	Tested flow rate	kg/hr-m^2	50.0	The flow rate per unit area at which the collector was tested in order to determine the collector efficiency parameters.
5	Intercept efficiency	-	0.7	The y-intercept of the collector efficiency vs. the temperature difference/radiation ratio curve ($F_R\tau\alpha_N$)
6	Efficiency slope	kJ/hr-m^2-K	15	The slope of the slope of the efficiency vs. (Tin-Tamb)/It curve.
7	Efficiency curvature	kJ/hr-m^2-K^2	0.0	The curvature of the efficiency curve.
8	Minimum flow rate	kg/hr	0	The minimum flow rate through the solar collector that can be achieved when the pump is operating.
9	Maximum flow rate	kg/hr	0	The maximum flow rate through the collector that the pump can deliver.
10	Logical unit for IAM data file	-	20	The logical unit that gets assigned to the data file containing the incidence angle modifier data.
11	Number of transverse angles	-	5	The number of transverse angles for which data is supplied in the file containing the IAM data.
12	Number of longitudinal angles	-	3	The number of longitudinal angles for which data is supplied in the file containing the IAM data.

INPUTS

Input Number	Name	Unit	Typical Value	Comment
1	Inlet temperature	C	20.0	The temperature of the fluid entering the solar collector.
2	Inlet flow rate	kg/hr	100.0	The flow rate of the fluid entering the solar collector.
3	Ambient temperature	C	10.0	The temperature of the environment in which the solar collector is located.
4	Incident radiation	kJ/hr-m^2	0.0	The total radiation incident on the plane of the solar collector per unit area.
5	Incident diffuse radiation	kJ/hr-m^2	0.0	The diffuse radiation incident on the plane of the collector.
6	Incidence angle	degrees	45.0	Angle of incidence of beam radiation on collector surface.

7	Solar zenith angle	degrees	0	The solar zenith angle.
8	Solar azimuth angle	degrees	0	The solar azimuth angle.
9	Collector slope	degrees	45.0	The slope of the collector surface.
10	Collector azimuth	degrees	0	The direction in which the collector is facing.
11	Pump control specification	-	0	The type of control that will be utilized by the solar collector 0 = Run at specified inlet flow and calculate the outlet temperature 1 = Attempt to keep the collector outlet at the user-specified condition by varying the flow rate. The outlet flow rate is then set by this component! 2 = Attempt the keep the collector outlet at the user specified condition by varying the flow rate. If the flow reaches its maximum condition, dump collected energy to keep the outlet at the desired condition.
12	Outlet temperature set point	C	60.	The desired outlet temperature from the collector.

OUTPUTS

Output Number	Name	Unit	Comment
1	Outlet temperature	C	The temperature of the fluid exiting the solar collector array.
2	Outlet flow rate	kg/hr	The flow rate of the fluid exiting the solar collector array.
3	Useful energy gain	kJ/hr	The rate of useful energy gain by the solar collector fluid.
4	IAM - Total radiation	-	The total incidence angle modifier at the current time step.
5	IAM - Beam radiation	-	The incidence angle modifier for beam radiation at the current time step.
6	IAM - Diffuse radiation	-	The incidence angle modifier for diffuse radiation at the current time step.
7	Dumped energy	kJ/hr	The rate at which the solar collector "dumps" energy by defocusing part of the array in order to keep the outlet temperature at or below the user-specified set point temperature.
8	Collector efficiency	-	The efficiency of the solar collector at transferring solar radiation into fluid energy.
9	Flow fraction	-	The fraction of the maximum flow rate that the collector is operating at in order to keep the outlet temperature at its user-specified value.

TYPE 539: FLAT PLATE SOLAR COLLECTOR WITH SPECIFIED OUTLET TEMPERATURE (EFFICIENCY: $f(T_{IN}-T_{AMB})$) – WITH CAPACITANCE EFFECTS

PARAMETERS

Parameter Number	Name	Unit	Typical Value	Comment
1	Number in series	-	1	The number of collectors hooked up in a series arrangement.
2	Collector area	m^2	2.0	The total area of the solar collector array consistent with the supplied efficiency parameters.
3	Fluid specific heat	kJ/kg-K	4.190	The specific heat of the fluid flowing through the solar collector array
4	Intercept efficiency	-	0.7	The y-intercept of the collector efficiency vs. the temperature difference/radiation ratio curve ($F_R\tau\alpha_N$).
5	Efficiency slope	kJ/hr-m^2-K	15	The slope of the slope of the efficiency vs. (Tin-Tamb)/It curve.
6	1st-order IAM	-	0.1	The b0 parameter in the Incidence Angle Modifier equation.
7	2nd-order IAM	-	0.0	The b1 parameter in the Incidence Angle Modifier equation.
8	Minimum flow rate	kg/hr	0	The minimum flow rate through the solar collector that can be achieved when the pump is operating.
9	Maximum flow rate	kg/hr	0	The maximum flow rate through the collector that the pump can deliver.
10	Capacitance of collector	kg	0	The capacitance of the solar collector and the fluid it contains.
11	Initial temperature	C	20.	The initial temperature of the collector and its fluid.
12	Number of nodes	-	1	The number of nodes into which the collector will be divided in the flow-direction.

INPUTS

Input Number	Name	Unit	Typical Value	Comment
1	Inlet temperature	C	20.0	The temperature of the fluid entering the solar collector.
2	Inlet flow rate	kg/hr	100.0	The flow rate of the fluid entering the solar collector.
3	Ambient temperature	C	10.0	The temperature of the environment in which the solar collector is located.
4	Incident radiation	kJ/hr-m^2	0.	The total radiation incident on the plane of the solar collector per unit area.
5	Total horizontal radiation	kJ/hr-m^2	0.0	The total horizontal radiation per unit area.
6	Horizontal diffuse radiation	kJ/hr-m^2	0.0	The horizontal diffuse radiation.
7	Ground reflectance	-	0.2	The reflectance of the surface above which the solar collector is positioned.
8	Incidence angle	degrees	45.0	Angle of incidence of beam radiation on collector surface

9	Collector slope	degrees	0.	The slope of the collector surface.
10	Pump control specification	-	0	The type of control that will be utilized by the solar collector 0 = Run at specified inlet flow and calculate the outlet temperature 1 = Attempt to keep the collector outlet at the user-specified condition by varying the flow rate. The outlet flow rate is then set by this component!!
11	Outlet temperature set point	C	0	The desired outlet temperature from the collector.

OUTPUTS

Output Number	Name	Unit	Comment
1	Outlet temperature	C	The temperature of the fluid exiting the solar collector array.
2	Outlet flow rate	kg/hr	The flow rate of the fluid exiting the solar collector array.
3	Useful energy gain	kJ/hr	The rate of useful energy gain by the solar collector fluid.
4	Fraction of maximum flow	-	The fraction of the user-specified maximum flow rate that the collector requires in order to meet the user-specified outlet temperature.

TYPE 540: FLAT PLATE SOLAR COLLECTOR WITH SPECIFIED OUTLET TEMPERATURE (EFFICIENCY: $f(T_{AVE}-T_{AMB})$) – WITH CAPACITANCE EFFECTS

PARAMETERS

Parameter Number	Name	Unit	Typical Value	Comment
1	Number in series	-	1	The number of collectors hooked up in a series arrangement.
2	Collector area	m^2	2.0	The total area of the solar collector array consistent with the supplied efficiency parameters.
3	Fluid specific heat	kJ/kg-K	4.190	The specific heat of the fluid flowing through the solar collector array
4	Tested flow rate	kg/hr-m^2	50.0	The flow rate per unit area at which the collector was tested in order to determine the collector efficiency parameters.
5	Intercept efficiency	-	0.7	The y-intercept of the collector efficiency vs. the temperature difference/radiation ratio curve ($F_R\tau\alpha_N$).
6	Efficiency slope	kJ/hr-m^2-K	15	The slope of the slope of the efficiency vs. (Tin-Tamb)/It curve.
7	Efficiency curvature	kJ/hr-m^2-K^2	0.0	The curvature of the efficiency curve.
8	1st-order IAM	-	0.1	The b0 parameter in the Incidence Angle Modifier equation.
9	2nd-order IAM	-	0.0	The b1 parameter in the Incidence Angle Modifier equation.
10	Minimum flow rate	kg/hr	0	The minimum flow rate through the solar collector that can be achieved when the pump is operating.
11	Maximum flow rate	kg/hr	0	The maximum flow rate through the collector that the pump can deliver.
12	Capacitance of collector	kg	0	The capacitance of the solar collector and the fluid it contains.
13	Initial temperature	C	20.	The initial temperature of the collector and its fluid.
14	Number of nodes	-	1	The number of nodes into which the collector will be divided in the flow-direction.

INPUTS

Input Number	Name	Unit	Typical Value	Comment
1	Inlet temperature	C	20.0	The temperature of the fluid entering the solar collector.
2	Inlet flow rate	kg/hr	100.0	The flow rate of the fluid entering the solar collector.
3	Ambient temperature	C	10.0	The temperature of the environment in which the solar collector is located.
4	Incident radiation	kJ/hr-m^2	0.	The total radiation incident on the plane of the solar collector per unit area.
5	Total horizontal radiation	kJ/hr-m^2	0.0	The total horizontal radiation per unit area.
6	Horizontal diffuse radiation	kJ/hr-m^2	0.0	The horizontal diffuse radiation.

7	Ground reflectance	-	0.2	The reflectance of the surface above which the solar collector is positioned.
8	Incidence angle	degrees	45.0	Angle of incidence of beam radiation on collector surface
9	Collector slope	degrees	0.	The slope of the collector surface.
10	Pump control specification	-	0	The type of control that will be utilized by the solar collector 0 = Run at specified inlet flow and calculate the outlet temperature 1 = Attempt to keep the collector outlet at the user-specified condition by varying the flow rate. The outlet flow rate is then set by this component!!
11	Outlet temperature set point	C	0	The desired outlet temperature from the collector.

OUTPUTS

Output Number	Name	Unit	Comment
1	Outlet temperature	C	The temperature of the fluid exiting the solar collector array.
2	Outlet flow rate	kg/hr	The flow rate of the fluid exiting the solar collector array.
3	Useful energy gain	kJ/hr	The rate of useful energy gain by the solar collector fluid.
4	Fraction of maximum flow	-	The fraction of the user-specified maximum flow rate that the collector requires in order to meet the user-specified outlet temperature.

TYPE 541: INTEGRAL COLLECTOR STORAGE SYSTEM WITH OPTIONAL HEAT EXCHANGER

PARAMETERS

Parameter Number	Name	Unit	Typical Value	Comment
1	Number of tank nodes	-	5	The number of isothermal tank nodes into which the storage tank will be divided.
2	Noding scheme	-	1	The noding scheme used to divide the storage tank into isothermal regions 1=Horizontal noding - Recommended for almost every application. 2=Perpendicular noding - Recommended only for very shallow tanks where the flow stream determines the majority of the temperature distribution.
3	Heat exchanger geometry	-	1	The type of heat exchanger immersed in the ICS storage tank 0=No Heat Exchanger 1=Horizontal Tube Bank Heat Exchanger 2=Vertical Tube Bank Heat Exchanger 3=Coiled Tube Heat Exchanger 4=Serpentine Tube Heat Exchanger
4	Tank length	m	2	The length of the rectangular storage tank. The length represents the edge that is rotated away from the horizontal for a sloped surface condition.
5	Tank width	m	1	The width of the rectangular storage tank.
6	Tank depth	m	0.4	The depth of the rectangular storage tank.
7	Tank fluid	-	1	The fluid contained in the storage tank 1=Pure water 2=Propylene glycol and water solution
8	Percent volume of tank fluid	-	0.0	The percentage by volume of the secondary fluid contained in the storage tank (propylene glycol for example).
9	Initial tank temperature	C	30.	The temperature of the storage tank at the beginning of the simulation. If derivatives are supplied (used as initial values), this parameter will be ignored.
10	Edge loss coefficient	kJ/hr-m^2-K	0	The loss coefficient for the edges of the storage tank.
11	Bottom loss coefficient	kJ/hr-m^2-K	0	The loss coefficient for the bottom surface of the storage tank.
12	Additional thermal conductivity mode	-	0	If this parameter > 0 then the conduction between nodes will be calculated based on the thermal conductivity of the storage fluid and the additional thermal conductivities supplied as input values. If this parameter < 0, all conductivity effects will be ignored.
13	IAM mode	-	1	The incidence angle modifier mode for the calculations: 1=No off-normal effects are considered 2=Use first-order IAMs from ASHRAE 3=Use second-order IAMs from ASHRAE 4=Use file of single-axis IAMs

				5=Use cover and absorber properties 6=Use multiplicative bi-axial method 7=Use bi-axial IAM's from data file
Optical Mode 2 (m=1)				
14	1st order IAM	-	0	1st order coefficient in the IAM function.
Optical Mode 3 (m=2)				
14	1st order IAM	-	0	1st order coefficient in the IAM function.
15	2nd order IAM	-	0	2nd order coefficient in the IAM function.
Optical Mode 4 (m=2)				
14	Logical unit for IAMs	-	20	The logical unit number ASSIGNed to the data file containing the incidence angle modifier data
15	Number of transverse angles	-	5	The number of angles for which IAM data is provided.
Optical Mode 5 (m=4)				
14	Plate absorptance	-	0.9	The absorptance of the collector plate
15	Number of covers	-	1	The number of identical covers on the collector.
16	Cover refractive index	-	1.53	The collector cover material's refractive index.
17	Extinction coefficient-thickness product	-	0.0125	The product of the cover material extinction coefficient and the cover thickness.
Optical Mode 6 (m=2)				
14	Logical unit for IAMs	-	20	The logical unit number ASSIGNed to the data file containing the biaxial incidence angle modifier data
15	Number of angles	-	0	The number of angles for which IAM data is provided.
Optical Mode 7 (m=3)				
14	Logical unit for IAMs	-	20	The logical unit number ASSIGNed to the data file containing the biaxial incidence angle modifier data
15	Number of transverse angles	-	0	The number of transverse angles for which IAM data is provided.
16	Number of longitudinal angles	-	0	The number of longitudinal angles for which IAM data is provided.
If HX Geometry = 0				
14+m	Flow inlet node	-	5	The tank node into which inlet flow occurs.
15+m	Flow outlet node	-	1	The tank node from which outlet flow occurs.
If HX Geometry = 1		(y=PAR(14+m))		
14+m	Number of HX nodes	-	5	The number of nodes into which the heat exchanger will be divided into in the flow direction.
Cycle based on nTankNodes	Fraction of HX tubes for each node	-	0.2	The fraction of the total heat exchanger tubes contained in each node of the tank.
IF HX Geometry = 2, 3, or 4		(y=2*PAR(14+m))		
14+m	Number of HX nodes	-	5	The number of nodes into which the heat exchanger will be divided into in the flow direction.
Cycle based on nHXnodes	Tank node for 1st HX node	-	1	The tank node into which the heat exchanger inlet occurs
	Fraction of HX length in each node	-	0.2	The fraction of heat exchanger length assigned to each heat exchanger node

15+m+y	Heat exchanger fluid	-	2	The type of fluid flowing through the heat exchanger 1=Pure water 2=Propylene glycol and water solution
16+m+y	Percent volume of HX fluid	-	0.1	The percentage by volume of the secondary fluid flowing through the heat exchanger (propylene glycol for example).
17+m+y	Multiplier for natural convection correlation	-	1	The value constant multiplier in the natural convection equation for the heat exchanger.
18+m+y	Exponent for Rayleigh number	-	0.25	The value for n in the natural convection heat transfer.
19+m+y	Geometry factor	-	1	The value for the geometry factor (GF) in the natural convection heat transfer equation.
20+m+y	Geometry factor exponent	-	0	The value of the geometry factor exponent (m) in the natural convection heat transfer correlation.
21+m+y	HX tube inner diameter	m	0.01	The inner diameter of one of the identical tubes comprising the heat exchanger.
22+m+y	HX tube outer diameter	m	0.015	The outer diameter of one of the identical tubes comprising the heat exchanger.
23+m+y	HX wall conductivity	kJ/hr-m-K	900	The thermal conductivity of the wall material comprising the tubes of the heat exchanger.
24+m+y	Length of heat exchanger tube	m	1.0	The length of one of the identical tubes comprising the heat exchanger.
25+m+y	Number of tubes	-	50	The number of identical tubes comprising the heat exchanger.
26+m+y	Header volume	m^3	0.01	The volume of the headers comprising the heat exchanger.
27+m+y	Initial HX temperature	C	20.0	The temperature of the fluid in the heat exchanger at the beginning of the simulation.
28+m+y	HX cross sectional area	m^2	0.005	The cross-sectional area of the heat exchanger at the tank nodal boundaries.
If HX Geometry = 3				
29+m+y	Coil diameter	m	0.005	The diameter of the coil tube heat exchanger.
30+m+y	Coil pitch	m	0.005	The pitch of the coil tube heat exchanger.

INPUTS

Input Number	Name	Unit	Typical Value	Comment
1	HX inlet temperature	C	20	The temperature of the fluid entering the storage tank at the flow inlet.
2	HX inlet flow rate	kg/hr	200	The flow rate of fluid entering the storage tank at the fluid inlet.
3	Top loss Temperature	C	20	The temperature of the environment for calculating losses from the collector surface of the ICS system.
4	Incident solar radiation	kJ/hr-m^2	0	The rate at which incident total solar radiation strikes the collector surface of the ICS system.
5	Horizontal diffuse radiation	kJ/hr-m^2	0	The rate at which diffuse radiation strikes a horizontal surface.
6	Total horizontal radiation	kJ/hr-m^2	0	The rate at which total solar radiation strikes a horizontal surface.

7	Incident diffuse radiation	kJ/hr-m^2	0	The rate at which diffuse radiation strikes the sloped collector surface.
8	Incidence angle	degrees	0	The angle of incidence between beam solar radiation and the sloped collector surface.
9	Solar zenith angle	degrees	0	The solar zenith angle at the current time step.
10	Solar azimuth angle	degrees	0	The solar azimuth angle at the current time step.
11	Collector slope	degrees	45	The slope of the top surface of the rectangular storage tank.
12	Surface azimuth	degrees	0	The direction toward which the collector faces.
13	Ground reflectance	-	0.2	The reflectance to solar radiation of the surface upon which the ICS collector is located.
14	Edge and back loss temperature	C	20.	The temperature to which the thermal losses from the back and edges of the rectangular IC storage tank occur.
15	Safety loss temperature	C	20.	The sink temperature to which the ICS system will dump excess energy if the safety loss feature activates.
16	Inversion mixing flow rate	kg/hr	0	The mixing rate at which temperature inversions between adjacent nodes of the storage tank will be addressed. Setting this value to zero will allow the storage tank to remain inverted - where one node of the storage tank remains hotter than the node above it.
17	Collector transmittance absorptance product	-	0.93	The transmittance-absorptance product for the collector surface (1=perfect collector).
18	Top loss coefficient	kJ/hr-m^2-K	3.0	The loss coefficient for the top surface of the ICS system.
19	Additional top losses	kJ/hr-m^2	0	Any additional losses from the collector cover per unit area. Losses from the system are considered to be positive inputs to this model.
Cycle based on n TankNodes	Safety loss coefficient for each node.	kJ/hr-K	0	The overall loss coefficient between each tank node and the safety device sink temperature.
Cycle based on nTankNodes - 1	Additional internodal conductivity between each node and the one below.	kJ/hr-m-K	0	If the thermal conductivity PARAMETER is set positive then this input is the additional thermal conductivity for the internodal conductivity heat transfer calculation due to the tank and heat exchanger walls for this node and the node directly below it (start with the top node.)

OUTPUTS

Output Number	Name	Unit	Comment
1	Temperature at outlet	C	The temperature of the fluid exiting the storage tank at the outlet.
2	Flow rate at outlet	kg/hr	The flow rate of fluid exiting the storage tank through the outlet (set by the inlet flow rate).
3	Overall IAM	-	The overall (beam plus diffuse) incidence angle modifier for the collector at the current time step.
4	Beam IAM	-	The incidence angle modifier for beam radiation at the current time step.
5	Diffuse IAM	-	The incidence angle modifier for diffuse radiation at the current time

			step.
6	Average tank temperature	C	The average temperature of the fluid in the storage tank.
7	Average HX temperature	C	The average temperature of the fluid in the heat exchanger.
8	Collector useful energy gain	kJ/hr	The rate at which energy is added to the storage tank from the net gains of the collector surface (absorbed solar radiation minus collector top losses).
9	Energy delivered to flow stream	kJ/hr	The rate at which energy is removed from the storage tank due to the fluid flow rate exiting through the outlet port minus the rate at which energy is added to the storage tank by the fluid flow rate entering the storage tank through the inlet port.
10	Edge and bottom losses	kJ/hr	The rate at which energy is lost to the environment through the bottom and edge surfaces of the storage tank.
11	Safety losses	kJ/hr	The rate at which energy is dumped to the environment due to the safety loss device.
12	Tank energy storage rate	kJ/hr	The rate at which energy is stored by the fluid in the storage tank due to a rise in temperature of the storage. (Capacitance Effects)
13	HX energy storage	kJ/hr	The rate at which energy is stored by the fluid in the immersed heat exchanger due to a temperature rise of the fluid (capacitance effects).
14	HX heat transfer	kJ/hr	The rate at which energy is transferred from the fluid in the storage tank to the fluid in the immersed heat exchanger.
15	Average top temperature	C	The average temperature of the top surface (collector surface) of the ICS collector system.
16	Average bottom temperature	C	The average temperature of the bottom surface of the ICS storage tank.
17	Collector tau-alpha	-	The transmittance-absorptance product of the top surface (collector surface) of the ICS system.
18	Top loss coefficient	kJ/hr-m^2-K	The top loss coefficient (collector surface) of the ICS system at the current time step.
19	Tank energy balance error	-	The percent energy balance error for the heat transfer in the storage tank.
20	HX energy balance	-	The percent energy balance error for the heat transfer for the fluid in the immersed heat exchanger.
Cycle based on nTankNodes	Temperature of each tank node	C	The average temperature of the fluid in the specified node of the storage tank for the current time step.
Cycle based on n TankNodes - 1	Nodal mixing rate between 1st and 2nd nodes	kg/hr	The rate at which this node is mixed with the node below this one due to a temperature inversion in the storage tank between adjacent nodes.
Cycle based on nTankNodes	Top area for each node	m^2	The top surface area of each tank node.
Cycle based on nTankNodes	Bottom area for each node	m^2	The bottom surface area of each tank node.

Cycle based on nTankNodes	Edge area for each node	-	The edge area for each tank node.
Cycle based on nHXNodes	Nodal HX temperatures	C	The average temperature of each node of the heat exchanger.
Cycle based on nHXNodes	Nodal inner resistances	hr-m^2-K/kJ	The resistance to heat transfer in the heat exchanger due to the inner surface fluid convection effects for each node.
Cycle based on nHXNodes	Nodal wall resistances	hr-m^2-K/kJ	The resistance to heat transfer in the heat exchanger due to the thermal conductivity effects of the material comprising the walls of the heat exchanger.
Cycle based on nHXNodes	Nodal outer resistances	hr-m^2-K/kg	The resistance to heat transfer in the heat exchanger due the natural convection heat transfer between the outer surface of the heat exchanger and the storage tank fluid for the specified node.
Cycle based on nHXNodes	Nodal UA values	kJ/hr-K	The overall heat transfer coefficient (UA) between each heat exchanger node and the fluid in the storage tank node containing the heat exchanger node.

DERIVATIVES

Input Number	Name	Unit	Typical Value	Comment
Cycle based on nTankNodes	Initial temperature of each tank node	C	20.	The initial temperature of the fluid in each tank node starting with the top node and proceeding to the bottom node.

TYPE 543: SINGLE COVER TOP LOSS CORRELATION

PARAMETERS

Parameter Number	Name	Unit	Typical Value	Comment
1	Plate to cover spacing	m	0.03	The distance between the plate and the glazing.
2	Cover emissivity	0..1	0.15	The emissivity of the glazing.
3	Cover IR transmittance	0..1	0.01	The transmittance of the glazing to infrared radiation.
4	Plate emissivity	0..1	0.09	The emissivity of the plate.
5	Plate length	m	2	The length of the plate. The cover is assumed to have the same length as the plate.
6	Plate width	m	1	The width of the plate. The cover is assumed to have the same width as the plate.

INPUTS

Input Number	Name	Unit	Typical Value	Comment
1	Plate temperature	C	40.0	The average temperature of the plate.
2	Ambient temperature	C	10.0	The temperature of the surroundings for the loss calculation.
3	Slope	degrees	45.0	The slope of the plate/cover system.
4	Sky temperature	C	5.0	The effective sky temperature.
5	Wind velocity	m/s	1.0	The velocity of the wind.
6	Regression variable	-	1	The regression variable can be used for fitting data. Set this value to 1.0 to have the theoretical U-value calculated by the model used as the output from the model.
7	Addition factor	-	0.0	The addition factor can be used for fitting data. Set this value to 0.0 to have the theoretical U-value calculated by the model used as the output from the model.
8	Atmospheric pressure	atm	1.0	The atmospheric pressure.

OUTPUTS

Output Number	Name	Unit	Comment
1	Top loss coefficient	kJ/hr-m^2-K	U top is defined as $Q/(T_{plate} - T_{ambient})$
2	Energy loss	kJ/hr-m^2	The total energy lost (positive) or gained (negative) from the plate/cover system.
3	Cover temperature	C	The temperature of the cover glazing.

TYPE 544: DOUBLE COVER TOP LOSS CORRELATION

PARAMETERS

Parameter Number	Name	Unit	Typical Value	Comment
1	Plate to inside cover spacing	m	0.03	The distance from the absorber surface (plate) to the inside of the first (innermost) cover.
2	Inside to outside cover spacing	m	0.03	The distance from the inside of the innermost glazing to the outside of the outermost glazing.
3	Plate emissivity	0..1	0.09	The emissivity of the absorber (plate) material.
4	Inside cover emissivity	0..1	0.1	The emissivity of the inside cover material.
5	Inside cover IR transmittance	0..1	0.01	The transmittance of the inner cover to infrared radiation.
6	Outside cover emissivity	0..1	0.1	The emissivity of the outside cover material.
7	Outside cover IR transmittance	0..1	0.01	The transmittance of the outer cover material to infrared radiation.
8	Plate length	m	2	The length of the plate. The glazings are assumed to have the same length as the plate.
9	Plate width	m	1	The width of the plate. The glazing covers are assumed to have the same width as the plate.

INPUTS

Input Number	Name	Unit	Typical Value	Comment
1	Plate temperature	C	40.0	The temperature of the plate.
2	Ambient temperature	C	10.0	The ambient temperature.
3	Slope	degrees	45	The slope of the plate/cover system. Slope is positive when tilted in the direction of the azimuth.
4	Sky temperature	C	5.0	The effective sky temperature.
5	Wind velocity	m/s	1.0	The velocity of the wind.
6	Regression variable	-	1	The regression variable can be used for fitting data. Set this value to 1.0 to have the theoretical U-value calculated by the model used as the output from the model.
7	Atmospheric pressure	atm	1.0	The atmospheric pressure.

OUTPUTS

Output Number	Name	Unit	Comment
1	Top loss coefficient	kJ/hr-m^2-K	The top loss coefficient is defined as Q_loss/(T_{plate} - $T_{ambient}$)

		K	
2	Energy loss	kJ/hr-m^2	The energy lost (positive) or gained (negative) from the plate/cover system.
3	Inside cover temperature	C	The temperature of the inside cover of the two-cover system.
4	Outside cover temperature	C	The temperature of the outside cover of the two-cover system.

TYPE 550: TUBULAR INTEGRAL COLLECTOR STORAGE (ICS) SYSTEM

PARAMETERS

Parameter Number	Name	Unit	Typical Value	Comment
1	Number of tubes	-	6	The number of unique storage tubes that comprise the ICS collector.
2	Total number of nodes	-	24	The total number of isothermal temperature nodes into which the ICS collector is divided. The total number of nodes must be evenly divisible by the number of tubes.
3	Collector length	m	1.0	The length of the rectangular collector enclosure. The length represents the edge along the length of the tubes.
4	Collector width	m	1.0	The width of the rectangular collector enclosure. The width represents the edge across the tube diameters.
5	Collector depth	m	0.4	The depth of the rectangular collector enclosure.
6	Fluid specific heat	kJ/kg.K	4.19	The specific heat of the fluid flowing through the storage section of the ICS collector.
7	Fluid density	kg/m^3	1000.0	The density of the fluid flowing through the storage section of the ICS collector.
8	Fluid thermal conductivity	kJ/h.m.K	6.23	The thermal conductivity of the fluid flowing through the storage section of the ICS collector.
9	Edge loss coefficient	$kJ/hr.m^2.K$	5.0	The loss coefficient for the edges of the collector enclosure.
10	Back loss coefficient	$kJ/hr.m^2.K$	0.5	The loss coefficient for the bottom (back) of the collector enclosure.
11	Heat transfer coefficient – corresponding nodes	kJ/hr.K	5.0	The overall heat transfer coefficient between corresponding nodes in adjacent tubes (the node directly above and below the current node).
12	Heat transfer coefficient – adjacent nodes	kJ/hr.K	5.0	The overall heat transfer coefficient between adjacent nodes in adjacent tubes.
13	Tube length	m	1.0	The length of one of the identical storage tubes of the ICS collector.
14	Tube diameter	m	0.15	The diameter of one of the identical storage tubes of the ICS collector.
15	Additional capacitance	kJ/K	0.0	The additional capacitance of the collector system beyond that provided by the storage fluid (walls, glass, fins etc.)
16	IAM mode	-	1	The incidence angle modifier mode for the calculations: 1=No off-normal effects are considered 2=Use first-order IAMs from ASHRAE 3=Use second-order IAMs from ASHRAE 4=Use file of single-axis IAMs 5=Use cover and absorber properties 6=Use multiplicative bi-axial method 7=Use bi-axial IAM's from data file
Optical Mode 2				
17	1^{st} order IAM	-	0	1^{st} order coefficient in the IAM function.

Optical Mode 3				
17	1st order IAM	-	0	1st order coefficient in the IAM function.
18	2nd order IAM	-		2nd order coefficient in the IAM function.
Optical Mode 4				
17	Logical unit for IAMs	-	20	The logical unit number ASSIGNed to the data file containing the incidence angle modifier data
18	Number of transverse angles	-	5	The number of angles for which IAM data is provided.
Optical Mode 5				
17	Plate absorptance	-	0.9	The absorptance of the collector plate
18	Number of covers	-	1	The number of identical covers on the collector.
19	Cover refractive index	-	1.53	The collector cover material's refractive index.
20	Extinction coefficient-thickness product	-	0.0125	The product of the cover material extinction coefficient and the cover thickness.
Optical Mode 6				
17	Logical unit for IAMs	-	20	The logical unit number ASSIGNed to the data file containing the biaxial incidence angle modifier data
18	Number of angles	-	0	The number of angles for which IAM data is provided.
Optical Mode 7				
17	Logical unit for IAMs	-	20	The logical unit number ASSIGNed to the data file containing the biaxial incidence angle modifier data
18	Number of transverse angles	-	0	The number of transverse angles for which IAM data is provided.
19	Number of longitudinal angles	-	0	The number of longitudinal angles for which IAM data is provided.

INPUTS

Input Number	Name	Unit	Typical Value	Comment
1	Inlet temperature	C	20.0	The temperature of the fluid entering the collector at the flow inlet.
2	Inlet flow rate	kg/hr	200.0	The flow rate of fluid entering the collector at the fluid inlet.
3	Top loss temperature	C	20.0	The temperature of the environment for calculating losses from the collector surface.
4	Incident solar radiation	kJ/hr-m^2	0.0	The rate at which incident solar radiation (beam + diffuse) strikes the collector surface of the ICS system.
5	Horizontal diffuse radiation	kJ/hr-m^2	0.0	The rate at which diffuse radiation strikes a horizontal surface.
6	Total horizontal radiation	kJ/hr-m^2	0.0	The rate at which total solar radiation (beam + diffuse) strikes a horizontal surface.
7	Incidence angle	degrees	0.0	The angle of incidence between beam solar radiation and the sloped collector surface.
8	Solar zenith angle	degrees	0.0	The solar zenith angle at the current time step.
9	Solar azimuth angle	degrees	0.0	The solar azimuth angle at the current time step.
10	Collector slope	degrees	45.0	The slope of the collector surface of the ICS enclosure

				(0=horizontal, 90=vertical facing the azimuth).
11	Surface azimuth	degrees	0.0	The direction toward which the collector faces (0=towards equator).
12	Ground reflectance	-	0.2	The reflectance to solar radiation of the surface upon which the ICS collector is located.
13	Edge and back loss temperature	C	20.0	The temperature of the environment for calculating losses from the edges and back of the ICS enclosure.
14	Collector τα product	-	0.90	The transmittance-absorptance product for the collector surface (1=perfect collector).
15	Top loss coefficient	kJ/hr-m^2-K	10.0	The loss coefficient for the collector surface of the ICS system.
16	Additional top losses	kJ/hr-m^2	0.0	Any additional losses from the collector cover per unit area. Losses from the system are considered to be positive inputs to this model.
Cycle based on PAR 2	Fraction of solar gains for node i	-	0.04167	The fraction of total solar gains that will be allocated to this node (from inlet to outlet).
Cycle based on PAR 2	Fraction of additional losses for node i	-	0.04167	The fraction of additional cover losses that will be allocated to this node (from inlet to outlet).

OUTPUTS

Output Number	Name	Unit	Comment
1	Temperature at outlet	C	The temperature of the fluid exiting the collector at the outlet.
2	Flow rate at outlet	kg/hr	The flow rate of fluid exiting the storage tank through the outlet (set by the inlet flow rate).
3	Overall IAM	-	The overall (beam plus diffuse) incidence angle modifier for the collector at the current time step.
4	Beam IAM	-	The incidence angle modifier for beam radiation at the current time step.
5	Diffuse IAM	-	The incidence angle modifier for diffuse radiation at the current time step.
6	Average storage temperature	C	The average temperature of the fluid in the storage.
7	Solar gains/losses	kJ/hr	The rate at which solar radiation is absorbed by the collector at the current time step minus the rate at which energy is lost from the cover system.
8	Delivered energy	kJ/hr	The rate at which energy is delivered to the load via the fluid flow stream through the collector.
9	Edge losses	kJ/hr	The rate at which energy is lost to the environment through the edges of the collector enclosure.
10	Back losses	kJ/hr	The rate at which energy is lost to the environment through the back surface of the collector enclosure.
11	Energy storage rate	kJ/hr	The rate at which energy is stored by the ICS system due to a rise in temperature of the storage (capacitance effects).
12	Collector tau-alpha	-	The transmittance-absorptance product of the top surface (collector surface) of the ICS system.
13	Top loss coefficient	kJ/hr-m^2-	The top loss coefficient (collector surface) of the ICS system at the

		K	current time step.
14	Energy balance error	-	The percent energy balance error for the heat transfers in the collector system.
Cycle based on PAR 2	Temperature of storage node i	C	The average temperature of the fluid in the specified node for the current time step (from inlet to outlet).

DERIVATIVES

Input Number	Name	Unit	Typical Value	Comment
Cycle based on PAR 1 * PAR 2	Initial temperature of node	C	20.	The initial temperature of the fluid in the storage node (from inlet to outlet).

TYPE 553: UNGLAZED FLAT PLATE COLLECTOR (EFFICIENCY COEFFICIENT METHOD)

PARAMETERS

Parameter Number	Name	Unit	Typical Value	Comment
1	Collector area	m^2	2.0	The total area of the solar collector array consistent with the supplied efficiency parameters (typically gross area and not net area).
2	Fluid specific heat	kJ/kg-K	4.19	The specific heat of the fluid flowing through the solar collector array.
3	Tested flow rate	kg/hr	50.0	The flow rate per unit area at which the collector was tested in order to determine the collector efficiency parameters. If no test was performed to get the efficiency parameters, set the tested flow rate equal to the flow rate under typical operating conditions.
4	Tested fluid specific heat	kJ/kg-K	4.19	The specific heat of the fluid flowing through the collector while it was being tested.
5	Number in series	-	1	The solar collector model can simulate an array of identical solar collectors hooked up in series. This parameter is used to specify how many collectors are hooked up in a series arrangement (outlet of first collector = inlet of second collector etc.). To account for a series arrangement, the efficiency parameters are multiplied by a modifying function as described in equation 4.2.1.12 of Volume 1 of the TRNSYS documentation set.

INPUTS

Input Number	Name	Unit	Typical Value	Comment
1	Inlet temperature	C	20.0	The temperature of the fluid entering the solar collector.
2	Inlet flow rate	kg/hr	100.0	The flow rate of the fluid entering the solar collector array.
3	Ambient temperature	C	10.0	The temperature of the environment in which the solar collector is located. This temperature will be used for loss calculations.
4	Incident radiation	kJ/m^2-hr	0.0	The total (beam + diffuse) radiation incident on the plane of the solar collector per unit area. This input is commonly hooked up to output 7 of the TYPE 16 radiation processor.
5	Intercept efficiency	0..1	0.7	Collector tests are often presented as curves of efficiency vs. (Tin-Tamb)/It with intercept FrTan and slope FrUl. This input is the y-intercept of the collector efficiency vs. the temperaure difference/radiation ratio curve (FrTan). In equation form, this input is a0 in the collector efficiency equation: Eff. = a0 - a1*(Tin-Tamb)/Radiation
6	Slope of efficiency curve	$kJ/hr\text{-}m^2\text{-}K$	15	Collector tests are often presented as plots of efficiency vs. (Tin-Tamb)/It with intercept of FrTan and slope of FrUl. This input is the slope of the slope of the efficiency vs. (Tin-Tamb)/It curve. In equation form, this input is a1 in the

				equation: Eff. = a0 - a1*(Tin-Tamb)/It

OUTPUTS

Output Number	Name	Unit	Comment
1	Outlet temperature	C	The temperature of the fluid exiting the solar collector array.
2	Outlet flow rate	kg/hr	The flow rate of the fluid exiting the solar collector array.
3	Useful energy gain	kJ/hr	The rate of useful energy gain by the solar collector fluid.
4	Collector efficiency	0..1	The efficiency of the solar collector in transferring incident solar radiation to useful fluid energy.

TYPE 559: THEORETICAL UNGLAZED FLAT PLATE COLLECTOR

PARAMETERS

Parameter Number	Name	Unit	Typical Value	Comment
1	Collector length	m	2.0	The length of the collector in the flow direction. If the user wishes to model an entire solar collector array using this model, this parameter should be set to the length of one collector multiplied by the number of collectors that are connected in series.
2	Collector width	m		The width of the collector (across the tubes). If the user wishes to model an entire solar collector array using this model, this parameter should be set to the width of one collector multiplied by the total number of collectors and divided by the number of collectors that are connected in series.
3	Fluid specific heat	kJ/kg-K	4.19	The specific heat of the fluid flowing through the solar collector array.
4	Plate absorptance	0..1	0.9	The absorptance of the collector absorber plate for solar radiation.
5	Plate emissivity	0..1	0.9	The emissivity of the collector absorber plate for long-wave radiation exchange with the sky.

INPUTS

Input Number	Name	Unit	Typical Value	Comment
1	Inlet temperature	C	20.0	The temperature of the fluid entering the solar collector.
2	Inlet flow rate	kg/hr	100.0	The flow rate of the fluid entering the solar collector array.
3	Ambient temperature	C	15.0	The temperature of the environment in which the solar collector is located. This temperature will be used for loss calculations.
4	Sky temperature	C	10.0	The temperature of the sky for calculating long-wave radiation losses from the collector surface.
5	Incident radiation	kJ/m^2-hr	0.0	The total (beam + diffuse) radiation incident on the plane of the solar collector per unit area. This input is commonly hooked up to output 7 of the TYPE 16 radiation processor.
6	Wind velocity	m/s	5.0	The velocity of the wind blowing across the top of the solar collector array.
7	Atmospheric pressure	atm	1.0	The absolute atmospheric pressure
8	Collector efficiency factor	0..1	0.84	The collector efficiency factor (F') at the current conditions.
9	Back and edge heat loss coefficient	kJ/hr-m^2-K		The heat loss coefficient for the collector for losses from the back and edges of the solar collector to the ambient. This heat transfer coefficient should be based on the collector top surface area.

OUTPUTS

Output Number	Name	Unit	Comment
1	Outlet temperature	C	The temperature of the fluid exiting the solar collector array.
2	Outlet flow rate	kg/hr	The flow rate of the fluid exiting the solar collector array.
3	Useful energy gain	kJ/hr	The rate of useful energy gain by the solar collector fluid.
4	Collector efficiency	0..1	The efficiency of the solar collector in transferring incident solar radiation to useful fluid energy.
5	Collector heat removal factor	0..1	The calculated value of the collector heat removal factor (FR).
6	Overall heat loss coefficient	kJ/hr-m^2-K	The overall heat loss coefficient of the solar collector; calculated from the top losses from convection and radiation plus the back and edge losses.
7	Mean plate temperature	C	The mean surface temperature of the absorber plate.

TYPE 561: UNGLAZED AIR HEATING COLLECTOR

PARAMETERS

Parameter Number	Name	Unit	Typical Value	Comment
1	Total collector area	m^2	1.00	The total area of the collector array. This value should be consistent with the loss coefficients.
2	Fluid specific heat	kJ/kg-K	1.007	The specific heat of the fluid flowing through the solar collector array.
3	Reflectance at normal incidence	0..1	0.1	The overall reflectance of the collector surface at normal incidence. The absorptance at normal incidence is found by subtracting this value from 1.
4	Emissivity of top surface	0..1	0.9	The emissivity of the collector surface for long-wave radiation exchange with the sky.
5	First order IAM	-	0.1	The absorptance of the collector plate is corrected for off-normal solar incidence by the use of a modifying factor of the form: Modifier = 1 - b0 * S where S=1/cos(Incidence angle)-1
6	Thermal resistance of substrate	hr-m^2-K/kJ	0.01	The resistance to heat transfer of the material located between the upper absorber surface cells and the upper flow channel surface. This resistance includes any conductive resistance of the absorber plate as well as any material between the plate and flow channel.
7	Emissivity – top surface of flow channel	0..1	0.9	The emissivity of the top surface of the flow channel (for radiation across the flow channel).
8	Emissivity – bottom surface of flow channel	0..1	0.9	The emissivity of the bottom surface of the flow channel (for radiation across the flow channel).
9	Thermal resistance of back material	hr-m^2-K/kJ	1.0	The resistance to heat transfer for material(s) located between the bottom of the flow channel and the back of the collector.
10	Emissivity of back surface	0..1	0.9	The emissivity of the collector back surface for long-wave radiation exchange with the environment.

INPUTS

Input Number	Name	Unit	Typical Value	Comment
1	Inlet temperature	C	20.0	The temperature of the fluid entering the solar collector.
2	Inlet flow rate	kg/hr	100.0	The flow rate of the fluid entering the solar collector array.
3	Ambient temperature	C	15.0	The temperature of the environment in which the solar collector is located. This temperature will be used for loss calculations.
4	Sky temperature	C	10.0	The temperature of the sky for calculating long-wave radiation losses from the collector surface.
5	Back surface environment temperature	C	20.0	The temperature of the air located behind the back surface of the collector.

6	Back surface radiation temperature	C	20.0	The temperature of the surfaces located behind the back surface of the collector for long-wave radiation loss calculations.
7	Incident radiation	kJ/m^2-hr	0.0	The total (beam + diffuse) radiation incident on the plane of the solar collector per unit area. This input is commonly hooked up to output 7 of the TYPE 16 radiation processor.
8	Total horizontal radiation	kJ/m^2-hr	0.0	The rate at which total solar radiation (beam + diffuse) strikes a horizontal surface.
9	Horizontal diffuse radiation	kJ/m^2-hr	0.0	The rate at which diffuse radiation strikes a horizontal surface.
10	Ground reflectance	0..1	0.2	The reflectance of the surface above which the solar collector is positioned. Typical values are 0.2 for ground not covered by snow and 0.7 for snow-covered ground. The reflectance is the ratio of reflected radiation to total incident radiation and therefore must be between 0 and 1.
11	Solar incidence angle	degrees	45.0	The angle of incidence between beam solar radiation and the normal vector to the sloped collector surface.
12	Collector slope	degrees	0.0	The slope of the collector surface (0=horizontal, 90=vertical facing the azimuth). Slope is positive when surface is tilted in the direction of the surface azimuth. As a general rule, performance is somewhat optimized when the collector slope is set to the latitude.
13	Top loss convection coefficient	kJ/hr-m^2-K	20.0	The convective heat loss coefficient from the top of the collector to the ambient (does not include radiative losses).
14	Back loss convection coefficient	kJ/hr-m^2-K	15.0	The convective heat transfer coefficient from the back of the collector to the environment (does not include radiative losses).
15	Fluid heat transfer coefficient	kJ/hr-m^2-K	200.0	The heat transfer coefficient from the fluid in the flow channels to the walls of the fluid channel enclosure.

OUTPUTS

Output Number	Name	Unit	Comment
1	Outlet temperature	C	The temperature of the fluid exiting the solar collector array.
2	Outlet flow rate	kg/hr	The flow rate of the fluid exiting the solar collector array.
3	Useful energy gain	kJ/hr	The rate of useful energy gain by the solar collector fluid.
4	Thermal efficiency	0..1	The efficiency of the solar collector in transferring incident solar radiation to useful fluid energy.
5	Collector FR	-	The calculated collector heat removal factor.
6	Plate temperature	C	The mean surface temperature of the absorber plate.
7	Upper air channel surface temperature	C	The mean temperature of the upper air channel surface.
8	Mean fluid temperature	C	The mean temperature of the air in the solar collector.
9	Lower air channel surface temperature	C	The mean temperature of the lower air channel surface.
10	Back surface temperature	C	The mean temperature of the back surface of the collector.

11	Overall IAM	-	The overall (beam plus diffuse) incidence angle modifier for the collector.
12	Collector top losses - convective	kJ/hr	The rate at which energy is lost to the environment through convection from the top surface of the collector.
13	Collector top losses - radiative	kJ/hr	The rate at which energy is lost to the environment through radiation losses from the top surface of the collector.
14	Collector back losses - convective	kJ/hr	The rate at which energy is lost to the environment through convection from the back surface of the collector.
15	Collector top losses - radiative	kJ/hr	The rate at which energy is lost to the environment through radiation losses from the back surface of the collector.
16	Absorbed solar radiation	kJ/hr	The net rate at which solar radiation is absorbed by the collector. This value includes the radiation that was absorbed by the PV cells and converted to electrical energy.
17	Collector UL	kJ/hr	The calculated overall loss coefficient for this collector.
18	FRtaN	-	The intercept term for the collector efficiency equation.
19	FRUL	kJ/hr	The linear term for the collector efficiency equation.

TYPE 564: THEORETICAL FIN/TUBE SOLAR COLLECTOR (POOL HEATER)

PARAMETERS

Parameter Number	Name	Unit	Typical Value	Comment
1	Collector length	m	1.00	The length of the collector in the flow direction. If the user wishes to model an entire solar collector array using this model, this parameter should be set to the length of one collector multiplied by the number of collectors that are connected in series.
2	Collector width	m	1.00	The width of the collector (across the tubes). If the user wishes to model an entire solar collector array using this model, this parameter should be set to the width of one collector multiplied by the total number of collectors and divided by the number of collectors that are connected in series.
3	Absorber plate thickness	m	0.003	The thickness of the absorber plate.
4	Conductivity of absorber material	kJ/hr-m.K	900.0	The thermal conductivity of the absorber plate material.
5	Number of tubes	-	10	The number of fluid flow tubes in the collector. If the user wishes to model an entire solar collector array using this model, this parameter should be set to the number of tubes for one collector multiplied by the total number of collectors and divided by the number of collectors that are connected in series.
6	Inner tube diameter	m	0.025	The inner diameter of the fluid tubes for the solar collector.
7	Outer tube diameter	m	0.028	The outer diameter of the fluid tubes for the solar collector.
8	Bond resistance	hr-m^2-K/kJ	0.05	The resistance to heat transfer provided by the bond material (bonding the tube to the plate).
9	Fluid specific heat	kJ/kg-K	4.19	The specific heat of the fluid flowing through the solar collector array.
10	Absorptance of the absorber plate	0..1	0.9	The absorptance of the collector absorber plate for solar radiation.
11	Emissivity of the absorber plate	0..1	0.9	The emissivity of the collector absorber plate for long-wave radiation exchange with the sky.
12	Top loss mode	-	2	This parameter indicates the top surface heat loss calculation mode for the collector: 1 = the top losses will be calculated from a theoretical analysis, 2 = the top loss heat transfer coefficient will be provided by the user
13	Number of identical covers	-	1	The number of identical covers for the solar collector.
14	Index of refraction of cover material	-	1.526	The index of refraction of the material comprising the covers of the solar collector.
15	Extinction coefficient, thickness product	-	0.005	The product of the cover material extinction coefficient and the thickness of the cover material.

INPUTS

Input Number	Name	Unit	Typical Value	Comment
1	Inlet temperature	C	20.0	The temperature of the fluid entering the solar collector.
2	Inlet flow rate	kg/hr	100.0	The flow rate of the fluid entering the solar collector array.
3	Ambient temperature	C	20.0	The temperature of the environment in which the solar collector is located. This temperature will be used for loss calculations.
4	Sky temperature	C	10.0	The temperature of the sky for calculating long-wave radiation losses from the collector surface.
5	Wind velocity	m/s	5.0	The velocity of the wind blowing across the top of the solar collector array.
6	Incident radiation	kJ/m^2-hr	0.0	The total (beam + diffuse) radiation incident on the plane of the solar collector per unit area. This input is commonly hooked up to output 7 of the TYPE 16 radiation processor.
7	Total horizontal radiation	kJ/m^2-hr	0.0	The rate at which total solar radiation (beam + diffuse) strikes a horizontal surface.
8	Horizontal diffuse radiation	kJ/m^2-hr	0.0	The rate at which diffuse radiation strikes a horizontal surface.
9	Ground reflectance	0..1	0.2	The reflectance of the surface above which the solar collector is positioned. Typical values are 0.2 for ground not covered by snow and 0.7 for snow-covered ground. The reflectance is the ratio of reflected radiation to total incident radiation and therefore must be between 0 and 1.
10	Solar incidence angle	degrees	45.0	The angle of incidence between beam solar radiation and the normal vector to the sloped collector surface.
11	Collector slope	degrees	0.0	The slope of the collector surface (0=horizontal, 90=vertical facing the azimuth). Slope is positive when surface is tilted in the direction of the surface azimuth. As a general rule, performance is somewhat optimized when the collector slope is set to the latitude.
12	Back loss convection coefficient	kJ/hr-m^2-K	20.0	The convective heat loss coefficient from the back of the collector to the ambient (does not include radiative losses).
13	Edge loss convection coefficient	kJ/hr-m^2-K	15.0	The convective heat transfer coefficient from the edge of the collector to the environment (does not include radiative losses).
14	Fluid heat transfer coefficient	kJ/hr-m^2-K	200.0	The heat transfer coefficient from the fluid in the flow channels to the walls of the pipe.
15	Atmospheric pressure	atm	1.0	The absolute atmospheric pressure.
IF Top Loss Mode (PARAMETER 12) = 2				
16	Top loss coefficient	kJ/hr-m^2-K	15.0	The heat transfer coefficient (combined radiative plus convective) for the top surface of the collector to the ambient.

OUTPUTS

Output	Name	Unit	Comment

Number			
1	Outlet temperature	C	The temperature of the fluid exiting the solar collector array.
2	Outlet flow rate	kg/hr	The flow rate of the fluid exiting the solar collector array.
3	Useful energy gain	kJ/hr	The rate of useful energy gain by the solar collector fluid.
4	Collector F'	-	The efficiency of the solar collector in transferring incident solar radiation to useful fluid energy.
5	Collector FR	-	The calculated collector heat removal factor.
6	Collector top losses	kJ/hr	The rate at which energy is lost to the environment through convection and radiation from the top surface of the collector.
7	Collector back losses	kJ/hr	The rate at which energy is lost to the environment through convection and radiation from the back surface of the collector.
8	Collector edge losses	kJ/hr	The rate at which energy is lost to the environment through convection and radiation from the edges of the collector.
9	Mean fluid temperature	C	The mean temperature of the fluid in the solar collector.
10	Plate temperature	C	The mean surface temperature of the absorber plate.
11	Incidence angle modifier	-	The radiation weighted average of the incidence angle modifiers for diffuse and beam radiation.
12	Overall heat loss coefficient	kJ/hr-m^2-K	The overall heat loss coefficient of the solar collector (top + edges + bottom).

TYPE 565: THEORETICAL SERPENTINE TUBE SOLAR COLLECTOR

PARAMETERS

Parameter Number	Name	Unit	Typical Value	Comment
1	Collector length	m	1.00	The length of the collector in the flow direction. If the user wishes to model an entire solar collector array using this model, this parameter should be set to the length of one collector multiplied by the number of collectors that are connected in series.
2	Collector width	m	1.00	The width of the collector (across the tubes). If the user wishes to model an entire solar collector array using this model, this parameter should be set to the width of one collector multiplied by the total number of collectors and divided by the number of collectors that are connected in series.
3	Absorber plate thickness	m	0.003	The thickness of the absorber plate.
4	Conductivity of absorber material	kJ/hr-m.K	900.0	The thermal conductivity of the absorber plate material.
5	Number of serpentine bends	-	10	The number of serpentine bends that the collector pipe makes as it travels up the absorber plate. The number of bends is 3 in the simple diagram below. 
6	Serpentine spacing	m	0.08	The distance between adjacent pipes of the serpentine pattern.
7	Serpentine length	m	0.9	The length of one of the tubes comprising the serpentine pattern.
8	Inner tube diameter	m	0.025	The inner diameter of the fluid tubes for the solar collector.
9	Outer tube diameter	m	0.028	The outer diameter of the fluid tubes for the solar collector.
10	Bond resistance	hr-m^2-K/kJ	0.05	The resistance to heat transfer provided by the bond material (bonding the tube to the plate).
11	Fluid specific heat	kJ/kg-K	4.19	The specific heat of the fluid flowing through the solar collector array.
12	Absorptance of the absorber plate	0..1	0.9	The absorptance of the collector absorber plate for solar radiation.
13	Emissivity of the absorber plate	0..1	0.9	The emissivity of the collector absorber plate for long-wave radiation exchange with the sky.
14	Top loss mode	-	2	This parameter indicates the top surface heat loss calculation mode for the collector: 1 = the top losses will be calculated from a theoretical analysis, 2 = the top loss heat transfer coefficient will be provided by the user
15	Number of identical covers	-	1	The number of identical covers for the solar collector.
16	Index of refraction of	-	1.526	The index of refraction of the material comprising the covers

	cover material			of the solar collector.
17	Extinction coefficient, thickness product	-	0.005	The product of the cover material extinction coefficient and the thickness of the cover material.

INPUTS

Input Number	Name	Unit	Typical Value	Comment
1	Inlet temperature	C	20.0	The temperature of the fluid entering the solar collector.
2	Inlet flow rate	kg/hr	100.0	The flow rate of the fluid entering the solar collector array.
3	Ambient temperature	C	20.0	The temperature of the environment in which the solar collector is located. This temperature will be used for loss calculations.
4	Sky temperature	C	10.0	The temperature of the sky for calculating long-wave radiation losses from the collector surface.
5	Wind velocity	m/s	5.0	The velocity of the wind blowing across the top of the solar collector array.
6	Incident radiation	kJ/m^2-hr	0.0	The total (beam + diffuse) radiation incident on the plane of the solar collector per unit area. This input is commonly hooked up to output 7 of the TYPE 16 radiation processor.
7	Total horizontal radiation	kJ/m^2-hr	0.0	The rate at which total solar radiation (beam + diffuse) strikes a horizontal surface.
8	Horizontal diffuse radiation	kJ/m^2-hr	0.0	The rate at which diffuse radiation strikes a horizontal surface.
9	Ground reflectance	0..1	0.2	The reflectance of the surface above which the solar collector is positioned. Typical values are 0.2 for ground not covered by snow and 0.7 for snow-covered ground. The reflectance is the ratio of reflected radiation to total incident radiation and therefore must be between 0 and 1.
10	Solar incidence angle	degrees	45.0	The angle of incidence between beam solar radiation and the normal vector to the sloped collector surface.
11	Collector slope	degrees	0.0	The slope of the collector surface (0=horizontal, 90=vertical facing the azimuth). Slope is positive when surface is tilted in the direction of the surface azimuth. As a general rule, performance is somewhat optimized when the collector slope is set to the latitude.
12	Top loss coefficient	kJ/hr-m^2-K	15.0	The heat transfer coefficient (combined radiative plus convective) for the top surface of the collector to the ambient. NOTE: this input is IGNORED if PARAMETER 14 (Top Loss Mode) is set to 1
13	Back loss convection coefficient	kJ/hr-m^2-K	20.0	The convective heat loss coefficient from the back of the collector to the ambient (does not include radiative losses).
14	Edge loss convection coefficient	kJ/hr-m^2-K	15.0	The convective heat transfer coefficient from the edge of the collector to the environment (does not include radiative losses).
15	Fluid heat transfer coefficient	kJ/hr-m^2-K	200.0	The heat transfer coefficient from the fluid in the flow channels to the walls of the pipe.
16	Atmospheric pressure	atm	1.0	The absolute atmospheric pressure.

OUTPUTS

Output Number	Name	Unit	Comment
1	Outlet temperature	C	The temperature of the fluid exiting the solar collector array.
2	Outlet flow rate	kg/hr	The flow rate of the fluid exiting the solar collector array.
3	Useful energy gain	kJ/hr	The rate of useful energy gain by the solar collector fluid.
4	Collector FR	-	The calculated collector heat removal factor.
5	Collector top losses	kJ/hr	The rate at which energy is lost to the environment through convection and radiation from the top surface of the collector.
6	Collector back losses	kJ/hr	The rate at which energy is lost to the environment through convection and radiation from the back surface of the collector.
7	Collector edge losses	kJ/hr	The rate at which energy is lost to the environment through convection and radiation from the edges of the collector.
8	Plate temperature	C	The mean surface temperature of the absorber plate.
9	Incidence angle modifier	-	The radiation weighted average of the incidence angle modifiers for diffuse and beam radiation.
10	Overall heat loss coefficient	kJ/hr-m^2-K	The overall heat loss coefficient of the solar collector (top + edges + bottom).

STORAGE TANK COMPONENTS

Storage Tank Components

TYPE 502: THREE-STAGE AQUASTAT IN HEATING MODE

PARAMETERS

Parameter Number	Name	Unit	Typical Value	Comment
1	Number of oscillations permitted	-	5	The number of oscillations of the controller state allowed in one time step before the output will be fixed and the solution found. -If the number of oscillations is set to an odd number, the control may bounce between two control states for successive time steps -If the number of oscillations is set to an even number, the control system may stay longer in one regime than actually intended.
2	1st stage heating in 2nd stage?	-	1	This controller will disable the 1st stage heating system when the 2nd stage heating system comes on (set this parameter to 0), or continue to operate the 1st stage heating system while the 2nd stage heating system is operating (set this parameter to 1).
3	2nd stage heating in 3rd stage?	-	1	This controller will disable the 2nd stage heating system when operating in 3rd stage heating mode (set this parameter to 0) or continue to operate the 2nd stage heating system when operating in 3rd stage heating mode (set this parameter to 1)
4	1st stage heating in 3rd stage?	-	1	This controller will disable the first stage heating system when in third stage heating mode (value = 0), or continue to operate the 1st stage heating system when in third stage heating mode (value = 1)
5	Dead band temperature	ΔC	5.0	The controller will turn the heaters ON at (set point – deadband/2) and OFF at (set point + deadband/2).

INPUTS

Input Number	Name	Unit	Typical Value	Comment
1	Fluid temperature	C	20.0	The temperature of the fluid being monitored by the controller
2	1st stage heating temperature	C	20.0	The tank (water) temperature below which first stage heating is commanded
3	2nd stage heating temperature	C	18.0	The tank (water) temperature below which second stage heating is commanded.
4	3rd stage heating temperature	C	16.0	The tank (water) temperature below which third stage heating (auxiliary) is commanded.

OUTPUTS

Output Number	Name	Unit	Comment
1	Control signal for 1st stage heating	-	The control signal for first stage heating 1 = 1st stage heating is require 0 = 1st stage heating is not require
2	Control signal for 2nd stage heating	-	The control signal for the second stage heating equipment 1 = 2nd stage heating is require 0 = 2nd stage heating is not required
3	Control signal for 3rd stage heating	-	The control signal for third stage heating: 0 = 3rd stage heating is not required 1 = 3rd stage heating is required
4	Conditioning signal	-	If any of the heating signals is non-zero, this output will be set to 1. This output can be used to control a pump or fan

TYPE 503: THREE-STAGE AQUASTAT IN COOLING MODE

PARAMETERS

Parameter Number	Name	Unit	Typical Value	Comment
1	Number of oscillations permitted	-	5	The number of oscillations of the controller state allowed in one time step before the output will be fixed and the solution found. -If the number of oscillations is set to an odd number, the control may bounce between two control states for successive time steps -If the number of oscillations is set to an even number, the control system may stay longer in one regime than actually intended.
2	1st stage cooling in 2nd stage?	-	1	This controller will disable the first-stage cooling system when the 2nd stage cooling system comes on (set this parameter to 0), or continue to operate the 1st stage cooling system while the 2nd stage cooling system is operating (set this parameter to 1)
3	2nd stage cooling in 3rd stage?	-	1	This controller will disable the 2nd stage cooling system when operating in 3rd stage cooling mode (set this parameter to 1) or continue to operate the 2nd stage cooling system when operating in 3rd stage cooling mode (set this parameter to 0)
4	1st stage cooling in 3rd stage?	-	1	This controller will disable the 1st stage cooling system when in 3rd stage cooling mode (set this parameter to 0), or continue to operate the 1st stage cooling system when in 3rd stage cooling mode (set this parameter to 1)
5	1st stage cooling temperature	C	20.0	The tank (water) temperature above which first stage cooling is commanded
6	2nd stage cooling temperature	C	18.0	The tank (water) temperature above which second stage cooling is commanded.
7	3rd stage cooling temperature	C	16.0	The tank (water) temperature above which third stage cooling is commanded.
8	Cooling set up temperature difference	ΔC	1.0	The set up temperature difference for cooling. This parameter is used to modify the set point for cooling operation based on the setback control function input. If no setback is desired, simply set this parameter to 0.0.
9	Temperature dead band	ΔC	2.0	The dead band temperature difference of the controller. In this model hysteresis effects can be modeled by setting this parameter to a non-zero value.

INPUTS

Input Number	Name	Unit	Typical Value	Comment
1	Fluid temperature	C	20.0	The temperature of the fluid being monitored by the controller
2	Set-up control function	-	1	The set-up control function. This input is usually connected to forcing function output or an equation. This input is multiplied by the setup temperature difference and used to modify the set point temperatures for cooling.

OUTPUTS

Output Number	Name	Unit	Comment
1	Control signal for 1st stage cooling	-	The control signal for first stage cooling 1 = 1st stage cooling is required 0 = 1st stage cooling is not required
2	Control signal for 2nd stage cooling	-	The control signal for the second stage cooling equipment 1 = 2nd stage cooling is required 0 = 2nd stage cooling is not required
3	Control signal for 3rd stage cooling	-	The control signal for third stage cooling 0 = 3rd stage cooling is not required 1 = 3rd stage cooling is required
4	Conditioning signal	-	If any of the cooling signals is non-zero, this output will be set to 1. This output can be used to control a pump or fan.

TYPE 531: RECTANGULAR STORAGE TANK WITH OPTIONAL HEAT EXCHANGER

The various options associated with this component make the Parameter/Input/Output list quite complex. For users of the TRNSYS Studio, a "plugin" was created to vastly simplify the process of entering input data. The following Parameter/Input/Output list is quite general in nature, and is intended primarily as a reference for users needing to employ this component in a distributable TRNSED application or in an input file not created by the TRNSYS Simulation Studio.

PARAMETERS

Parameter Number	Name	Unit	Typical Value	Comment
1	Logical unit	-	-10	The logical unit ASSIGNed to the data file containing the parameters for this model. If this value is less than 10, the parameters will be read from the input file as they are for any other model. If this value is 10 or greater, the parameters after parameter 5 will be read from the data file.
2	Number of tank nodes	-	5	The number of isothermal tank nodes into which the storage tank will be divided.
3	Number of ports	-	1	The number of paired inlet/outlet ports in the tank
4	Number of immersed heat exchangers	-	1	The number of heat exchangers that are immersed in the storage tank
5	Number of miscellaneous heat gains	-	1	The number of miscellaneous heat gains into the storage tank. For each miscellaneous heat gain the user must specify which node of the tank gets the heat gain (a parameter cycled below) and the value of the heat gain (a cycled input).
	If parameter 1 is greater than or equal to 10, the following parameters are read from the data file. If parameter 1 is less than 10, the following parameters are required to be specified in the input file.			
	Tank volume	m^3	0.3	The internal volume of the storage tank.
	Tank height	m	1.0	The height of the rectangular tank.
	Tank perimeter	m	2.20	The perimeter of the rectangular tank.
	Tank fluid	-	1	The fluid contained in the storage tank: 0 = user-provided fluid properties 1 = pure water 2 = propylene glycol and water solution 3 = ethylene glycol and water solution.
	If tank fluid = 0 five additional parameters are required (m=5)			
	Fluid specific heat	kJ/kg-K	4.190	The specific heat of the tank fluid.
	Fluid density	kg/ m^3	1000.0	The density heat of the tank fluid.
	Fluid thermal conductivity	kJ/hr-m-K	2.14	The thermal conductivity of the tank fluid.
	Fluid viscosity	kg/m/hr	3.21	The dynamic viscosity of the tank fluid.
	Fluid thermal expansion coefficient	1/K	0.00026	The volumetric expansion coefficient of the tank fluid.
	If tank fluid = 1, No further parameters needed (m=0)			
	If tank fluid = 2 or 3, one additional parameters is required (m=1)			
	Percent volume of tank fluid	%	0.0	The percentage by volume of the secondary fluid contained in the storage tank (propylene glycol for example).
Continuing on with the parameter specification for all tank fluids				

	Top loss coefficient	kJ/hr-m^2-K	5.0	The loss coefficient for the top of the storage tank.
The following parameter is cycled with the number of tank nodes				
Cycle	Edge loss coefficient	kJ/hr-m^2-K	5.0	The heat loss coefficient for the edges of the storage tank.
	Bottom loss coefficient	kJ/hr-m^2-K	5.0	The loss coefficient for the bottom of the storage tank.
	Additional thermal conductivity	kJ/hr-m-K	0.0	The additional effective thermal conductivity due to the walls of the storage tank and any additional heat transfer promoting devices immersed in the storage tank. Set this parameter to 0 to indicate that only the conduction between the fluid nodes should be considered. Set this parameter less than zero to indicate that no fluid conduction should be considered for this simulation.
The following parameters are cycled with the number of inlet ports				
Cycle This block of parameters is cycled with the number of ports	Inlet Flow Mode	-	1	An indicator as to how the inlet flow shall be treated: 1 = The user will provide the locations of the inlet and outlet ports in the storage tank 2 = The user will provide the outlet port locations and the fraction of inlet flows that end up in each node 3 = The inlet flow will seek the tank node closest in temperature to the inlet temperature
	If Inlet Flow Mode =1, two additional parameters are required			
	Entry node for Inlet i	-	1	The tank node into which the specified fluid inlet occurs.
	Exit node for Outlet i	-	5	The storage tank node from which the specified outlet occurs.
	If Inlet Flow Mode =2 the next parameter is required and the following parameter is cycled with the number of tank nodes.			
	Exit node for Outlet i	-	5	The storage tank node from which the specified outlet occurs.
	CYCLE Fraction of inlet flow into node	-	0.2	The fraction of the specified inlet flow that enters the specified node of the storage tank.
	If Inlet Flow Mode =3, one additional parameters is required			
	Exit node for Outlet i	-	5	The storage tank node from which the specified outlet occurs.
The following parameter is cycled with the number of tank nodes				
Cycle	Overall flue heat loss coefficient for specified node	kJ/h-K	3.0	The overall heat transfer coefficient (UA) from the specified node to the gas flue temperature (an input). The losses from the gas flue are set to zero for those periods where auxiliary energy is being added to the storage tank.
The following parameter is cycled with the number of miscellaneous heat gains				
Cycle	Node for misc. heat gain	-	1	The node into which the miscellaneous heat flow should be directed. This parameter is cycled with the number of misc. heat gains parameter,
The following parameters are cycled with the number of immersed heat exchangers				
Cycle This block of parameters is cycled with	Type of heat exchanger	-	4	The type of heat exchanger immersed in the storage tank. 1 = horizontal tube bank 2 = vertical tube bank 3 = coiled tube heat exchanger 4 = serpentine tube heat exchanger

cycled with the number of immersed heat exchangers	Number of HX nodes	-	5	The number of nodes into which the heat exchanger will be divided into in the flow direction.
	Heat exchanger fluid	-	2	The type of fluid flowing through the heat exchanger 0 = user-provided fluid properties 1 = pure water 2 = propylene glycol and water solution 3 = ethylene glycol and water solution.
	If HX fluid = 0, five additional parameters are required			
	Fluid specific heat	kJ/kg.K	4.190	The specific heat of the HX fluid.
	Fluid density	kg/ m^3	1000.0	The density heat of the HX fluid.
	Fluid thermal conductivity	kJ/hr-m-K	2.14	The thermal conductivity of the HX fluid.
	Fluid viscosity	kg/m/hr	3.21	The dynamic viscosity of the HX fluid.
	If HX fluid = 1, No further parameters needed			
	If HX fluid = 2 or 3, one additional parameter is required			
	Percent volume of HX fluid	-	0.1	The percentage by volume of the secondary fluid flowing through the heat exchanger (propylene glycol for example).
	Continuing on for all HX fluids			
	Multiplier for natural convection correlation	-	1	The value constant multiplier in the natural convection equation for the heat exchanger.
	Exponent for Rayleigh number	-	0.25	The value for n in the natural convection heat transfer.
	Geometry factor	-	1	The value for the geometry factor (GF) in the natural convection heat transfer equation.
Continued cycle 	Geometry factor exponent	-	0	The value of the geometry factor exponent (m) in the natural convection heat transfer correlation.
	HX tube inner diameter	m	0.01	The inner diameter of one of the identical tubes comprising the heat exchanger.
	HX tube outer diameter	m	0.015	The outer diameter of one of the identical tubes comprising the heat exchanger.
	HX wall conductivity	kJ/hr-m-K	900	The thermal conductivity of the wall material comprising the tubes of the heat exchanger.
	Length of heat exchanger tube	m	1.0	The length of one of the identical tubes comprising the heat exchanger.
	Number of tubes	-	50	The number of identical tubes comprising the heat exchanger.
	Header volume	m^3	0.01	The volume of the headers comprising the heat exchanger.
	HX cross sectional area	m^2	0.005	The cross-sectional area of the heat exchanger at the tank nodal boundaries.
	If HX Geometry = 3, two additional parameters are required			
	Coil diameter	m	0.5	The diameter of the coiled tube heat exchanger.
	Coil pitch	m	0.05	The pitch of the coiled tube heat exchanger.
	If HX Geometry = 1, The following parameter is required and cycled with the number of tank nodes			
	 Fraction of horizontal HX tubes in specified tank node	-	0.2	The fraction of the total heat exchanger tubes contained in this node of the storage tank.

	If HX Geometry =2, 3, or 4, the following two parameters are cycled with the number of heat exchanger nodes				
	CYCLE	Tank node for specified HX node	-	5	The tank node in which this heat exchanger node is completely immersed
		Fraction of HX length for specified HX node	-	0.2	The fraction of heat exchanger length assigned to this heat exchanger node.

INPUTS

Input Number	Name	Unit	Typical Value	Comment
The following two inputs are cycled with the number of inlet ports				
Cycle	Temperature at inlet	C	20.0	The temperature of the fluid entering the storage tank at the specified inlet.
	Flow rate at inlet	kg/hr	0.0	The flow rate of fluid entering the storage tank at the specified inlet.
The following two inputs are cycled with the number of heat exchangers				
Cycle	Temperature at HX inlet	C	20.0	The temperature of the fluid flowing into the immersed heat exchanger in the storage tank.
	Flow rate at HX inlet	kg/hr	0.0	The flow rate of fluid entering the immersed heat exchanger in the storage tank.
	Top loss temperature	C	20.0	The temperature of the environment for calculating losses from the top of the storage tank.
The following input is cycled with the number of tank nodes				
Cycle	Edge loss temperature	C	20.0	The temperature of the environment for calculating losses from the edge of the storage tank.
	Bottom loss temperature	C	20.0	The temperature of the environment for calculating losses from the bottom of the storage tank.
	Flue loss temperature	C	20.0	The temperature of the gas flue for calculating losses from the flue of the storage tank.
	Inversion mixing flow rate	kg/hr	-1.0	The mixing rate at which temperature inversions between adjacent nodes of the storage tank will be addressed. Setting this value to zero will allow the storage tank to remain inverted - where one node of the storage tank remains hotter than the node above it. Setting this value less than zero will cause the offending tank nodes to be completely mixed at the end of the time step.
The following input is cycled with the number of tank nodes				
Cycle	Auxiliary heating rate for node	kJ/hr	0.0	The rate at which energy is added to the specified node of the storage tank.
The following input is cycled with the number of miscellaneous heat gains				
Cycle	Miscellaneous heat addition for node	kJ/hr	0.0	The rate at which miscellaneous energy is added to the storage tank. The node into which this heat addition occurs is specified in the parameters to this model.

OUTPUTS

Output Number	Name	Unit	Comment
The following two outputs are cycled with the number of inlet ports			
	Temperature at outlet	C	The temperature of the fluid exiting the storage tank at the specified outlet.
	Flow rate at outlet	kg/hr	The flow rate of fluid exiting the storage tank through the specified outlet.
	Average tank temperature	C	The average temperature of the fluid in the storage tank.
	Energy delivered to tank flows	kJ/hr	The total rate at which energy is removed from the storage tank due to the fluid flow rate exiting through the outlet ports minus the rate at which energy is added to the storage tank by the fluid flow rate entering the storage tank through the inlet ports.
The following output is cycled with the number of inlet ports			
	Energy delivered to tank flow	kJ/hr	The rate at which energy is removed from the storage tank due to the fluid flow rate exiting through the specified outlet ports minus the rate at which energy is added to the storage tank by the fluid flow rate entering the storage tank through the specified inlet port.
	Top losses	kJ/hr	The rate at which energy is lost to the environment through the top of the storage tank.
	Edge losses	kJ/hr	The rate at which energy is lost to the environment through the edges of the storage tank.
	Bottom losses	kJ/hr	The rate at which energy is lost to the environment through the bottom of the storage tank.
	Flue losses	kJ/hr	The rate at which energy is lost to the environment through the storage tank flue.
	Auxiliary heating rate	kJ/hr	The rate at which auxiliary heat energy is added to the storage tank.
	Miscellaneous heating gains	kJ/hr	The rate at which miscellaneous energy is added to the tank.
	Tank energy storage rate	kJ/hr	The rate at which energy is stored by the fluid in the storage tank due to a rise in temperature of the storage.
	Energy delivered to all HX's	kJ/hr	The rate at which energy is removed from the immersed heat exchanger due to the fluid flow rate exiting the heat exchanger at the outlet minus the rate at which energy is added to the heat exchanger by the fluid flow rate entering through the HX inlet.
	Tank energy balance error	%	The percent energy balance error for the heat transfer in the storage tank.
The following output is cycled with the number of tank nodes			
	Temperature of tank node	C	The average temperature of the fluid in the specified node of the storage tank for the current time step.
The following two outputs are cycled with the number of heat exchangers			
	Temperature at HX exit	C	The temperature of the fluid exiting the storage tank from the immersed heat exchanger.
	Flow rate at HX exit	kg/hr	The flow rate of fluid exiting the storage tank from the immersed heat exchanger. This flow rate is set by the inlet flow rate to the heat exchanger.

The following output is cycled with the number of heat exchangers			
Cycle	Average HX temperature	C	The average temperature of the fluid in the immersed heat exchanger.
The following four outputs are cycled with the number of heat exchangers			
Cycle	Energy delivered from HX	kJ/hr	The rate at which energy is removed from the immersed heat exchanger due to the fluid flow rate exiting the heat exchanger at the outlet minus the rate at which energy is added to the heat exchanger by the fluid flow rate entering through the HX inlet.
	HX energy storage rate	kJ/hr	The rate at which energy is stored by the fluid in the immersed heat exchanger due to a temperature rise of the fluid.
	HX heat transfer	kJ/hr	The rate at which energy is transferred from the fluid in the storage tank to the fluid in the immersed heat exchanger.
	HX energy balance error	%	The percent energy balance error for the heat transfer for the fluid in the immersed heat exchanger.

DERIVATIVES

Derivative Number	Name	Unit	Comment
The following derivative is cycled with the number of tank nodes (Parameter 1)			
Cycle	Initial temperature of tank node	C	The temperature of the fluid in the specified node of the storage tank at the beginning of the simulation. All HX nodes contained within this storage tank node will also be initialized to this temperature.

TYPE 532: SPHERICAL STORAGE TANK WITH OPTIONAL HEAT EXCHANGER

The various options associated with this component make the Parameter/Input/Output list quite complex. For users of the TRNSYS Studio, a "plugin" was created to vastly simplify the process of entering input data. The following Parameter/Input/Output list is quite general in nature, and is intended primarily as a reference for users needing to employ this component in a distributable TRNSED application or in an input file not created by the TRNSYS Simulation Studio.

PARAMETERS

Parameter Number	Name	Unit	Typical Value	Comment
1	Logical unit	-	-10	The logical unit ASSIGNed to the data file containing the parameters for this model. If this value is less than 10, the parameters will be read from the input file as they are for any other model. If this value is 10 or greater, the parameters after parameter 5 will be read from the data file.
2	Number of tank nodes	-	5	The number of isothermal tank nodes into which the storage tank will be divided.
3	Number of ports	-	1	The number of paired inlet/outlet ports in the tank
4	Number of immersed heat exchangers	-	1	The number of heat exchangers that are immersed in the storage tank
5	Number of miscellaneous heat gains	-	1	The number of miscellaneous heat gains into the storage tank. For each miscellaneous heat gain the user must specify which node of the tank gets the heat gain (a parameter cycled below) and the value of the heat gain (a cycled input).
	If parameter 1 is greater than or equal to 10, the following parameters are read from the data file. If parameter 1 is less than 10, the following parameters are required to be specified in the input file.			
	Tank volume	m^3	0.3	The internal volume of the storage tank.
	Tank fluid	-	1	The fluid contained in the storage tank: 0 = user-provided fluid properties 1 = pure water 2 = propylene glycol and water solution 3 = ethylene glycol and water solution.
	If tank fluid = 0 five additional parameters are required (m=5)			
	Fluid specific heat	kJ/kg-K	4.190	The specific heat of the tank fluid.
	Fluid density	kg/ m^3	1000.0	The density heat of the tank fluid.
	Fluid thermal conductivity	kJ/hr-m-K	2.14	The thermal conductivity of the tank fluid.
	Fluid viscosity	kg/m/hr	3.21	The dynamic viscosity of the tank fluid.
	Fluid thermal expansion coefficient	1/K	0.00026	The volumetric expansion coefficient of the tank fluid.
	If tank fluid = 1, No further parameters needed (m=0)			
	If tank fluid = 2 or 3, one additional parameters is required (m=1)			
	Percent volume of tank fluid	%	0.0	The percentage by volume of the secondary fluid contained in the storage tank (propylene glycol for example).
Continuing on with the parameter specification for all tank fluids				
The following parameter is cycled with the number of tank nodes				

Cycle	Side loss coefficient	kJ/hr-m^2-K	5.0	The heat loss coefficient for the side of the storage tank.
	Additional thermal conductivity	kJ/hr-m-K	0.0	The additional effective thermal conductivity due to the walls of the storage tank and any additional heat transfer promoting devices immersed in the storage tank. Set this parameter to 0 to indicate that only the conduction between the fluid nodes should be considered. Set this parameter less than zero to indicate that no fluid conduction should be considered for this simulation.
The following parameters are cycled with the number of inlet ports				
Cycle This block of parameters is cycled with the number of ports	Inlet Flow Mode	-	1	An indicator as to how the inlet flow shall be treated: 1 = The user will provide the locations of the inlet and outlet ports in the storage tank 2 = The user will provide the outlet port locations and the fraction of inlet flows that end up in each node 3 = The inlet flow will seek the tank node closest in temperature to the inlet temperature
	If Inlet Flow Mode =1, two additional parameters are required			
	Entry node for Inlet i	-	1	The tank node into which the specified fluid inlet occurs.
	Exit node for Outlet i	-	5	The storage tank node from which the specified outlet occurs.
	If Inlet Flow Mode =2 the next parameter is required and the following parameter is cycled with the number of tank nodes.			
	Exit node for Outlet i	-	5	The storage tank node from which the specified outlet occurs.
	CYCLE Fraction of inlet flow into node	-	0.2	The fraction of the specified inlet flow that enters the specified node of the storage tank.
	If Inlet Flow Mode =3, one additional parameters is required			
	Exit node for Outlet i	-	5	The storage tank node from which the specified outlet occurs.
The following parameter is cycled with the number of tank nodes				
Cycle	Overall flue heat loss coefficient for specified node	kJ/h-K	3.0	The overall heat transfer coefficient (UA) from the specified node to the gas flue temperature (an input). The losses from the gas flue are set to zero for those periods where auxiliary energy is being added to the storage tank.
The following parameter is cycled with the number of miscellaneous heat gains				
Cycle	Node for misc. heat gain	-	1	The node into which the miscellaneous heat flow should be directed. This parameter is cycled with the number of misc. heat gains parameter,
The following parameters are cycled with the number of immersed heat exchangers				
Cycle This block of parameters is cycled with the number of immersed heat	Type of heat exchanger	-	4	The type of heat exchanger immersed in the storage tank. 1 = horizontal tube bank 2 = vertical tube bank 3 = coiled tube heat exchanger 4 = serpentine tube heat exchanger
	Number of HX nodes	-	5	The number of nodes into which the heat exchanger will be divided into in the flow direction.

immersed heat exchangers	Heat exchanger fluid	-	2	The type of fluid flowing through the heat exchanger 0 = user-provided fluid properties 1 = pure water 2 = propylene glycol and water solution 3 = ethylene glycol and water solution.
	If HX fluid = 0, five additional parameters are required			
	Fluid specific heat	kJ/kg-K	4.190	The specific heat of the HX fluid.
	Fluid density	kg/ m^3	1000.0	The density heat of the HX fluid.
	Fluid thermal conductivity	kJ/hr-m-K	2.14	The thermal conductivity of the HX fluid.
	Fluid viscosity	kg/m/hr	3.21	The dynamic viscosity of the HX fluid.
	If HX fluid = 1, No further parameters needed			
	If HX fluid = 2 or 3, one additional parameter is required			
	Percent volume of HX fluid	-	0.1	The percentage by volume of the secondary fluid flowing through the heat exchanger (propylene glycol for example).
	Continuing on for all HX fluids			
	Multiplier for natural convection correlation	-	1	The value constant multiplier in the natural convection equation for the heat exchanger.
	Exponent for Rayleigh number	-	0.25	The value for n in the natural convection heat transfer.
Continued cycle Cycle	Geometry factor	-	1	The value for the geometry factor (GF) in the natural convection heat transfer equation.
	Geometry factor exponent	-	0	The value of the geometry factor exponent (m) in the natural convection heat transfer correlation.
	HX tube inner diameter	m	0.01	The inner diameter of one of the identical tubes comprising the heat exchanger.
	HX tube outer diameter	m	0.015	The outer diameter of one of the identical tubes comprising the heat exchanger.
	HX wall conductivity	kJ/hr-m-K	900	The thermal conductivity of the wall material comprising the tubes of the heat exchanger.
	Length of heat exchanger tube	m	1.0	The length of one of the identical tubes comprising the heat exchanger.
	Number of tubes	-	50	The number of identical tubes comprising the heat exchanger.
	Header volume	m^3	0.01	The volume of the headers comprising the heat exchanger.
	HX cross sectional area	m^2	0.005	The cross-sectional area of the heat exchanger at the tank nodal boundaries.
	If HX Geometry = 3, two additional parameters are required			
	Coil diameter	m	0. 5	The diameter of the coiled tube heat exchanger.
	Coil pitch	m	0.05	The pitch of the coiled tube heat exchanger.
	If HX Geometry = 1, The following parameter is required and cycled with the number of tank nodes			
	CYCLE Fraction of horizontal HX tubes in specified tank node	-	0.2	The fraction of the total heat exchanger tubes contained in this node of the storage tank.
	If HX Geometry =2, 3, or 4, the following two parameters are cycled with the number of heat exchanger nodes.			

	CYCLE	Tank node for specified HX node	-	5	The tank node in which this heat exchanger node is completely immersed
		Fraction of HX length for specified HX node	-	0.2	The fraction of heat exchanger length assigned to this heat exchanger node.

INPUTS

Input Number	Name	Unit	Typical Value	Comment
The following two inputs are cycled with the number of inlet ports				
Cycle	Temperature at inlet	C	20.0	The temperature of the fluid entering the storage tank at the specified inlet.
	Flow rate at inlet	kg/hr	0.0	The flow rate of fluid entering the storage tank at the specified inlet.
The following two inputs are cycled with the number of heat exchangers				
Cycle	Temperature at HX inlet	C	20.0	The temperature of the fluid flowing into the immersed heat exchanger in the storage tank.
	Flow rate at HX inlet	kg/hr	0.0	The flow rate of fluid entering the immersed heat exchanger in the storage tank.
The following input is cycled with the number of tank nodes				
Cycle	Side loss temperature	C	20.0	The temperature of the environment for calculating losses from the side of the storage tank.
	Flue loss temperature	C	20.0	The temperature of the gas flue for calculating losses from the flue of the storage tank.
	Inversion mixing flow rate	kg/hr	-1.0	The mixing rate at which temperature inversions between adjacent nodes of the storage tank will be addressed. Setting this value to zero will allow the storage tank to remain inverted - where one node of the storage tank remains hotter than the node above it. Setting this value less than zero will cause the offending tank nodes to be completely mixed at the end of the time step.
The following input is cycled with the number of tank nodes				
Cycle	Auxiliary heating rate for node	kJ/hr	0.0	The rate at which energy is added to the specified node of the storage tank.
The following input is cycled with the number of miscellaneous heat gains				
Cycle	Miscellaneous heat addition for node	kJ/hr	0.0	The rate at which miscellaneous energy is added to the storage tank. The node into which this heat addition occurs is specified in the parameters to this model.

OUTPUTS

Output Number	Name	Unit	Comment

The following two outputs are cycled with the number of inlet ports			
Cycle	Temperature at outlet	C	The temperature of the fluid exiting the storage tank at the specified outlet.
	Flow rate at outlet	kg/hr	The flow rate of fluid exiting the storage tank through the specified outlet.
	Average tank temperature	C	The average temperature of the fluid in the storage tank.
	Energy delivered to tank flows	kJ/hr	The total rate at which energy is removed from the storage tank due to the fluid flow rate exiting through the outlet ports minus the rate at which energy is added to the storage tank by the fluid flow rate entering the storage tank through the inlet ports.
The following output is cycled with the number of inlet ports			
Cycle	Energy delivered to tank flow	kJ/hr	The rate at which energy is removed from the storage tank due to the fluid flow rate exiting through the specified outlet ports minus the rate at which energy is added to the storage tank by the fluid flow rate entering the storage tank through the specified inlet port.
	Side losses	kJ/hr	The rate at which energy is lost to the environment through the side of the storage tank.
	Flue losses	kJ/hr	The rate at which energy is lost to the environment through the storage tank flue.
	Auxiliary heating rate	kJ/hr	The rate at which auxiliary heat energy is added to the storage tank.
	Miscellaneous heating gains	kJ/hr	The rate at which miscellaneous energy is added to the tank.
	Tank energy storage rate	kJ/hr	The rate at which energy is stored by the fluid in the storage tank due to a rise in temperature of the storage.
	Energy delivered to all HX's	kJ/hr	The rate at which energy is removed from the immersed heat exchanger due to the fluid flow rate exiting the heat exchanger at the outlet minus the rate at which energy is added to the heat exchanger by the fluid flow rate entering through the HX inlet.
	Tank energy balance error	%	The percent energy balance error for the heat transfer in the storage tank.
The following output is cycled with the number of tank nodes			
Cycle	Temperature of tank node	C	The average temperature of the fluid in the specified node of the storage tank for the current time step.
The following two outputs are cycled with the number of heat exchangers			
Cycle	Temperature at HX exit	C	The temperature of the fluid exiting the storage tank from the immersed heat exchanger.
	Flow rate at HX exit	kg/hr	The flow rate of fluid exiting the storage tank from the immersed heat exchanger. This flow rate is set by the inlet flow rate to the heat exchanger.
The following output is cycled with the number of heat exchangers			
Cycle	Average HX temperature	C	The average temperature of the fluid in the immersed heat exchanger.
The following four outputs are cycled with the number of heat exchangers			
Cycle	Energy delivered from HX	kJ/hr	The rate at which energy is removed from the immersed heat exchanger due to the fluid flow rate exiting the heat exchanger at the outlet minus the rate at which energy is added to the heat exchanger by the fluid flow rate entering through the HX inlet.
	HX energy storage rate	kJ/hr	The rate at which energy is stored by the fluid in the immersed heat exchanger due to a temperature rise of the fluid.

	HX heat transfer	kJ/hr	The rate at which energy is transferred from the fluid in the storage tank to the fluid in the immersed heat exchanger.
	HX energy balance error	%	The percent energy balance error for the heat transfer for the fluid in the immersed heat exchanger.

DERIVATIVES

Derivative Number	Name	Unit	Comment
The following derivative is cycled with the number of tank nodes (Parameter 1)			
	Initial temperature of tank node	C	The temperature of the fluid in the specified node of the storage tank at the beginning of the simulation. All HX nodes contained within this storage tank node will also be initialized to this temperature.

TYPE 533: HORIZONTALLY CYLINDRICAL STORAGE TANK WITH OPTIONAL HEAT EXCHANGER

The various options associated with this component make the Parameter/Input/Output list quite complex. For users of the TRNSYS Studio, a "plugin" was created to vastly simplify the process of entering input data. The following Parameter/Input/Output list is quite general in nature, and is intended primarily as a reference for users needing to employ this component in a distributable TRNSED application or in an input file not created by the TRNSYS Simulation Studio.

PARAMETERS

Parameter Number	Name	Unit	Typical Value	Comment
1	Logical unit	-	-10	The logical unit ASSIGNed to the data file containing the parameters for this model. If this value is less than 10, the parameters will be read from the input file as they are for any other model. If this value is 10 or greater, the parameters after parameter 5 will be read from the data file.
2	Number of tank nodes	-	5	The number of isothermal tank nodes into which the storage tank will be divided.
3	Number of ports	-	1	The number of paired inlet/outlet ports in the tank
4	Number of immersed heat exchangers	-	1	The number of heat exchangers that are immersed in the storage tank
5	Number of miscellaneous heat gains	-	1	The number of miscellaneous heat gains into the storage tank. For each miscellaneous heat gain the user must specify which node of the tank gets the heat gain (a parameter cycled below) and the value of the heat gain (a cycled input).
	If parameter 1 is greater than or equal to 10, the following parameters are read from the data file. If parameter 1 is less than 10, the following parameters are required to be specified in the input file.			
	Tank volume	m^3	0.3	The internal volume of the storage tank.
	Tank length	m	1.0	The length of the horizontal cylinder.
	Tank fluid	-	1	The fluid contained in the storage tank: 0 = user-provided fluid properties 1 = pure water 2 = propylene glycol and water solution 3 = ethylene glycol and water solution.
	If tank fluid = 0 five additional parameters are required (m=5)			
	Fluid specific heat	kJ/kg-K	4.190	The specific heat of the tank fluid.
	Fluid density	kg/ m^3	1000.0	The density heat of the tank fluid.
	Fluid thermal conductivity	kJ/hr-m-K	2.14	The thermal conductivity of the tank fluid.
	Fluid viscosity	kg/m/hr	3.21	The dynamic viscosity of the tank fluid.
	Fluid thermal expansion coefficient	1/K	0.00026	The volumetric expansion coefficient of the tank fluid.
	If tank fluid = 1, No further parameters needed (m=0)			
	If tank fluid = 2 or 3, one additional parameters is required (m=1)			
	Percent volume of tank fluid	%	0.0	The percentage by volume of the secondary fluid contained in the storage tank (propylene glycol for example).
Continuing on with the parameter specification for all tank fluids				

	Left end loss coefficient	kJ/hr-m^2-K	5.0	The loss coefficient for the left end of the storage tank.
The following parameter is cycled with the number of tank nodes				
Cycle	Edge loss coefficient	kJ/hr-m^2-K	5.0	The heat loss coefficient for the edges of the storage tank.
	Right end loss coefficient	kJ/hr-m^2-K	5.0	The loss coefficient for the right end of the storage tank.
	Additional thermal conductivity	kJ/hr-m-K	0.0	The additional effective thermal conductivity due to the walls of the storage tank and any additional heat transfer promoting devices immersed in the storage tank. Set this parameter to 0 to indicate that only the conduction between the fluid nodes should be considered. Set this parameter less than zero to indicate that no fluid conduction should be considered for this simulation.
The following parameters are cycled with the number of inlet ports				
Cycle This block of parameters is cycled with the number of ports	Inlet Flow Mode	-	1	An indicator as to how the inlet flow shall be treated: 1 = The user will provide the locations of the inlet and outlet ports in the storage tank 2 = The user will provide the outlet port locations and the fraction of inlet flows that end up in each node 3 = The inlet flow will seek the tank node closest in temperature to the inlet temperature
	If Inlet Flow Mode =1, two additional parameters are required			
	Entry node for Inlet i	-	1	The tank node into which the specified fluid inlet occurs.
	Exit node for Outlet i	-	5	The storage tank node from which the specified outlet occurs.
	If Inlet Flow Mode =2 the next parameter is required and the following parameter is cycled with the number of tank nodes.			
	Exit node for Outlet i	-	5	The storage tank node from which the specified outlet occurs.
	CYCLE Fraction of inlet flow into node	-	0.2	The fraction of the specified inlet flow that enters the specified node of the storage tank.
	If Inlet Flow Mode =3, one additional parameters is required			
	Exit node for Outlet i	-	5	The storage tank node from which the specified outlet occurs.
The following parameter is cycled with the number of tank nodes				
Cycle	Overall flue heat loss coefficient for specified node	kJ/h-K	3.0	The overall heat transfer coefficient (UA) from the specified node to the gas flue temperature (an input). The losses from the gas flue are set to zero for those periods where auxiliary energy is being added to the storage tank.
The following parameter is cycled with the number of miscellaneous heat gains				
Cycle	Node for misc. heat gain	-	1	The node into which the miscellaneous heat flow should be directed. This parameter is cycled with the number of misc. heat gains parameter,
The following parameters are cycled with the number of immersed heat exchangers				
Cycle This block of parameters is cycled with	Type of heat exchanger	-	4	The type of heat exchanger immersed in the storage tank. 1 = horizontal tube bank 2 = vertical tube bank 3 = coiled tube heat exchanger 4 = serpentine tube heat exchanger

cycled with the number of immersed heat exchangers	Number of HX nodes	-	5	The number of nodes into which the heat exchanger will be divided into in the flow direction.
	Heat exchanger fluid	-	2	The type of fluid flowing through the heat exchanger 0 = user-provided fluid properties 1 = pure water 2 = propylene glycol and water solution 3 = ethylene glycol and water solution.
	If HX fluid = 0, five additional parameters are required			
	Fluid specific heat	kJ/kg.K	4.190	The specific heat of the HX fluid.
	Fluid density	kg/ m^3	1000.0	The density heat of the HX fluid.
	Fluid thermal conductivity	kJ/hr-m-K	2.14	The thermal conductivity of the HX fluid.
	Fluid viscosity	kg/m/hr	3.21	The dynamic viscosity of the HX fluid.
	If HX fluid = 1, No further parameters needed			
	If HX fluid = 2 or 3, one additional parameter is required			
	Percent volume of HX fluid	-	0.1	The percentage by volume of the secondary fluid flowing through the heat exchanger (propylene glycol for example).
	Continuing on for all HX fluids			
	Multiplier for natural convection correlation	-	1	The value constant multiplier in the natural convection equation for the heat exchanger.
	Exponent for Rayleigh number	-	0.25	The value for n in the natural convection heat transfer.
	Geometry factor	-	1	The value for the geometry factor (GF) in the natural convection heat transfer equation.
Continued cycle 	Geometry factor exponent	-	0	The value of the geometry factor exponent (m) in the natural convection heat transfer correlation.
	HX tube inner diameter	m	0.01	The inner diameter of one of the identical tubes comprising the heat exchanger.
	HX tube outer diameter	m	0.015	The outer diameter of one of the identical tubes comprising the heat exchanger.
	HX wall conductivity	kJ/hr-m-K	900	The thermal conductivity of the wall material comprising the tubes of the heat exchanger.
	Length of heat exchanger tube	m	1.0	The length of one of the identical tubes comprising the heat exchanger.
	Number of tubes	-	50	The number of identical tubes comprising the heat exchanger.
	Header volume	m^3	0.01	The volume of the headers comprising the heat exchanger.
	HX cross sectional area	m^2	0.005	The cross-sectional area of the heat exchanger at the tank nodal boundaries.
	If HX Geometry = 3, two additional parameters are required			
	Coil diameter	m	0. 5	The diameter of the coiled tube heat exchanger.
	Coil pitch	m	0.05	The pitch of the coiled tube heat exchanger.
	If HX Geometry = 1, The following parameter is required and cycled with the number of tank nodes			
	Fraction of horizontal HX tubes in specified tank node	-	0.2	The fraction of the total heat exchanger tubes contained in this node of the storage tank.

	If HX Geometry =2, 3, or 4, the following two parameters are cycled with the number of heat exchanger nodes.				
	CYCLE	Tank node for specified HX node	-	5	The tank node in which this heat exchanger node is completely immersed
		Fraction of HX length for specified HX node	-	0.2	The fraction of heat exchanger length assigned to this heat exchanger node.

INPUTS

Input Number	Name	Unit	Typical Value	Comment
The following two inputs are cycled with the number of inlet ports				
Cycle	Temperature at inlet	C	20.0	The temperature of the fluid entering the storage tank at the specified inlet.
	Flow rate at inlet	kg/hr	0.0	The flow rate of fluid entering the storage tank at the specified inlet.
The following two inputs are cycled with the number of heat exchangers				
Cycle	Temperature at HX inlet	C	20.0	The temperature of the fluid flowing into the immersed heat exchanger in the storage tank.
	Flow rate at HX inlet	kg/hr	0.0	The flow rate of fluid entering the immersed heat exchanger in the storage tank.
	Left end loss temperature	C	20.0	The temperature of the environment for calculating losses from the left end of the storage tank.
The following input is cycled with the number of tank nodes				
Cycle	Edge loss temperature	C	20.0	The temperature of the environment for calculating losses from the edge of the storage tank.
	Right end loss temperature	C	20.0	The temperature of the environment for calculating losses from the right end of the storage tank.
	Flue loss temperature	C	20.0	The temperature of the gas flue for calculating losses from the flue of the storage tank.
	Inversion mixing flow rate	kg/hr	-1.0	The mixing rate at which temperature inversions between adjacent nodes of the storage tank will be addressed. Setting this value to zero will allow the storage tank to remain inverted - where one node of the storage tank remains hotter than the node above it. Setting this value less than zero will cause the offending tank nodes to be completely mixed at the end of the time step.
The following input is cycled with the number of tank nodes				
Cycle	Auxiliary heating rate for node	kJ/hr	0.0	The rate at which energy is added to the specified node of the storage tank.
The following input is cycled with the number of miscellaneous heat gains				
Cycle	Miscellaneous heat addition for node	kJ/hr	0.0	The rate at which miscellaneous energy is added to the storage tank. The node into which this heat addition occurs is specified in the parameters to this model.

OUTPUTS

Output Number	Name	Unit	Comment
The following two outputs are cycled with the number of inlet ports			
	Temperature at outlet	C	The temperature of the fluid exiting the storage tank at the specified outlet.
	Flow rate at outlet	kg/hr	The flow rate of fluid exiting the storage tank through the specified outlet.
	Average tank temperature	C	The average temperature of the fluid in the storage tank.
	Energy delivered to tank flows	kJ/hr	The total rate at which energy is removed from the storage tank due to the fluid flow rate exiting through the outlet ports minus the rate at which energy is added to the storage tank by the fluid flow rate entering the storage tank through the inlet ports.
The following output is cycled with the number of inlet ports			
	Energy delivered to tank flow	kJ/hr	The rate at which energy is removed from the storage tank due to the fluid flow rate exiting through the specified outlet ports minus the rate at which energy is added to the storage tank by the fluid flow rate entering the storage tank through the specified inlet port.
	Left end losses	kJ/hr	The rate at which energy is lost to the environment through the left end of the storage tank.
	Edge losses	kJ/hr	The rate at which energy is lost to the environment through the edges of the storage tank.
	Right end losses	kJ/hr	The rate at which energy is lost to the environment through the right end of the storage tank.
	Flue losses	kJ/hr	The rate at which energy is lost to the environment through the storage tank flue.
	Auxiliary heating rate	kJ/hr	The rate at which auxiliary heat energy is added to the storage tank.
	Miscellaneous heating gains	kJ/hr	The rate at which miscellaneous energy is added to the tank.
	Tank energy storage rate	kJ/hr	The rate at which energy is stored by the fluid in the storage tank due to a rise in temperature of the storage.
	Energy delivered to all HX's	kJ/hr	The rate at which energy is removed from the immersed heat exchanger due to the fluid flow rate exiting the heat exchanger at the outlet minus the rate at which energy is added to the heat exchanger by the fluid flow rate entering through the HX inlet.
	Tank energy balance error	%	The percent energy balance error for the heat transfer in the storage tank.
The following output is cycled with the number of tank nodes			
	Temperature of tank node	C	The average temperature of the fluid in the specified node of the storage tank for the current time step.
The following two outputs are cycled with the number of heat exchangers			
	Temperature at HX exit	C	The temperature of the fluid exiting the storage tank from the immersed heat exchanger.
	Flow rate at HX exit	kg/hr	The flow rate of fluid exiting the storage tank from the immersed heat exchanger. This flow rate is set by the inlet flow rate to the heat exchanger.

The following output is cycled with the number of heat exchangers			
Cycle	Average HX temperature	C	The average temperature of the fluid in the immersed heat exchanger.
The following four outputs are cycled with the number of heat exchangers			
Cycle	Energy delivered from HX	kJ/hr	The rate at which energy is removed from the immersed heat exchanger due to the fluid flow rate exiting the heat exchanger at the outlet minus the rate at which energy is added to the heat exchanger by the fluid flow rate entering through the HX inlet.
	HX energy storage rate	kJ/hr	The rate at which energy is stored by the fluid in the immersed heat exchanger due to a temperature rise of the fluid.
	HX heat transfer	kJ/hr	The rate at which energy is transferred from the fluid in the storage tank to the fluid in the immersed heat exchanger.
	HX energy balance error	%	The percent energy balance error for the heat transfer for the fluid in the immersed heat exchanger.

DERIVATIVES

Derivative Number	Name	Unit	Comment
The following derivative is cycled with the number of tank nodes (Parameter 1)			
Cycle	Initial temperature of tank node	C	The temperature of the fluid in the specified node of the storage tank at the beginning of the simulation. All HX nodes contained within this storage tank node will also be initialized to this temperature.

TYPE 534: VERTICALLY CYLINDRICAL STORAGE TANK WITH OPTIONAL HEAT EXCHANGER

The various options associated with this component make the Parameter/Input/Output list quite complex. For users of the TRNSYS Studio, a "plugin" was created to vastly simplify the process of entering input data. The following Parameter/Input/Output list is quite general in nature, and is intended primarily as a reference for users needing to employ this component in a distributable TRNSED application or in an input file not created by the TRNSYS Simulation Studio.

PARAMETERS

Parameter Number	Name	Unit	Typical Value	Comment
1	Logical unit	-	-10	The logical unit ASSIGNed to the data file containing the parameters for this model. If this value is less than 10, the parameters will be read from the input file as they are for any other model. If this value is 10 or greater, the parameters after parameter 5 will be read from the data file.
2	Number of tank nodes	-	5	The number of isothermal tank nodes into which the storage tank will be divided.
3	Number of ports	-	1	The number of paired inlet/outlet ports in the tank
4	Number of immersed heat exchangers	-	1	The number of heat exchangers that are immersed in the storage tank
5	Number of miscellaneous heat gains	-	1	The number of miscellaneous heat gains into the storage tank. For each miscellaneous heat gain the user must specify which node of the tank gets the heat gain (a parameter cycled below) and the value of the heat gain (a cycled input).
	If parameter 1 is greater than or equal to 10, the following parameters are read from the data file. If parameter 1 is less than 10, the following parameters are required to be specified in the input file.			
	Tank volume	m^3	0.3	The internal volume of the storage tank.
	Tank height	m	1.0	The height of the vertical cylinder.
	Tank fluid	-	1	The fluid contained in the storage tank: 0 = user-provided fluid properties 1 = pure water 2 = propylene glycol and water solution 3 = ethylene glycol and water solution.
	If tank fluid = 0 five additional parameters are required (m=5)			
	Fluid specific heat	kJ/kg-K	4.190	The specific heat of the tank fluid.
	Fluid density	kg/ m^3	1000.0	The density heat of the tank fluid.
	Fluid thermal conductivity	kJ/hr-m-K	2.14	The thermal conductivity of the tank fluid.
	Fluid viscosity	kg/m/hr	3.21	The dynamic viscosity of the tank fluid.
	Fluid thermal expansion coefficient	1/K	0.00026	The volumetric expansion coefficient of the tank fluid.
	If tank fluid = 1, No further parameters needed (m=0)			
	If tank fluid = 2 or 3, one additional parameters is required (m=1)			
	Percent volume of tank fluid	%	0.0	The percentage by volume of the secondary fluid contained in the storage tank (propylene glycol for example).
Continuing on with the parameter specification for all tank fluids				

	Top loss coefficient	kJ/hr-m^2-K	5.0	The loss coefficient for the top of the storage tank.
The following parameter is cycled with the number of tank nodes				
Cycle	Edge loss coefficient	kJ/hr-m^2-K	5.0	The heat loss coefficient for the edges of the storage tank.
	Bottom loss coefficient	kJ/hr-m^2-K	5.0	The loss coefficient for the bottom of the storage tank.
	Additional thermal conductivity	kJ/hr-m-K	0.0	The additional effective thermal conductivity due to the walls of the storage tank and any additional heat transfer promoting devices immersed in the storage tank. Set this parameter to 0 to indicate that only the conduction between the fluid nodes should be considered. Set this parameter less than zero to indicate that no fluid conduction should be considered for this simulation.
The following parameters are cycled with the number of inlet ports				
Cycle This block of parameters is cycled with the number of ports	Inlet Flow Mode	-	1	An indicator as to how the inlet flow shall be treated: 1 = The user will provide the locations of the inlet and outlet ports in the storage tank 2 = The user will provide the outlet port locations and the fraction of inlet flows that end up in each node 3 = The inlet flow will seek the tank node closest in temperature to the inlet temperature
	If Inlet Flow Mode =1, two additional parameters are required			
	Entry node for Inlet i	-	1	The tank node into which the specified fluid inlet occurs.
	Exit node for Outlet i	-	5	The storage tank node from which the specified outlet occurs.
	If Inlet Flow Mode =2 the next parameter is required and the following parameter is cycled with the number of tank nodes.			
	Exit node for Outlet i	-	5	The storage tank node from which the specified outlet occurs.
	CYCLE Fraction of inlet flow into node	-	0.2	The fraction of the specified inlet flow that enters the specified node of the storage tank.
	If Inlet Flow Mode =3, one additional parameters is required			
	Exit node for Outlet i	-	5	The storage tank node from which the specified outlet occurs.
The following parameter is cycled with the number of tank nodes				
Cycle	Overall flue heat loss coefficient for specified node	kJ/h-K	3.0	The overall heat transfer coefficient (UA) from the specified node to the gas flue temperature (an input). The losses from the gas flue are set to zero for those periods where auxiliary energy is being added to the storage tank.
The following parameter is cycled with the number of miscellaneous heat gains				
Cycle	Node for misc. heat gain	-	1	The node into which the miscellaneous heat flow should be directed. This parameter is cycled with the number of misc. heat gains parameter,
The following parameters are cycled with the number of immersed heat exchangers				
Cycle This block of parameters is cycled with	Type of heat exchanger	-	4	The type of heat exchanger immersed in the storage tank. 1 = horizontal tube bank 2 = vertical tube bank 3 = coiled tube heat exchanger 4 = serpentine tube heat exchanger

cycled with the number of immersed heat exchangers	Number of HX nodes	-	5	The number of nodes into which the heat exchanger will be divided into in the flow direction.
	Heat exchanger fluid	-	2	The type of fluid flowing through the heat exchanger 0 = user-provided fluid properties 1 = pure water 2 = propylene glycol and water solution 3 = ethylene glycol and water solution.
	If HX fluid = 0, five additional parameters are required			
	Fluid specific heat	kJ/kg.K	4.190	The specific heat of the HX fluid.
	Fluid density	kg/ m^3	1000.0	The density heat of the HX fluid.
	Fluid thermal conductivity	kJ/hr-m-K	2.14	The thermal conductivity of the HX fluid.
	Fluid viscosity	kg/m/hr	3.21	The dynamic viscosity of the HX fluid.
	If HX fluid = 1, No further parameters needed			
	If HX fluid = 2 or 3, one additional parameter is required			
	Percent volume of HX fluid	-	0.1	The percentage by volume of the secondary fluid flowing through the heat exchanger (propylene glycol for example).
	Continuing on for all HX fluids			
	Multiplier for natural convection correlation	-	1	The value constant multiplier in the natural convection equation for the heat exchanger.
	Exponent for Rayleigh number	-	0.25	The value for n in the natural convection heat transfer.
	Geometry factor	-	1	The value for the geometry factor (GF) in the natural convection heat transfer equation.
Continued cycle Cycle	Geometry factor exponent	-	0	The value of the geometry factor exponent (m) in the natural convection heat transfer correlation.
	HX tube inner diameter	m	0.01	The inner diameter of one of the identical tubes comprising the heat exchanger.
	HX tube outer diameter	m	0.015	The outer diameter of one of the identical tubes comprising the heat exchanger.
	HX wall conductivity	kJ/hr-m-K	900	The thermal conductivity of the wall material comprising the tubes of the heat exchanger.
	Length of heat exchanger tube	m	1.0	The length of one of the identical tubes comprising the heat exchanger.
	Number of tubes	-	50	The number of identical tubes comprising the heat exchanger.
	Header volume	m^3	0.01	The volume of the headers comprising the heat exchanger.
	HX cross sectional area	m^2	0.005	The cross-sectional area of the heat exchanger at the tank nodal boundaries.
	If HX Geometry = 3, two additional parameters are required			
	Coil diameter	m	0. 5	The diameter of the coiled tube heat exchanger.
	Coil pitch	m	0.05	The pitch of the coiled tube heat exchanger.
	If HX Geometry = 1, The following parameter is required and cycled with the number of tank nodes			
	CYCLE Fraction of horizontal HX tubes in specified tank node	-	0.2	The fraction of the total heat exchanger tubes contained in this node of the storage tank.

	If HX Geometry =2, 3, or 4, the following two parameters are cycled with the number of heat exchanger nodes.				
	CYCLE	Tank node for specified HX node	-	5	The tank node in which this heat exchanger node is completely immersed
		Fraction of HX length for specified HX node	-	0.2	The fraction of heat exchanger length assigned to this heat exchanger node.

INPUTS

Input Number	Name	Unit	Typical Value	Comment
The following two inputs are cycled with the number of inlet ports				
Cycle	Temperature at inlet	C	20.0	The temperature of the fluid entering the storage tank at the specified inlet.
	Flow rate at inlet	kg/hr	0.0	The flow rate of fluid entering the storage tank at the specified inlet.
The following two inputs are cycled with the number of heat exchangers				
Cycle	Temperature at HX inlet	C	20.0	The temperature of the fluid flowing into the immersed heat exchanger in the storage tank.
	Flow rate at HX inlet	kg/hr	0.0	The flow rate of fluid entering the immersed heat exchanger in the storage tank.
	Top loss temperature	C	20.0	The temperature of the environment for calculating losses from the top of the storage tank.
The following input is cycled with the number of tank nodes				
Cycle	Edge loss temperature	C	20.0	The temperature of the environment for calculating losses from the edge of the storage tank.
	Bottom loss temperature	C	20.0	The temperature of the environment for calculating losses from the bottom of the storage tank.
	Flue loss temperature	C	20.0	The temperature of the gas flue for calculating losses from the flue of the storage tank.
	Inversion mixing flow rate	kg/hr	-1.0	The mixing rate at which temperature inversions between adjacent nodes of the storage tank will be addressed. Setting this value to zero will allow the storage tank to remain inverted - where one node of the storage tank remains hotter than the node above it. Setting this value less than zero will cause the offending tank nodes to be completely mixed at the end of the time step.
The following input is cycled with the number of tank nodes				
Cycle	Auxiliary heating rate for node	kJ/hr	0.0	The rate at which energy is added to the specified node of the storage tank.
The following input is cycled with the number of miscellaneous heat gains				
Cycle	Miscellaneous heat addition for node	kJ/hr	0.0	The rate at which miscellaneous energy is added to the storage tank. The node into which this heat addition occurs is specified in the parameters to this model.

OUTPUTS

Output Number	Name	Unit	Comment
The following two outputs are cycled with the number of inlet ports			
	Temperature at outlet	C	The temperature of the fluid exiting the storage tank at the specified outlet.
	Flow rate at outlet	kg/hr	The flow rate of fluid exiting the storage tank through the specified outlet.
	Average tank temperature	C	The average temperature of the fluid in the storage tank.
	Energy delivered to tank flows	kJ/hr	The total rate at which energy is removed from the storage tank due to the fluid flow rate exiting through the outlet ports minus the rate at which energy is added to the storage tank by the fluid flow rate entering the storage tank through the inlet ports.
The following output is cycled with the number of inlet ports			
	Energy delivered to tank flow	kJ/hr	The rate at which energy is removed from the storage tank due to the fluid flow rate exiting through the specified outlet ports minus the rate at which energy is added to the storage tank by the fluid flow rate entering the storage tank through the specified inlet port.
	Top losses	kJ/hr	The rate at which energy is lost to the environment through the top of the storage tank.
	Edge losses	kJ/hr	The rate at which energy is lost to the environment through the edges of the storage tank.
	Bottom losses	kJ/hr	The rate at which energy is lost to the environment through the bottom of the storage tank.
	Flue losses	kJ/hr	The rate at which energy is lost to the environment through the storage tank flue.
	Auxiliary heating rate	kJ/hr	The rate at which auxiliary heat energy is added to the storage tank.
	Miscellaneous heating gains	kJ/hr	The rate at which miscellaneous energy is added to the tank.
	Tank energy storage rate	kJ/hr	The rate at which energy is stored by the fluid in the storage tank due to a rise in temperature of the storage.
	Energy delivered to all HX's	kJ/hr	The rate at which energy is removed from the immersed heat exchanger due to the fluid flow rate exiting the heat exchanger at the outlet minus the rate at which energy is added to the heat exchanger by the fluid flow rate entering through the HX inlet.
	Tank energy balance error	%	The percent energy balance error for the heat transfer in the storage tank.
The following output is cycled with the number of tank nodes			
	Temperature of tank node	C	The average temperature of the fluid in the specified node of the storage tank for the current time step.
The following two outputs are cycled with the number of heat exchangers			
	Temperature at HX exit	C	The temperature of the fluid exiting the storage tank from the immersed heat exchanger.
	Flow rate at HX exit	kg/hr	The flow rate of fluid exiting the storage tank from the immersed heat exchanger. This flow rate is set by the inlet flow rate to the heat exchanger.

The following output is cycled with the number of heat exchangers			
Cycle	Average HX temperature	C	The average temperature of the fluid in the immersed heat exchanger.
The following four outputs are cycled with the number of heat exchangers			
Cycle	Energy delivered from HX	kJ/hr	The rate at which energy is removed from the immersed heat exchanger due to the fluid flow rate exiting the heat exchanger at the outlet minus the rate at which energy is added to the heat exchanger by the fluid flow rate entering through the HX inlet.
	HX energy storage rate	kJ/hr	The rate at which energy is stored by the fluid in the immersed heat exchanger due to a temperature rise of the fluid.
	HX heat transfer	kJ/hr	The rate at which energy is transferred from the fluid in the storage tank to the fluid in the immersed heat exchanger.
	HX energy balance error	%	The percent energy balance error for the heat transfer for the fluid in the immersed heat exchanger.

DERIVATIVES

Derivative Number	Name	Unit	Comment
The following derivative is cycled with the number of tank nodes (Parameter 1)			
Cycle	Initial temperature of tank node	C	The temperature of the fluid in the specified node of the storage tank at the beginning of the simulation. All HX nodes contained within this storage tank node will also be initialized to this temperature.

UTILITY COMPONENTS

Utility Components

TYPE 501: GROUND TEMPERATURE

PARAMETERS

Parameter Number	Name	Unit	Typical Value	Comment
1	Number of temperature nodes	-	1	The number of temperatures that will be output from the model. For each output temperature desired, the user has to specify the depth at which the output temperature should be calculated. These depths should be entered in parameters 8 to 7 +n, where n is the number of temperature nodes (this parameter).
2	Mean surface temperature	C	10.0	The mean (average) surface temperature of the ground during the year. The temperature of the ground at an infinite depth will be this temperature. This temperature is typically the average annual air temperature for the given location.
3	Amplitude of surface temperature	ΔC	5.0	The amplitude of the surface temperature function throughout the year. The maximum temperature of the surface will be TMEAN+TAMPL.
4	Time shift	day	30	The time difference (in days) between the beginning of the calendar year and the occurrence of the minimum surface temperature.
5	Soil thermal conductivity	kJ/hr-m-K	8.72	The thermal conductivity of the soil for which the temperature is being calculated.
6	Soil density	kg/m^3	3200.0	The density of the soil for which the temperature is being calculated.
7	Soil specific heat	kJ/kg-K	0.84	The specific heat of the soil for which the temperature is being calculated.
	Depth at point n	m	0.25	The depth of the soil at which the temperature for this node should be evaluated. 0 = Surface

OUTPUTS

Output Number	Name	Unit	Comment
	Soil temperature at node n	C	The soil temperature at the specified depth for each node.

TYPE 571: INFILTRATION TO A CONDITIONED ZONE

PARAMETERS

Parameter	Name	Unit	Typical	Comment

Number			Value	
1	Humidity mode	-	1	1: humidity ratio will be provided as an input 2: relative humidity will be provided as an input
2	Volume of zone	m^3	10.0	The volume of the conditioned zone for which the infiltration is being calculated.
3	K1 coefficient	ACH	0.10	The K1 coefficient (constant term) in the infiltration function.
4	K2 coefficient	-	0.017	The K2 coefficient (multiplier on temperature difference) in the infiltration function.
5	K3 coefficient	-	0.049	The K3 coefficient (windspeed multiplier) in the infiltration function.

INPUTS

Input Number	Name	Unit	Typical Value	Comment
1	Zone temperature	C	20.0	The temperature of the conditioned zone for which the infiltration is being calculated.
2	Zone humidity ratio	kgH2O/kgAir	0.001	The humidity ratio of the conditioned zone for which the infiltration is being calculated. This input is ignored in Humidity Mode 2.
3	Zone RH	%	50	The relative humidity of the conditioned zone for which the infiltration is being calculated. This input is ignored in Humidity Mode 1.
4	Zone air pressure	atm	1.0	The absolute pressure of the zone air
5	Ambient temperature	C	10.0	The ambient temperature.
6	Ambient humidity ratio	kgH2O/kgAir	0.001	The humidity ratio of ambient air. This input is ignored in Humidity Mode 2.
7	Ambient RH	%	50	The relative humidity of ambient air. This input is ignored in Humidity Mode 1.
8	Ambient air pressure	atm	1.0	The absolute pressure of the ambient air
9	Wind speed	m/s	5.0	The velocity of the wind.

OUTPUTS

Output Number	Name	Unit	Comment
1	Infiltration	ACH	The calculated infiltration rate in air changes per hour.
2	Infiltration flow rate	kg/hr	The calculated value of infiltration flow rate.
3	Infiltration energy to zone	kJ/hr	The rate at which infiltration energy is convected *to* the zone.
4	Heating Infiltration	ACH	The infiltration flow rate when the zone temperature is greater than the ambient temperature (0 if the zone temperature is less than the ambient temperature).
5	Cooling Infiltration (ACH)	ACH	The infiltration flow rate when the ambient temperature is greater then the zone temperature (0 if the zone temperature is greater than the ambient)

TYPE 572: EQUIPMENT FOULING

PARAMETERS

Parameter Number	Name	Unit	Typical Value	Comment
1	Daily fouling fraction rate	-	0.05	The daily rate (fraction/day) at which the equipment is fouled if it were on for the entire day.
2	Days between scheduled cleanings	days	14	The number of days between scheduled equipment cleanings. At the end of the scheduled clean time, the fouling fraction will be reset to 0.0.
3	Unscheduled daily cleaning fraction rate	-	0.50	The daily rate (fraction/day) that the equipment will be cleaned when the external unscheduled cleaning signal indicates a cleaning condition. For example, if a collector is cleaned at a rate of 50% per day while it is raining, this parameter would be set to 0.5.
4	Reset mode	-	0	The time indicator for the scheduled cleanings: 0 = cleaning time is relative to the simulation starting time 1 = cleaning time is relative to hour zero

INPUTS

Input Number	Name	Unit	Typical Value	Comment
1	Equipment control signal	-	1.0	The control signal (0 to 1) for the equipment operation. If this control signal is non-zero, the equipment will be fouled at the rate of this input multiplied by the first parameter.
2	Cleaning control signal	-	0.0	The unscheduled cleaning control signal (0 to 1). The equipment will be cleaned at the rate of this input times the third parameter when this control signal is non-zero.

OUTPUTS

Output Number	Name	Unit	Comment
1	Equipment fouling fraction	0..1	The fraction that the equipment is fouled on average over the current time step (0=completely clean, 1=completely fouled).
2	Fraction equipment is unfouled	0..1	The fraction of the equipment that remains unfouled on average over the current time step (0=completely fouled, 1=completely clean).

TYPE 573: OUTPUT DEVICE FOR AVERAGE DAY OF EACH MONTH

PARAMETERS

Parameter Number	Name	Unit	Typical Value	Comment
1	Logical unit for output file	-	20	The logical unit which will be ASSIGNed to the output file created by this Type.

INPUTS

Input Number	Name	Unit	Typical Value	Comment
1	Input for alternative 1	any	0.0	The input that will be used as alternative 1 in the output file comparison.
2	Input for alternative 2	any	0.0	The input that will be used as alternative 2 in the output file comparison.

TYPE 574: ASHRAE OCCUPANCY LOADS

PARAMETERS

Parameter Number	Name	Unit	Typical Value	Comment
1	Number of activity levels (n)	-	2	The number of unique activity types that will be processed by this model. For each activity type, the user must specify the activity level indicator and the number of people at this activity level.
	Activity level indicator	-	4	The indicator for the specified activity level: 1 : Seated at theater 2 : Seated at theater, night 3 : Seated, very light work 4 : Moderately active office work 5 : Standing, light work, or walking slowly 6 : Walking, standing 7 : Sedentary work 8 : Light bench work 9 : Moderate dancing 10 : Walking at 4.8 km/h, light machine work 11 : Bowling 12 : Heavy work 13 : Heavy machine work, lifting 14 : Heavy work, athletics

INPUTS

Input Number	Name	Unit	Typical Value	Comment
	Number of people at 1st activity level	-	25	The number of people at the 1st specified activity level.

OUTPUTS

Output Number	Name	Unit	Comment
1	Sensible energy gain rate	kJ/hr	The rate at which sensible energy is added to the space by ALL of the occupants.
2	Latent energy gain rate	kJ/hr	The rate at which latent energy is added to the space by ALL of the occupants.
3	Total energy gain rate	kJ/hr	The rate at which energy (latent + sensible) is added to the space by ALL of the occupants.

4	Moisture gain rate	kg/hr	The rate at which moisture is generated inside the space by ALL of the occupants.
Cycle	Sensible gain rate for activity n	kJ/hr	The rate at which sensible energy is added to the space by the occupants at the n^{th} specified activity type.
	Latent gain rate for activity n	kJ/hr	The rate at which latent energy is added to the space by the occupants at the n^{th} specified activity type.
	Total energy gain rate for activity n	kJ/hr	The rate at which energy is added (sensible and latent) to the space by the occupants at the n^{th} specified activity type.
	Moisture gain rate for activity n	kg/hr	The rate at which moisture is generated within the space by the occupants at the n^{th} specified activity type.

TYPE 575: SKY TEMPERATURE

PARAMETERS

Parameter Number	Name	Unit	Typical Value	Comment
1	Input data mode	-	1	1 : dew point temperature and fraction (0..1) of cloud cover are provided 2 : relative humidity and fraction (0..1) of cloud cover are provided 3 : dew point temperature and percent cloud cover are provided 4 : relative humidity and percent cloud cover are provided

INPUTS

Input Number	Name	Unit	Typical Value	Comment
If Input Data Mode (PAR 1) = 1				
1	Dew point temperature	C	10.0	The dew point temperature of the ambient air.
2	Fraction of opaque cloud cover	0..1	0.50	The fraction of the sky that is covered by opaque clouds
If Input Data Mode (PAR 1) = 2				
1	Relative humidity	%	60.0	The relative humidity (%) of the ambient air.
2	Fraction of opaque cloud cover	0..1	0.50	The fraction of the sky that is covered by opaque clouds
If Input Data Mode (PAR 1) = 3				
1	Dew point temperature	C	10.0	The dew point temperature of the ambient air.
2	Percent opaque cloud cover	%	50	The percent of the sky that is covered by opaque clouds
If Input Data Mode (PAR 1) = 4				
1	Relative humidity	%	60.0	The relative humidity (%) of the ambient air.
2	Percent opaque cloud cover	%	50	The percent of the sky that is covered by opaque clouds
3	Ambient temperature	C	15.0	The ambient temperature.
4	Emissivity of clouds	-	0.80	The emissivity of the clouds in the sky.
5	Atmospheric pressure	atm	1.0	The atmospheric pressure at the location for the study.

OUTPUTS

Output Number	Name	Unit	Comment
1	Effective sky temperature	C	The effective sky temperature for loss calculations.
2	Sky emissivity	-	The effective emissivity of the sky and clouds.
3	Clear sky emissivity	-	The emissivity of the sky if it were perfectly clear (no clouds).
4	Dew point temperature	C	The ambient dew point temperature.

TYPE 576: TWO-DIMENSIONAL BIN SORTER

PARAMETERS

Parameter Number	Name	Unit	Typical Value	Comment
1	Logical unit for output file	-	29	The logical unit to which the bin analysis results will be sent. The logical unit number for this output file must be unique and ASSIGNed to an output file name in the TRNSYS input file.
2	Number of bins for input 1	-	5	The number of bins into which the first input will be sorted.
3	Number of bins for input 2	-	5	The number of bins into which the first input will be sorted.
4	Minimum value for input 1	any	0.0	The minimum value for the bins of input 1.
5	Maximum value for input 1	any	50.0	The maximum value for the bins of input 1.
6	Minimum value for input 2	any	0.0	The minimum value for the bins of input 2.
7	Maximum value for input 2	any	100.0	The maximum value for the bins of input 2.

INPUTS

Input Number	Name	Unit	Typical Value	Comment
1	Input 1	any	0.0	The first input to be sorted.
2	Input 2	any	0.0	The second input to be sorted.

This component can accept a TRNSYS LABELS statement. The first LABEL corresponds to the INPUT 1 values. The second LABEL corresponds to the INPUT 2 values and so on. In the TRNSYS Studio, the LABELS are specified in the "Special Cards" tab.

```
TRNSHELL Example:
UNIT 1 TYPE 576 TWO DIMENSIONAL BIN SORTER
PARAMETERS 7
29    5     5     0     50    0     100
INPUTS 2
1,1   1,2
0.    0.
LABELS 2
"Dry Bulb Temperature [C]"
"Relative Humidity [%]"
```

TYPE 577: RANDOM NUMBER GENERATOR DRAWN FROM UNIFORM DISTRIBUTION

PARAMETERS

Parameter Number	Name	Unit	Typical Value	Comment
1	Minimum value for function	any	0	The minimum value for the uniform distribution function from which the outputs will be generated.
2	Maximum value for function	any	100	The maximum value for the uniform distribution from which the outputs will be generated.
3	Initial seed	-	153789	The initial value of the seed used to drive the random normal distribution function.

INPUTS

Input Number	Name	Unit	Typical Value	Comment
1	Generation signal	-	1	Setting this input to ≥ 0.5 will cause the model to find a random number from the uniform distribution. Setting this value to 0 skips the generation at this time step.

OUTPUTS

Output Number	Name	Unit	Comment
1	Random real number	any	The random number drawn from the uniform distribution.
2	Random integer	any	The integer value corresponding to the generated random number from the uniform distribution.

TYPE 578: RANDOM NUMBER GENERATOR DRAWN FROM NORMAL DISTRIBUTION

PARAMETERS

Parameter Number	Name	Unit	Typical Value	Comment
1	Mean value	any	50.0	The mean (average) value of the normal distribution function.
2	Standard deviation	any	20.0	The standard deviation of the normal distribution function.
3	Initial seed	-	736549	The initial value of the seed used to drive the random normal distribution function.

INPUTS

Input Number	Name	Unit	Typical Value	Comment
1	Generation signal	-	1.0	Setting this input ≥ 0.5 allows the model to find a random number from the normal distribution. Setting this value to 0 skips the generation at this time step.

OUTPUTS

Output Number	Name	Unit	Comment
1	Random real number	any	The random number drawn from the normal distribution.
2	Random integer	any	The integer value corresponding to the random number drawn from the normal distribution.

TYPE 579: NESTED FORCING FUNCTION

PARAMETERS

Parameter Number		Name	Unit	Typical Value	Comment
1		Number of tiers (n)	-	2	The number of levels (tiers) for the multi-level forcing function.
The following PARAMETER is cycled based on the value of PARAMETER 1					
Cycle		Length of the n^{th} cycle	hr	24	The length of time after which the n^{th} cycle will repeat. The cycles should be defined in order of longest to shortest where the primary cycle is longer than the secondary cycle, which in turn is longer than the tertiary cycle.
The following PARAMETERS are cycled based on the value of PARAMETER 1					
Cycle	2+n	Number of ON periods for n^{th} cycle	-	2	The number of unique ON periods during the n^{th} cycle. For each ON period, the user must specify the start and stop times of the ON period using the following parameters.
	The following PARAMETERS are cycled based on the value of PARAMETER 2+n, 3+n, 4+n, etc.				
	Cycle	Start of ON period for n^{th} cycle	hr	1	The start of the ON period for the current cycle.
		End of ON period for n^{th} cycle	hr	3	The end of the ON period for the current cycle.

INPUTS

Input Number	Name	Unit	Typical Value	Comment
The following INPUT is cycled based on the value of 2**((PARAMETER 1)-1)				
Cycle	n^{th} Input	any	0.0	The n^{th} input required

OUTPUTS

Output Number	Name	Unit	Comment
1	Output of combined cycles	any	The output at the current combination of forcing functions
The following OUTPUT is cycled based on the value of PARAMETER 1			
Cycle	Current state of n^{th} tier	any	The current state of the OUTPUT for the n^{th} tier.

TYPE 581: MULTI DIMENSIONAL DATA INTERPOLATION

PARAMETERS

Parameter Number	Name	Unit	Typical Value	Comment
1	Logical unit number for data file	-	20	The logical unit through which the performance data will be read. Every external file that TRNSYS reads to or writes from must be assigned a unique logical unit number in the TRNSYS input file.
2	Number of independent variables	-	4	The number of independent variables on which the interpolation / equipment performance depends.
3	Number of dependent variables	-	3	The number of dependent variables to be read from the external data file.
4	Number of values of 1st independent variable	-	5	The number of values of the first independent variable for which data is supplied in the external file.
5	Number of values of 2nd independent variable (if PAR(2)>1)	-	5	The number of values of the second independent variable for which data is supplied in the external file
6	Number of values of 3rd independent variable (if PAR(2)>2)	-	3	The number of values of the third independent variable for which data is supplied in the external file.
7	Number of values of 4th independent variable (if PAR(2)>3)	-	2	The number of values of the fourth independent variable for which data is supplied in the external file.

INPUTS

Input Number	Name	Unit	Typical Value	Comment
1	Control function	-	1.0	The control function for the interpolation/equipment operation. The outputs from this component are the interpolated values from the data file multiplied by this control function OFF if CTRL < 0. ON if CTRL >= 0.5
2	First independent variable (if PAR(2)>1)	any	0.0	The value of the 1st independent variable on which the data interpolation/equipment performance depends.
3	Second independent variable (if PAR(2)>2)	any	0.0	The value of the 2nd independent variable on which the data interpolation/equipment performance depends.
4	Third independent variable (if	any	0.0	The value of the 3rd independent variable on which the data interpolation/equipment performance depends.

	PAR(2)>3)			
5	Fourth independent variable (if PAR(2)>3)	any	0.0	The value of the 4th independent variable on which the data interpolation/equipment performance depends.

OUTPUTS

Output Number	Name	Unit	Comment
	Value of each dependent variable	any	The value of each dependent variable / equipment performance variable.

TYPE 582: LIFE CYCLE COST ECONOMIC ANALYSIS

PARAMETERS

Parameter Number	Name	Unit	Typical Value	Comment
1	Mode	-	2	1: P1 and P2 are provided as PARAMETERS 2: P1 and P2 are computed based on supplied information.
2	Number of system alternatives	-	2	The number of system alternatives that will be included in the analysis.
Mode 1: P1 and P2 are provided as parameters				
3	P1	-	1	The value of P1
Cycle based on n System Alternatives (PAR 2)	Comparison system	-	2	The system to which this alternative will be compared in the analysis.
	Purchase price	currency	100000	The equipment purchase price.
	P2	-	10	The value of P2 for this alternative
Mode 2: P1 and P2 are computed based on supplied information				
3	Analysis period	years	20	The period of the economic analysis.
4	Loan period	years	0	The number of years over which the equipment purchase will be financed (the term of the mortgage or loan).
5	Commercial flag	-	1	A flag telling whether the equipment is purchased by a commercial or non commercial organization. 1: commercial 0: non commercial.
6	Fuel cost inflation rate	0..1	0.04	The rate at which fuel costs are expected to increase.
7	Discount rate	0..1	0.07	The discount rate is the interest rate that can be expected on the money if the equipment is not purchased.
8	Income tax rate	0..1	0.45	The rate at which income is taxed.
9	Inflation rate	0..1	0.05	The general inflation rate is the rate at which prices are generally expected to increase.
10	Property tax rate	0..1	0.03	The rate at which property is taxed.
11	Interest rate	0..1	0.0	The interest rate on the loan used to finance the equipment purchase.
Cycle based on n System Alternatives (PAR 2)	Comparison system	-	2	The system to which this alternative will be compared in the analysis.
	Purchase price	currency	100000	The equipment purchase price.
	Depreciation life	years	10	The equipment depreciation life.
	Down payment fraction	0..1	1.0	The down payment on the equipment expressed as a fraction of the purchase price.
	Installation fraction	0..1	0.15	The installation cost of the equipment expressed as a fraction of the purchase price.
	Rebate fraction	0..1	0.3	The rebate or refund on the equipment expressed as a fraction of the purchase price.

	Salvage fraction	0..1	0.2	The salvage price of the equipment at the end of its life time expressed as a fraction of the purchase price.
	Miscellaneous cost fraction	0..1	0.07	Miscellaneous annual expenses on the equipment expressed as a fraction of the purchase price.

INPUTS

Input Number	Name	Unit	Typical Value	Comment
Cycle based on n System Alternatives (PAR 2)	Fuel cost rate	currency/ hr	0	The cost of fuel provided to the equipment in this system alternative at the current time step.

OUTPUTS

Output Number	Name	Unit	Comment
Cycle based on n System Alternatives (PAR 2)	Integrated fuel cost	currency	The total fuel cost for this system alternative, integrated over the simulation.
	Annual fuel cost	currency	The annual fuel cost for this system alternative, integrated over the simulation and annualized.
	Life cycle cost	currency	The life cycle cost of this system alternative
	Life cycle savings	currency	The life cycle savings of this system as compared to the system specified as the first cycled INPUT (the system to which this alternative was compared in the analysis)
	Payback period	years	The payback period of this system as compared to the system specified as the first cycled INPUT (the system to which this alternative was compared in the analysis)
	Return on investment	0..1	The return on investment of this system as compared to the system specified as the first cycled INPUT (the system to which this alternative was compared in the analysis)
	Allowable equipment cost	currency	The allowable equipment cost of this system as compared to the system specified as the first cycled INPUT (the system to which this alternative was compared in the analysis)

TYPE 584: OUT OF SET POINT WATCHER

PARAMETERS

Parameter Number	Name	Unit	Typical Value	Comment
1	Number of zones to watch	-	2	The number of zones (or temperatures) that are to be watched.
2	Logical unit number for output file	-	31	The logical unit number that has been ASSIGNed to the output file for this component.
3	Printing mode	-	1	0: do not write information to the external output file 1: write information to the external output file

INPUTS

Input Number	Name	Unit	Typical Value	Comment
	Heating set point temperature	ºC	20	The heating set point temperature for each zone
	Heating dead band	ºC	2	The heating dead band for each zone.
	Cooling set point temperature	ºC	28	The cooling set point temperature for each zone
	Cooling dead band	ºC	2	The cooling dead band for each zone.
	Zone temperature	ºC	22	The temperature of the zone being watched
	Control signal	0..1	1	The control signal for watching the zone temperature and recording its excursions beyond the set point conditions.

OUTPUTS

Output Number	Name	Unit	Comment
	Total time below heating set point	hr	The cumulative number of time steps during which the zone temperature has been lower than the heating set point minus the heating dead band temperature.
	Total time above cooling set point	hr	The cumulative number of time steps during which the zone temperature has been higher than the cooling set point plus the cooling dead band temperature.