Input Output Reference

The Encyclopedic Reference to EnergyPlus Input and Output

## Group – Evaporative Coolers

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### EvaporativeCooler:Direct:ResearchSpecial

This cooler is similar in principal to the EvaporativeCooler:Direct:CelDekPad. The model differs in that it gives the user a simple way of specify the cooler effectiveness. Using the ResearchSpecial input object also allows the cooler to control the amount of cooling based on node setpoints (controlled by SetpointManagers). This avoid problems from over cooling when conditions are such that loads are low and cooling power is high.

The model allows to vary the effectiveness depending on the primary air flow rates. The design effectiveness is modified by multiplying with Effectiveness Flow Fraction Modifier Curve value. The flow fraction is the ratio of the current primary airflow rate to the design flow rate. The recirculating and spray water pump power is assumed to vary with the primary air flow. The design pump power is modified using user specified pump modifier curve value. The normalized pump power modifier curve is a function of primary air flow fraction as a independent variable.

Also the direct evaporative cooler operating range can be controlled depending on the entering air dry bulb and wet bulb temperatures. The operating range controlled based on minimum and maximum inlet node air temperature limits. The evaporative cooler can be turned on or off depending user specified minimum and maximum temperature limits. If the inlet node entering air temperature is lower or higher than the minimum and maximum limits, respectively, then the direct research special evaporative cooler is turned off. If these two input fields are left blank then, no user specified operating temperature control is applied. Operating range control feature is primarily intended for application in data centers.

#### Field: Name

A unique identifying name for each cooler.

#### Field: Availability Schedule Name

The name of a schedule that defines when the evaporative cooler is available. A schedule value of 0 indicates that the evaporative cooler is off for that time period. A schedule value greater than 0 indicates that the evaporative cooler can operate during the time period. If this field is blank, the schedule has values of 1 for all time periods.

#### Field: Cooler Design Effectiveness

This field specifies the effectiveness at design flow rate that is applied to the wetbulb depression to determine the conditions leaving the cooler. This model assumes that the effectiveness can vary with supply air flow rate. For effectiveness variation with supply air flow fraction enter the “Effectiveness Flow Ratio Modifier Curve Name” input field below. The flow fraction is the ratio of the sum of current primary air and secondary air sides flow rates and the sum of the design flow rates.

#### Field: Effectiveness Flow Ratio Modifier Curve Name

This curve modifies the effectiveness design value specified the previous field by multiplying the value by the result of this curve. The modifying curve is a function of flow fraction, which is the ratio of the current primary air flow rates divided by the design primary air flow rates. If this input field is left blank, the effectiveness is assumed to be constant. Any curve or table with one independent variable can be used. Any curve or table with one independent variable can be used: Curve:Linear, Curve:Quadratic, Curve:Cubic, Curve:Quartic, Curve:Exponent, Curve:ExponentialSkewNormal, Curve:Sigmoid, Curve:RectuangularHyperbola1, Curve:RectangularHyperbola2, Curve:ExponentialDecay, Curve:DoubleExponentialDecay, and Table:OneIndependentVariable.

#### Field: Recirculationg Water Pump Design Power

This numeric input field is the recirculating and spray pump electric power at Secondary Design Air Flow Rate in W. This is the nominal water recirculating and spray pump power of evaporative cooler at primary air design flow rates and cooler design effectiveness. This input field is autosizable.

#### Field: Water Pump Power Sizing Factor

This numeric input field value is recirculating water pump sizing factor in W/(m3/s). This field is used when the previous field is set to autosize. The pump design electric power is scaled with Secondary Design Air Flow Rate.

#### Field: Water Pump Power Modifier Curve Name

This alpha input field is the name of a dimensionless normalized pump power modifying curve. This curve modifies the pump electric power in the previous field by multiplying the design power by the result of this curve. The normalized curve is a function of the primary air flow fraction as independent variable. The curve shall yield a value of 1.0 at a flow fraction of 1.0. The flow fraction is the ratio of the primary air during current operation divided by primary air Design Air Flow Rate. If this input field is left blank, the pump power is assumed to lineary vary with the load.Any curve or table with one independent variable can be used: Curve:Linear, Curve:Quadratic, Curve:Cubic, Curve:Quartic, Curve:Exponent, Curve:ExponentialSkewNormal, Curve:Sigmoid, Curve:RectuangularHyperbola1, Curve:RectangularHyperbola2, Curve:ExponentialDecay, Curve:DoubleExponentialDecay, and Table:OneIndependentVariable.

#### Field: Air Inlet Node Name

The name of the air inlet node for the primary air flow path through the cooler.

#### Field: Air Outlet Node Name

The name of the air outlet node for the primary air flow path through the cooler.

#### Field: Sensor Node Name

This field specifies the name of a node that will provide system air temperature setpoint information. A separate SetpointManager object should be setup to update this node.

#### Field: Water Supply Storage Tank Name

This field is optional. It is used to describe where the cooler obtains water used for evaporative cooling. If blank or omitted, then the cooler will obtain water directly from the mains. If the name of a WaterUse:Storage object is used here, then the cooler will obtain its water from that tank. If a tank is specified, the cooler will attempt to obtain all the water it uses from the tank. However, if the tank cannot provide all the water the cooler needs, then the cooler will still operate and obtain the rest of the water it needs from the mains.

#### Field: Drift Loss Fraction

This field is optional and can be used to model additional water consumed by the cooler from drift. Drift is water that leaves the cooling media as droplets and does not evaporate into the process air stream. For example, water may get blown off the evaporative media by winds and escape the air system. The value entered here is a simple fraction of the water consumed by the cooler for normal process evaporation. The amount of drift is this fraction times the water evaporated for the normal cooling process. This field can be left blank and then there will be no added water consumption from drift.

#### Field: Blowdown Concentration Ratio

This field is optional and can be used to model additional water consumed by the cooler from blowdown. Blowdown is water that is intentionally drained from the cooler’s sump to offset the build up of solids in the water that would otherwise occur because of evaporation. The value entered here is dimensionless. It can be characterized as the ratio of solids in the blowdown water to solids in the make up water. Typical values are 3 to 5. The default is 3.0.

***Field: Evaporative Cooler Operation Minimum Drybulb Temperature***

This numeric field defines the evaporative cooler inlet node drybulb temperature minimum limit in degrees Celsius. The evaporative cooler will be turned off when evaporator cooler air inlet node dry-bulb temperature falls below this value. The typical minimum value is 16°C. Users are allowed to specify their own limits. If this field is left blank, then there is no drybulb temperature lower limit for evaporative cooler operation.

***Field: Evaporative Operation Maximum Limit Wetbulb Temperature***

This numeric field defines the evaporative cooler air inlet node air wetbulb temperature maximum limits in degree Celsius. When the evaporative cooler air inlet node air wetbulb temperature exceeds this limit, then the evaporative cooler is turns off. The typical maximum value is 24°C. If this input field is left blank, then there is no wetbulb temperature upper limit for evaporative cooler operation.

***Field: Evaporative Operation Maximum Limit Drybulb Temperature***

This numeric field defines the evaporative cooler air inlet node drybulb temperature maximum limits in degree Celsius. The evaporative cooler will be turned off when the evaporative cooler air inlet node drybulb temperature exceeds this value. The typical maximum value is 28°C. If this input field is left blank, then there is no upper drybulb temperature limit for evaporative cooler operation.

An example IDF entry is

EvaporativeCooler:Direct:ResearchSpecial,

Direct Evap Cooler, !- Name

ALWAYS\_ON, !- Availability Schedule Name

0.7 , !- Cooler Design Effectiveness

, !- Effectiveness Flow Ratio Modifier Curve Name

30.0 , !- Recirculating Water Pump Design Power

, !- Water Pump Power Sizing Factor

, !- Water Pump Power Modifier Curve Name

OAIndRDD Evap Cooler- OADirect Evap CoolerNode , !- Air Inlet Node Name

OADirect Evap Cooler- OAMixing BoxNode, !- Air Outlet Node Name

OADirect Evap Cooler- OAMixing BoxNode, !- Sensor Node Name

, !- Water Supply Storage Tank Name

0.0, !- Drift Loss Fraction

3; !- Blowdown Concentration Ratio

### EvaporativeCooler:Direct:ResearchSpecial Outputs

The output variables that are available for this direct evaporative cooler are shown below:

HVAC,Average, Evaporative Cooler Electric Power[W]

HVAC,Average, Evaporative Cooler Stage Effectiveness []

HVAC,Sum, Evaporative Cooler Electric Energy [J]

HVAC,Sum, Evaporative Cooler Water Volume[m3]

HVAC,Sum,Evaporative Cooler Mains Water Volume [m3]

HVAC,Sum,Evaporative Cooler Storage Tank Water Volume [m3]

HVAC,Sum,Evaporative Cooler Starved Water Volume [m3]

HVAC,Sum,Evaporative Cooler Starved Mains Water Volume [m3]

#### Evaporative Cooler Electric Power[W]

#### Evaporative Cooler Electric Energy [J]

These output variables report the electric power and electric energy required to operate the water pump.

***Evaporative Cooler Stage Effectiveness []***

The cooler stage efficiency is defined as the temperature change of the supply air divided by the difference between the outdoor dry-bulb and wet-bulb temperatures, including the effect of the reduction in the primary air flow rate in other words, it is a measure of the approach to the entering air wet-bulb temperature.

#### Evaporative Cooler Water Volume [m3]

The water consumption is the water evaporated from the pad. This water consumption is only from the direct thermodynamics of water evaporation and does not include other sources of consumption such as drift or concentration blow down. This output variable appears when mains water is supplied to the cooler.

#### Evaporative Cooler Mains Water Volume [m3]

This is the source of the water consumed. This output variable appears when mains water is supplied to the cooler.

#### Evaporative Cooler Storage Tank Water Volume [m3]

The water consumption is the water evaporated from the pad. This water consumption is only from the direct thermodynamics of water evaporation and does not include other sources of consumption such as drift or concentration blow down. This output variable appears when storage tank water is supplied to the cooler.

#### Evaporative Cooler Starved Water Volume [m3]

This is the water consumed by the evaporative cooler that could not accually be met by the storage tank. This output variable appears when storage tank water is supplied to the cooler.

#### Evaporative Cooler Starved Mains Water Volume [m3]

This is the source (mains) of water consumed by the evaporative cooler that could not accually be met by the storage tank. This output variable appears when storage tank water is supplied to the cooler.

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### EvaporativeCooler:Indirect:ResearchSpecial

This cooler is similar in principal to the EvaporativeCooler:Indirect:CelDekPad and EvaporativeCooler:Indirect:WetCoil (see Figure 145, Figure 146, and Figure 147). The model differs in that it gives the user more flexibility to specify the source of secondary air. The cooler effectiveness with respect to wetbulb depression is allowed to go beyond 1.0. Using the ResearchSpecial input object also allows the cooler to control the amount of cooling based on node setpoints (controlled by SetpointManagers). This avoid problems from over cooling when conditions are such that loads are low and cooling power is high. Fan power is assumed to vary linearly when the cooler is operating at less than full capacity.

The indirect evaporative cooler research special calculation procedure allows accounting for dry and wet effectiveness value variation with flow fraction. Two effectiveness modifier curves are included as optional user inputs for this purpose. Effectiveness modifier curves operate on the design dry and wet effectiveness values. The flow fraction is calculated as a ratio of the sum of current primary and secondary air flow rates to the sum of the design flow rates. Model also accounts for fan and recirculation water pump power variation with secondary air flow rates using pump power modifying curve. The fan power is calculated by multiplying the design fan power using fan power modify curve value evaluated at current secondary air flow fraction. Similarly, recirculating pump power is is calculated by multiplying the design pump power by pump power modifier curve value evaluated at current secondary air flow fraction. If the secondary air fan and recirculating pump power modifier curves are not specified, then fan and pump power are assumed to vary linearly with part load fraction.

#### Field: Name

A unique identifying name for each cooler.

#### Field: Availability Schedule Name

The name of a schedule that defines when the evaporative cooler is available. A schedule value of 0 indicates that the evaporative cooler is off for that time period. A schedule value greater than 0 indicates that the evaporative cooler can operate during the time period. If this field is blank, the schedule has values of 1 for all time periods.

#### Field: Cooler Wetbulb Design Effectiveness

This field specifies the design effectiveness that is applied to the wetbulb depression to determine the conditions leaving the cooler. This effectiveness is a complicated function of the efficiency with which heat and mass are transferred on the secondary side and the efficiency of heat exchange between the secondary and primary flows. The model assumes that the effectiveness is a function of flow fraction. The flow fraction is the ratio of the sum of primary air and secondary air current flow rates and the sum of the primary air and secondary air design flow rates.

***Field: Wet Bulb Effectiveness Flow Ratio Modifier Curve Name***

This curve modifies the wet bulb effectiveness design value specified the previous field by multiplying the value by the result of this curve. The modifying curve is a function of flow fraction, which is the ratio of the sum of the primary and secondary flow rates divided by the sum of the design flow rates. If this input field is left blank, the effectiveness is assumed to be constant**.** Any curve or table with one independent variable can be used. Any curve or table with one independent variable can be used: Curve:Linear, Curve:Quadratic, Curve:Cubic, Curve:Quartic, Curve:Exponent, Curve:ExponentialSkewNormal, Curve:Sigmoid, Curve:RectuangularHyperbola1, Curve:RectangularHyperbola2, Curve:ExponentialDecay, Curve:DoubleExponentialDecay, and Table:OneIndependentVariable.

***Field: Cooler Drybulb Design Effectiveness***

This input value is dry bulb design effectiveness of the evaporative cooler. This is the nominal design dry blub effectiveness with respect to dry bulb temperature difference, i.e., dry operation and at design air flow rates, and no water evaporation or spraying on the secondary side.

***Field Drybulb Effectiveness Flow Ratio Modifier Curve Name***

This this curve modifies the drybulb effectiveness in the previous field (eff\_db\_design) by multiplying the design effectiveness value by the result of this curve. The curve is evaluated flow fraction as independent variable. The flow fraction is the ratio of sum of the primary and secondary flow rates divided by the sum of the design flow rates. If this input field is left blank, the effectiveness is assumed to be constant. Any curve or table with one independent variable can be used: Curve:Linear, Curve:Quadratic, Curve:Cubic, Curve:Quartic, Curve:Exponent, Curve:ExponentialSkewNormal, Curve:Sigmoid, Curve:RectuangularHyperbola1, Curve:RectangularHyperbola2, Curve:ExponentialDecay, Curve:DoubleExponentialDecay, and Table:OneIndependentVariable.

#### Field: Recirculating Water Pump Design Power

This numeric input field is the recirculating pump electric power at Secondary Design Air Flow Rate in W. This is the nominal design pump power water recirculation and spray for evaporation at design secondary air flow rates and cooler design effectiveness. This input field is autosizable.

#### Field: Water Pump Power Sizing Factor

This numeric input field value is recirculating water pump sizing factor in W/(m3/s). This field is used when the previous field is set to autosize. The pump design electric power is scaled with Secondary Design Air Flow Rate.

#### Field: Water Pump Power Modifier Curve Name

This alpha input field is the name of a dimensionless normalized pump power modifying curve. This curve modifies the pump electric power in the previous field by multiplying the design power by the result of this curve. The normalized curve is a function of the secondary side flow fraction as independent variable. The curve shall yield a value of 1.0 at a flow fraction of 1.0. The flow fraction is the secondary air flow rate during operation divided by Secondary Design Air Flow Rate. If this input field is left blank, the pump power is assumed to be constant. Any curve or table with one independent variable can be used: Curve:Linear, Curve:Quadratic, Curve:Cubic, Curve:Quartic, Curve:Exponent, Curve:ExponentialSkewNormal, Curve:Sigmoid, Curve:RectuangularHyperbola1, Curve:RectangularHyperbola2, Curve:ExponentialDecay, Curve:DoubleExponentialDecay, and Table:OneIndependentVariable.

#### Field: Secondary Air Design Flow Rate

This field is used to specify the secondary fan flow rate and is specified in m3/s. This flow rate would typically be similar in magnitude to the flow through the primary side. This field can be autosized. When it is autosized, the program detects if the component is in the main air loop or on an outdoor air path. If it is on the main air loop, then the flow rate is set to the AirLoopHVAC system’s design supply air flow rate (which is the maximum required for heating and cooling). If it is on the outdoor air path, then the flow rate is set to the larger of either the design minimum outdoor air flow rate or one-half of the main air loop design flow rate. The flow rate is used to determine parasitic fan energy and cooler effectiveness. The flow rate (and fan power) is effectively reduced by cycling when the amount of cooling needs to be restricted for control purpose. This field can be autosized. When this input is autosized, the program calculates by scaling the Primary Air Design Flow Rate using secondary air scaling factor specified in the input field below.

#### Field: Secondary Air Flow Scaling Factor

#### This numeric input field is used to scale the secondary air design flow rate and it is dimensionless. This field is used when the previous field is set to autosize. The Primary Design Air Flow Rate is scaled using this factor to calculate the secondary design air flow rate.Field: Secondary Air Fan Design Power

This numeric input field is the fan electric power at Secondary Design Air Flow Rate. This is the nominal design electric power at full speed of the secondary air fan. This input field is autosizable.

#### Field: Secondary Air Fan Sizing Specific Power

This input field value is secondary air fan sizing specific power in W/(m3/s). This field is used when the previous field is set to autosize. The fan power is scaled with Secondary Design Air Flow Rate.

#### Field: Secondary Air Fan Power Modifier Curve Name

This input field is the name of a dimensionless normalized curve. The normalized curve modifies the design secondary air fan power in the previous field by multiplying the value by the result of this curve. The normalized curve is a function of the secondary side flow fraction as independent variable. The curve shall yield a value of 1.0 at a flow fraction of 1.0. The flow fraction is the secondary air flow rate during operation divided by Secondary Design Air Flow Rate. If this input field is left blank, the fan power is assumed to be constant. Any curve or table with one independent variable can be used: Curve:Linear, Curve:Quadratic, Curve:Cubic, Curve:Quartic, Curve:Exponent, Curve:ExponentialSkewNormal, Curve:Sigmoid, Curve:RectuangularHyperbola1, Curve:RectangularHyperbola2, Curve:ExponentialDecay, Curve:DoubleExponentialDecay, and Table:OneIndependentVariable.

#### Field: Primary Air Inlet Node Name

The name of the air inlet node for the primary air flow path through the cooler.

#### Field: Primary Air Outlet Node Name

The name of the air outlet node for the primary air flow path through the cooler.

#### Field:Primary Design Air Flow Rate

This numeric input field is the primary air design air flow rate in m3/s. This is the design primary air flow rate. This input field is autosizable. If the evaporative cooler is on main air loop branch, the design flow rate is the same as branch design flow rate, or else if it is on outdoor air system it will be the same as the outdoor air design flow rate.

#### Field: Dewpoint Effectiveness Factor

This field specifies an effectiveness that is applied to the dewpoint depression to determine a bound for the conditions leaving the cooler. The model uses the warmer of the two temperatures determined from wetbulb depression and dewpoint depression.

#### Field: Secondary Air Inlet Node Name

This field specifies the name of the node providing air to the secondary/wet side of the cooler. Typically this node could appear in an outdoor air node list or be part of an air system loop.

#### Field: Secondary Air Outlet Node Name

This alpha input field is the name of the secondary air side outlet node.

#### Field: Sensor Node Name

This field specifies the name of a node that will provide system air temperature setpoint information. A separate SetpointManager object should be setup to update this node.

#### Field: Relief Air Inlet Node Name

This field is optional, but can be used to feed two sources of secondary air into the wet side of the cooler. Typical use is to run the air system relief air into the system. The model first uses all of the air flow available from this node and then adds the air flow from the secondary air inlet node to make up the total defined by Secondary Fan Flow Rate.

#### Field: Water Supply Storage Tank Name

This field is optional. It is used to describe where the cooler obtains water used for evaporative cooling. If blank or omitted, then the cooler will obtain water directly from the mains. If the name of a WaterUse:Storage object is used here, then the cooler will obtain its water from that tank. If a tank is specified, the cooler will attempt to obtain all the water it uses from the tank. However, if the tank cannot provide all the water the cooler needs, then the cooler will still operate and obtain the rest of the water it needs from the mains.

#### Field: Drift Loss Fraction

This field is optional and can be used to model additional water consumed by the cooler from drift. Drift is water that leaves the cooling media as droplets and does not evaporate into the process air stream. For example, water may get blown off the evaporative media by winds and escape the air system. The value entered here is a simple fraction of the water consumed by the cooler for normal process evaporation. The amount of drift is this fraction times the water evaporated for the normal cooling process. This field can be left blank and then there will be no added water consumption from drift.

#### Field: Blowdown Concentration Ratio

This field is optional and can be used to model additional water consumed by the cooler from blowdown. Blowdown is water that is intentionally drained from the cooler’s sump to offset the build up of solids in the water that would otherwise occur because of evaporation. The value entered here is dimensionless. It can be characterized as the ratio of solids in the blowdown water to solids in the make up water. Typical values are 3 to 5. The default is 3.0.

#### Field: Evaporative Operation Minimum Limit Drybulb Temperature

This input field value defines the secondary air inlet node drybulb temperature limits in degree Celsius. When the secondary side entering air dry bulb temperature drops below this limit, then the evaporative cooler operation mode changes to dry heat exchanger. Users specify their own limits. If this field is left blank, then there is no drybulb temperature lower limit for evaporative cooler operation. If operating range control is desired then this input field and the next two input fields should be specified or all the three should be left blank or left out. If no minimum drybulb temperature limit is required while there are maximum drybulb and wetbulb temperature limits then specify very low temperature limit value (e.g., -99.0 C).

#### Field: Evaporative Operation Maximum Limit Wetbulb Temperature

This input field value defines the secondary air inlet node wetbulb temperature limits in degree Celsius. When the secondary side entering air wet bulb temperature exceeds this limit, then the evaporative cooler is turns off and does not attempt to do any cooling. If this field is left blank, then there is no wetbulb temperature maximum limit for evaporative cooler wet operation mode. If no upper wetbulb temperature limits is desired while there are minimum drybulb and maximum drybulb upper temperature limits then then specify very high maximum wetbulb temperature limit value (e.g. 99.0 C).

#### Field: Evaporative Operation Maximum Limit Drybulb Temperature

This input field value defines the secondary air inlet node drybulb temperature limits in degree Celsius. When the secondary side entering air drybulb temperature exceeds this limit, the evaporative cooler will not run in dry operation mode or may be turned off depending on its wetbulb temperature. If this field is left blank, then there is no drybulb temperature maximum limit for evaporative cooler dry operation mode.

If no drybulb temperature limit is desired while there are minimum drybulb and maximum wetbulb temperature limits then specify very high maximum drybulb temperature limit value (e.g. 99.0 C).

An IDF example is shown below:

EvaporativeCooler:Indirect:ResearchSpecial,

DataC\_IndirectEvapCooler, !- Name

ALWAYS\_ON, !- Availability Schedule Name

0.75, !- Cooler Wetbulb Design Effectiveness

, !- Wetbulb Effectiveness Flow Ratio Modifier Curve Name

, !- Cooler Drybulb Design Effectiveness

, !- Drybulb Effectiveness Flow Ratio Modifier Curve Name

autosize, !- Recirculating Water Pump Power

autosize, !- Secondary Air Design Flow Rate

1.0, !- Secondary Air Flow Scaling Factor

autosize, !- Secondary Air Fan Design Power

800.0, !- Secondary Air Fan Sizing Specific Power W

, !- Secondary Air Fan Power Modifier Curve Name

Return Air Node, !- Primary Air Inlet Node Name

IndEC Outlet Node, !- Primary Air Outlet Node Name

autosize, !- Primary Design Air Flow Rate

0.9 , !- Dewpoint Effectiveness Factor

IndEC OA Air Inlet Node, !- Secondary Air Inlet Node Name

IndEC OA Air Outlet Node, !- Secondary Air Outlet Node Name

IndEC Outlet Node, !- Sensor Node Name

, !- Relief Air Inlet Node Name

, !- Water Supply Storage Tank Name

0.0, !- Drift Loss Fraction

; !- Blowdown Concentration Ratio

### EvaporativeCooler:Indirect:ResearchSpecial Outputs

The output variables that are available for the EvaporativeCooler:Indirect:ResearchSpecial object are shown below:

HVAC,Average,Evaporative Cooler Total Stage Effectiveness []

HVAC,Average,Evaporative Cooler Part Load Ratio []

HVAC,Average,Evaporative Cooler Dewpoint Bound Status []

HVAC,Average,Evaporative Cooler Operating Mode Satus []

HVAC,Sum,Evaporative Cooler Electric Energy [J]

HVAC,Average,Evaporative Cooler Electric Power [W]

HVAC,Sum,Evaporative Cooler Storage Tank Water Volume [m3]

HVAC,Sum,Evaporative Cooler Starved Water Volume [m3]

HVAC,Sum,Evaporative Cooler Starved Mains Water Volume [m3]

#### Evaporative Cooler Total Stage Effectiveness []

The Total Stage Efficiency is defined as the temperature change of the supply air divided by the difference between the primary air entering dry-bulb temperature and the secondary air enterig wet-bulb temperature for wet operating mode or the the difference between the primary air entering dry-bulb temperature and the secondary air enterig dry-bulb temperature for dry operating mode, including the effect of the reduction in flow because of the secondary air stream. In other words, it is a measure of the approach to the secondary air wet-bulb temperature for wet operating mode, or it is a measure of the approach to the secondary air entering dry-bulb temperature for dry operating mode.

#### Evaporative Cooler Operating Mode Status []

This output variable provides the operating modes or status of the indirect evaporative cooler. This output variable can have status indicator integer value of 0, 1, or 2 representing Off, Dry and Wet operating modes, respectively.

#### Evaporative Cooler Part Load Ratio []

This output variable provides the part load fraction of the indirect cooler. The ResearchSpecial cooler model is able to modulate to meet a temperature set point to avoid over cooling. This output variable is the fraction formed by the ratio of the capacity needed over the maximum cooling capacity available. A value of 1.0 corresponds to full capacity cooling.

#### Evaporative Cooler Dewpoint Bound Status []

This output variable is a flag that indicates if the modeling was based on dewpoint effectivenss rather than wetbulb effectiveness The ResearchSpecial model is usually based on wet-bulb approach, but since values in excess of 1.0 are allowed, there is a secondary constraint imposed by dewpoint. If the dewpoint effectiveness was applied, then this flag variable will have the value 1.0, otherwise it is 0.0.

#### Evaporative Cooler Electric Power [W]

#### Evaporative Cooler Electric Energy [J]

These output variables report the electric power and energy that are consumed by the secondary air fan and the sump pump.

#### Evaporative Cooler Water Volume [m3]

The water consumption is the water evaporated from the pad. This water consumption is only from the direct thermodynamics of water evaporation and does not include other sources of consumption such as drift or concentration blow down. This output variable appears when mains water is supplied to the cooler.

#### Evaporative Cooler Mains Water Volume [m3]

This is the source of the water consumed. This output variable appears when mains water is supplied to the cooler.

#### Evaporative Cooler Storage Tank Water Volume [m3]

The water consumption is the water evaporated from the pad. This water consumption is only from the direct thermodynamics of water evaporation and does not include other sources of consumption such as drift or concentration blow down. This output variable appears when storage tank water is supplied to the cooler.

#### Evaporative Cooler Starved Water Volume [m3]

This is the water consumed by the evaporative cooler that could not accually be met by the storage tank. This output variable appears when storage tank water is supplied to the cooler.

#### Evaporative Cooler Starved Mains Water Volume [m3]

This is the source (mains) of water consumed by the evaporative cooler that could not accually be met by the storage tank. This output variable appears when storage tank water is supplied to the cooler.

## Group – Heat Recovery

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