### Coil:Cooling:Water

The sizing is done in function *SizeWaterCoil* of module *WaterCoils*

#### Initial Calculations

##### System Coils

For central cooling coils, the first step is to determine the design air flow rate, load, and design air entering and exit conditions. The coil design air flow rate is not generally the same as the maximum system air flow rate (used to size the central fans). The cooling coil peak load (either sensible or total) can occur at a different time than the system peak flow rate. Hence the coil air entering conditions can be different than those at the peak system flow rate. Also, the method of controlling the coil's cooling output may also affect coil design flow rate as well as the coil design exit temperature and humidity.

By choosing *Type of Load to Size On* = *Sensible* or *Total* in *Sizing:System* the user indicates to the program to save the cooling coil air flow rate and system air conditions (mixed, return, outside) at the time of either the system cooling sensible or total load peak. Note that the choice *VentilationRequirement* uses the time of the sensible peak.

Choosing *Central Cooling Capacity Control Method* = *VAV*, *Bypass*, *VT*, or *OnOff* indicates which type of cooling output control the program should assume when calculating the design air flow rate. The function *GetCoilDesFlowT* in module *ReportSizingManager* calculates the air flow rate and exit air temperature for each capacity control method.

VAV: and 

Bypass:and 

where 

VT:  and 

OnOff: and 

:the specific heat of air [J/kg°C]  
: the air mass flow rate through the cooling coil at the sensible or total system peak cooling load [m3/s]

: sum of the zone sensible cooling loads at the time of the peak system cooling load.

: the density of air [kg/m3]

: the design cooling coil exit temperature [°C]

: the supply air temperature for cooling specified in *Sizing:System* [°C]

: the mixed air temperature at the time of the system peak cooling load [°C]

: the average zone temperature at the time of the system peak cooling load [°C]

: the design volumetric air flow rate through the cooling coil [m3/s]. This is the flow rate at either the sensible or total cooling load peak from the design period calculations.

: the maximum cooling volumetric air flow rate from the design calculations [m3/s]. This flow rate occurs at the maximum zone cooling demand.

: the maximum volumetric air flow rate from the design calculations [m3/s]. This flow rate occurs at either the maximum zone cooling or heating demand.

#### Design Coil Load (W)

Design coil load (cooling capacity) is not an input for *Coil:Cooling:Water*. It is used for calculating the design water flow rate.

##### System Coils

The design load is calculated using:



where

is the coil design inlet air enthalpy [J/kg];

is the coil design outlet air enthalpy [J/kg]; and

is the coil design air mass flow rate [kg/s].

The design air mass flow rate depends on the location of the coil. If the coil is in the outside air stream the flow rate is set to , where is the design outside air volumetric flow rate for the system. Otherwise  is set to  where is calculated above in the Initial Calculations section.

To obtain the inlet and outlet enthalpies, we need the inlet and outlet temperatures and humidity ratios. The inlet and outlet conditions depend on whether the coil is in the outside air stream and if it is not, whether or not there is outside air preconditioning.

1. Coil in outside air stream
   1. ** (the outside air temperature at the design cooling peak)
   2. ** (the specified Precool Design Temperature from the *Sizing:System* object).
   3.  (the outside humidity ratio at the design cooling peak)
   4.  (the specified Precool Design Humidity Ratio from the *Sizing:System* object)
2. Coil in main air stream, no preconditioning of outside air
   1.  (the mixed air temperature at the design cooling peak)
   2.  (the mixed air humidity ratio at the design cooling peak)
   3. *Tair,out,des* is set to *Tcc,exit* calculated above in the Initial Calculation section.
   4. **(the specified *Central Cooling Design Supply Air Humidity Ratio* from the *Sizing:System* object)
3. Coil in main air stream, outside air preconditioned. The outside air fraction is calculated as**, where is calculated above.
   1. ** where is the specified *Precool Design Temperature* from *System:Sizing*. is the return temperature at the system cooling peak load.
   2. ** where is the specified *Precool Design Humidity Ratio* from *Sizing:System*  and is the return humidity ratio at the system cooling peak load.

*Tair,out,des* and *Wair,out,des* are defined as in 2).

With the inlet and outlet conditions established, we can obtain the inlet and outlet enthalpies:

*hair,coil,des,in* = *PsyHFnTdbW*(*Tair,in,des*, *Wair,in,des*)

*hair,coil,des,out*= *PsyHFnTdbW*(*Tair,out,des*, *Wair,out,des*)

where *PsyHFnTdbW* is the EnergyPlus function for calculating air specific enthalpy given the air temperature and humidity ratio. We now have all we need to calculate *.*

##### Zone Coils

If the coil is part of an *AirTerminal:SingleDuct:ConstantVolume:FourPipeInduction* unit or an *ZoneHVAC:FourPipeFanCoil*, the cooling load (cooling capacity) is passed down from the terminal unit or fan coil sizing calculations. Otherwise the load is defined as:



where

is the coil design inlet air enthalpy [J/kg];

is the coil design outlet air enthalpy [J/kg]; and

is the coil design air mass flow rate [kg/s].

The enthalpies are given by:





where *Tair,in,des* and *Wair,in,des* are the coil inlet design conditions. For coils in terminal units these are set at the system level to the system design supply air temperature. For zonal usits they are set to design return air, mixed air, or outside air as appropriate to the unit. *Tair,out,des* is set to the zone cooling design supply air temperature as specified in the *Zone:Sizing* inputs. *Wair,out,des* is set to the zone cooling design supply air humidity ratio as specified in the *Zone:Sizing* inputs.



where *ΔTw,des* is just the *Loop Design Temperature Difference* user input from *Sizing:Plant* (if the coil is in the outside air stream, ½ the *Loop Design Temperature Difference* is used).

##### Zone Coils

If the coil is part of an *AirTerminal:SingleDuct:ConstantVolume:FourPipeInduction* unit or an *ZoneHVAC:FourPipeFanCoil*, the chilled water flow rate is passed down from the terminal unit or fan coil sizing calculations. Otherwise the flow is set to:



where *ΔTw,des* is just the *Loop Design Temperature Difference* user input from *Sizing:Plant*. is calculated as described above.

#### Design Air Flow Rate

##### System Coils

The design air volumetric flow rate for the system cooling coil is set to:

1. the design outside air flow rate if the coil is in the outside air stream;
2. the coil design flow rate from function *GetCoilDesFlowT* described in section "Initial Calculations";
3. the design flow rate set by the parent component (such as a unitary system) containing the cooling coil.

##### Zone Coils

Zone chilled water coils are always part of a zone HVAC component. In almost all cases the design flow rate is passed down from the design flow rate of the parent component. Otherwise if the parent component does cooling only the flow rate for the coil is set to the zone design cooling flow rate. And if the parent component does both cooling and heating, the coil flow rate is set to the maximum of the zone design cooling and heating flow rates.

#### Design Inlet Air Temperature

##### System Coils

The inlet air temperature depends on whether the coil is in the outside air stream and if it is not, whether or not there is outside air preconditioning.

##### Coil in outside air stream: (the outside air temperature at the design cooling peak).

##### Coil in main air stream, no preconditioning of outside air: (the mixed air temperature at the design cooling peak).

##### Coil in main air stream, outside air preconditioned. The outside air fraction is calculated as *,* where is calculated above. Then where is the specified *Precool Design Temperature* from *System:Sizing*. is the return temperature at the system cooling peak load.

##### Zone Coils

The design inlet temperature depends on whether the coil is in a terminal unit or a zonal unit, and where the coil is positioned within the unit.

1. For the *AirTerminal:SingleDuct:ConstantVolume:FourPipeInduction* terminal unit the design inlet temperature is set to the zone temperature at the time of the zone cooling peak, since the coil is located in the induced air stream.
2. For fan coil units the design inlet temperature is set to the mixed air temperature:  where .
3. In all other cases the design inlet temperature is set to the zone design cooling coil inlet temperature which is calculated in the zone sizing simulation and is basically the same calculation as the fan coil unit.

#### Design Outlet Air Temperature

##### System Coils

The outlet air temperature depends on whether the coil is in the outside air stream.

1. Coil in outside air stream: *Tair,out,des* *=* *Tsys,des,precool* (the specified Precool Design Temperature from the *Sizing:System* object).
2. Coil in main air stream: the design outlet air temperature is set to the temperature calculated in the Initial Calculation section above.

##### Zone Coils

If the coil is part of an *AirTerminal:SingleDuct:ConstantVolume:FourPipeInduction* unit, then:









For all other cases *Tair,out,des* is set to *Tz,sup,des* (the zone design supply air temperature as specified in *Sizing:Zone*).

#### Design Inlet Air Humidity Ratio

##### System Coils

The design inlet humidity ratio depends on whether the coil is in the outside air stream and if it is not, whether or not there is outside air preconditioning.

1. Coil in outside air stream: ** (the outside air humidity ratio at the design cooling peak).
2. Coil in main air stream, no preconditioning of outside air:  (the mixed air humidity ratio at the design cooling peak).
3. Coil in main air stream, outside air preconditioned. The outside air fraction is calculated as *,* where is calculated above. Then ** where is the specified *Precool Design Humidity Ratio* from *System:Sizing*. is the return air humidity ratio at the system cooling peak load.

##### Zone Coils

The design inlet humidity depends on whether the coil is in a terminal unit or a zonal unit, and where the coil is positioned within the unit.

1. For the *AirTerminal:SingleDuct:ConstantVolume:FourPipeInduction* terminal unit the design inlet humidity ratio is set to the zone humidity ratio at the time of the zone cooling peak, since the coil is located in the induced air stream.
2. For fan coil units the design inlet humidity ratio is set to the mixed air humidity ratio:  where .
3. In all other cases the design inlet temperature is set to the zone design cooling coil inlet humidity ratio which is calculated in the zone sizing simulation and is basically the same calculation as the fan coil unit.

#### Design Outlet Air Humidity Ratio

##### System Coils

The outlet air humidity ratio depends on whether the coil is in the outside air stream.

1. Coil in outside air stream: *Wair,out,des* = *Wsys,des,precool* (the specified Precool Design Humidity Ratio from the *Sizing:System* object)
2. Coil in main air stream:  where *PsyWFnTdbRhPb* is the EnergyPlus psychrometric function to calculate humidity ratio from drybulb temperature, relative humidity, and atmospheric pressure. The design outlet humidity ratio is being set to the humidity ratio at 90% relative humidity and design outlet temperature.

##### Zone Coils

If the coil is part of an *AirTerminal:SingleDuct:ConstantVolume:FourPipeInduction* unit, then:

get the dewpoint temperature at *Wair,in,des*: .

If *Tdp,in* ≤ *Tw,in,des* set *Wair,out,des* = *Wair,in,des*. Otherwise set 

If the coil is not part of an *AirTerminal:SingleDuct:ConstantVolume:FourPipeInduction* unit, set *Wair,out,des* to W*z,sup,des* (the zone design supply air humidity ratio as specified in *Sizing:Zone*).

#### Design Inlet Water Temperature

##### System Coils

The Design Inlet Water Temperature is set to the *Design Loop Exit Temperature* specified in the *Sizing*:*Plant* object for the water loop serving this coil.

##### Zone Coils

The Design Inlet Water Temperature is set to the *Design Loop Exit Temperature* specified in the *Sizing*:*Plant* object for the water loop serving this coil.