# TYPE 651: RESIDENTIAL COOLING COIL (AIR CONDITIONER)

## General Description

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

## Nomenclature

| | | |
|---|---|---|
| $T_{evap,in}$ | [ºC] | Temperature of air entering the evaporator side of the coil |
| $h_{evap,in}$ | [kJ/kg] | Enthalpy of air exiting the evaporator side of the coil |
| $\omega_{evap,in}$ | [kg$H_2O$/kgAir] | Humidity ratio of air entering the evaporator side of the coil |
| $P_{evap,in}$ | [atm] | Pressure of air entering the evaporator side of the coil |
| $T_{evap,out}$ | [ºC] | Temperature of air exiting the evaporator side of the coil |
| $h_{evap,out}$ | [kJ/kg] | Enthalpy of air entering the evaporator side of the coil |
| $\omega_{evap,out}$ | [kg$H_2O$/kgAir] | Humidity ratio of air exiting the evaporator side of the coil |
| $P_{evap,out}$ | [atm] | Pressure of air exiting the evaporator side of the coil |
| $\dot{Q}_{total}$ | [kJ/hr] | Rate of total energy transferred by the coil |
| $\dot{Q}_{sensible}$ | [kJ/hr] | Rate of sensible energy transferred by the coil |
| $\dot{Q}_{rejected}$ | [kJ/hr] | Rate of energy rejected by the coil to ambient |
| $SHR$ | [0..1] | Sensible heat ratio |
| $\dot{m}_{evap}$ | [kg/hr] | Flow rate of air on the evaporator side of the coil |
| $\dot{m}_{condensate}$ | [kg/hr] | Mass flow rate of condensate exiting the coil |
| $Cp_{air}$ | [kJ/kg.K] | Specific heat of dry air |
| $\Delta P_{evap}$ | [atm] | Pressure drop across the evaporator side of the coil |
| $COP$ | [ - ] | Coil Coefficient of Performance |
| $Pwr_{total}$ | [kJ/hr] | Total power draw by the air conditioner (residential cooling coil) |
| $EER$ | [ - ] | Energy Efficiency Rating of the coil |

## Detailed Description

Type651 relies on a catalog data lookup method to predict the performance of residential air conditioning devices. The user must provide two text based data files in the standard TRNSYS data file format. The first of these files must provide the air conditioner's total cooling capacity (in kW) and the air conditioners power draw (in W) for varying values of evaporator air flow rates (in liters per second), for varying indoor air wet bulb temperatures (in ºC) and for varying condenser temperatures (in ºC). The second data file provides values of sensible heat ratio (as defined in Equation 651.1) for varying values of indoor dry bulb temperature (in ºC), evaporator flow rate (in liters per second), and indoor wet bulb temperature (in ºC).

$$SHR = \frac{SensibleEnergy\,\mathrm{Re}moved}{TotalCoolingCapacity} \quad \text{(Eq. 651.1)}$$

Type651 first performs a call to the TRNSYS psychrometrics routine in order to obtain the remaining air properties that are not specified by the user among the component's inputs. If indoor dry bulb temperature and humidity ratio are inputs to the model and a humidity ratio higher than the saturation humidity ratio for that dry bulb temperature is specified, the psychrometrics routine will reset the humidity ratio to its saturated condition and print a warning in the TRNSYS list file. Having fully defined the entering indoor air state, Type651 next determines the volumetric flow rate of evaporator air using the mass flow rate specified by the user and the dry air density returned by the psychrometrics routine. It then calls the TRNSYS DynamicData routine, which reads the first data file and returns total cooling capacity and total power draw. Type651 then recalls the DynamicData routine to determine the appropriate sensible cooling ratio for the current conditions.

The outlet conditions of the evaporator side air stream are calculated using Equations 651.2a, 651.2b, and 651.2c,

$$h_{evap,out} = h_{evap,in} - \frac{\dot{Q}_{total}}{\dot{m}_{evap}} \quad \text{(Eq. 651.2a)}$$

$$T_{evap,out} = T_{evap,in} - \frac{\dot{Q}_{sensible}}{\dot{m}_{evap} Cp_{air}} \quad \text{(Eq. 651.2b)}$$

$$P_{evap,out} = P_{evap,in} - \Delta P_{evap} \quad \text{(Eq. 651.2c)}$$

The total power draw of the air conditioner, as specified in the first data file is assumed to include controller power draw, blower power draw and compressor power draw. Both controller and blower power draw are requested as inputs to the model; the compressor power is simply the difference between the power read from the data file and the combined blower and controller power. The heat rejection of the device (the rate at which heat is rejected from the device to the ambient is calculated using Equation 651.3

$$\dot{Q}_{rejected} = \dot{Q}_{total} + Pwr_{total} \quad \text{(Eq. 651.3)}$$

The COP (coefficient of performance) and EER (energy efficiency rating) are therefore:

$$COP = \frac{\dot{Q}_{total}}{Pwr_{total}} \quad \text{(Eq. 651.4)}$$

$$EER = COP * 3.413 \quad \text{(Eq. 651.5)}$$

The amount of moisture removed from the evaporator air stream leaves the device via a condensate stream whose fluid temperature is that of the air exiting the evaporator and whose flowrate is given by Equations 651.6.

$$\dot{m}_{condensate} = \dot{m}_{evap}\left(\omega_{evap,in} - \omega_{evap,out}\right) \quad \text{(Eq. 651.6)}$$

Example data files are provided in the Catalog_Data\ResCC\Sample directory. The format of the data files is shown below for reference.

Example Cooling Capacity Data File

```
330.33 401.12 471.9          !evaporator air flow rates in liters per second [l/s]
17.22  19.44  21.67          !indoor air wet bulb temperatures [C]
29.44  35 40.56 46.11        !condenser temperatures [C]
3.735  740    !total cooling capacity [kW] and power draw [W] at 330.33/17.22/29.44
3.59   840    !total cooling capacity [kW] and power draw [W] at 330.33/17.22/35
3.46   940    !total cooling capacity [kW] and power draw [W] at 330.33/17.22/40.56
3.31   1045   !total cooling capacity [kW] and power draw [W] at 330.33/17.22/46.11
3.94   745    !total cooling capacity [kW] and power draw [W] at 330.33/19.44/29.44
3.81   840    !total cooling capacity [kW] and power draw [W] at 330.33/19.44/35
3.665  945    !total cooling capacity [kW] and power draw [W] at 330.33/19.44/40.56
3.515  1050   !total cooling capacity [kW] and power draw [W] at 330.33/19.44/46.11
4.16   750    !total cooling capacity [kW] and power draw [W] at 330.33/21.67/29.44
4.03   845    !total cooling capacity [kW] and power draw [W] at 330.33/21.67/35
3.87   950    !total cooling capacity [kW] and power draw [W] at 330.33/21.67/40.56
3.72   1055   !total cooling capacity [kW] and power draw [W] at 330.33/21.67/46.11
3.915  745    !total cooling capacity [kW] and power draw [W] at 401.12/17.22/29.44
3.765  840    !total cooling capacity [kW] and power draw [W] at 401.12/17.22/35
3.62   940    !total cooling capacity [kW] and power draw [W] at 401.12/17.22/40.56
3.445  1050   !total cooling capacity [kW] and power draw [W] at 401.12/17.22/46.11
4.12   745    !total cooling capacity [kW] and power draw [W] at 401.12/19.44/29.44
3.97   840    !total cooling capacity [kW] and power draw [W] at 401.12/19.44/35
3.825  945    !total cooling capacity [kW] and power draw [W] at 401.12/19.44/40.56
3.665  1050   !total cooling capacity [kW] and power draw [W] at 401.12/19.44/46.11
4.34   750    !total cooling capacity [kW] and power draw [W] at 401.12/21.67/29.44
4.19   845    !total cooling capacity [kW] and power draw [W] at 401.12/21.67/35
4.045  950    !total cooling capacity [kW] and power draw [W] at 401.12/21.67/40.56
3.885  1060   !total cooling capacity [kW] and power draw [W] at 401.12/21.67/46.11
4.045  745    !total cooling capacity [kW] and power draw [W] at 471.9/17.22/29.44
3.885  840    !total cooling capacity [kW] and power draw [W] at 471.9/17.22/35
3.735  945    !total cooling capacity [kW] and power draw [W] at 471.9/17.22/40.56
3.575  1050   !total cooling capacity [kW] and power draw [W] at 471.9/17.22/46.11
4.25   750    !total cooling capacity [kW] and power draw [W] at 471.9/19.44/29.44
4.105  845    !total cooling capacity [kW] and power draw [W] at 471.9/19.44/35
3.94   950    !total cooling capacity [kW] and power draw [W] at 471.9/19.44/40.56
3.78   1055   !total cooling capacity [kW] and power draw [W] at 471.9/19.44/46.11
4.455  750    !total cooling capacity [kW] and power draw [W] at 471.9/21.67/29.44
4.31   850    !total cooling capacity [kW] and power draw [W] at 471.9/21.67/35
4.145  955    !total cooling capacity [kW] and power draw [W] at 471.9/21.67/40.56
3.985  1065   !total cooling capacity [kW] and power draw [W] at 471.9/21.67/46.11
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Example Sensible Ratio Data File

```
23.89  26.67  29.44      ! Indoor dry bulb temperature (C)
330.33  401.12  471.90   ! Evaporator flow rate (l/s)
17.22  19.44  21.67      ! Indoor wet bulb temperature (C)
0.69                       ! Sensible heat ratio (SHR) for 23.89/330.33/17.22
0.54                       ! Sensible heat ratio (SHR) for 23.89/330.33/19.44
0.41                       ! Sensible heat ratio (SHR) for 23.89/330.33/21.67
0.73                       ! Sensible heat ratio (SHR) for 23.89/401.12/17.22
0.57                       ! Sensible heat ratio (SHR) for 23.89/401.12/19.44
0.42                       ! Sensible heat ratio (SHR) for 23.89/401.12/21.67
0.77                       ! Sensible heat ratio (SHR) for 23.89/471.90/17.22
0.59                       ! Sensible heat ratio (SHR) for 23.89/471.90/19.44
0.43                       ! Sensible heat ratio (SHR) for 23.89/471.90/21.67
0.84                       ! Sensible heat ratio (SHR) for 26.67/330.33/17.22
0.68                       ! Sensible heat ratio (SHR) for 26.67/330.33/19.44
0.54                       ! Sensible heat ratio (SHR) for 26.67/330.33/21.67
0.9                        ! Sensible heat ratio (SHR) for 26.67/401.12/17.22
0.71                       ! Sensible heat ratio (SHR) for 26.67/401.12/19.44
0.56                       ! Sensible heat ratio (SHR) for 26.67/401.12/21.67
0.96                       ! Sensible heat ratio (SHR) for 26.67/471.90/17.22
0.77                       ! Sensible heat ratio (SHR) for 26.67/471.90/19.44
0.58                       ! Sensible heat ratio (SHR) for 26.67/471.90/21.67
0.98                       ! Sensible heat ratio (SHR) for 29.44/330.33/17.22
0.82                       ! Sensible heat ratio (SHR) for 29.44/330.33/19.44
0.68                       ! Sensible heat ratio (SHR) for 29.44/330.33/21.67
1                          ! Sensible heat ratio (SHR) for 29.44/401.12/17.22
0.88                       ! Sensible heat ratio (SHR) for 29.44/401.12/19.44
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0.71                    ! Sensible heat ratio (SHR) for 29.44/401.12/21.67
1                       ! Sensible heat ratio (SHR) for 29.44/471.90/17.22
0.94                    ! Sensible heat ratio (SHR) for 29.44/471.90/19.44
0.76                    ! Sensible heat ratio (SHR) for 29.44/471.90/21.67
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