# TYPE 688: DEHUMIDIFIER

## General Description

Type688 models a stand-alone "all in one" dehumidifier in which the air stream is in contact with the evaporator section (cools and dehumidifies the air), and with the condenser section (reheats the air) of the refrigerant loop. The user can control the amount of heat that is added to the flow stream by setting an input value; a value of zero signifies that no air reheating is done and that all the compressor and evaporator energy is rejected to the surroundings. A value of one signifies that all the compressor and evaporator energy is added back into the air stream flowing across the coils. The model relies on a data file containing performance data at various entering air conditions. The power reported in this data file should contain only the compressor power as the fan power is handled separately.

## Nomenclature

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|---|---|---|
| $\dot{m}_{air}$ | [kg/hr] | Current mass flow rate of air across the dehumidifier coils. |
| $\dot{m}_{rated}$ | [kg/hr] | Rated (maximum) mass flwo rate of air across the dehumidifier coils |
| $\gamma_{fan}$ | [0..1] | Fan control signal. 0: fan is OFF, 1: fan is full ON. The control signal may have any value between 0 and 1. |
| $\dot{P}_{fan}$ | [kJ/hr] | The power drawn by the fan. |
| $\dot{P}_{rated}$ | [kJ/hr] | The power drawn by the fan when operating at is rated condition. |
| $\dot{P}_{comp}$ | [kJ/hr] | The power drawn by the compressor when ON |
| $\dot{P}_{tot}$ | [kJ/hr] | The total power drawn by the dehumidifier. |
| $c_0, c_1, c_2, c_3, ...$ | [ - ] | Fan power curve coefficients relating dimensionless mass flow rate to dimensionless fan power draw. |
| $h_{air,in}$ | [kJ/kg] | The enthalpy of air entering the dehumidifier |
| $h_{air,out}$ | [kJ/kg] | The enthalpy of air exiting the dehumidifier |
| $f_{ToAir}$ | [0..1] | The fraction of rejection energy that impacts the air stream passing across the dehumidifier coils. The remainder of the rejection energy impacts the dehumidifier environment. |
| $\dot{Q}_{air}$ | [kJ/hr] | The energy transferred to the air stream |
| $\dot{Q}_{env}$ | [kJ/hr] | The energy transferred to the dehumidifier environment. |
| $\dot{Q}_{rej}$ | [kJ/hr] | The energy rejected by the dehumidifier. |
| $Cap$ | [kJ/hr] | The capacity of the dehumidifier under current conditions |
| $\dot{m}_{cond}$ | [kg/hr] | The mass flow rate of condensate exiting the dehumidifier. |
| $\omega_{air,in}$ | [kg$H_2O$/kgAir] | The absolute humidity ratio of air entering the dehumidifier |
| $\omega_{air,out}$ | [kg$H_2O$/kgAir] | The absolute humidity ratio of air exiting the dehumidifier. |

## Detailed Description

Often, dehumidifiers are simply refrigerant loops in which the evaporator and condenser coils are not separated by a thermal barrier. Instead, a single air stream passes first over the evaporator (where it is cooled and dehumidified) then directly over the condenser coils where it picks up the condenser and compressor power energy. Type684 augments this standard design by offering the user the ability to

direct what fraction of the rejection energy (condenser energy plus compressor power) is added back into the air stream and what fraction of the same energy is rejected to the dehumidifier surroundings. The dehumidifier modeled by Type688 is shown schematically in Figure 1.

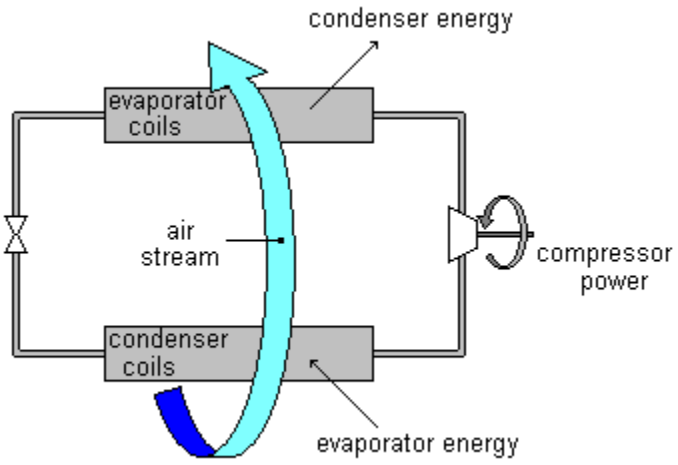



**Figure 1: Dehumidifier Schematic**

Each time that Type688 is called, it fully determines the inlet air state. The TRNSYS Psychrometrics routine is called with pressure, temperature, and either relative humidity or absolute humidity ratio (depending upon the value of the humidity mode parameter). If the Psychrometrics routine is called with an absolute humidity ratio greater than the saturation humidity ratio for the specified temperature, the humidity ratio will be reset to the saturation humidity ratio and a warning will be printed to the simulation log and list files. The Psychrometrics routine returns the inlet air pressure, temperature, relative humidity, humidity ratio and enthalpy.

Type688 has two control signals, one for the dehumidifier itself and one for the air stream fan. The two control signals are independent of one another. The dehumidifier control is either ON (control signal = 1) or OFF (control signal = 0) while the fan control signal can have any value between 0 and 1. When both the control signals are OFF then the outlet air pressure, temperature, enthalpy, humidity ratio, and relative humidity are set to their corresponding inlet values. The energy rejected to the environment, the device's capacity, the energy rejected to the air stream, the power drawn by the fan and the power drawn by the compressor are all set to zero.

*Fan Only Operation*

If the fan control signal is greater than zero but the dehumidifier is OFF, then the air outlet condition is largely governed by the fan pressure rise. The mass flow rate of air through the dehumidifier is given by equation 688.1

$$\dot{m}_{air} = \dot{m}_{rated}\ \gamma_{fan} \qquad \text{(Eq. 688.1)}$$

The power drawn by the fan is dictated by a polynomial fan curve whose coefficients are supplied by the user. The form of the fan curve is given in equation 688.2

$$\dot{P}_{fan} = \dot{P}_{rated}\left(c_0 + c_1\ \gamma_{fan} + c_2\ \gamma_{fan}^{\ 2} + c_3\ \gamma_{fan}^{\ 3} + \ldots\right) \qquad \text{(Eq. 688.2)}$$

The above equation relates fan power to non dimensional mass flow rate ($m/m_{rated}$) because the pump control signal (a value between 0 and 1) is linearly related to the pump flow rate as given by equation 688.1.

Since only the fan is drawing power, the enthalpy of air exiting the dehumidifier is given by equation 688.3 in which $f_{ToAir}$ is the fraction of the fan power that impacts the air stream.

$$h_{air,out} = h_{air,in} + \frac{\dot{P}_{fan}\ f_{ToAir}}{\dot{m}_{air}} \qquad \text{(Eq. 688.3)}$$

With the enthalpy of outlet air known, a call to the Psychrometrics routine provides the remaining outlet air properties. Psychrometrics is called with outlet air enthalpy, outlet air pressure (inlet air pressure + delta P) and outlet air humidity ratio, which is equal to inlet air humidity ratio. Lastly, Type688 calculates the amount of energy rejected to the dehumidifier environment and the amount of energy rejected to the dehumidifier air stream using equations 688.4a and 688.4b respectively.

$$\dot{Q}_{air} = \dot{P}_{fan}\ f_{ToAir} \qquad \text{(Eq. 688.4a)}$$

$$\dot{Q}_{env} = \dot{P}_{fan}\ \left(1 - f_{ToAir}\right) \qquad \text{(Eq. 688.4b)}$$

*Fan and Dehumidification Operation*

When the dehumidification control signal is ON, the fan signal is checked. If the user has supplied a non zero fan control signal then the mass flow rate of air passing across the dehumidifier is again given by equations 688.1 and the power drawn by the fan is again given by equation 688.2. If the user has specified a zero control signal, then Type688 automatically sets the fan to its "full on" condition in which case it supplies its rated mass flow rate of air to the dehumidifier and draws its corresponding rated power.

The performance of the dehumidifier itself is governed by a data file that conforms to the standard TRNSYS data file format. The data file must contain three lines of independent variable values. The first line must contain at least one value of non dimensional air flow rate. A value of 0 indicates zero flow while a value of 1 indicates rated flow. The second line of the data file must contain at least one value of entering air relative humidity (specified in %). The third line of the data file must contain at least one value of inlet air temperature (specified in ºC). The subsequent lines of the data file must each contain two values: dehumidifier capacity (in kJ/hr) and compressor power (also in kJ/hr). Based on the fan control signal value, and on the inlet air relative humidity and temperature, Type688 calls the TRNSYS Data routine, which returns the current capacity and compressor power. As with all queries, Data is able to linearly interpolate in three dimensions between the values present in the data file. It is not, however, able to extrapolate beyond the data range specified in the file. If a value above or below a given range is sent to the Data routine, Data will return the corresponding value at the end of its range and will print a warning to the list file and simulation log file. For more information on the TRNSYS Data routine please refer to the TRNSYS Main Manual.

The total power drawn by the dehumidifier when both the fan and dehumidification are ON is given by equation 688.5.

$$\dot{P}_{tot} = \dot{P}_{fan} + \dot{P}_{comp} \quad \text{(Eq. 688.5)}$$

The total amount of rejected energy (whether to the air stream, to the dehumidifier environment, or to a combination thereof) is given by 688.6

$$\dot{Q}_{rej} = Cap + \dot{P}_{tot} \quad \text{(Eq. 688.6)}$$

The enthalpy of the outlet air is given by equation 688.7

$$h_{air,out} = h_{air,in} - \frac{Cap}{\dot{m}_{air}} + \frac{\dot{Q}_{rej}\ f_{ToAir}}{\dot{m}_{air}} \quad \text{(Eq. 688.7)}$$

For the moment, it is assumed that the humidity ratio of exiting air is equal to the humidity ratio of entering air. This assumption, if incorrect will be corrected by a call to the Psychrometrics routine. Psychrometrics is called with the outlet air enthalpy, the inlet air humidity ratio and the outlet air pressure (inlet air pressure plus fan pressure rise). As with previous calls to Psychrometrics, if the humidity ratio sent to the routine is above the saturation point for the given value of enthalpy, the humidity ratio returned will be reset to the saturation condition. The amount of condensation flowing from the dehumidifier can then be calculated as

$$\dot{m}_{cond} = \dot{m}_{air}\left(\omega_{air,in} - \omega_{air,out}\right) \quad \text{(Eq. 688.8)}$$

The amount of energy transferred to the air and the amount of energy rejected to the dehumidifier surroundings are given by 688.9a and 688.9b.

$$\dot{Q}_{air} = \dot{m}_{air}\left(h_{air,out} - h_{air,in}\right) \quad \text{(Eq. 688.9a)}$$

$$\dot{Q}_{env} = \dot{Q}_{rej}\ \left(1 - f_{ToAir}\right) \quad \text{(Eq. 688.9b)}$$