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

## General Description

Type507 models an evaporative cooling device for which the user supplies the inlet air conditions and a target air outlet relative humidity. The outlet air dry bulb temperature is modulated given to achieve the desired outlet relative humidity. The cooling process is assumed to be a constant wet bulb temperature process meaning that air enters and exits at the same wet bulb temperature.

## Nomenclature

| | | |
|---|---|---|
| $\dot{Q}_{air}$ | [kJ/hr] | Energy transferred to or removed from the air stream. |
| $\dot{m}$ | [kg/hr] | Mass flow rate of air through the device |
| $h_{AirIn}$ | [kJ/kg] | Enthalpy of air entering the device |
| $h_{AirOut}$ | [kJ/kg] | Enthalpy of air exiting the device |

## Detailed Description

An evaporative cooler (sometimes called a fogging device) is a device that cools air by passing it across a wet medium or passing it through a cool spray of water. As hot air passes through the wet media, some of its energy goes to evaporating water. The air comes out of the other side of the device having given up some of its energy and consequently, exits at a lower temperature and a higher humidity. Figure 1 shows a schematic diagram of a possible evaporative cooler configuration.

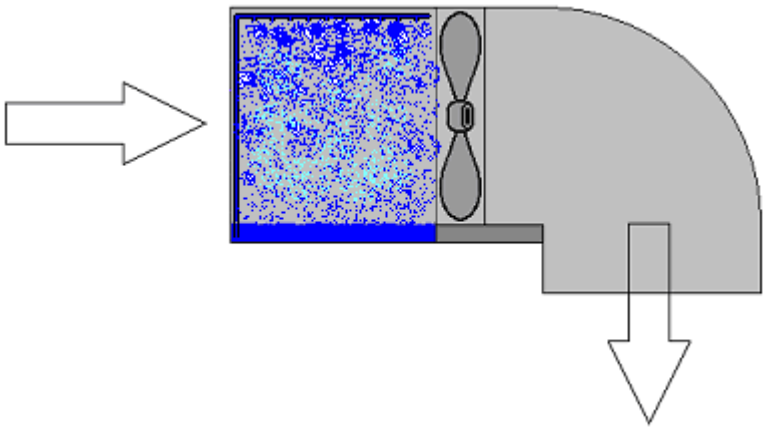


*Figure 1: Evaporative Cooler Schematic*

Evaporative cooling devices can be broken into two groups: direct and indirect. Direct devices contain a single air stream that is passed through or across the wetted media. Indirect devices involve two air streams in which the primary air stream does not come in direct contact with moisture but comes into contact with an evaporatively cooled surface. A secondary air stream passes in direct contact with the other side of the same wetted surface and performs the evaporative cooling. Additionally, evaporative cooling devices may either be controlled or uncontrolled. In an uncontrolled device, air passes across the wetted media at a rate set by a fan. The flow rate is not modulated in any way except by external

controls and the air comes out at a state determined entirely by the inlet air conditions and the effectiveness of the device. In a controlled evaporative cooler, some aspect of the outlet air is monitored. In the case of Type507, the dry bulb temperature of the outlet air is modulated to meet a desired relative humidity.

When air is passing through the fogging device and whether or not the control signal input is set to ON (active evaporative cooling), the component calls the TRNSYS Psychrometrics routine to fully determine the state of the inlet air. Depending upon the Type507 mode of operation, the user must specify inlet air pressure, temperature, and either relative humidity or humidity ratio. The Psychrometrics routine returns the inlet air wet bulb temperature and enthalpy. If the inlet conditions sent to Psychrometrics were such that the inlet air is saturated, the returned wet bulb temperature, relative humidity and humidity ratio will correspond to the saturated air condition at the inlet temperature. If this situation arises and Psychrometrics modifies the inlet air condition, the user will find a warning printed in the simulation log and list files.

When active fogging is OFF (control signal set to 0) but air is flowing through the device the enthalpy and humidity ratio of the outlet air are set to the respective inlet air conditions. The outlet air pressure is determined by subtracting the user specified device pressure drop from the air inlet pressure. Psychrometrics routine is called with pressure and humidity ratio to fully determine the outlet state. Because of the pressure drop across the device, the enthalpy of air exiting the device may be different from the enthalpy of air entering the device. The corresponding energy removed from the air stream to evaporate water under these circumstances is given by equation 507.1.

$$\dot{Q}_{air} = \dot{m}\left(h_{AirIn} - h_{AirOut}\right) \qquad \text{Eq. 507.1}$$

When active fogging is ON, and there is air flowing through the device, an iterative process is initiated to find the air outlet state that corresponds to the desired outlet relative humidity. In the iterative process, the gauge pressure of outlet air is always set to the gauge inlet pressure minus the user specified pressure drop. The air outlet wet bulb temperature is always set to the air inlet wet bulb temperature. With these two values fixed, an air outlet dry bulb temperature is guessed and the Psychrometrics routine is called. The initial temperature guess is that the air exits the device at the same dry bulb temperature at which it entered; this is the same condition as when the device is OFF. If the returned relative humidity is less than the desired relative humidity, the air outlet dry bulb temperature guess is decreased from the initial guess and Psychrometrics is recalled. Iteration continues until the returned relative humidity matches the desired relative humidity.

Once the desired outlet condition has been found, the energy removed from the air stream is calculated using equation 507.1 and the power drawn by the device is set to value specified by the user among Type507's parameters.