CONTROLLING HUMIDITY IN TIGHT GREENHOUSES

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High relative humidity was very seldom a serious problem in lapped glass houses. During those periods of the year when outdoor temperatures were mild but too low to permit venting, the air moving through the cracks at the glass laps was enough to remove excess moisture. As outside temperatures fell, the temperature of the inside surface of the glass dropped to provite an excellent dehumidifying surface. These actions also removed heat from the greenhouse but heating was not a major production cost.

As fuel prices increased, air exchange was reduced to lower heating costs by using lapseal, single and double layer polyethylene (PE), and internal thermal blankets. The use of double layer PE and thermal blankets also resulted in higher temperatures of the inside surface thus reducing the dehumidifying potential.

The dew point temperature of an air-water vapor mixture is the temperature at which condensation will begin. For example, greenhouse air at 60°F dry bulb and 80 percent relative humidity has a dew point temperature of 54°F. Moisture would condense out of any of the air striking a surface whose temperature was at or below 54°F. If the inside air temperature was 60°F, the inside surface of a single layer glasshouse would reach dew point temperature (54°F) at an outdoor temperature of 52°F.

If a thin thermal blanket was installed, the outdoor temperature would have to drop to 42°F before the inside surface of the blanket was cooled to the dew point temperature. If a double walled material like the extruded structural panels was used, the outdoor temperature would have to drop to 37°F before the inside surface cooled to the dew point temperature. Where thermal blankets are used, the temperature outdoors would drop to 27°F before the inside surface of the blanket cooled to the dew point temperature. Any changes in the amount of water vapor in the inside air would change the dew point temperature and changes in the inside dry bulb temperature would change the surface temperature.

Table 1. Temperatures of greenhouse enclosure surfaces with 0°F outside air and 60°F inside air.

Temperature Location	Single Glazing	Single Glazing + Eave to Eave Blanket	Double Glazing	Double Glazing + Eave to Eave Blanket
		Temperatures (°F)		
Outside air	0.0	0.0	0.0	0.0
Outside surface of glazing	10.8	5.3	4.1	2.9
Inside surface of glazing	21.1	10.3	45.4	32.6
Air space between glazing and blanket	--	25.0	--	40.7
Outside surface of blanket	--	39.7	--	48.8
Inside surface of blanket	--	40.9	--	49.5
Inside air	60.0	60.0	60.0	60.0

Table 2. Inside surface temperatures of greenhouse enclosures with 60°F inside air temperature.

Outside Temperature (°F)	Single Glazing	Single Glazing Eave to Eave Blanket	Double Glazing	Double Glazing Eave to Eave Blanket
	Temperature of surface facing plant (°F)			
57	58	59	59	60
47	52	56	57	58
37	45	53	54	56
27	39	50	52	54
17	32	46	50	53
7	26	43	47	51
-3	19	40	45	49
-8	16	38	43	48

The condensation rate depends on the rate of air movement across the surface, the rate at which the heat of condensation is removed from the surface, and the rate of evaporation from other surfaces in the greenhouse. In general, the relative humidity of the inside air will be controlled by the temperature of the coldest inside surface. For example, if the inside surface temperature is 36°F and the inside air temperature is 60°F, the inside relative humidity will be at or near 40 percent. Tables 1 and 2 illustrate the effect of construction on the temperature of the inside surfaces.

When two air masses at different temperatures and relative humidities are mixed, the temperature and relative humidity of the mixture will be somewhere between the two original conditions. An example will illustrate this.

Air mass one is 1000 cubic feet of greenhouse air at 60°F and 80 percent relative humidity. Air mass two is 940 cubic feet of outside air at 35°F and 60 percent relative humidity. The mixture will be at 47°F, 80 percent relative humidity. Heat must be added to bring the mixture to 60°F. Where 1000 Btu's are used to warm the 940 cubic feet of air to 60°F, the resulting air mixture will be at 52 percent relative humidity and the dew point temperature will be 42°F. The dew point temperature has been lowered by 11°F which reduces the potential for condensation because an inside surface must be at or below 42°F before any condensation will occur.

The most simple method to use for humidity control in cool or cold weather is to bring in outside air, heat it and have it absorb the moisture before exhausting it to the outside.

The evapotranspiration rate for greenhouse crops will vary depending on crop and solar radiation. A greenhouse filled with mature pot plants may lose about 0.15 lb of water vapor per square foot of greenhouse area per hour during the day. If this is not removed, the relative humidity will increase until the air is saturated or until condensation begins on a cold surface. The use of a horizontal air flow system in the greenhouse will help alleviate high relative humidity problems by moving air across plant surfaces thereby keeping them dry. The moving air mass also increases mixing and prevents temperature stratification in the greenhouse. In the example cited, about five air changes per hour are needed to hold relative humidity at 80 percent. Estimated natural air exchange for a tight greenhouse is about one-half air change per hour. Therefore, a positive system is needed to move outside air through the greenhouse to remove the moisture.

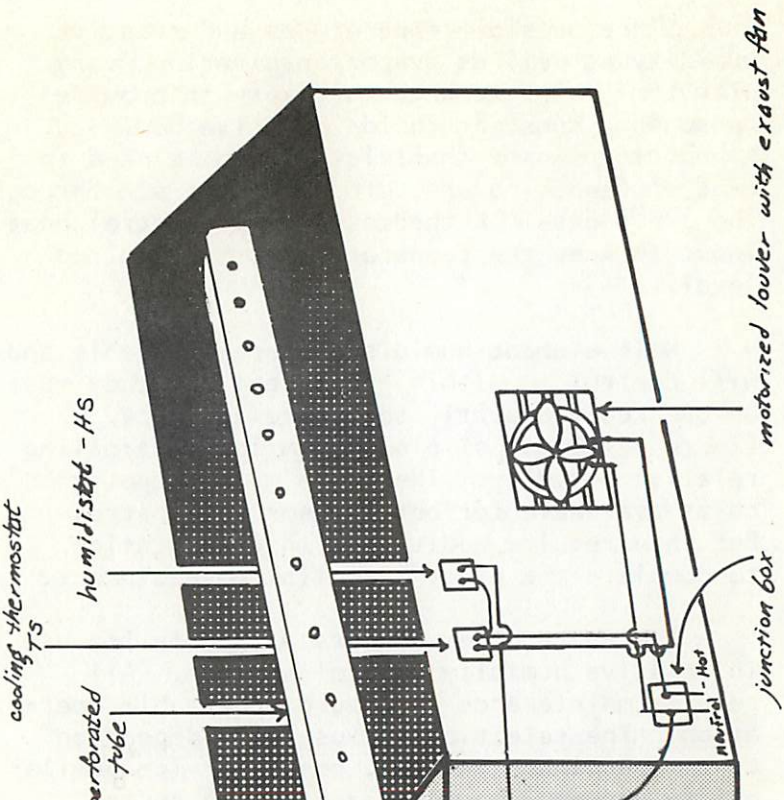

Figure 1. A humidistat is shown connected in parallel with a cooling thermostat so either sensor can control fan and inlet louver operation. The sensors should be located in an aspirated chamber to provide the best control.

Since outside temperatures and relative humidity as well as evapotranspiration vary with time, air exchange must vary to provide reasonably constant inside relative humidity. A humidity sensor (humidistat) can be used to control fans, louvers, etc., to move air through the greenhouse. A thermostat will control heat input to keep the temperature at the desired level.

Hair element humidistats are available and will control to within ±5 percent but they must be checked frequently to insure accuracy. Figure 1 shows a simple system for controlling relative humidity. There are microcomputer chips available for both sensor and control but they require additional instrumentation to complete the electrical link to equipment.

There are other sensors available for use in relative humidity control systems. All require maintenance to insure acceptable operation. The selection and use will depend on control accuracy desired, cost, service availability and equipment already in the system.