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WINTER HUMIDITY IN COLORADO GREENHOUSES

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Misting systems are not likely to maintain relative humidities if set much less than 70%. Humidity is determined by outside air temperature and the type of heating system. Relative humidities go below 40% at night under heavy heating loads with hot-air systems. In general, a misting system will operate regardless of conditions if set above 70 % RH or about 5 mb VPD.

CGGA Bulletin 461 described typical environments that may be found during the summer in Colorado greenhouses. In general, due to high outside temperatures at that time, relative humidities will be close to 100% at night. With good fan-and-pad cooling, relative humidities will seldom be much below 60% during the day — although outside Relative humidity can be less than 20%. On the other hand, absolute humidity seldom changes significantly over a 24 hr period. The actual humidity that may be maintained in a greenhouse, summer or winter, varies with outside conditions and the type of heating system one may be using.

This past winter, we set two of the Colorado State University computer controlled greenhouses to maintain a 3 millibar (mb) vapor pressure deficit (VPD), and two houses to a 15 mb VPD, one house in each VPD treatment was heated with hot water and had forced air circulation, and the second house had a fan-jet, hot-air heating system. As noted in Bulletin 465, however a 3 mb VPD results in relative humidities between 80 to 90%, over the temperature range of 60 to 80 F. A 15 mb VPD, however, will result in an RH ranging from less than 40% to around 55% over the same temperature range. Thus, a misting system set to 15 mb VPD will seldom operate. The actual greenhouse humidity will be determined by outside air temperature, and humidity and the heating system employed.

As the outside air temperature changes seasonally, so does the absolute humidity outside. Under extreme cold, vapor pressures can be less than 1 mb (-15 F) with relative humidities of 70 to 80%. Cobb (CGGA Bul. 325) showed this seasonal variation of outside humidity by plotting dew point temperatures for a few years while examining mildew control on roses. Based on this past winter's observations, outside temperature, even in the winter, played the most significant role in determining outside relative humidity. As noted in **Fig. 1**, on Dec. 27, a ten or more degree F rise in outside day temperature dropped outdoor RH from nearly 80% to less than 50%, the RH rising again into the evening hours. On Feb. 4 (**Fig. 2**), at steady outdoor temperatures approaching -20 F, outside relative humidity remained in the range of 60 to 70% for the entire day.

At 3 mb VPD humidity level, regardless of heating system, absolute vapor pressures and relative humidities will be close to the desired setting — unless the inside air temperature is different between houses. This can be noted in the extreme case on Feb. 4 (**Fig. 2**) when the higher heat loss, resulting from rapid air movement with fan-jet, hot-air systems prevented maintenance of temperature setpoints. House 1 (fan-jet, hot air), had the lowest temperature for most of the 24 hr period, resulting in a lower absolute vapor pressure and relative humidity compared to House 2 with a hot water system. In the case of the houses set at 15 mb VPD (Houses 3 and 4), the actual humidities were strongly influenced by the heating system with forced, hot-air systems (House 3) nearly always having lower relative humidities, lower absolute humidity, and higher nighttime actual VPD. The difference between the two heating systems became a function of outside air temperature, with relative humidities often dropping below 40% under heavy heating loads.

Rapid air movement inside a greenhouse (fan-jet system) will increase infiltration (CFGA Bul. 286), and, when the outside humidity is low, the greenhouse will dry out more than

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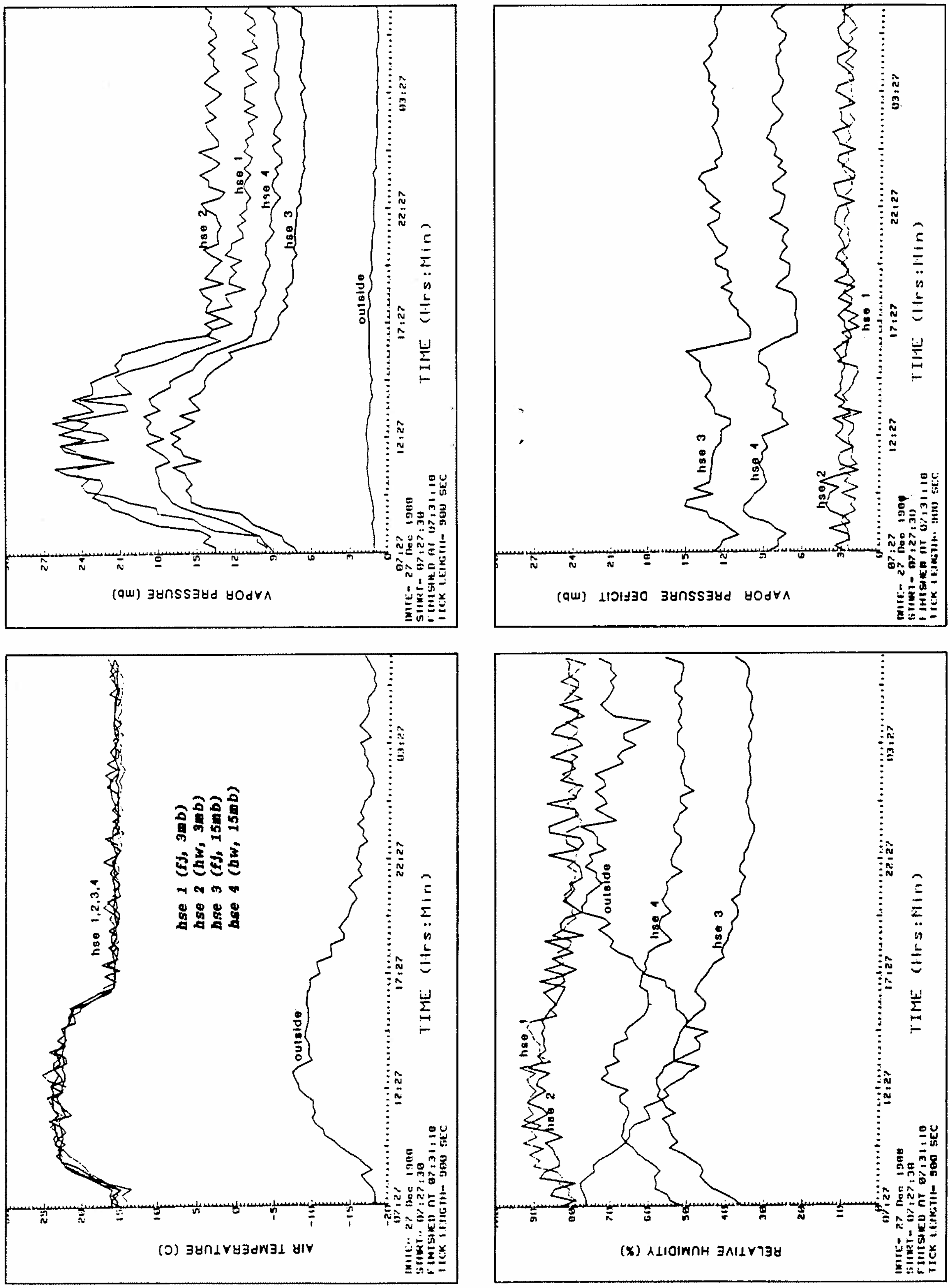

Fig. 1: Air temperatures and humidities inside four identical, computer controlled greenhouses for the 24 hr period, Dec. 27. House 1 = 3 mb VPD humidity setting, forced, fan-jet hot-air heating; House 2 = 3 mb VPD humidity and hot water heating; House 3 = 15 mb VPD humidity setting and forced, fan-jet hot-air; House 4 = 15 mb VPD humidity setting and hot water heat. Note the change in outside relative humidity as the outside air temperature rose during daylight hours.

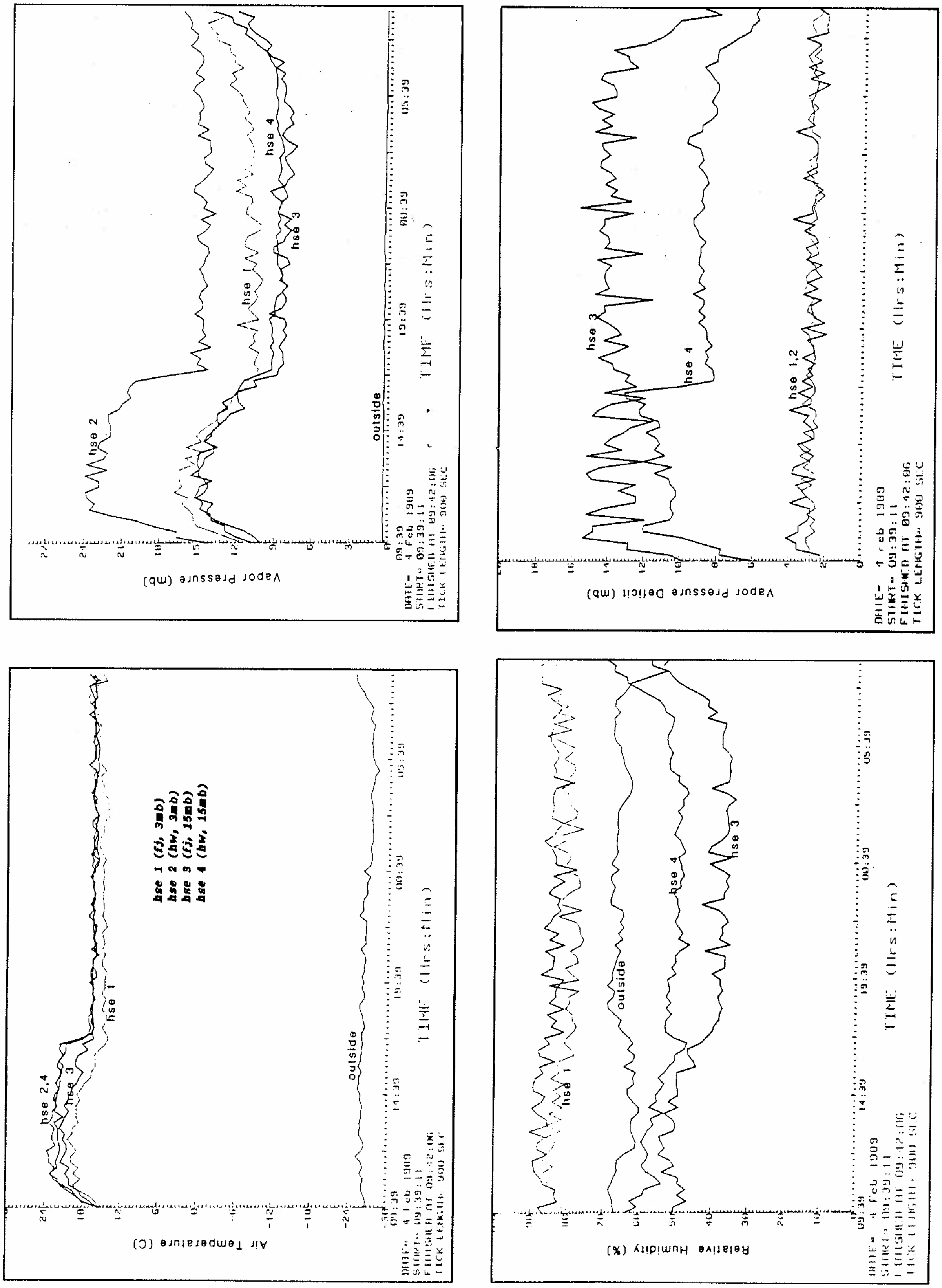

Fig. 2: Air temperatures and humidities for four identical greenhouses for the 24 hr period, Feb. 4. House 1 = 3 mb VPD humidity and forced, hot-air; House 2 = 3 mb VPD humidity and hot water; House 3 = 15 mb VPD humidity and hot-air heating; House 4 = 15 mb VPD humidity and hot water heat. Note outside temperatures ranged from -15 F to -20 F with the failure To maintain temperature setpoints in House 3 and House 1 (upwind) especially — both houses hot-air heated. Outside absolute humidity was less than 1 mb for the entire period although outside relative humidity was greater than 60%.

a house with natural convective air movement. There have been some statements to the effect that horizontal air flow (HAF) will decrease fuel consumption by maintaining an insulative layer of air next to the roof. Colorado State University data does not substantiate such a statement nor does it agree with what I have been taught. Any significant increase in air circulation within a greenhouse will decrease resistance to heat transfer across a surface, thereby increasing heat loss. Preliminary results on heat loss this past winter indicated higher natural gas consumption in those houses with forced, hot-air heating. One should also keep in mind the converse of the situation; i.e. rapid air movement will also increase heat transfer from the heating radiative surfaces. Depending upon the installation, there may be a greater output from the heating system than the conducting loss through the roof, with rapid air circulation. This might result in an apparent lower gas consumption.

The greenhouse environment is closely related to the climate and weather conditions outside the structure. This places strict limits on what can be done inside. Failure to take outside conditions into account is likely to result in decreased efficiency and increased costs to the operator. Only a computer system can instantly sense and react to correlate inside conditions with those outside the greenhouse structure.

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