# Potato Storage Design Using Weather Bureau Records


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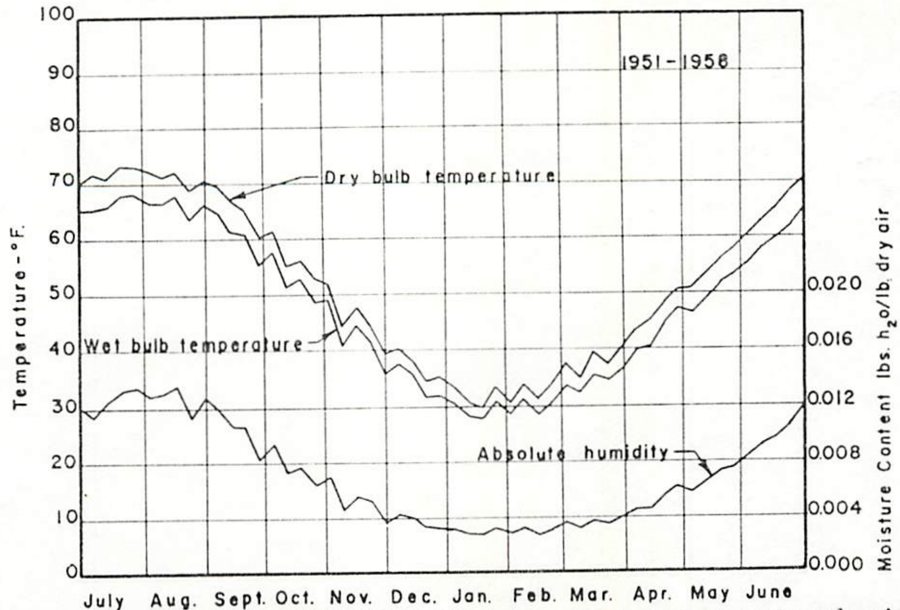


**FIG. 1 Seven-year average (1951-58) weekly mean ambient air temperature and moisture content recorded at Suffolk County Air Force Base, Westhampton Beach, Long Island, New York.**

CLIMATOLOGICAL factors such as rainfall, wind, snow, temperature, and humidity have always influenced the design of farm buildings. The designer of a structure, whether it be for housing farm animals or for storing farm commodities, certainly must take into consideration one or more of these weather constituents.

In modern potato storages located in the humid regions of the United States, potatoes are cooled by forcing ambient air (whose temperature is below that at some select point inside the storage) through the storage where it is circulated across the individual tuber surfaces. This is accomplished through the use of automatically controlled, proportioning-type, forced-air ventilation systems (2, 5)*. Considering Newton's basic equation, $Q = hA \Delta t$, the rate of cooling depends primarily on the velocity of air across the tuber surface and the temperature difference between the air and the surface of the potatoes. These two factors are governed by the availability of ambient air within certain dry-bulb temperature limits. The upper limit is fixed by the temperature of the stored potatoes at the time of ventilation. The lower limit is established according to the minimum storage temperature desired. For table stock and for long-term storage, 40 F is often required; for processing potatoes or for shorter storage periods, a minimum of 50 F is preferred (7). When the ambient-air temperature is below the minimum storage temperature desired, the ventilation system automatically mixes the proportionate amount of ambient air with recirculated storage air to produce air at the established lower temperature limit.

Unsaturated ventilating air, in flowing across the surface of potatoes, vaporizes moisture from the potatoes causing them to shrink. The rate of shrinkage depends somewhat upon the vapor pressure deficit between the ventilating air and air at saturation (4). This deficit can be minimized by vaporizing water into the incoming ventilating air (1).


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* Numbers in parentheses refer to the appended references.

Statistical summarizations showing the relationship between magnitude and hourly occurrence of atmospheric wet and dry-bulb temperature for any given locality and analyses enabling the prediction of future occurrences, can be a valuable aid in the determination of the amount of ambient air and supplemental water needed to provide the optimum storage environment at any time during the storage period. This paper illustrates how wet and dry-bulb readings can be used for environmental control of potato storages on Long Island.

The data for this study were recorded from July 1, 1951, through June 30, 1958, at the Suffolk County Air Force Base, Westhampton Beach, Long Island, New York. It was obtained, in the form of IBM punched cards, from the U.S. Weather Bureau records center at Asheville, N.C.

To illustrate the general annual pattern of air temperature and moisture content, Fig. 1 was prepared from weekly means of wet and dry-bulb temperature representing an average for the seven years investigated. Absolute humidity, shown on the chart, was calculated by use of the relationship

$$W_o = \frac{0.622\, p_s\, \phi}{P_t - p_s\, \phi}$$

where

$W_o$ = moisture content of air
$P_t$ = total pressure
$p_s$ = vapor pressure at saturation
$\phi$ = percent relative humidity

Percent relative humidity and total pressure were taken from the cards. The saturation vapor pressure corresponding to the dry-bulb temperature indicated on the cards was taken from Marvin's tables (6). While weekly mean deviations from the seven-year average do occur from year to year, the curves of Fig. 1 provide a means of making reasonable predictions of future seasonal trends.

Improved potato-storage designs and increased efficiency in operating practices are possible through the use of information such as the number of hours per given unit of time that one can expect the dry-bulb temperature and relative humidity to fall within certain ranges. Also of interest is the probability that these variables will occur above or below a certain level. The method described by Best and Panofsky (3) was employed to make the summarization.

The initial storage cooling period may be described as that portion of the normal storage season when the field or harvest heat within the potatoes, and the build-up of heat, by respiration, within the storage is removed sufficiently to reduce the temperature of the potatoes to the desired level. On Long Island this period occurs during the months from September through December. The histograms showing frequency distributions and hourly occurrences of dry-bulb temperature and percent relative humidity, by


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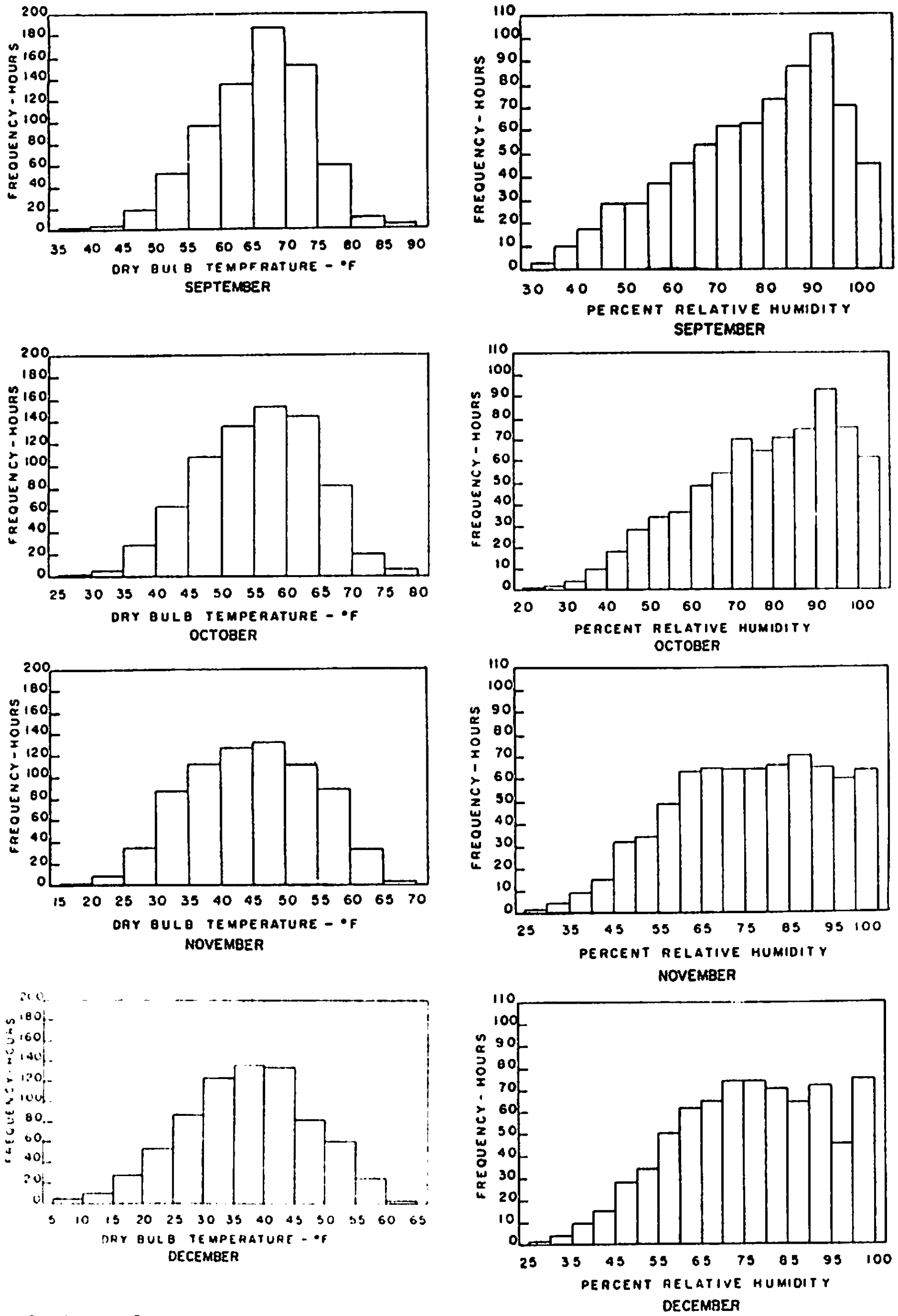


**FIG. 2 Hourly occurrences of dry-bulb temperature and percent relative humidity in class intervals of 5 F and 5 percent relative humidity for the period of September through December on Long Island.**

class intervals, for September through December are given in Fig. 2.

Curves having the empirical probability (based on seven years data) of 5 F class intervals of dry-bulb temperature and 5 percent intervals of relative humidity for the same seasonal period are given in Fig. 3. To illustrate the curves, by reference to the temperature chart for November, it is seen that a dry-bulb temperature below 40 F will likely occur 33 percent of the time. Likewise, for the same month, relative humidity below 60 percent will likely occur only 20 percent of the time.

Analyses and summarizations similar to the foregoing may be used to predict average seasonal trends or expected frequency of occurrences of certain climatic variables. Such information may be used to determine how one may be able to use outdoor air as a means of regulating the environment within fruit and vegetable storages.

As a more positive means of predicting the temperature history within an automatically controlled, proportioning-type, forced-air-ventilated potato storage, equation [1] was developed. By use of this equation, the daily storage temperature reduction for a 12,000 hundredweight capacity Long Island potato storage, ventilated at the rate of 0.833 cfm per hundredweight, may be computed from daily means of wet and dry-bulb temperature based on any select number of years of weather data.

where

$\frac{\Delta t}{\Delta \tau}$ = daily storage temperature reduction, F

$M_o$ = mass of air delivered, pounds per day, during case 1 ventilation

$h_{ms}$ = enthalpy of the mixture of storage air and water vapor, Btu per pound of dry air

$h_{mo}$ = enthalpy of the mixture of outside air and water vapor during ventilation with ambient air only, Btu per pound of dry air

$M_v$ = mass of air delivered, pounds per day, during case 2 ventilation

$h'_{ms}$ = enthalpy of the mixture of storage air and water vapor during case 2 ventilation, Btu per pound of dry air

$h_{mv}$ = enthalpy of the mixture of ventilating air and water vapor after mixing during case 2 ventilation, Btu per pound of dry air

$Q_s$ = Btu per ton per 24 hours

$w$ = daily water loss from potatoes, pounds per hundredweight

$h_g$ = enthalpy of water at dry-bulb temperature of storage, Btu per pound

$t_a$ = daily mean dry-bulb temperature of ambient air, F

$t_s$ = daily mean storage dry-bulb temperature, F

Case 1: When the dry-bulb temperature of the outside air is less than the dry-bulb temperature of the storage air, but greater than 40 F. This is for ventilation with outside air only.

Case 2: When the dry-bulb temperature of the outside air is less than 40 F. When this condition exists, outside air is mixed with storage air in proportionate amounts to result in a final dry-bulb temperature of 40 F in the ventilating air.

The derivation of this equation is given in the thesis upon which this paper is based.

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$$\frac{\Delta t}{\Delta \tau} = \frac{M_o\,(h_{ms} - h_{mo}) + M_v\,(h'_{ms} - h_{mv}) - 600Q_s - 12\times10^3 w\, h_g - 535t_a + 3270t_s - 145{,}000}{1.03 \times 10^6} \qquad [1]$$

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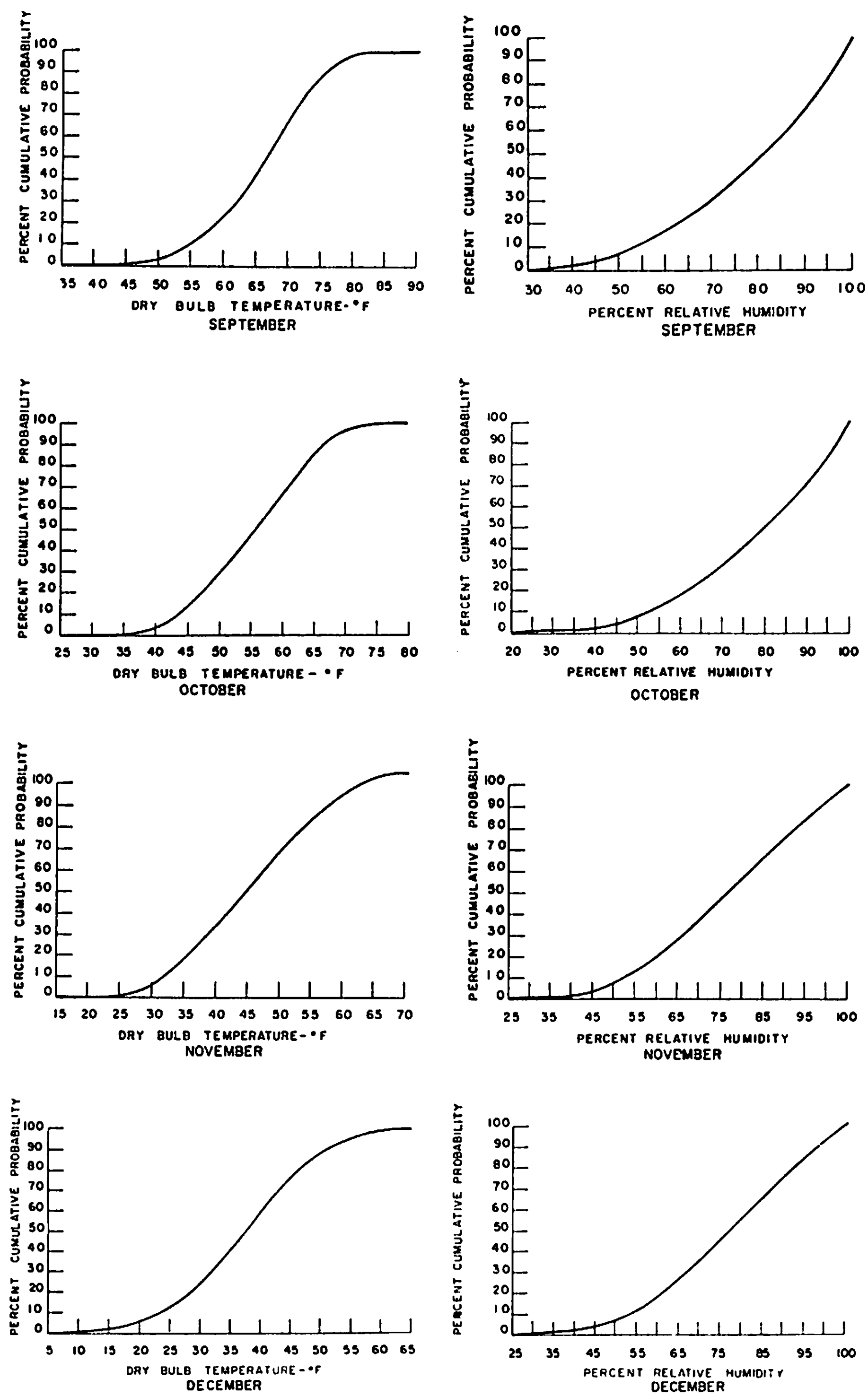


**FIG. 3** Cumulative frequency or empirical probability of dry-bulb temperature and relative-humidity occurrences by months from September through December.