CONTROL OF CONDENSATION IN POTATO STORAGES

by
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With improvements in humidification systems, the relative humidity in many storages is being maintained at higher levels each year. High humidity is essential for wound healing and the maturation process, particularly during the first two months of storage. Along with the high humidity some problems have developed, one of which is condensation. Why is condensation a problem? According to Dr. Arthur Kelman of the University of Wisconsin, whenever potatoes are kept continuously wet by free moisture from condensation or other means, an anaerobic condition is created within the tuber. This condition is an ideal environment for soft rot (Erwinia cartovora) development. Dr. Kelman states that apparently healthy tubers can carry a high population of soft rot bacteria in the lenticels. Even in the absence of bruising, the bacteria in the lenticels can invade potato tissue provided that anaerobic conditions, such as continuously wet potatoes, are provided.

Generally, condensation results when warm, humid air comes into contact with a cold surface which is at a lower temperature than the dew point of the humid air. Dew point is the temperature at which condensation of water vapor takes place for a given state of humidity. As shown in Table 1, as relative humidity is increased for a given air temperature, the dew point temperature increases. In other words, the ceiling surface temperature can be lower without condensation taking place with lower humidities. For example, if the inside air temperature is 45°F, with a relative humidity of 98 percent, a one-half degree colder ceiling surface temperature would cause condensation. With a 90 percent relative humidity the air could be cooled two and one-half degrees before condensation occurs.

Table 1. Change of ceiling dew point temperature with change of relative humidity at a constant inside temperature of 45 F.

CEILING DEW POINT TEMPERATURES AS INFLUENCED BY RELATIVE HUMIDITY

INSIDE R.H.	INSIDE AIR TEMP F°	CEILING DEW POINT TEMP
85	45 F	40.8 F
90	45 F	42.5 F
95	45 F	43.6 F
98	45 F	44.5 F

What factors influence ceiling surface temperature? First of all, as would be expected, the outside temperature has the greatest influence. Secondly, the amount of insultation, R, (or resistance) value which is dependent upon type and amount of insulation is important.

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Generally, R of 25 is recommended for the ceiling. This is equivalent to about four inches of polyurethane, or six to eight inches of fiberglass batt insulation. Thirdly, the emissivity of the ceiling surface can be important. Emissivity is the capacity of a surface to emit radiant heat. A shiny, reflective surface is generally regarded as a cold surface. As shown in Table 2, it would be one degree colder than a rough textured, dark ceiling surface. One degree can mean the difference between having or not having condensation. Fourthly, movement of air over the ceiling surface would tend to bring the ceiling temperature closer to the air temperature, decreasing considerably the chances of condensation taking place. (Table 2). The application of heat by the placement of a heat tape along the inside ceiling eave, as suggested by Walter Sparks of Idaho, is another means of controlling condensation. Warming of the ceiling air, warms the ceiling surface and also increases the capacity of the air to hold moisture, decreasing chances of condensation.

Table 2. The effect of emissivity and air movement on ceiling surface temperature with outside temperature of 5 F and inside temperature of 45 F.

TEMPERATURE OF CEILING SURFACE AT R25	
OUTSIDE TEMPERATURE	5 F
INSIDE TEMPERATURE	45 F
SHINY SURFACE	43 F
ROUGH SURFACE	44 F
5 mph AIR	44.4 F
7.5 mph AIR	44.6 F

The most obvious means of controlling condensation which, in some cases is a last resort, is lowering of the relative humidity in the storage. Studies during the past several years indicate that lowering of the relative humidity to 85-90% in mid-December, after the wound healing period, increased weight loss approximately 0.5% over a six-week period. (Figure 1). If potatoes are properly matured and suberized early, they develop considerable resistance to water loss. With time in storage the capability of wound healing and maturation decreases.

Deterioration of Insulation

Reduction of thermal resistivity (R-value) of insulating material, particularly foam insulation occurs with age and a humid environment, but limited data are available on the degree of deterioration. If moisture is allowed to penetrate the vapor barrier into the insulation, its R-value decreases. The following factors can influence the deterioration of foam insulation.

1. Age of foam - generally the closed cells of polyurethane foam contain freon gas. With extended exposure to high humidities and low temperatures the freon gas can condense and allow air and moisture to diffuse into the cells, decreasing the insulating value of the foam.

2. Temperature - as shown in Figure 2, the R-value of new urethane increases at the higher temperature. With aged urethane, temperature had very little influence on changing the R-value. The R-value of polystyrene decreases with increasing temperature.

3. Thickness of insulation - obviously with thick insulation the time required for water vapor or air to penetrate into the insulation is longer, thus the decrease in R-value is slower.

4. Density of insulation - foam insulation can be applied with different densities. The denser insulation offers more resistance to penetration of moisture and air.

5. Surface protection - foam insulation applied to walls should be protected physically by a stacking wall or other means. Potatoes piled against urethane compresses it and equipment can gouge holes into it, decreasing its value as insulation. Painting of the surface would also offer resistance to moisture and air penetration.

Figure 1. The influence of changing the relative humidity after 12 weeks of wound healing and maturation from high (above 95%) to low (85-90%) humidity and from low to high humidity on percent weight loss of potatoes.

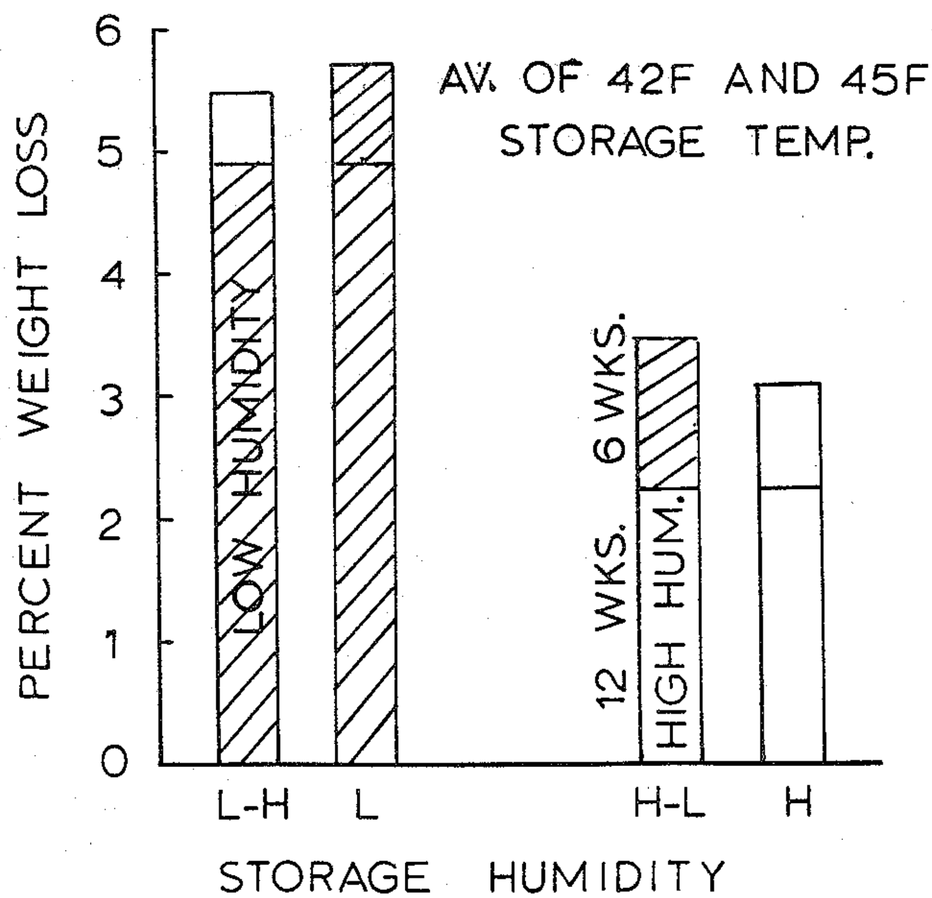
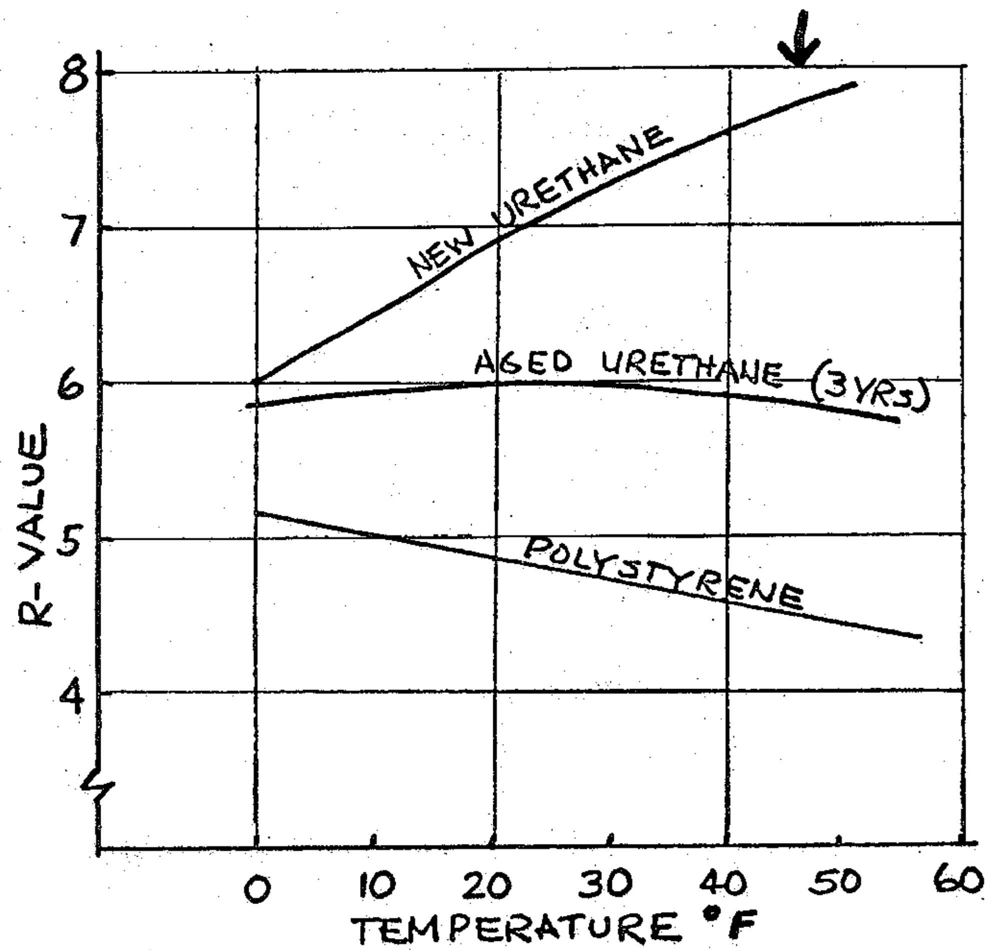


Figure 2. The influence of aging and temperature on changes in R-value of insulation.

Adapted from: Low Temperature Insulation Insulfoam, Western Insulfoam Corporation General Technical Data, June, 1975.



EFFECT OF AGING AND TEMPERATURE ON INSULATION