INSULATION AND VAPOR BARRIER MATERIALS FOR POTATO STORAGES

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The primary purpose of a potato storage is to control the temperature and humidity of the air in and around a large pile of potatoes over an extended period of time. So the building shell must serve as a retarder to the movement of both heat and moisture out of the potato pile. Totally stopping either heat or moisture movement through the building surfaces is not possible on a practical basis, but both need to be controlled enough that the conditions in the potato pile can be maintained, and that the building components are not damaged by moisture.

As air temperature is lowered, the amount of moisture it can hold is also lowered. When there is more moisture than the air can hold, it will condense into droplets. The temperature at which this begins to happen is the dew point temperature. When the warmer air from a potato pile is moved near a cooler wall or ceiling surface, moisture will condense on that surface if the surface temperature is less than the dew point temperature. Condensation can also occur within a wall if so much moisture moves into it that the air there cannot hold all of it. Once the moisture has condensed, it is difficult to remove. If the condensation is in insulation, it will reduce the insulating value of that insulation, which lowers the temperature even more and may cause more condensation. If the condensation is on wood, the wood will begin to rot and lose strength.

Moisture Movement

Moisture, like heat, tends to move from locations where there is more to where there is less. In a typical potato storage at 40° F and 90% relative humidity, there is five times as much moisture in a cubic foot of air as there is outdoors at 5° F and 90% relative humidity. Therefore moisture will move out of the building any way it can.

Water vapor can move through a wall by diffusion, but most of it can be stopped with a vapor retarder (formerly called a vapor barrier). A good quality vapor retarder will eliminate condensation inside the wall if the entire wall is fully covered and there are no holes or cracks in the retarder.

In most potato storages water vapor is lost by air currents passing through cracks, pinholes, and larger holes in the inner wall surfaces. If the air moves slowly through the wall, it will become colder as it gets closer to the outside. If it drops to the dew point temperature, moisture will begin to condense on the building material. The best defense against condensation inside a wall is construction that is as airtight as possible. Air that leaves a building quickly, such as exhaust openings, will not be cooled before it gets away from the building and so the moisture in it will not condense.

Surface condensation on walls and ceilings can occur when the surface temperature is below the dew point temperature of the moist air in the building. When air inside a potato pile is at 40° F and 90% relative

humidity, its dew point temperature is 37.5° F. The inside surface can be kept above this temperature by insulating the wall or ceiling well, and by blowing air over the surface so that it cannot cool down the air next to it. If moisture still condenses, such as when the outdoor air gets really cold, then it may be necessary to lower the relative humidity somewhat.

Thermal Insulation and Vapor Retarders

The insulation "R" value for walls of potato storages in Wisconsin should be between 23 and 30, and for ceilings between 30 and 40. Some insulating materials can absorb considerable moisture and lose insulating value. Since in-wall condensation must always be considered a possibility, such insulations are often not the best choice. Some insulations, in addition to low water absorption properties, have vapor retardant properties and are barriers to air movement. All of these factors should be considered when selecting building materials.

The permeability of vapor retarders is rated in "perms". For houses, vapor retarders should have a rating of 1 or less. For potato storages, the perm rating should be 0.1 or less. Some typical perm values for building materials* are listed below:

Material	Perm
Concrete, 1-2-4 mix, 8" thick	0.4
Concrete block, cored, 8"	2.4
Wood, pine, 1"	0.4-5.4
Plywood, douglas fir, exterior, ¼"	0.25
Expanded polyurethane (R-11 blown) board stock	0.4-1.6
Expanded polystyrene-extruded	1.2
Expanded polystyrene-bead	2.05-5.8
Phenolic foam, covering removed, 3"	8.7
Aluminum foil	0.001
Polyethylene, 4 mil	0.08
Polyethylene, 6 mil	0.06
Polyethylene, 8 mil	0.04
Blanket thermal insulation back-up paper, asphalt coated	0.4
Asphalt-saturated and coated vapor retarder paper	0.2-0.3
Asphalt-saturated but not coated sheathing paper	3.3
Asphalt paint on plywood, 2 coats	0.4
Oil based paint on wood, 3 coats	0.3-1.0
Asphalt mastic, 1/16"	0.14
Asphalt mastic, 3/16"	0.0
Hot melt asphalt, 2 oz/sq.ft.	0.5
Hot melt asphalt, 3.5 oz/sq.ft.	0.1

* Values are from the 1989 ASHRAE Handbook of Fundamentals, Chapter 22, Table 7.

(Perm = grains/hr*ft²*inches of mercury)

Construction Concerns

Not only must the proper materials be selected for a building to retain the heat and moisture necessary for satisfactory potato storage, but good construction practice must be followed with attention to details such as the following.

a. The joints of all vapor retarder materials must be sealed against air and water vapor movement. This includes the edge along the foundation. For polyethylene a good practice is to roll and tape all joints.

b. If an asphalt mastic is sprayed on to form a vapor retarder, it must be thick enough to form a coating without pinholes.

c. Since all moisture movement through walls and ceiling cannot be stopped, the exterior layers of the building should allow the moisture that does pass through the retarders to escape. Moisture that moves up through the storage ceiling is a particular concern because roofing materials are relatively impermeable to moisture. If there is an attic above the ceiling vapor retarder and insulation, it should be ventilated to remove the moisture. If the insulation and retarder are placed under or between the rafters, there should be free air circulation between the insulation and the roof decking. If there cannot be a continuous opening from eave to eave, then ridge vents may be necessary.

d. A difficult joint to seal is where the bottom chord of a roof truss rests on an interior wall. A vapor retarder below the chord may not be continuous over the wall plate. As a result, moisture can move through the wall plate and up into the insulation lying on it in the attic. The amount of moisture getting through may be enough to condense on or in insulation there. If that insulation holds condensed moisture next to wood members, that wood could begin to rot.

e. The vapor retarder should be in contact with the insulation so that it also acts as a barrier to air movement around and through the insulation.

f. The building wall and ceiling components will move slightly when the bins are loaded and unloaded, when temperatures change, and when foundations and footings settle with time. These small shifts can cause cracks to open in vapor retarders and allow moisture to escape. Good construction will allow for such shifts, and so minimize the number of cracks that open.

Other factors that can contribute to the amount of moisture that is lost from a storage are poor seals around doors and other openings, and cracked vapor retarders caused by bumping into them with machinery or tools. Although one hole may not be significant, the combination of many small ones can add up to problems in moisture and temperature control.