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## Controlled Temperature and Humidity Storage

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## CONTROLLED TEMPERATURE AND HUMIDITY STORAGE

R. S. Munford 1/

"Controlled Temperature and Humidity Storage" for your SEED is spelled "Money" most any way you approach it. The quality of the SEED you sell -- it's viability, means money to you, and I'm sure it means money to your customers. I can also assure you that this controlled atmosphere storage is going to cost a lot of money, but I just hope that this information will help you get the maximum amount of storage for every dollar you spend.

### Viability

The germination of seed after long storage is dependent on two things: the moisture and temperature at which they were stored from the time they first matured until they reach Mother Earth again. Experimenters have given us much useful information on this, and are continuing their studies and experiments to find out the exact conditions that give the best results -- the highest rate of germination.

I am sure that the specific conditions vary for each type of seed but it's generally an accepted practice to try to maintain seed storage rooms at a temperature of 40<sup>o</sup>F. and a relative humidity of 50% or less for best results.

Whether the humidity or the temperature is **most important** we don't know, but they seem to be closely related, and for this reason we frequently find that the refrigeration that cools the room is also used to maintain the proper moisture content of the air. There are also solid and liquid desiccants that will remove moisture from the air.

Humidity - relative humidity, dew point, pounds of moisture per pound of dry air or vapor pressure are all names of the water-in-atmosphere relationship. Its importance may be somewhat exaggerated because of the tremendous amount of attention this simple and common phenomena has received in recent years and even months. I refer to the world wide symposium in Washington in January, 1965 where people came from all over the world just to hear talks on humidity. If you have had your seed mildew and think

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1/ Mr. Munford is president, Munford Engineering Company, Inc., Jackson, Mississippi.

that this humidity is a great detriment to the seed industry -- don't feel lonesome, think of the moisture problems in textiles, drying ovens, candy manufacturers, bakeries, printing, leather manufacturers, and we even ran into a real problem last year in an egg processing room.

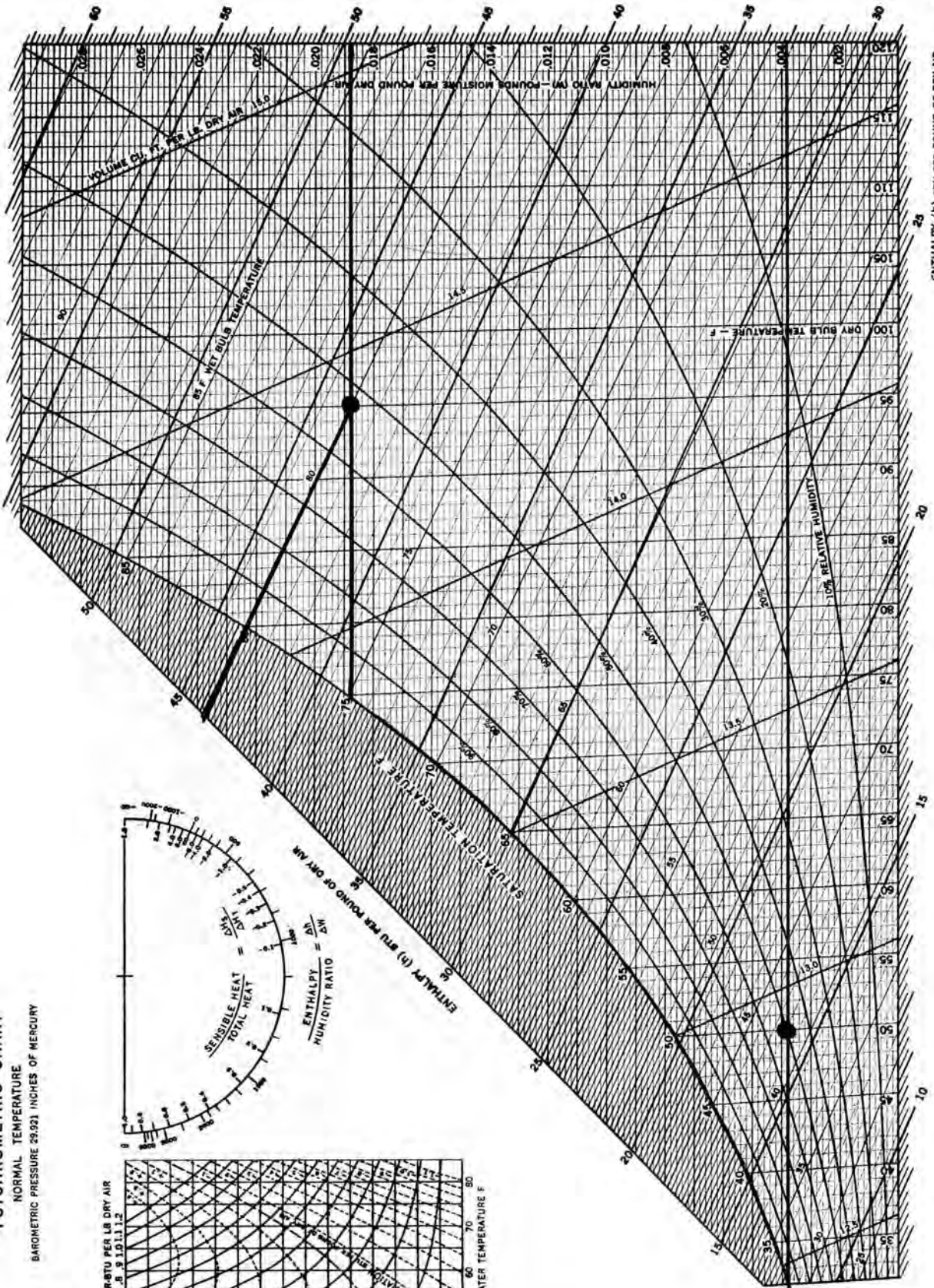
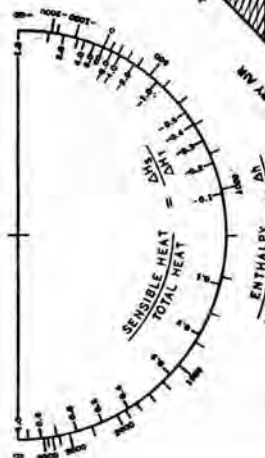
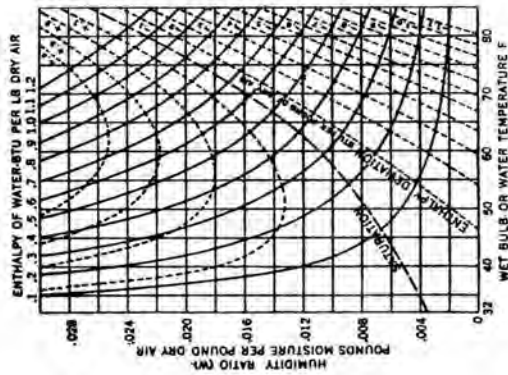
This moisture-in-air is most frequently spoken of as relative humidity. This is nothing more than the relationship of the amount of moisture actually in the air to the maximum amount of moisture that could be in the air, this being at the same pressure and temperature.

Illustration No. 1 will show what I mean. The vertical lines indicate the dry bulb temperatures -- what you read on common thermometers. The diagonal lines show wet bulb temperatures and the curved lines indicate the relative humidity. For instance, look at 95° dry bulb and run up that line until it crosses the 80° wet bulb line. The point where these lines cross is just above the 50% relative humidity line, and if we read horizontally to the right, it indicates a moisture content of .019 pounds of moisture per pound of dry air; reading on up the wet bulb line to the left, the heat content at this specific condition is about 44 BTUs per pound of air. You see from this chart that if we cool down to 80° dry Bulb with the same moisture, the relative humidity jumps up to 85%, and if we heat up to 110°, it drops to about 35%. Now suppose we are maintaining 50° F and 50% relative humidity in our cold storage and air from the outside leaks in. Please note that we first have to cool it over to the saturation temperature or dew point, to about 74° in our case, then we have to drain the moisture out of it down to a point where it has the same moisture content as our design temperature -- which happens to be 35° in our case -- a removal of 44 - 11 BTU or 33 BTU/Lb. or .019 - .004 or 0.015 Lb./Lb. - of moisture removed per pound of dry air. To bring this to the design condition will also require some reheat from motors, lights, other air or an external source. This is really not a study in the reading of a psychometric chart, but all this is just to help you see how important it is to vapor seal your seed storage. This means it takes about a ton of refrigeration for each 5,000 cubic feet of leakage per hour. Leakage varies widely, but even in well sealed rooms, under normal usage, will leak 10 to 12 times their volume in a 24 hour day. So you see that a room that leaked 5,000 cubic feet/hour would have a leakage of 120,000 cubic feet/day and would equal a room of 10,000 to 12,000 cubic foot volume, say 20' x 50' x 10' high. This is of course dependent upon the door openings as well as construction. This infiltration would require the removal of 16 gallons of water just in cooling this air from the outside. If you have careless operators, or poor construction, it will be much more.

In constructing structures for seed storage, we must keep this vapor leakage in mind in every phase of the job.

# PSYCHROMETRIC CHART

NORMAL TEMPERATURE  
BAROMETRIC PRESSURE 29.921 INCHES OF MERCURY



ENTHALPY (h) BTU PER POUND OF DRY AIR

Illustration No. 1

Floors for storages may or may not be insulated, this will depend on the size and temperature (Illustration No. 2). On large rooms there is considerable

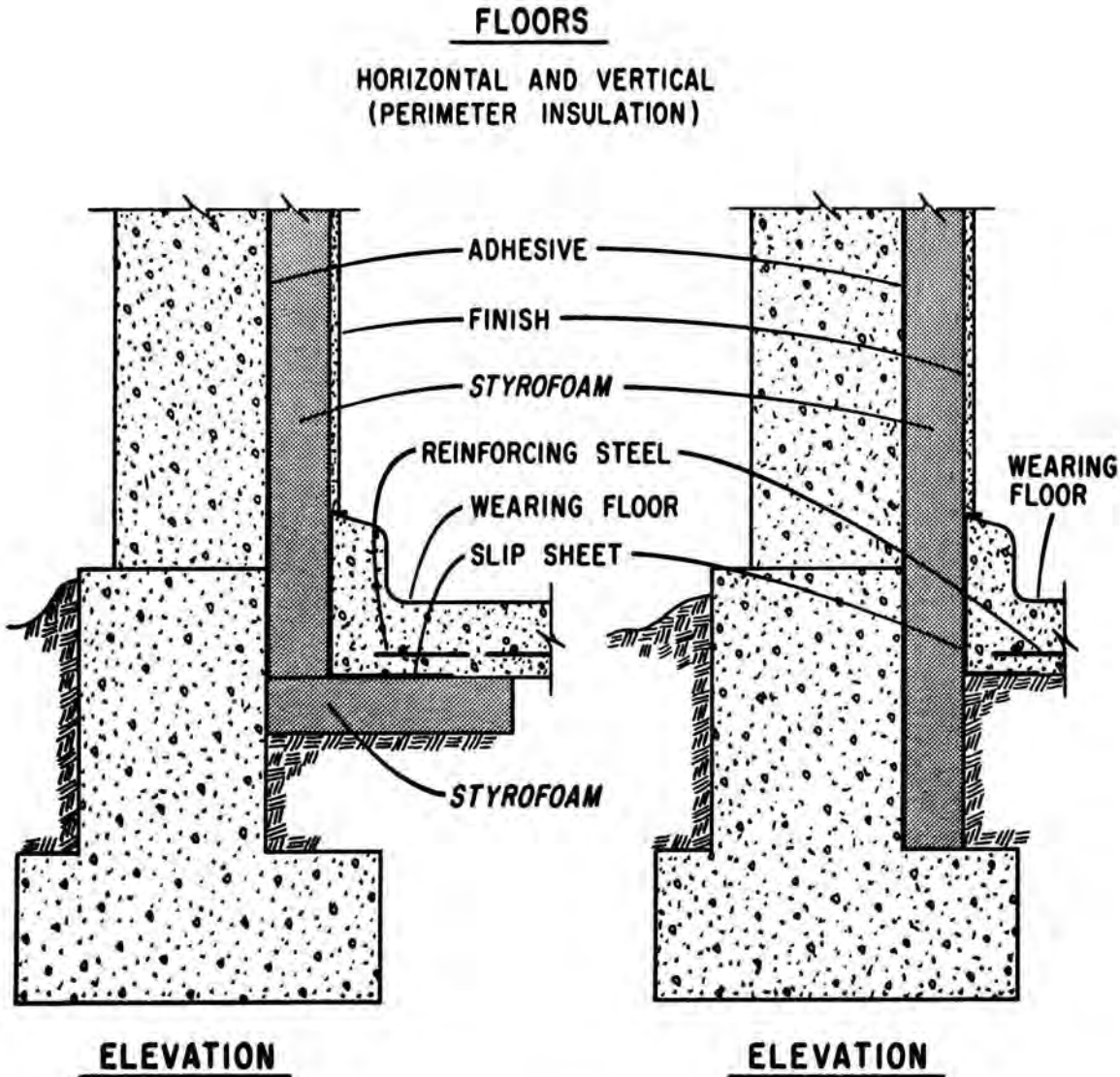


Illustration No. 2

savings in omitting the floor insulation. When we do this we believe in extending the wall insulation down the grade beam at least 3 feet below the floor level to prevent heat leakage at the wall floor-juncture. Regardless of this, the floor should be vapor sealed with polyethelene film, preferably 6 Mil. or another suitable

vapor proof membrane, with joints well lapped and sealed with mastic and run up the wall or down the grade beam a foot or so.

If we insulate the floor we usually omit the polyethylene film under the slab and lay our insulation in a bed of hot asphalt. This gives a very good vapor seal, but we frequently put a layer of film over the top of the floor insulation before we pour the concrete wearing floor.

The amount of insulation used depends on the temperature and the type of insulation. A 50°F. room should require no more than 3 inches of Styrofoam or Dorvon or possibly 4 inches of cork and possibly only 2 inches of Thurane. If we drop this temperature to 40°F. we usually use 4 inches of Styrofoam or 4 inches of Cork Board or 3 inches of Thurane. These figures are based on theoretical and actual test data pertaining to heat transfer rates, but remember the insulation must be kept dry to maintain these rates. If the insulation material does not have a built in characteristic for dryness, you have to provide it. We have always contended that sawdust would be a possible insulator if we could just keep it dry and use enough of it.

The board type insulations should be applied in two or more layers with the joints lapped or staggered, so that air or heat will have a longer travel to get to a joint. This is probably more important with Styrofoam. Styrofoam will not allow vapor passage through the body of the insulation, so we especially have to guard the cracks.

On masonry walls Styrofoam is applied usually in a bed of portland cement mortar. The beadboards, Dorvon, etc. require a vapor sealed wall. We frequently do this by painting with an asphalt priming paint, then applying the insulation with a Latex concrete -- we use styrocrete, and have found it excellent. I presume Thurane could be installed in the same manner, but cork board would require a plastered wall smooth and true, primed with an asphalt priming paint, and then the cork board applied in hot asphalt.

When insulation is applied to a wood wall, we generally use a film of polyethylene tacked and sealed with mastic to the wood and the insulation nailed through it into the wood for support. The mastic seals the nail holes -- or is suppose to. This is even more common for construction of the ceilings. The first layer of insulation is nailed through the polyethylene or "Moistop" paper film with galvanized or treated big headed insulation nails; the second layer is then placed beneath the first using some adhesive and either shoring up until this sets or use wooden skewers to hold it in place. We usually use "Styrocrete" the latex adhesive, since it has a lot more holding power than just mortar.

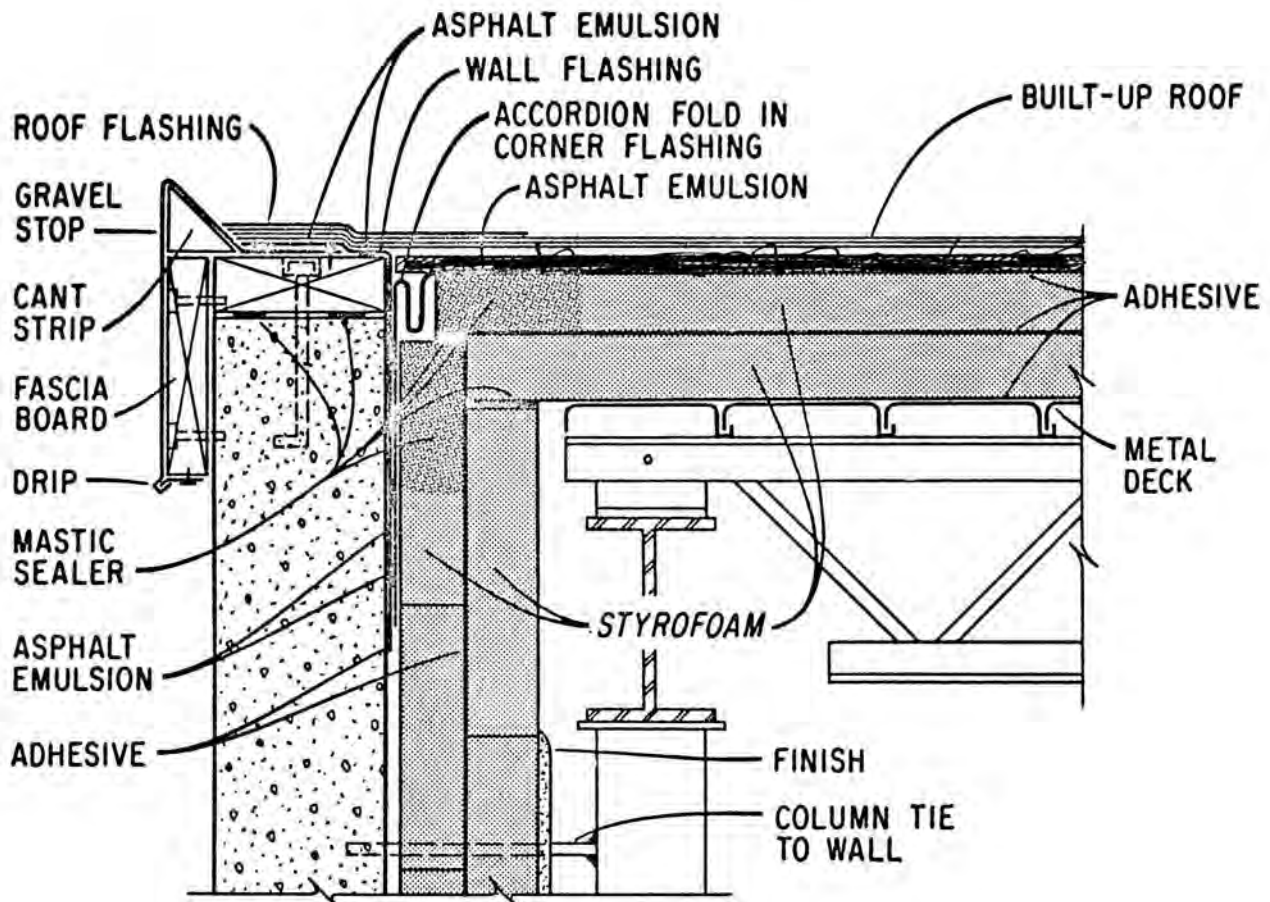
Don't get me wrong -- just plain mortar will do a fair job as a ceiling adhesive when only a 1 or 2 inch layer of Styrofoam is used with it and no finish is used -- and it's much less expensive than Styrocrete.

The vapor seal we use at the floor-wall juncture and in the corners is "Moistop" paper made by Sisolcraft. It is plastered to the wall with 507SF Mastic made by Pittsburg Chemical Corporation. We also put the mastic sealer on the outside to catch the insulation too. This goes all around the floor and up in each corner to the wall ceiling juncture.

We have the additional problem of building movement caused by wide variations of temperature. Here special precautions should be taken. We usually make an accordion fold (Illustration No. 3) of this same Moistop paper, sealed

### OVERDECK WALL-CEILING DETAIL

(FLUSH)

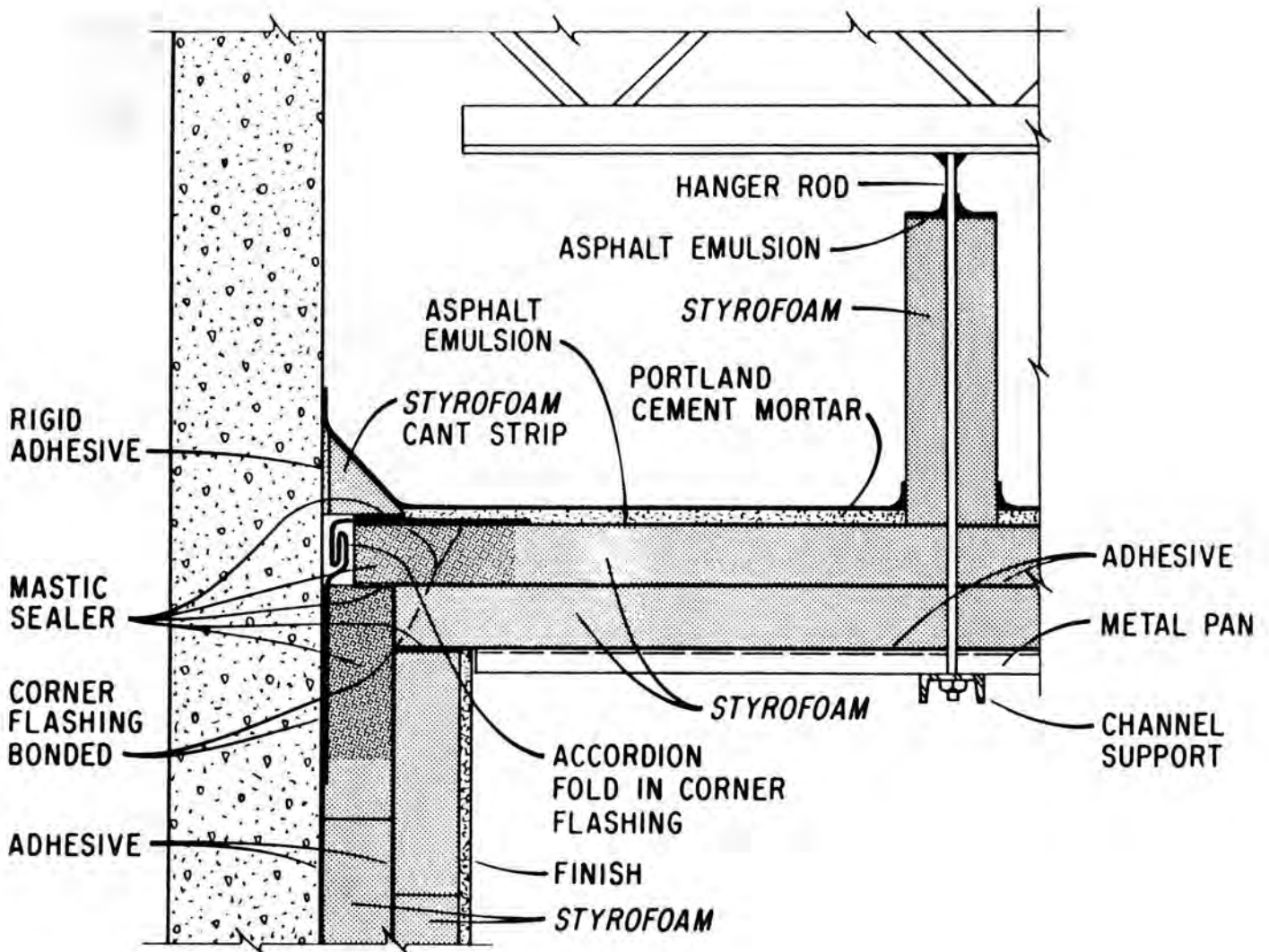


ELEVATION

with Mastic and tied in with the wall and extended at least 12 inches into or over the insulation.

Ceiling insulations can be of many kinds. We call it an envelope when the supports are all in the room, then the ceiling is suspended on a metal pan. (Illustration No. 4) or "T" iron (Illustration No. 5).

### SUSPENDED METAL PAN CEILING



### ELEVATION

Illustration No. 4



**SUSPENDED T-BAR CEILINGS**  
(THREE LAYERS)

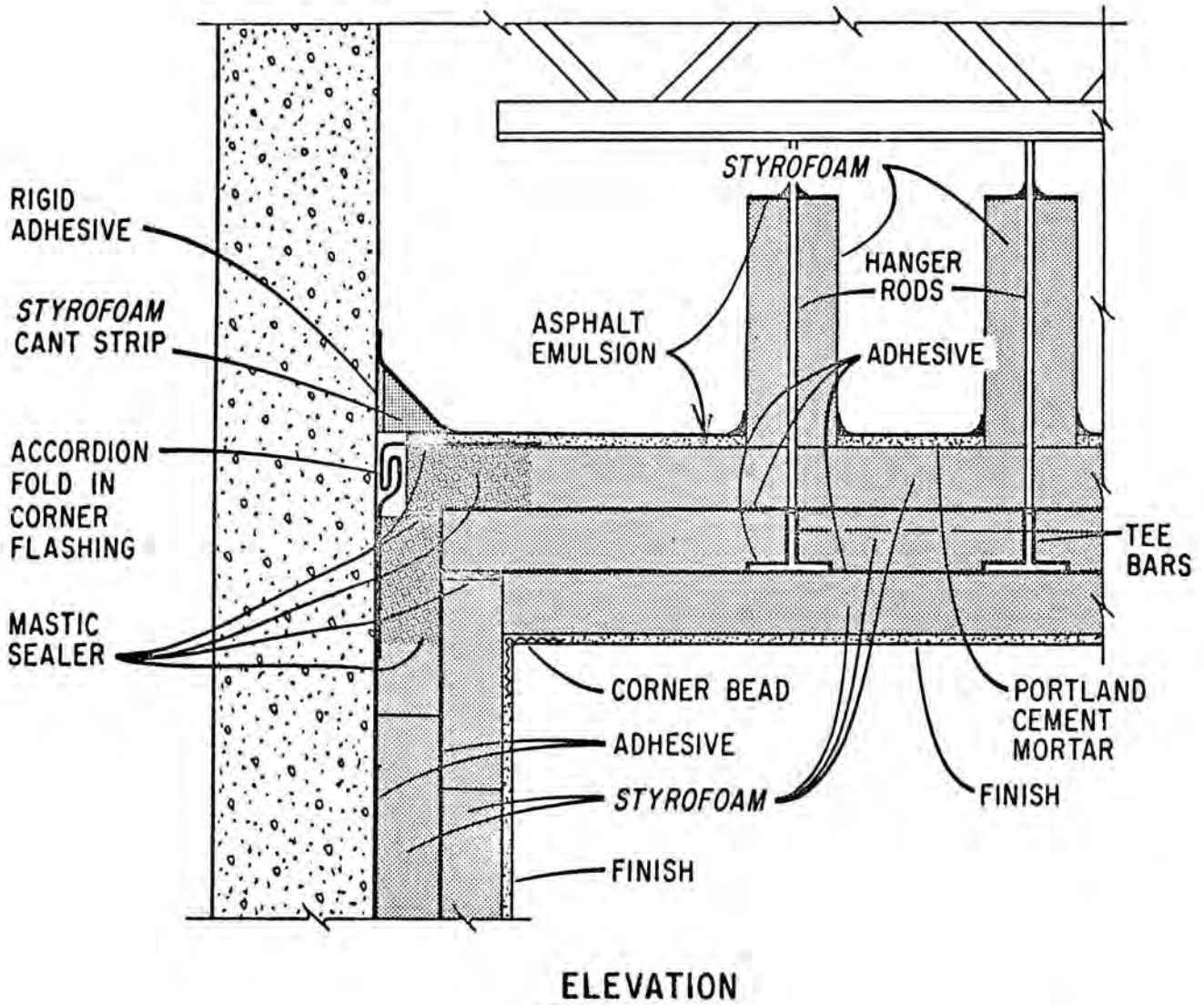


Illustration No. 5

The envelope ceiling has the advantage of being easy to lay and the build-up roof on top provides a fair vapor seal. We can apply the first layer in hot asphalt just as we mentioned for the floor. The second layer would have mortar as an adhesive. The top presents some problems -- hot asphalt melts Styrofoam, so if the built-up roof is to be applied directly, we have to use, what is called a rool coater or the "Mop & Flop" method. Here the asphalt is applied to the felt

before the felt is applied to the roof. A layer of builder's roofing insulation board or an inch of concrete could also be used and the build-up roof applied in the normal manner. We recommend that such roofs be covered with a light colored gravel or marble chips or painted white -- they should also be sloped and not flat.

From the insulation standpoint, the suspended deck (Illustration No. 4) is probably no better than another type -- just more expensive. When a metal deck is used, the application is similar to the envelope operation. We lay the insulation in the pan and apply successive layers to it in an adhesive. These can be covered with mortar and a layer of polyethylene or "Moistop Paper" placed over it in mastic. Take special care in cutting around the suspending rods and lap, and seal the joints. The rods should also be insulated 12 to 18 inches above the insulation or they will sweat. The ceiling suspended on "T" iron is much the same as one layer set in the T's and another applied beneath. The mortar helps hold down the top layer while the bottom layer is being applied.

Finishes used are usually 2 coats of Portland Cement plaster with a thickness of over one-half inch. These can be reinforced with galvanized metal lath where the wall is subject to any shock of consequence. In fact, we always reinforce both sides of all self supporting walls from top to bottom and frequently use lath 6 feet high on walls where trucks might hit them. We also recommend bumpers, wood, metal or concrete. We frequently omit the finish from the ceiling leaving the insulation exposed -- thus reducing the weight of the material that holds it in place. However, they may be finished with plaster as thin as possible or with some good paint that will not react with the type insulation being used.

Cold storage doors are another problem in connection with admitting moisture, in fact, nothing is worse than operators who won't keep the doors closed. We believe the rolling door will help eliminate some of this trouble, but only if they are kept closed. If they are properly installed and adjusted they will give a tighter seal than swinging doors. Also, the big doors permit use of lift trucks and they seem more practical and certainly less trouble to hang. You can also get these electrically operated, if you want to spend the money. They may be worth it just because they will be closed more of the time. The manually rolled door is also very satisfactory even in the fairly large sizes. We have used 6' x 8' very successfully.

Another relatively new idea is the use of a high velocity, thin, air curtain across the face of the door, usually from top to bottom. This

is not the complete answer to the entrance of heat or moisture, but is better than the swinging door which is always stuck open or knocked off by a truck.

Some moisture will enter regardless, so the best thing to do is to keep the doors shut as much as possible -- and after we have learned to keep them shut and have built a well sealed room, we have reduced our refrigerating problem about half.

Our refrigeration problem is dependent on the actual heat leakage through the walls, roof and floor, and the heat of the product. The heat leakage is dependent on the difference between the outside and inside temperatures and the resistance to heat flow of the insulation we have selected. Cooling the seed initially could be quite a refrigeration load, but most people seem to think that this can be done rather slowly, in a week - 10 days, two weeks. Frequently loading facilities limit the amount that can enter in one day. The specific heat of seed is relatively low and with a long time to cool them, this load is usually light. The lights can be eliminated most of the time -- but the fan motors run constantly and the infiltration increases with greater usage. The trouble is that in the design of our refrigeration machinery, we must be able to meet the maximum condition. The seed enters the storage at the hottest time of the year and their heat must be removed. The doors are opened a lot more than normal, more people are in the storage and the lights are shining brightly, thus refrigerating machinery must have enough capacity to struggle by and hold the temperatures until it can catch up and start pulling down the humidity to the best storage conditions.

Most of the systems we have installed use forced air circulation through a cooling coil that is refrigerated with one of the common refrigerants. We primarily use the Freons or Ammonia for this purpose. Most of our seed storages use Freon-12, but we have used Ammonia in two large peanut and pecan storages. We helped prevent leakage of the Ammonia in the rooms by putting all valves and controls outside the room walls. This refrigerant is expanded through the cooling coil and pumped up to the pressure at which it will condense by a compressor, reciprocating type, either open V-Belt driven or hermetically sealed with it's motor. The refrigerant is condensed by water or air. Water is the old standby, but most of the new plants use air only if Freon-12 is the refrigerant, or an evaporative condenser using water sprayed on condensing coils while air is blown over them. The air cooled is the most expensive -- and the least trouble. The cold air is blown over the room by centrifugal or propeller type fans and the deflecting valves on the air cooling units outlets spread it out over the room or it may be distributed through ducts. It is important to get the air evenly placed and leave no dead spots. If a room is over 50 feet wide with a 10 or 12 foot ceiling, duct

work should be used. The type and arrangement of the ceiling will govern the means of air distribution to some extent. Also leave a little room -- at least a couple of feet between the top of the seed and the ceiling for air distribution.

Humidity control is build into the coil design -- for low humidity at least a  $20^{\circ}$  to  $25^{\circ}$  temperature difference between room temperature and refrigerant suction temperature should be maintained -- at least when designed for maximum load. If a room is to be held at  $40^{\circ}$  F the compressor should have a capacity to refrigerate it when operating at  $15^{\circ}$  or  $20^{\circ}$  F or even lower and the coil should have no more than this capacity at this temperature difference. Since we are below freezing we have to provide some means of removing the moisture from the coil which is now in the form of ice. This can be done by blowing hot discharge gas through the coil periodically, or by electric heat in the coil or even by water. Usually one of the first two is used and controlled at regular intervals by a time clock.

You can also use an automatic by pass for humidity control as is done in many air conditioning plants. Here a small part of the air is cooled and a lot of the moisture removed -- then it is mixed with the other air and put back in the room. But the method with which we are most familiar is humidity control by the addition of reheat to a system with a proper coil design. This is simply a heating coil -- strip heater or heating unit located in the air discharge from the unit cooler. It is operated by a simple humidistat and its addition of heat keeps the refrigerating compressor operating longer -- removing more moisture reducing the humidity. This is a simple, direct, and easily maintained system and is not too expensive to operate if the coil and compressor are properly designed.

I, frankly, prefer V-belt driven compressors to hermetic units -- mostly from maintenance standpoint. You can usually get a replacement for the motor and can also change the speed if you are out of balance. The "burnouts" we have seen with hermetics have caused so much trouble we have just about quit using them. As far as condensers are concerned, be sure and get them big enough. A unit designed for the temperatures up North is just too small down here. We usually figure evaporative condensers with air entering at  $80^{\circ}$  wet bulb and air cooled condensers with a  $95^{\circ}$  ambient temperature and a  $15^{\circ}$  or  $20^{\circ}$  temperature difference between the air and condensing temperatures. It is also important to prevent this temperature from going too low, so we have devices to stop the fans to prevent this. For best results from your refrigerating machinery, keep the products off the floor and away from the walls. Use pallets on the

floor and provide at least a 6 inch air space along all the walls, and the air circulation -- temperature and humidity will be better.

To assemble these random notes and get the most storage for your money --

Remember to:

1. Be careful with the vapor seal.
2. Select a good insulation.
3. Use tight fitting doors.
4. Get sufficient capacity in your refrigerating system with air cooler and compressor properly balanced.
5. Be sure your air circulation is adequate and gets down all walls.
6. Don't forget to keep the doors closed as much as you can.

## Storage of seed in sub-tropical and tropical regions

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### Summary

Adequate provisions and facilities for storage of seed are important components of seed production-marketing operations in all climatic regions. However, they are essential in sub-tropical and tropical regions because of the general adversity of the climate for storage of seed.

The storability of seed in a specific environment is largely determined by its inheritance and prestorage history. Inherent differences in longevity among species and cultivars are biological facts over which seed specialists have no control. These differences, however, must be recognised and taken into account in planning for storage. The prestorage history of seed, however, is controllable. Timely harvesting and threshing, prompt and adequate drying, and careful handling minimise quality losses from field exposure, high moisture contents, and mechanical damage, and contribute to a seed history favourable for storage.

Relative humidity and temperature of the storage environment are the most important factors affecting maintenance of seed quality during the storage period. Of these two factors, relative humidity is most important because of its direct relation to seed moisture content. Ambient temperature and relative humidity in the subtropics and tropics are usually sufficiently adverse for storage of seed that some conditioning of the environment is necessary for successful storage. The degree of environmental conditioning needed is determined by ambient conditions, the kind of seed to be stored, its quality at the beginning of storage, and the length of the storage period. In most seed operations, conditions satisfactory for three storage periods are needed: (a) short term storage - 1 to 9 months; (b) intermediate term storage - 18 to 24 months; and (c) long term storage - 3 to 10 years.

The storage environment is conditioned by drying the seed to a low moisture content and packaging in moisture vapour proof containers or by air cooling and/or dehumidification. Conditions favourable for short to intermediate term storage can be achieved in well constructed storerooms with room-type airconditioners of suitable heat removal capacity alone, or in combination with condensation or desiccant dehumidifiers.

The high degree of conditioning needed for intermediate to long term storage requires special construction, moisture vapour proofing, and insulation of the storeroom, and rather sophisticated air cooling and dehumidification systems, specifically designed for efficient operation under the prevailing ambient conditions.

Experience and specialised knowledge of both environmental engineering and seed storage are needed for the proper and economical design of rooms and systems for all levels of conditioning. If this experience and knowledge is not available within the organisation concerned with seed storage, it should be obtained from a reliable source.

### Résumé

#### *Conservation des semences dans les régions tropicales et sub-tropicales*

Dans toutes les régions climatiques, des dispositions appropriées et l'existence d'installations pour la