Farm Structures
FACTSHEET

BRITISH COLUMBIA
Ministry of Agriculture and Food

Order No. 306.300-2
October 1989
Agdex: 736

LAYOUT AND DESIGN OF REFRIGERATED STORAGES

There are a number of questions that have to be asked when planning an on-farm refrigerated storage structure. These would include such items as location, accessibility, size, cooling capacity, construction techniques, expandability, cost and returns.

On-farm cold storage can be either free standing, that is a building of its own, or built into an existing structure. It is of prime importance that the facilities are located so that it is easily accessible for bringing produce into the structure and for taking it out. If large volumes are anticipated, truck loading should be considered. Additional building space may be required for receiving, grading, processing, packing and loading out. The building site should be well drained. It has been stated that a normal operation will expand facilities as many as four times in any generation and, therefore, expansion capabilities should be planned for in the initial layout.

When forklifts are used in the storage facility, floor construction should take into account these concentrated loads and well compacted sub-grades should be prepared prior to pouring any concrete.

A room that is square-shaped is most economical in that surface areas per total volume are minimized. This will reduce heat losses and reduce construction costs. Adequate space must be provided in the room for the evaporator unit as well as for maneuverability of the produce in the cooler. The cooler should be sized specifically for the containers which will be stored and for the air circulation system used within the cooler.

A number of methods of construction can be employed and will depend on the size of the facility, whether it will be free standing or in an existing building and who will build it. The most common methods are:

- steel construction – usually larger facilities
- masonry – medium size facilities
- wood frame – small facilities

Doors

Special doors are required and these can be bought ready-made or U-built. Ensure manufacturer's size is determined prior to framing when purchasing manufactured doors. Special hinges, door openers, safety bars, sealing strips and insulation is required for the doors. Four feet by seven feet is recommended as an absolute minimum size. Obviously, larger sizes will be required for forklift operations.

Vapour Barriers

It is of prime importance that the vapour barrier be placed on the exterior or warm side of the insulation. Normal house construction has a vapour barrier toward the inside of the house which is opposite to the requirements of refrigerated spaces. The vapour barrier must encompass the whole cold storage structure and all joints must be well sealed. (See Engineering Plan 330.10 "Cold Storage Wall Sections".

Insulation

Insulation used in these storages can be polyurethane, styrofoam, fiberglass batts, any other good insulating material or any combination of the above. Walls should have a minimum "R" value (insulation factor) of 20, ceilings of 30 and floors and foundations of 10.

Based on the actual construction, an "R" value (insulation factor) is calculated. See Table 1 for thermal properties of selected insulating and building materials. Typical "R" calculations are given:

Wall	**"R" Factor**
Outside air	0.28
5-1/2" fiberglass	18.26
1" rigid insulation	5.26
1/2" plywood	0.63
Inside air	0.17
Total "R" for wall	24.60 (hr ft^2 ^oF/BTU)

Ceiling	
Outside air	0.28
5-1/2" fiberglass	18.26
2" rigid insulation	10.52
½" plywood	0.63
Inside air	0.17
Total "R" for ceiling	29.86 (hr ft^2 ^oF/BTU)

Floor and Foundations	**"R" Factor**
2" rigid insulation	10.52
4" concrete (6" foundation)	0.44
Inside air	0.17
Total "R" for floor	11.12 (hr ft^2 ^oF/BTU)

Note: For floors, assume ground temperature to be 45^{o}F.

Table 1

Thermal Properties of Selected Insulating and Building Materials

Material	"R" Factor British Units (hr $ft^{2o}F$/BTU)	"R" Factor Metric[1] Units ($m^{2o}K$)/W
Insulation		
Fiberglass batts[2]	3.32/inch	.230/cm
Fiberglass, loose	2.55/inch	.177/cm
Fiberglass, board	4.00/inch	.277/cm
Cellular glass (Foamglas)	2.86/inch	.198/cm
Styrofoam, extruded	5.26/inch	.346/cm
Styrofoam, beadboard[3]	4.17/inch	.289/cm
Polyurethane, board	6.25/inch	.433/cm
Polyurethane, foamed-in-place	6.25/inch	.433/cm
Polyisocyanurate, board	7.04/inch	.488/cm
Building Materials		
Fir plywood	1.25/inch	.087/cm
Fiberboard sheathing1/2"	1.32	.233
Particle board 1/2" (Aspenite)	0.92	.162
Gypsum board (5/8")	0.56	.099
Concrete, cast	0.11/inch	.008/cm
Concrete block 8"	1.11	.195
Concrete block 12"	1.28	.225
Glass, single pane	0.10	.018
Fire Coatings for Foam		
Perlite Gypsum Plaster (1/2")	0.33	.058
Vermiculite Gypsum Plaster (1/2")	0.30	.053
Fire Retardant Cellulose (1")	4.00	.71
Air Film and Air Gaps		
Air Film, outside summer or inside heated	0.28	.044
Air Film, outside winter or inside cold storage	0.17	.030
1 inch or greater air gap (average value)	0.72	.127

[1]Metric Conversion Factors: ((hr $ft^{2o}F$)/BTU) * 0.176 = ($m^{2o}K$)/W
inches * 2.54 = cm

[2]Unfaced, average value for several types

[3]1.5 lb/ft^3 (0.024g/cc) density

Layout

The storage room layout and refrigeration system should be designed for maximum temperature pull-down efficiency. Optimum field heat removal is obtained in a system having both adequate refrigeration capacity and an efficient air distribution system.

The cooling air from the evaporators must be delivered in sufficient quantity and at proper velocity to provide effective cooling throughout the storage volume. Ceiling mounted, direct throw evaporators must be sized according to the cooling load, be equipped with fans of correct capacity to move air throughout the storage, and be positioned in the proper location to facilitate maximum air movement. Better air distribution is obtained with several small evaporators located along one wall than a single, large unit of equivalent capacity located in the centre of the same wall. Coils must be kept free of ice to ensure efficient heat exchange and proper air velocity.

Loading and Stacking

Room loading and stacking patterns have a profound effect upon air distribution and the rate of cooling. Ideally, the warm product should be spread out in the storage with the warmest commodity exposed to the coldest portion of the air stream. This may not always be possible due to separation of product lots and the configuration of the room, but every attempt should be made to distribute warm products in the room during loading. Stacking the first hot product directly underneath the evaporator helps to ensure that the warmest product is in contact with the coldest air as the evaporator discharge stream is moved over the top and back through the stacks of newly loaded produce.

Rooms should always be stacked with the pallet bin runners oriented in the same direction as the evaporator discharge. It is essential that the bins be properly oriented to provide air distribution channels for faster cooling. If the pallet runners are properly aligned, cooling air can absorb heat from the top and bottom bin surfaces more effectively. It is important to use identical pallet bins in each row to ensure that the runner openings are continuous from the front to the back of the room.

It is desirable to leave a four to six inch spacing between stacks of bins to promote heat transfer along the sides of the containers. Bin spacing is easily managed if the bin row location is marked on the floor of the storage with paint. The stacking patterns for new storage rooms should be established so that the bin orientation and spacing, relative to the refrigeration system, is known before construction takes place. This will ensure optimum use of floor space and refrigeration capacity during pull-down.

A minimum of eight to ten inches should be left between the pallet bin stack and the wall, downstream from the evaporator. This space is necessary to ensure that all of the cooling air may pass down behind the stacks on the far wall, circulate uniformly back through the produce and be picked up by the evaporator at the near wall. A six to eight inch space is usually left between the outside bins and the side walls. A curb is usually secured to the floor around the perimeter of the store room to guarantee the bin to wall spacing and to protect the wall insulation from damage by bins stacked near the wall.

In summary, the following clearances are recommended:

Walls	- 6-8 inches
Ceiling	- 24 inches
Between pallets	- 4-6 inches

FOR FURTHER INFORMATION CONTACT
Bert van Dalfsen, Mechanization Engineer (Written by: Erich Schulz, Engineering Technologist)
Phone: (604) 556-3109
Email: Bert.vanDalfsen@gems4.gov.bc.ca

RESOURCE MANAGEMENT BRANCH
Ministry of Agriculture and Food
1767 Angus Campbell Road
Abbotsford, BC V3G 2M3