DESIGN PROCEDURES FOR CONTROLLED ATMOSPHERE STORAGES

by
F. H. Theakston
Member C.A.Eng.S.

Engineering Science Department, Ontario Agricultural College, Guelph, Ont.

The most recent trend in storages for apples is by controlling the atmosphere in which the fruit is contained to very fine limits with respect to oxygen, and carbon dioxide.

The technique has been well known to horticulturists for several years but is only gaining true acceptance in Canada at the present time as a practical method of holding apples for an extended period.

Controlled atmosphere storage presents a very interesting and provocative field to the Agricultural Engineer for the challenge to design a structure which is both efficient in operation and containing almost perfectly sealed storage chambers is present in this type of storage.

It should first be explained that controlling the atmospheric conditions in storages where apples are contained actually limits the respiratory rate of the apples to such an extent that the fruit is placed in a state of "suspended animation". This term, while not commonly used with any thing but animal life, can be applied to fruit because even though detached from a tree the fruit is a living object. That is, respiration does go on because fruit sugars are oxidized in the presence of oxygen in the air and as a result carbon dioxide, water vapour, and heat are produced. It has been observed in all types of storages that the more rapid the rate of respiration the quicker fruits break down or deteriorate.

The process of respiration can be retarded by low temperatures which is a standard method of storage. Other principles, such as decreasing oxygen, which is necessary in respiration, and increasing carbon dioxide, may be exployed to assist the refrigeration practices, the summation of these principles being controlled atmosphere storage.

The first requirement in a controlled atmosphere room is gastight construction and by proper design close to 100 per cent tightness should be attained.

It is thus necessary to observe the gas condition in the room periodically and a gas analysis must be made two or three times daily to ensure close control of conditions inside the room. An Orsat analyser is used to observe conditions from outside the chamber since the low content of oxygen will not permit observations inside unless absolutely necessary and even then respirators must be used.

Carbon dioxide is a product of respiration and increases while respiration takes place. If the total percentages of oxygen and carbon dioxide reaches 21 per cent ventilation can be employed but if the atmosphere does not contain a total of 21 per cent but rather quantities such as 3 per cent oxygen and 5 per cent carbon dioxide to operate satisfactorily any quantities of carbon dioxide over 5 per cent must be "washed" out of the air. This is usually done by means of an atmospheric washer using caustic-soda solution as a washing agent.

Since control of temperature and air tightness are essential qualities in the C.A. rooms rigid design and construction procedures must be followed. Insulation of walls and ceilings should be carefully applied using 4 inches of cork board or equivalent in the walls and floor, and 6 inches of cork board or equivalent in the ceiling. Vapour barriers are imperative and heavy kraft paper with asphalt binding has been used successfully.

The seal on the interior of the rooms must be given special consideration to provide a minimum of leaks. The most successful liner thus far is a series of galvanized metal sheets of twenty-eight gauge with overlapper joints each joint being overlapped by 1½ inches and cemented with a high grade caulking compound. Large headed galvanized roofing nails are spaced about 2 inches on centre to give a tight seal but each nail must be finally covered with a good bead of caulking compound.

Normal stud wall construction is permitted if the sealing qualities of the lining is not impaired but at least 2 inches of cork should cover the entire face of the stude while another 2 inches or more should fill the space between the studs. The layers of cork can be fastened together by wood skewers which limits the transfer of heat through the wall.

Cork is an excellent insulation material provided it is not in contact with moisture but readily crumbles and fills the bottom portion of the wall if attacked by water vapour.

The floor is constructed by filling up to platform level with fill and gravel, well tamped, and then topping with a layer of concrete about 3 inches thick. At this point in the construction it is recommended that the galvanized side wall liner be continued so that it covers at least 1 foot of floor, thus giving air tightness at the foot of the walls. A vapour barrier may now be placed on top of the 3 inches of concrete and 4 inches of cork-board placed above this to ensure good insulation. A final 4 inches of reinforced concrete can now be laid to carry the load from the storage product and machinery used within the chambers.

It is good practice to leave a gap of ¾ inch to 1 inch at the perimeter of the top layer of concrete which can be filled with an asphalt compound to allow for expansion and contraction.

Some storages have attached 1 inch by 2 inch material to the walls by means of caulking compound to provide air space around the fruit boxes for proper air circulation. Others have provided a bumper board about the storage rooms to provide ventilation space and also to prevent damage to the metal walls by loading equipment.

The only equipment in the room is an evaporator with blower and duct work and the caustic soda spray chamber.

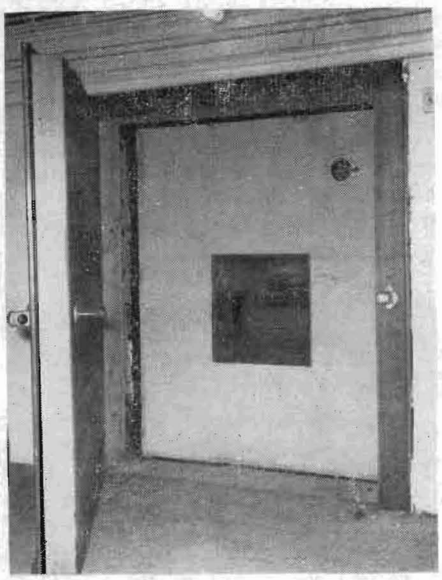
Each chamber is tested under air pressure to ensure positive seal before loading takes place. This can be done by releasing carbon dioxide from cylinders until the room is pressurized and leaks observed.

Since air escape is critical no floor drains can be installed unless tightly trapped so washing of the floor is not an easy operation.

Several materials have been tried for use as lining for controlled atmosphere storage rooms but were found to have joint leaks even though impervious to gas through the material itself.

The door leading to the chamber consists of a large steel door set into angles and then tightly sealed around the edges by caulking compound. A glass about 2 feet square is installed in the upper central portion of the door for observation purposes while in some storages an additional port about 4 inches in diameter is installed so that oxygen can be supplied to the room when necessary. This door is very heavy and even though moved only when the storage is loaded and unloaded is too cumbersome to be practical. A reinforced plastic door has been used on some cold storage rooms and may well replace the heavy steel door just described.

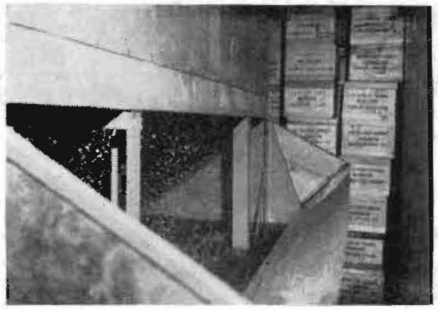
In order to insulate the door section from the chamber a conventional refrigerator door is installed on the outside.



A sealed door with an observation window is important.

The framing and exterior construction is very similar to standard practices but some practical ideas have been incorporated in recent storages which enhance the appearance of the buildings, and provides functional features.

The use of open web beam or bar joists have enabled storage construction with long post free spans and gives freedom of movement within the storage compartments as well as in the central work alley at the center



A caustic soda bath picks up excess carbon dioxide from the air.

of the building.

The bar joists allow an additional function by providing passage of air over the ceiling insulation which decreases heat transfer to some degree. One storage operation has applied corrugated asbestos cement board to the exterior wall, leaving the corrugations open at the bottom so air may be carried over the walls across the ceiling and thence through roof ventilators to provide, in effect, jacket cooling by natural air currents. The asbestos cement board also provides fire-proofing qualities necessary for buildings of this type.

A timber sill is bolted to the top of the concrete foundation and is covered by a metal protective sheet which forms a drip cap over the concrete. This protection is advised to prevent excessive moisture affecting the timber sill and also discourages infestation by insects and penetration by rodents.

A similar metal flashing may be placed at the plate for the same reasons as that at the sill and it provides a pleasing appearance to the structure.

Since the operation of controlled atmosphere storages in this country is comparatively new it can be expected to increase rapidly within the next few years and even plants now in use will have to increase their capacity. It is, therefore, expedient to choose a site carefully to take care of expansion. One storey structures are probably easier to manage and buildings should be designed for flexibility with this in mind. Always locate the building on a well drained site and accessible to highways and railways with adequate electric power facilities.

While the interior mechanical equipment may be a problem for specialists it is certainly the duty of the Agricultural Engineer designing in this field to have sufficient knowledge of the refrigeration capacities and the capabilities of labour saving equipment to advise on proper layout.

The refrigeration unit is usually designed for 32 deg. F. during the loading period but need only hold the C.A. chamber at 38 deg. F. after the room is sealed. Only the evaporator and the blower is installed within the room with sufficient duct length to provide complete circulation of the cool air.

It should be explained in conclusion that apples controlled in storages so described do not *improve* in quality but *maintain* the quality reached at loading time. It is, therefore, necessary that apples of good quality be stored and care taken to prevent damage during loading. In this way the life of the apple may be extended to control market prices at a reasonable operating profit.

This type of storage may well be the answer to problems of many growers in the fruit belts of Canada and it is indeed a stirring challenge to Agricultural Engineers to participate more actively in designing structures of this type to keep alive an important industry in our fast growing nation.

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type of work are in many cases quite apparent.

I have also attempted to list briefly some of the qualifications we believe most desirable for the engineer in our industry. Aside from a training in agriculture, a knowledge of farm operations and a desire to improve the production facilities of agriculture, the desirable qualifications will not differ much from any other occupation or career. Such qualifications as judgment, honesty, integrity, loyalty, proper attitude, and diligence are essentials of any calling.

In closing, let me leave this thought with you. The retired chairman of our Board of Directors, who is now 86 years of age, had a standard statement that he always used when called upon to close almost any type of company gathering. It was very brief. He would always conclude, "Deere's best years are ahead". I'd like to paraphrase that and say to you, "The best years of agricultural Engineers and Engineering in both the United States and Canada are ahead of us".