Breather Bag for CA Fruit-Vegetable Storages

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The author discusses selection and operation of a breather bag for the controlled-atmosphere type of fruit and vegetable storage, and shows how it acts to reduce air leakage and as a safety device

IN the CA (controlled-atmosphere) type fruit and vegetable storage described by Smock (4)* the temperature is regulated and the level of oxygen and carbon dioxide is controlled. The equilibrium oxygen level must be equal to or below the desired control point if the oxygen level is to be controlled. The equilibrium oxygen level is determined by the rate at which the fruit consumes oxygen and the rate at which oxygen leaks into the storage room with the outside air. The rate of utilization or respiration is more or less fixed by the fruit variety and the storage temperature; therefore, the suitability of a room for CA storage is determined by leakage rate. Since leakage is a function of pressure differentials arising from several sources, (Pflug and Dewey, 2) any mechanism that reduces pressure differentials will have a substantial effect on the equilibrium oxygen level.

The possible use of an expansion device or breather bag to reduce leakage in CA storages was proposed by Pflug and Southwick (3). They found that pressure differentials and accompanying leakage due to temperature cycling of the refrigerator could be reduced through the use of a suitable breathing device. Continued study of the leakage characteristics of refrigerated CA storages indicates that the volume change is proportional to absolute temperature changes and that the temperature cycle is of the general shape illustrated in Fig. 1. The frequency of the temperature cycle is a function of the temperature differential of the off-on thermostat and the heat gain on the refrigerator; however, total leakage is related to the heat gain of the storage rather than the differential of the thermostat.

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*Numbers in parentheses refer to the appended references.

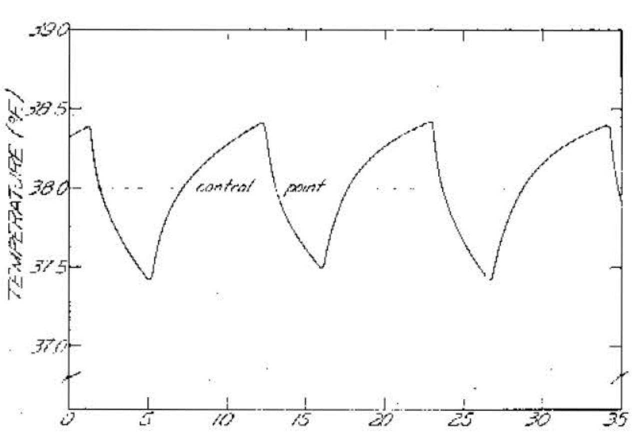

Fig. 1 Actual temperature cycle of refrigerated apple storage using on-off temperature control

The breather bag serves as a reservoir for the confined storage room and functions by giving up air to the room during the cooling part of the temperature cycle. It operates in parallel with the leaks in the storage room; therefore, to be effective it must supply and recover air with very small pressure differentials. As the bag is made more efficient, the amount of air entering the room through the leaks will be reduced; however, some air will always enter and leave the storage room through the leaks.

In making recommendations for a breather bag, the space requirement and cost must be balanced with desired efficiency. The breather bag should be large enough to supply the room with the required air with a differential pressure of 0.005 in of water. The shape of the breather bag is very important, since it must supply and then recover air from the storage. The breather bag is located outside of the storage room and in order to function must contain a large volume of air at equilibrium (The pressure inside the bag is equal to atmospheric pressure). To accomplish this the bag is supported by a rectangular frame (Fig. 2) that permits the lower portion of the bag to assume the shape of a catenary (at equilibrium). The pressure-volume characteristics of a bag that contains air at equilibrium are related

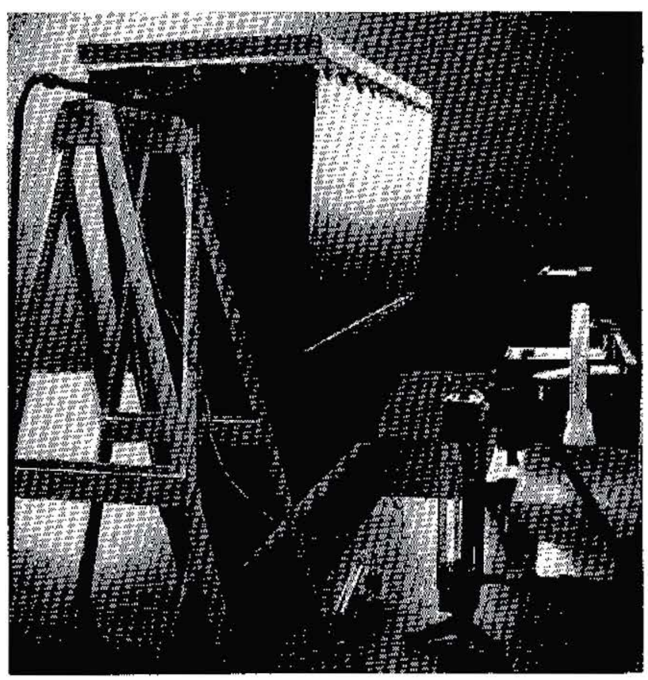

Fig. 2 Breather bag undergoing tests to determine pressure-volume characteristics

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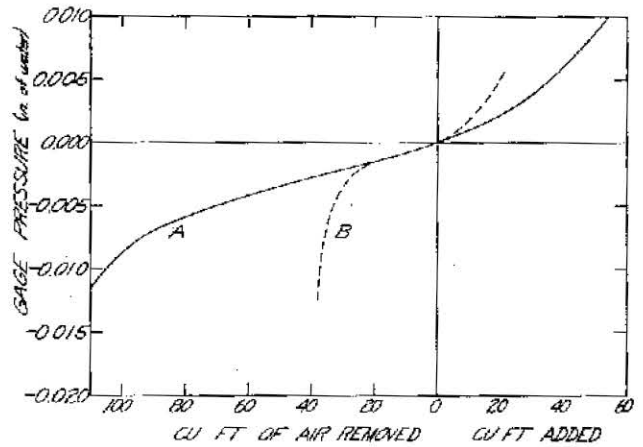

Fig. 3 Pressure-volume characteristics of two sizes of breather bags

to the length and width of the supported top, the depth, and the weight of the material from which the bag is fabricated. Increasing either the length, width, or depth increases the quantity of air that can be removed from the bag for a given pressure differential. Increasing the weight of material from which the bag is fabricated reduces this quantity.

Two sizes of breather bags have been designed specifically for CA rooms and have been tested to determine their pressure-volume characteristics. One of these breather bags is illustrated in Fig. 2. The large bag has a 3×10-ft top and a depth of 7 ft at equilibrium; the smaller bag has a 3×5 ft top and a 7-ft depth. Both bags were fabricated from 12 mil (0.012 in) vinyl sheeting. The pressure-volume characteristics of these bags are illustrated in Fig. 3.

The size of breather bag required for a given CA storage will depend on the air exchanged per temperature cycle. This is a function of the size of the room, the temperature differential of the thermostat and the refrigeration capacity in relation to the storage size. In making a design for general application the following average conditions will be used: thermostat differential, 2 F; cubic feet of atmosphere per cubic foot of storage volume, 0.65. The resulting volume change per 1000 cu ft of storage is 2.6 cu ft per 2 F temperature change. Referring to Fig. 3 it is found that the large bag (Curve A) will give up about 60 cu ft under the design conditions and is sufficient to take care of a 23,000-cu ft room and the small bag (Curve B) is adequate for a 9200-cu ft storage.

A breather bag will not be of value in reducing room leakage if the connecting tubing and fittings require large pressure differentials to move the air from the bag to the room. The effect of an undersized connecting tube was pointed out by Pflug and Southwick (3). It is recommended that a 3-in I.D. duct be used to connect the breather bag to the storage room. This duct should be as short as possible with minimum number of bends or elbows. If the conditions of the installation call for a long duct or several elbows, the duct should be sized for the particular installation using a design pressure drop of 0.005 in of water and duct friction data contained in the ASHVE Guide (1).

The breather bag should be connected to the room at a point where it will not be subjected to negative or positive pressures created by the evaporator fans. Some type of rigid perforated duct should be used in the bag to prevent the collapsing bag from sealing the outlet when the CA storage room rapidly withdraws air from the bag.

Summary

The selection of the proper size of breather bag and connecting duct for a CA fruit or vegetable storage has been outlined and the operation of the bag explained. The breather bag acts to reduce air leakage due to temperature cycling and at the same time acts as a safety device for the room. In general, a properly sized and installed breather bag may reduce the leakage from temperature cycles by 50 percent; however, the breather bag will not reduce leakage from pressure differentials induced by evaporator fans, wind or changing barometric pressures.

References

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4 Smock, R. M. Controlled-atmosphere storage of apples. Cornell University, Ext. Bul. 759, 39 pp. 1949.