Leak-Testing a CA Storage Room
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Leak-Testing a CA Storage Room

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An efficient, properly operating controlled atmosphere (CA) storage room must be adequately airtight so that it will develop and maintain the desired low level of oxygen (O_2) (usually 3%) when it is filled with fruit. If the room is not adequately tight, the low O_2 required for CA storage must be established and maintained by the frequent or constant use of a gas-fired generator. This is not particularly desirable because of the high cost of fuel, either natural or liquid propane gas, the high capital investment for the generator equipment, and the high cost of removing the excess carbon dioxide produced by the burner. Additionally, generators add heat to the storage room so that the refrigeration system must be operated for longer periods.

To meet the CA storage requirement established by law, the oxygen must be reduced to 5% within a given period (30 days in Michigan) after the room is sealed. Rooms tight enough to operate through the storage season at 3% solely by fruit respiration will usually establish the proper level of O_2 within the specified time limits. However, many storage operators use a generator initially to more quickly establish the desired level of oxygen. The several days of generator operation does not add greatly to the overall cost of storage, and is a recommended and widely accepted practice.

Fruit Respiration

Fresh apples, being living plant material, carry on respiration throughout the storage period. This is a normal physiological process in which oxygen from the surrounding atmosphere is consumed and an approximate equal amount of another gas, carbon dioxide, is produced. In CA, we allow the fruit to use up most of the oxygen that is confined within the room, then admit merely enough outside air to satisfy the oxygen requirement for respiration once the desired low level is attained. The carbon dioxide is allowed to accumulate to a predetermined acceptable level (frequently 5%), then the excess is removed to maintain a proper level.

Although it is not economically sound to build a completely hermetic room, the room must be adequately airtight so that the leakage of outside air into the room is such that the amount of oxygen moving inward with the air (about 21% of the air is oxygen) is no greater than the amount of oxygen being consumed by fruit respiration. There must be an added tolerance of tightness so as to compensate for pressure differences between the interior and exterior of the room due to changes in barometric pressure, temperature changes in the storage room and removal of carbon dioxide, and the effect of strong outside winds. Therefore, a good room almost always needs to be vented to obtain enough oxygen for the fruit.

Low levels of oxygen for CA, such as 3%, require a greater degree of tightness than higher levels, such as 5%. Likewise, a room to be operated at 1.5% O_2 would have to be tighter than one to be operated at 3%. This is because of the larger differential in the oxygen concentration between the inside and the outside atmospheres of the room. Additionally, the fruit will likely have a lower rate of respiration at the lower oxygen level, and hence a lower consumption rate for the oxygen that leaks into the room.

Standard for Airtightness

The ideal method of measuring the leakage rate of a storage room probably is to determine the rate at which air must be supplied to a room in order to maintain a given pressure differential on the room such as 0.1 to 0.4 inch of water pressure, as described by Pflug and Southwick (1954). Unfortunately, this method is often impractical because of the equipment requirements. Instead, the standard procedure is the one recommended by Smock and Blanpied (1972) whereby gas leakage is measured as the number of minutes required for the pressure in a room to return to zero after it has been pumped to a pressure of 1 inch of water.

The tightness requirements are given in Table 1 as the minimum time to drop from 1 inch to 0. Rooms of smaller capacity than 2,500 bushels would have to be considerably tighter, perhaps even twice as tight for a 1,250-bushel room as for a 2,500-bushel room. Larger rooms can have a higher leakage rate than smaller rooms because of the greater ratio of fruit volume to surface area of walls, ceiling and floor. Perhaps a 40,000-bushel room would need to be only 0.8 times as tight as a 20,000-bushel room, so that it would retain pressure for 17 instead of 20 minutes for a 38°-room. Since there are no data to serve as a basis for recommendations for smaller or larger rooms, these times have been estimated.

Table 1. Airtightness requirements of CA storage rooms for apples as recommended by Smock and Blanpied (1972).

Storage temperature (°F)	Room capacity (bushels)	Minimum time for pressure change from 1" to 0 (minutes)
38°	2,500	60
	5,000	40
	10,000	30
	20,000	20
32°	2,500	70
	5,000	50
	10,000	40
	20,000	30

Test Procedures

Test rooms under relatively stable temperature and barometric pressure conditions. Avoid periods of high velocity or gusty winds. Turn off the refrigeration and blowers. Attach an inclined manometer (Fig. 1) to the room and establish air pressure with a vacuum cleaner blower or similar blower to a pressure slightly above one inch. Close the air line from the blower and start the timing when the air pressure within the room returns to one inch on the manometer. The time required to reach zero can be determined within 15 or 20 minutes by using the semilogarithmic chart of Fig. 2. Starting at the upper right corner, enter the pressures on the chart at 0 minutes (when there is 1 inch of water pressure), then at 5, 10, 15 and 20 minutes. As illustrated on the chart for an example room, these points will form almost a straight line which can be then projected to the bottom axis of the chart (which is marked as zero, but actually is 0.01 inch pressure). The intersection of this line and the baseline will denote the time required for the pressure to be almost completely dissipated as a result of air leakage.

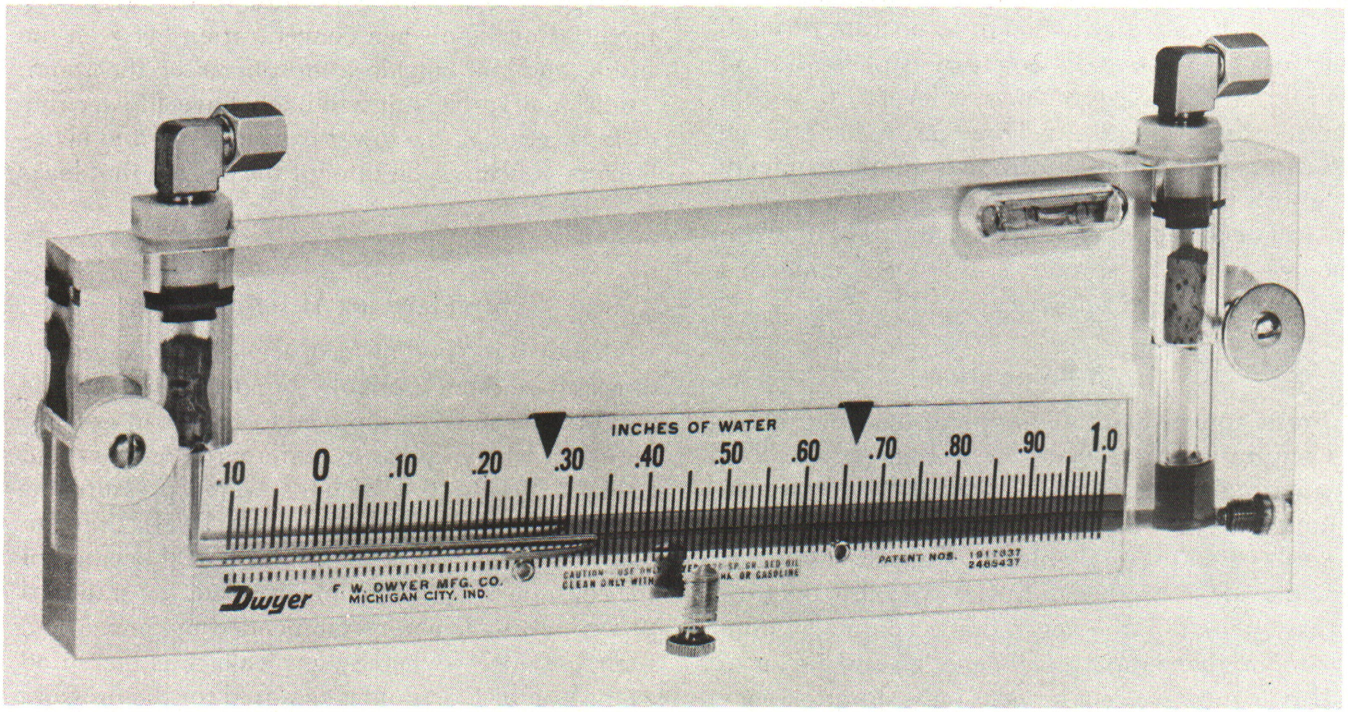

Fig. 1. An inclined manometer of this type connected to a CA room will provide accurate readings of the pressure loss during the leakage test (photo courtesy of Dwyer Instruments, Inc.).

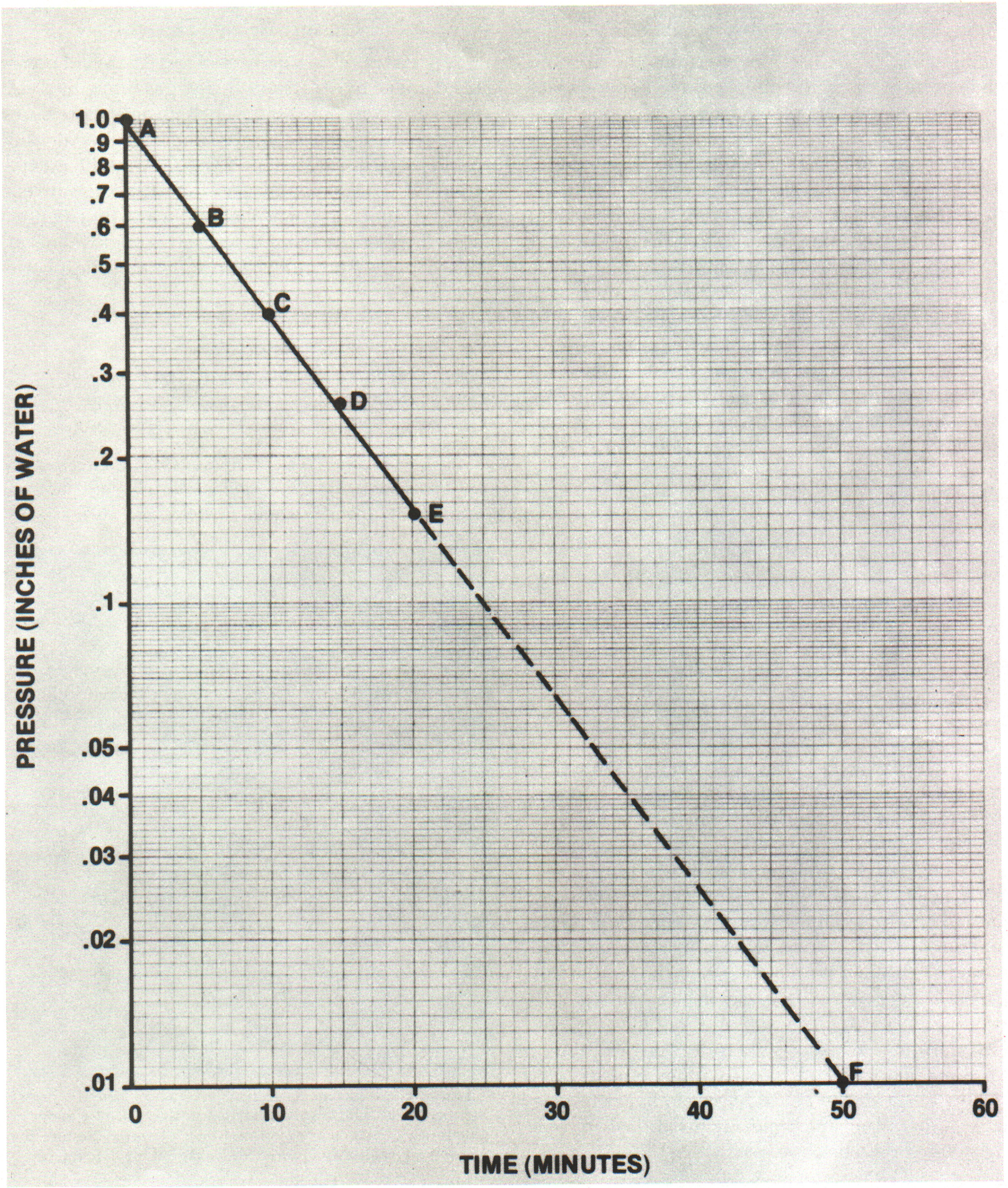

Fig. 2. Chart with logarithmic scale on the vertical axis for water pressure (.01 to 1 inch) and arithmetic scale on horizontal axis for time (0 to 60 minutes) for determining the leakage rate of a CA room. Mark the initial pressure of 1 inch of water at the upper right corner at 0 minute. As the pressure falls plot the readings at 5, 10, 15 and 20 minutes. Then draw a line through these points to the bottom line of the chart to estimate the total time required for the room pressure to return to .01 (approximately zero). The actual pressure fall for a sample room is illustrated by the points A-E and the corresponding solid line, which is then drawn as a dotted line to the base line of the chart. Approximately 50 minutes was required for a complete loss of the original 1-inch water pressure created in the room for testing purposes.

Precautions

A U-tube can be used to determine the pressure change in a room, but its accuracy is poor compared to the inclined manometer. It is so poor that the semilogarithmic chart cannot be easily used to predict the total time required to reach zero. Furthermore, there is the danger of misreading the pressure. To get a 1-inch reading, measure a total of 1 inch between the water level of the two sides of the tube. In other words, at zero the two levels are equal; when one level moves down ½ inch as a result of room pressure, the other side moves up ½ inch to give a total of 1 inch of water pressure.

Avoid pressures on a room greater than 1.2 inches of water to prevent damage to the building. A 1-inch water pressure places a force of approximately 5.2 pounds on each square foot of surface area. A 40-foot x 60-foot ceiling receives a total upward force of over 6 tons when subjected to 1 inch of water pressure.

Changes in temperature during the test period will affect the pressure reading so that a true measure of leakage is impossible. Room pressure increases as the temperature rises, it decreases when the air is cooled.

Locating and Repairing Leaks

A rapid pressure drop when testing a room indicates there are rather large leaks such as those that occur around conduit, refrigeration piping, doors and windows. This sometimes can be detected by a "whoosh" sound of air, but frequently a smoke pot must be used to find the site of air movement. Small leaks usually whistle and can be found by careful listening during the leak test. Both large and small leaks can be sealed by caulking compound. Workmen within the room during the test period need scaffolding or an electric lift truck to provide access to all wall and ceiling surfaces. Deterioration of the structure due to aging, pressure changes and various other stresses and strains result in the constant development of new leaks, thus testing and repairing for air leakage of a CA room should be done yearly.

Pressure Release Device

A pressure release valve will serve to avoid possible damage to the structure and gas lining of a CA room as a result of excessively high or low pressures developing in the room. A simple device for this purpose is illustrated in Fig. 3. Air will escape from the CA room whenever the room pressure exceeds the outside atmospheric pressure by 1.0 inch; air will enter the room through this vent whenever the room pressure falls 1.0 inch below atmospheric pressure.

References

Pflug, I. J. and F. W. Southwick. 1954. Air leakage in controlled-atmosphere storage. Agric. Eng. 35(9):635-637.

Smock, R. M. and G. D. Blanpied. 1972. Controlled atmosphere storage of apples. Cornell Univ. Inform. Bul. 41 (Plant Sciences, Pomology 3). 16 pp.

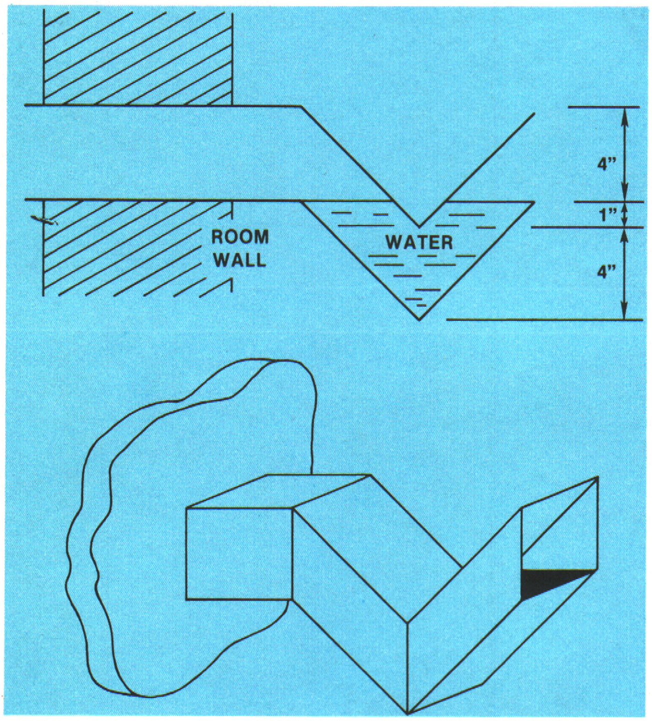

Fig. 3. Cross section diagram (above) and schematic drawing (below) of release valve installed in the wall of a room to release air pressures in excess of 1 inch of water. Restore the water level frequently to avoid air leakage at lower pressures.

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