Lecture 12

DESIGN OF COLD STORAGE

COLD STORAGE

- Cold storage is the one widely practiced method for bulk handling of the perishables between production and marketing processing.
- It is one of the methods of reserving perishable commodities in fresh and whole some state for a longer period by controlling temperature and humidity with in the storage system.
- Maintaining adequately low temperature is critical, as otherwise it will cause chilling injury to the produce.
- Also, relative humidity of the storeroom should be kept as high as 80-90% for most of the perishables, below (or) above which his detrimental effect on the keeping quality of the produce.

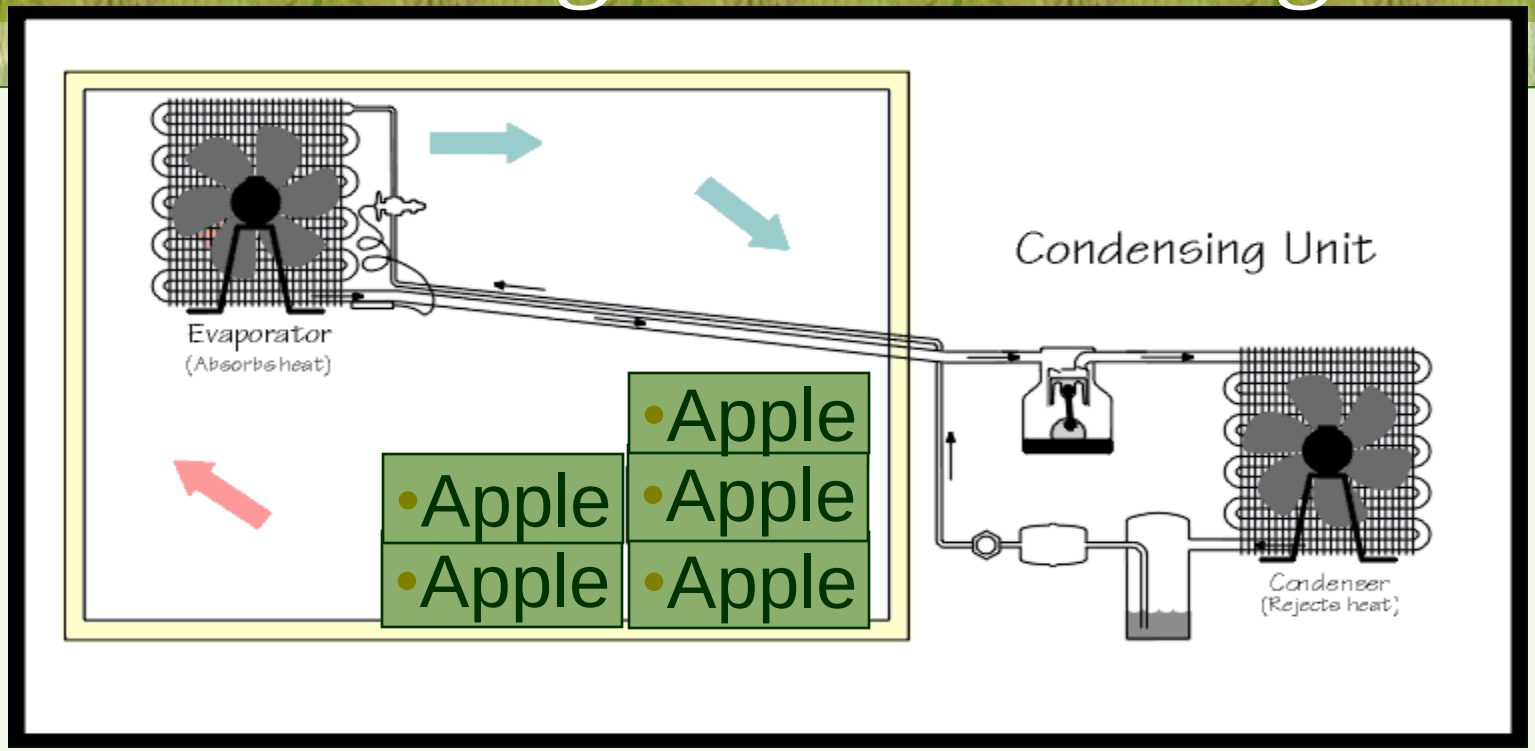
- Postharvest cooling rapidly removes field heat, allowing longer storage periods.

- **Proper postharvest cooling can:**
- Reduce respiratory activity and degradation by enzymes;
- Reduce internal water loss and wilting;
- Slow or inhibit the growth of decay-producing microorganisms;
- Reduce the production of the natural ripening agent, ethylene.

- Cold storage can be combined with storage in an environment with added of carbon dioxide, sulfur dioxide, etc. according to the nature of product to be preserved.

- The cold storage of dried/dehydrated vegetables in order to maintain vitamin C, storage temperature can be varied with storage time and can be at 0°-10°C for a storage time of more than one year, with a relative humidity of 80-95 %.

Working of Cold Storage



Based on the purpose the present day cold stores are classified into following groups:

- **Bulk cold stores:** Generally, for storage of a single commodity which mostly operates on a seasonal basis E.g.: stores for potatoes, chilies, apples etc.
- **Multi purpose cold stores:** It is designed for storage of variety of commodities, which operate practically, throughout the year.
- **Small cold stores:** It is designed with pre cooling facilities. For fresh fruits and vegetables, mainly for export oriented items like grapes etc.
- **Frozen food stores:** It is designed for with (or) without processing and freezing facilities for fish, meat, poultry, dairy products and processed fruits and vegetables.
- **Mini units /walk in cold stores:** It is located at distribution center etc.
- **Controlled atmosphere (CA) stores:** It is mainly designed for certain fruits and vegetables

GENERAL ARRANGEMENTS AND CONSIDERATIONS

- If produce is to be stored, it is important to begin with a high quality product.
- The produce must not contain damaged or diseased units, and containers must be well ventilated and strong enough to withstand stacking.
- In general proper storage practices include **temperature control, relative humidity control, air circulation** and **maintenance of space** between containers for adequate ventilation, and avoiding incompatible product mixes.
- Commodities stored together should be capable of tolerating the same temperature, relative humidity and level of ethylene in the storage environment.
- High ethylene producers (such as ripe bananas and apples) can stimulate physiological changes in ethylene sensitive commodities (such as lettuce, cucumbers, carrots, potatoes, sweet potatoes) leading to often undesirable color, flavor and texture changes.

- The land area must be large enough for the store, its areas for traffic, parking and possible future enlargement. A land area about six to ten times the area of the covered surface will suffice.
- The general features of a cold store operational program me (products, chilling and chilled storage and freezing) include **total capacity, number and size of rooms, refrigeration system, storage and handling equipment and access** facilities.
- The site of the cold chambers should be decided once the sizes are known, but as a general rule they should be in the shade of direct sunlight.

- There is a general trend to construct **single-storey cold stores**, in spite of the relatively high surface: volume ratio influencing heat losses.

- The single storey has many advantages: lighter construction; span and pillar height can be increased; building on lower resistance soils is possible; internal mechanical transport is easier.

- Mechanical handling with forklift trucks allows the building of stores of great height, reducing the costs of construction for a given total volume.

- The greater the height of the chambers the better, limited only by the mechanical means of stacking and by the mechanical resistance either of the packaging material or of the unpackaged merchandise.

- Thermal and hygrometric requirements are not so strict as to justify a lot of rooms: the accuracy of the measuring instruments and the regulation of conditions inside the chamber always produce higher deviations than those of ideal storage conditions for different products. This is particularly true for frozen products.

- Refrigeration and control equipment is simplified and reduced, affecting investment and running costs.

- Large chambers allow easier control of temperature and relative humidity and also better use of storage space.

- Only in very particular situations should the cold store be designed with more than five or six cold chambers.

- If the total volume of the chambers is filled, the quantity of produce by unit of volume will express storage density.

- Temperature management during storage can be aided by constructing **square rather than rectangular buildings**.
- Rectangular buildings have more wall area per square meter of storage space, so more heat is conducted across the walls, making them more expensive to cool.
- Temperature management can also be aided by shading buildings, painting storehouses white or silver to help reflect the sun's rays, or by using sprinkler systems on the roof of a building for evaporative cooling.
- The United Nations' Food and Agriculture Organization (FAO) recommends the use of **Ferro cement** for the construction of storage structures in tropical regions, with thick walls to provide insulation.
- Facilities located at higher altitudes can be effective, since air temperature decreases as altitude increases.

- Increased altitude therefore can make evaporative cooling, night cooling and radiant cooling more feasible.

- The air composition in the storage environment can be manipulated by increasing or decreasing the **rate of ventilation** (introduction of fresh air) or by using **gas absorbers** such as potassium permanganate or activated charcoal.

- Large-scale controlled or modified atmosphere storage requires complex technology and management skills; however, some simple methods are available for handling small volumes of produce**.**

Heat transfer through wall, ceilings and floor

$$Q = U\ A\ (T_0 - T_i) \qquad kJ/s$$

Where:

A = Area of the wall, ceiling, and floor (m2)

U = Over all heat transfer coefficient kJ /s m2 K

Ti = Internal temperature (C)

To = External temperature (C)

Heat gain from product

$$Q = \frac{mC_p(Tj - Tz)}{t} \quad kJ/s$$

Where:

Q = Rate of heat transfer (kJ / d)

Cp = Specific heat of the product (J / kg K)

t = Chilling time (d)

m = Mass of the product (kg)

Tz = Desired final product temperature (°C)

Tj = Entering product temperature (°C)

Heat generated by labour working

$$Q = nSHG \quad kJ/s$$

Where:

n **=** Number of people working in cold storage

SHG **=** Sensible heat gain per person, 1500 kJ

Heat given out by the power equipments

$$Q = \frac{Power\ range\ of\ \ motor\ in\ \ Hp}{Motor\ efficiency} \times 746 \times 3.41 kJ\ s^{-1}$$

Total refrigeration required

$$Total\ refrigeration\ required = \frac{Total\ heat\ removed\ in\ kJs^{-1}}{3.5\ kJs^{-1}}$$

- 1 Ton of refrigeration = 3.5 kJ /s

Constants used

- 1 ton of refrigeration removes 3.5 kJ of heat per second
- Ammonia (NH3) is the only refrigerant taken
- Ammonia R40 is selected
- 1 ton of refrigeration = 0.97 Hp (R40 ammonia)

LOCATION CONSIDERATIONS IN DESIGN OF COLD STORAGE

CONSIDERATION	SPECIFIC FACTOR	DETAILED INFORMATION
Location	Altitude Latitude (For calculating solar loads)	Elevation above sea level 1) North or south of equator 2) Degree Line
	Place	1) Outside design conditions 2) Unusual surroundings
Environment	Water	1) Corrosion and scaling properties of local water
	Atmosphere	Outdoor contaminants which could affect outdoor equipment, air handling equipment filtration
Local Factors	Labor	1) Availability, skill and costs 2) Design should be based on use of local labor
	Materials Transportation	Availability and costs Shipping, receiving and storage availability of equipment

THANK YOU