Module 44
Cold Store Mechanics

Contributor: Koos Bouwer

Introduction

It is essential that the grower and packhouse manager understand the basic mechanics of cooling, in order to make the right decision about cooling their product, whether they are choosing a cold store facility, or thinking about having a cold store constructed at the packhouse or another convenient location.

Principle of Cooling

Heat Load Transfer

Fruit are pre-cooled in a cold store using a heat-load transfer principle. This means that we are actually not cooling the product down, but removing heat from the product. This may sound as if we are merely restating a fact, but it is important to understand the distinction, as it will help you realise the importance of airflow during cooling. The basic principle of cooling is based on the absorption of heat during the evaporation of the cooling agent from a liquid to a gas.

Cooling Components

There are five main components in any cooling system, being the:

- Compressors
- Condensers
- Liquid receiver
- Expansion valve and
- Evaporators

There is then also the cooling agent, also known as the refrigerant, which can be a gas or liquid.
**Compressor**

The cooling agent enters the compressor as a low pressure gas returning from the evaporator. The compressor places the gas under pressure, thereby heating the gas. The gas leaves the compressor as a high pressure, high temperature gas and goes to the condenser.

**Condenser**

At the condenser the gas is cooled by the air being forced through the plates by the condenser’s fan. The effectiveness of this cooling depends on adequate air flow around the condenser.

In the condenser, the gas is condensed into a high pressure, high temperature liquid and then moved to the liquid receiver.

**Liquid Receiver**

From the liquid receiver the high temperature liquid is forced to the expansion valves.

**Expansion Valve**

The expansion valve only allows a small amount of this liquid through at a time, thereby lowering the pressure on the liquid. The lower pressure causes the temperature of the liquid to drop. The lower pressure liquid, at the lower temperature, is then moved to the evaporator.

**Evaporator**

During the evaporation process, the cooling agent absorbs heat from the air being forced through the evaporator coils by the fans at the evaporator, cooling the air. The liquid refrigerant absorbs the heat and starts changing into a gas. The low pressure, low temperature gas leaves the evaporator and is sucked to the compressor to start the process again.
Air Temperature Reading

Two air temperatures are of importance in a cold room, being the delivery air temperature (DAT) and return air temperature (RAT).

The DAT is the temperature of the air that has been cooled by the evaporator that is entering the cold store and being blown onto the fruit through the evaporator coils and fans. When the DAT is too low, it may cause chilling injury to the fruit. The RAT is the temperature of the air coming off the fruit. The difference between the two temperatures gives an indication of how much heat is removed from the fruit.

Cold Store Design

To help facilitate the process of removing heat from air, there are a few things that we must look at when building or choosing a cold store.

Cold Store Types

The first thing we need to decide is whether the cold room is going to be used for pre-cooling or for holding pre-cooled fruit, or for both. As we have already explained, both a pre-cooling chamber and a holding room are needed during the citrus cold chain.

The average temperature of fruit entering a pre-cooling chamber is of course considerably higher than that of fruit entering a holding chamber.

This means that a lot more heat must be removed from air in a pre-cooling chamber, which means that a pre-cooling chamber must have high airflow to exchange cooled air and hot air quickly, and a compressor, evaporator and condenser big enough to cool down the higher temperature and volume of return air.

A holding room receiving fruit that has been cooled already is therefore a lot cheaper to build and operate, as the difference between the DAT and the RAT is a lot smaller than in a pre-cooling chamber. Pre-cooling chambers also tend to be smaller than holding rooms, because fruit spends the minimum amount of time in the pre-cooling chamber before being moved to the holding room.
Site Selection

After we have decided what sort of cooling facilities we need, we must look at where we are going to build the cold store.

The area where the cold store is built should be naturally higher ground than the surrounds, because we do not want water collecting on the site during rain, while still being protected from the wind, because we also do not want the area to get too dusty.

The area must also be flat, and large enough to also allow for the construction of loading bays, where fruit can be loaded and offloaded. They should be easily accessible for trucks and preferably under cover so that the pallets of fruit waiting to be loaded will be protected.

Volume and Climate Conditions

In terms of cold store design, the first determining factor is of course the volumes that the cold store will have to accommodate in a season.

Secondly, we look at the climatic conditions of that area, and specifically at the temperature and relative humidity. The ambient relative humidity influences the air’s ability to exchange heat. In an area with higher relative humidity, more cooling power is needed.

In some areas that have very dry conditions, with a low relative humidity during the packing season, a humidifier will need to be placed in the cold room. The humidifier helps to keep the relative humidity in the cold room fairly high to stop fruit from losing too much moisture during storage. Never put water on the floor to increase the humidity, as this can compromise the packing material and fruit.

Cold Store Entrances

In warmer areas, with a higher average daytime temperature during the time that the store will be in use, more insulation is needed to prevent the loss of cold air. Another option is to build the cold store with an airlock. A forklift enters the airlock, the outer doors are sealed, and only then does the forklift proceed into the cooling chamber.
This is done to minimise hot air entering from outside. It costs extra to build an airlock entrance to the cold store, but in the long term this airlock can save the cold store operator money as less temperature loss occurs.

In colder areas it is usually not necessary to build an airlock entrance and door curtains give enough protection.

**Racking Systems**

Another factor that determines the design of a cold store is the type of racking that will be used. With the advent of high-cube containers, more and more pallets are being stacked in high-cube formation.

Traditional racking system designs are not able to accommodate high-cube pallets. It makes sense to choose a racking system that is able to accommodate both standard and high-cube pallets, and design the cold store accordingly.

**Floor Insulation**

The floor of a cold store is also insulated to minimise temperature loss. Various methods can be used for this and all of them work to one degree or another. The floor in store must be smooth and easy to clean.

**Mechanical Equipment**

**Compressors**

The type and size of compressor that is needed are dictated by various factors, such as the:

- Purpose of the store
- Volume of the cold store
- Required temperature
- Outside temperature and relative humidity

Redundancy should also be built into the system – it is always better to have a little extra cooling power, than too little or just enough.
BTUs

The size of the compressor needed in a cold room is determined by the volume of air that it needs to cool, and is measured in BTU.

BTU stands for British Thermal Unit and technically it means the amount of energy needed to cool one pound of water down one degree Fahrenheit. (You may know of BTUs from the air conditioner in your house or office – the power of air conditioners are also expressed in BTUs).

BTU calculators are available widely and are used to determine the amount of cooling power needed to cool the cold room to the desired temperature.

Condensers and Evaporators

The design of the cold store and the type of compressor determine the size of the condenser and evaporators needed.

The predicted and required DAT and RAT must be kept in mind, as the evaporator and fans must be able to handle cooling the predicted air volume.

Fans

The number and placement of evaporator fans are critical, as the fans must circulate the cold air in the room.

Fans should be big enough to handle the airflow, and positioned where cold air is blown into the room, so that the air cools the product and does not just circulates without coming into contact with the product.

Lighting

Inside the cold store there must be adequate lighting. There are specifications and minimum requirements for the type of lights that are used.

All lights must be covered, so that if they should break, the glass does not fall on the fruit, and must be placed where they cannot easily be damaged by pallets being moved.
Drainage

There must be adequate drainage in the cold store. Water used for cleaning must be able to flow away without obstruction. Water left on floor may damage cartons and fruit. It may also freeze and become slippery, creating a hazard that can cause injuries.

Doors

Seals and Design

The doors of the cold store must have seals so that the store is airtight when they are closed. The doors must also be big enough and placed where they allow easy access for forklifts. A door that is too small or badly placed will be damaged often, and require constant repairs.

Door Curtains

Door curtains hang inside doors to minimise temperature loss when the cold store doors are opened. These curtains must be durable and made of a clear plastic, so that a forklift driver entering the cold room can see if there is anyone inside. Door curtains are only used when the cold store does not have an airlock entrance.

Aluminium Corner Pieces

All corners inside the cold store must be moulded with aluminium corner pieces to lessen damage to corners, and because it is easier to keep clean.

Placement of Racking Systems

Regulations stipulate that no food may be stored directly on a floor. The cartons of citrus in the cold room must be stacked on pallets or in racking systems. When designing the placement of these racking systems, ensure that when stacked with pallets the air flow will not be interrupted or obstructed. In most cases areas on the floor are painted where pallets should be stacked, to ensure adequate airflow.
Temperature Sensors

The types of temperature sensors are determined by what the cold store is used for. Different types of sensors are available on the market, but usually air temperature sensors and pulp sensors, used for measuring the temperature inside a fruit, are used in a cold store.

Sensor Placement

Air sensors must be placed where they can record both the delivery air temperature and the return air temperature. The cooling temperature is set electronically and the air flow and cooling are automatically regulated to achieve the required temperature.

Calibrating Sensors

All sensors must be checked regularly using a calibrated thermometer to make sure that temperature readings are accurate. It is recommended that sensors are checked at least once a week during peak times.

Standby Sensors

Temperature probes and sensors are sensitive pieces of equipment that are prone to breakdown. At least three new sensors of each type should be kept on hand to replace broken sensors immediately.

Cold Store Maintenance

Annual Service

The effectiveness and lifespan of your cold store depends on good maintenance. Compressors, condensers and evaporators should be serviced by a professional company at least once a year.
Before the packing season starts, all sensors and probes should be removed and properly calibrated with the help of a hand-held thermometer, using temperatures within the normal operating parameters of the sensors. Sensors that are not working properly should be replaced immediately.

**Ongoing Maintenance**

Condensers must be kept clean and free from dust. It is recommended that they are washed at least once a month, using a cleaning solution prescribed by the manufacturer.

Fans and fan blades must also be checked and cleaned regularly to achieve optimum cooling. Lights must be checked and replaced when necessary, and light covers must always be clean and free of cracks.

Door runners and door hinges must be oiled and set regularly to ensure that they open and close smoothly. Also check and replace door seals when necessary.

The area around the compressors and condensers must be well ventilated to keep the compressors cool, and must be kept clean. Drains and drainage pipes should be checked and cleaned on a regular basis, and kept free of blockages.

**Regulations and Inspections**

Cold stores that are used to store and cool down fruit must adhere to specific regulations.

The regulation pertaining specifically to food storage is R918 of the South African Standards and Requirements for the Display, Storage and Temperature of Food, published by the Department of Health. To ensure food safety, these regulations must be strictly adhered to when building and using your cold store.

In most packhouses a food safety system such as HACCP will be used. Make sure that the necessary monitoring and recordkeeping documentation is in place for the cold store. Check that regulations governing the use of lights and drain covers are adhered to. A food safety system might also require that storage areas and areas where forklift are allowed to drive, are demarcated on the floor.
In terms of environmental safety, ensure that the type of compressor and the gas used by the compressor bring about as little as possible damage to the environment and that the compressors and other electrical equipment are as energy-efficient as possible.

Before you are allowed to use your cold store for the cooling and storage of export citrus, the PPECB will inspect the cold store and approve it for use if all the inspection criteria are met.

The PPECB also performs yearly inspections to ensure that the cold stores still complies with the requirements for effective cooling and food safety.

**Conclusion**

It is important to know the basics of cooling and what you should look for when inspecting a cold store.

If you have decided to have your own cold store built, always use a reputable company with a good track record for the design and construction of the store – remember that a cold store is a long term investment.

The accuracy of cooling is essential as it adds value to your product by extending its shelf-life.

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**active learning**

Watch the DVD clips, read through the learning material and do workplace research to gather the knowledge and information to complete the assignments below.

**Activity 44.1 – Group Discussion**

In your group, list and discuss the different requirements for holding rooms and pre-cooling chambers. Make keynotes on the discussion and your conclusions in your workbook.

**Activity 44.2 – Case Study**

A farmer decides to build a new pre-cooling chamber on his premises to accommodate the expected growth over the next few seasons. The farmer plans to use the cold room for storing lemons for non-sensitive export markets, and the farm is in the Letsitele area. The dimension of the room will be 4m x 20m x 20m.

Use a BTU calculator to determine the size of the compressor he will need to cool fruit to the required holding temperature of 5°C.
Activity 44.1 – Group Discussion

In your group, list and discuss the different requirements for holding rooms and pre-cooling chambers. Make keynotes on the discussion and your conclusions below.
Activity 44.2 – Case Study

Consider the case study below and answer the question based on it.

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