ROHINI
COLLEGE OF ENGINEERING & TECHNOLOGY

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(AUTONOMOUS)

AI3001 REFRIGERATION AND COLD STORAGE

UNIT V

Cold storage can be described as a special facility or unit that is used primarily for storing temperature-sensitive, perishable products to enhance the shelf-life and avoid degradation or contamination.

When short-lived products get destroyed due to unsuitable storage conditions, it leads to big losses in the inventory and profitability. Plus, there is a health risk involved for your consumers.

Therefore, the effort should be to identify cost-effective and energy-efficient cold storage solutions based on the product type and the appropriate temperature range for their long-term storage.

Objectives of Cold Storage

- Reduce **respiration rate** of produce
- Minimize **microbial activity**
- Prevent **moisture loss and spoilage**
- Extend **shelf life** of agricultural produce

Design Considerations

(a) Storage Conditions

Commodity	Temperature (°C)	Relative Humidity (%)
Potato	2–4	85–90
Apple	0–1	90–95
Onion	0–2	65–75
Milk	2–4	85–90

(b) Capacity Determination

- Based on **daily intake**, **peak load**, and **holding period**
- Expressed in **tonnes (MT)**
- Typical rural cold storages: **50–5000 MT**

(c) Heat Load Estimation

Total refrigeration load includes:

1. **Product load** – cooling of incoming produce
2. **Respiration heat**
3. **Transmission load** – heat through walls, roof, floor
4. **Air infiltration load**
5. **Internal load** – lights, motors, workers

(d) Building Design

- **Thick insulated walls and roof**
- Vapor barrier to prevent moisture ingress
- Proper floor insulation to avoid **frost heave**
- Ante-room and air-lock system

(e) Insulation Materials

Material	Thermal Conductivity (W/m·K)
PUF panels	0.020–0.025
Expanded polystyrene (EPS)	0.030–0.040
Cork	0.040–0.045

(f) Refrigeration System Selection

Depends on:

- Storage temperature
- Size of cold storage
- Power availability
- Initial and operating cost

Cold Storage: Industry and Applications

Cold storage has widening applications across industries.

Retail food industry: Frozen foods including meat, poultry, seafood, dairy, fruits, and vegetables need to be maintained at a temperature of around -18°C to avoid deterioration or contamination. Depending on the duration of the storage and logistics to make the product accessible to the customers, you can choose your cold storage solutions.

Post-harvest products: Post-harvest fresh produce, including fruits, vegetables, milk or even fish, must be stored at cooler temperatures or refrigerated to avoid ripening and degradation. Fruit and vegetables especially need a controlled atmosphere with the right amount of oxygen, carbon dioxide, nitrogen, humidity, etc. to prolong their shelf-life.

Pharmaceuticals industry: Drugs, vaccines, biologics, laboratory specimens or samples, and other pharmaceuticals need to be maintained at specified temperatures to ensure safety and integrity. Usually, the temperature requirement is between 2°C and 8°C.

Hospitality industry: Restaurants and hotels need to keep the beverages, food ingredients, and stock items safe and ready to use. These places also keep surplus meal preps for quick serving and catering, requiring effective refrigeration solutions that keep the flavour, quality, and texture intact.

Horticulture: Florists or suppliers also require cold storage facilities to store ornamental plants or flower stems (once they have been cut). Even seeds, spices, and dry fruits need appropriate cold storage conditions for a longer shelf-life.

Cold Storage Working

A cold storage facility or unit relies on a refrigeration system to maintain appropriate temperature conditions and primarily consists of the following components.

Compressor: It is a significant component of a cold room and consumes maximum power. It increases the temperature and pressure of the refrigerant gas from the evaporator. With increasing pressure, the boiling point also increases and the compressor then condenses the refrigerant gas to the temperature of the condenser.

Condenser: This component acts as a heat exchanger and removes heat from the refrigerant and the circulating water. Higher the efficiency of a condenser, better the working of a cold room.

Evaporator: It takes heat from the storage unit or the atmosphere to keep the area cooler, vapourising the liquid refrigerant.

Receiver: It can be primarily considered a storage area for liquid condensate. Also, the liquid refrigerant enters the expansion valve from this component for the reduction in temperature and pressure.

Expansion valve: It is used to reduce the pressure and temperature of the refrigerant. The pressure change occurs from the receiver to the evaporator.

Fans: The fans or blowers are used to circulate the cooler air across the cold room through the process of convection.

Types of Cold Storage

Depending on the product type, capacity, and storage duration, a variety of cold storage are available for businesses.

Multi-commodity cold warehouses: These warehouses are used to store a variety of products and fresh produce that require different temperature and storage conditions. These modular warehouses are quick and easy to install. Plus, with effective racking solutions, you can maximise the space for storage.

Walk-in chillers and freezers: Walk-in chillers (2°C to 8°C) and freezers (-18°C to -20°C) are modular cold rooms for storage of food, beverages, pharmaceutical products, etc.

Step-in chillers and freezers: Step-in chillers and freezers are compact cold storage rooms for short-life, perishable products.

Display cum cold rooms: These units are a combination of display and backend cold rooms and are used for packaged frozen food, beverages, dairy products etc. Display cum cold rooms find extensive usage in supermarkets, hotels, and retail chains.

Refrigerated transportation (Reefer trucks): Reefer trucks are critical in cold supply chain logistics. Effectively supporting last-mile deliveries and long-distance transportation, reefer trucks with insulated walls can help maintain a stable temperature for a longer time. There are also eco-friendly eutectic trucks that are not only energy efficient but offer significant cost savings.

Controlled atmosphere (CA) and modified atmosphere (MA) chambers: CA and MA chambers help store fruits, vegetables, grains, and other food items including dry fruits and spices. These units control the gaseous environment (O2, O2, N2, and

ethane), so you can effectively reduce the rate of respiration, microbial growth, and enzymatic spoilage or browning.

Insulation properties and types of insulation material for cold storage

Cold insulation materials play a vital role in maintaining low temperatures in various applications, from industrial processes to residential settings. These materials are designed to minimize heat transfer, ensuring that cold environments remain stable and efficient. The primary types of cold insulation materials include thermal insulation sheets, polystyrene and specialized cold room panels. Each type offers unique features and benefits, such as high thermal resistance, durability and ease of installation. Understanding the characteristics of these materials can help in selecting the right insulation for specific needs, ultimately leading to improved energy efficiency and cost savings.

Cold insulation is essential for industries like food storage, pharmaceuticals, and chemical processing, where maintaining a controlled temperature is crucial. By using effective cold insulation materials, businesses can prevent temperature fluctuations, reduce energy consumption and enhance the longevity of their equipment. Additionally, these materials help in preventing condensation and moisture build-up, which can lead to structural damage and product spoilage. Investing in the right cold insulation solutions not only ensures operational efficiency but also contributes to sustainability by reducing the overall carbon footprint.

Cold insulation materials offer substances or products used to prevent the transfer of heat in environments where maintaining low temperatures is crucial. These insulation materials are developed to minimize thermal energy transfer, helping to maintain a controlled and stable cold environment. Here are some best examples of cold insulation materials including polyurethane foam, polystyrene, fiberglass and various types of cold room panels specifically designed for cold storage insulation facilities and refrigeration systems.

These panels find application in various parts of the cold room, including floors, walls, and roof Insulation. To ensure their effectiveness, additional supporting materials are necessary. Their use significantly contributes to preventing temperature fluctuations and reinforces the overall structure of the cold room or cooling room panels, minimizing the risk of air leakage.

Types of Cold Insulation Materials

Various types of **cold insulation materials** are used for **cold insulation**, each with its unique properties and applications. Here are some types of cold insulation materials:

1. Insulation Sheet

Insulation sheets are versatile materials used to enhance thermal efficiency in buildings and industrial applications. They help maintain desired temperatures which can lead to significant energy savings. Available in various materials like foam, fiberglass, and polystyrene, insulation sheets are easy to install and provide long-lasting performance.

2. Polystyrene:

Polystyrene offers good thermal resistance and it is often used in the form of expanded polystyrene (EPS) or extruded polystyrene (XPS) for cold insulation and cold room panels.

3. Fiberglass:

It is a widely used material that provides effective thermal insulation for cold environments, mostly used in the form of blankets, boards, or preformed pipe sections.

4. Phenolic Foam:

Known for its excellent fire resistance and low smoke emission, making it suitable for cold insulation in areas with strict fire safety requirements.

5. Polyisocyanurate (PIR) Foam:

Exhibits low thermal conductivity and high fire resistance, often used in cold storage and refrigeration applications where fire safety is a priority.

6. Cellular Glass:

Offers high compressive strength and resistance to moisture, making it suitable for cold insulation in areas where moisture infiltration is a concern.

These **cold insulation materials** are utilized based on specific requirements, such as the desired temperature range, environmental conditions, and application areas, in industries such as food storage, pharmaceuticals, and cold chain logistics.

Benefits of Cold Insulation Materials

If you're involved in handling fruits, foods, or even wine, maintaining the appropriate storage temperature is crucial. While a standard refrigerator or cellar might suffice for smaller quantities, they aren't the most practical options for handling large volumes of goods. This is where the integration of cooling room panels becomes imperative. If you find yourself uncertain about investing in these panels, continue reading to understand the myriad benefits they can bring to you and your business.

1. Outstanding Thermal Insulation Properties

A key advantage of the cold room panels available at Central West Refrigeration lies in their exceptional insulation capabilities. The insulation properties play a critical role in achieving precise control over the temperature within your refrigerated space. Whether you opt for a panel with a cell structure or board insulation, you can count on impressive thermal performance with any of the available solutions.

2. Enhanced Energy Efficiency

In Australia, energy expenses pose a significant challenge for numerous industries. Regulating room temperatures often leads to substantial cooling costs. However, integrating cool room panels can alleviate this burden. These panels not only enable better control over interior temperature using less energy but also contribute to stabilizing the overall environment.

3. Temperature Stability

A notable feature of these cool room panels is their ability to maintain a consistent environment. Similar to the operation of a freezer, the panels facilitate passive temperature control, ensuring heightened efficiency and a comfortable atmosphere within the refrigerated rooms.

4. Cost-effective and Low-Maintenance Solutions

Given the current economic climate, many businesses operate under stringent budget constraints. Therefore, investing in efficient cooling equipment is a critical consideration for any budget-conscious business owner. Cool room panels offer a practical solution; they allow for rapid construction, minimizing the number of trades required and reducing overall **cold insulation materials** and operational costs.

5. Versatile Design and Safety

Renowned for their adaptability, panels designed for the commercial refrigeration industry come in various colors, shapes, sizes, and construction materials. Whether for interior walls, roofs, or exterior walls, cool room panels cater to diverse design requirements.

Additionally, these panels prioritize safety and hygiene. With high fire ratings and long-term performance, they provide enhanced protection for both your goods and your well-being.

Cold storage for milk, meat, fruits, vegetables, poultry and marine product

Cold storage conditions vary depending on **respiration rate, moisture content, perishability, and microbial activity** of each commodity.

1. Cold Storage for Milk and Milk Products

Purpose

- Slow down **bacterial growth**
- Preserve **quality and freshness**

Storage Conditions

Product	Temperature (°C)	Relative Humidity (%)	Storage Period
Raw milk	2–4	85–90	24–48 hours
Pasteurized milk	2–4	85–90	3–5 days
Butter	–10 to –20	80–85	6–12 months
Cheese	2–10	85–90	Several months

Design Features

- Stainless steel surfaces
- High hygiene standards
- Rapid cooling after milking (milk chilling units)

2. Cold Storage for Meat

Purpose

- Reduce enzymatic and microbial spoilage
- Maintain color and texture

Storage Conditions

Type	Temperature (°C)	Relative Humidity (%)	Storage Life
Chilled meat	0 to 1	85–90	1–2 weeks
Frozen meat	–18 to –25	90–95	6–12 months

Design Features

- Blast chilling/freezing
- Proper air circulation

- Hygienic flooring and drainage

3. Cold Storage for Fruits

Purpose

- Reduce respiration rate
- Delay ripening and senescence

Storage Conditions

Fruit	Temperature (°C)	Relative Humidity (%)	Storage Life
Apple	0–1	90–95	4–6 months
Banana	13–14	90–95	2–3 weeks
Mango	12–14	85–90	2–3 weeks
Citrus fruits	4–8	85–90	2–3 months

Special Storage

- Controlled Atmosphere (CA) storage
- Ethylene control systems

4. Cold Storage for Vegetables

Purpose

- Reduce moisture loss and wilting
- Maintain freshness

Storage Conditions

Vegetable	Temperature (°C)	Relative Humidity (%)	Storage Life
Potato	2–4	85–90	4–6 months
Onion	0–2	65–75	4–6 months
Tomato	10–13	85–90	2–3 weeks
Leafy vegetables	0–1	95–98	1–2 weeks

Design Features

- High humidity control
- Ventilation for gas removal

5. Cold Storage for Poultry

Purpose

- Prevent microbial spoilage
- Maintain texture and taste

Storage Conditions

Product	Temperature (°C)	Relative Humidity (%)	Storage Life
Chilled poultry	0 to 2	85–90	7–10 days
Frozen poultry	–18 to –25	90–95	8–12 months

Design Features

- Rapid chilling post-slaughter
- Separation from red meat storage

6. Cold Storage for Marine Products (Fish & Seafood)

Purpose

- Extremely perishable → rapid temperature control essential

Storage Conditions

Product	Temperature (°C)	Relative Humidity (%)	Storage Life
Fresh fish (iced)	0 to –1	90–95	7–14 days
Frozen fish	–18 to –30	90–95	6–12 months
Shrimp	–20 to –30	90–95	6–8 months

Design Features

- Flake ice or slurry ice systems
- Blast freezers
- Odor control and corrosion-resistant materials

Cold storage for milk, meat, fruits,vegetables, poultry and marine product in India

India is the largest producer of fruits and second largest producer of vegetables in the world. In spite of that per capita availability of fruits and vegetables is quite low because of post harvest losses which account for about 25% to 30% of production. Besides, quality of a sizable quantity of produce also deteriorates by the time it reaches the consumer. Most of the problems relating to the marketing of fruits and vegetables can be traced to their perishability. Perishability is responsible for high marketing costs, market gluts, price fluctuations and other similar problems. At low temperature, perishability is considerably reduced and the shelf life is increased and thus the importance of cold storage or refrigeration. The first cold store in India was reported to have been established in Calcutta in 1892. However significant progress in the expansion of the cold storage industry in the country has been made only after independence. With a view to ensuring the observance of proper conditions in the cold stores and to providing for development of the industry in a scientific manner, the govt of India and the ministry of agriculture promulgated an order known as "Cold Storage Order, 1964" under Section 3 of the Essential Commodities Act,1955. The Agricultural Marketing Advisor to the Govt of India is the Licensing Officer.A cold storage facility accessible to them will go a long way in removing the risk of distress sale to ensure better returns.

Status of Cold storage and its potential in India

The estimated annual production of fruits and vegetables in the country is about 130 million tonnes. This accounts for 18% of our agricultural output. Due to diverse agro climatic conditions and better availability of package of practices, the production is gradually rising. Although, there is a vast scope for increasing the production, the lack of cold storage and cold chain facilities are becoming major bottlenecks in tapping the potential. The cold storage facilities now available are mostly for a single commodity like potato, orange, apple, grapes, pomegranates, flowers, etc. which results in poor capacity utilization.

Storage of foods and Storage Conditions

Foods and many other commodities can be preserved by storage at low temperature, which retards the activities of micro organisms. Micro organisms are the spoilage agents and consist of bacteria, yeasts and molds. Low temperature does not destroy those spoilage agents as does high temperature, but greatly reduces their activities, providing a practical way of preserving perishable foods in their natural state which otherwise is not possible through heating. The low temperature necessary for preservation depends on the storage time required often referred to as short or long term shortage and the type of product.

In general, there are three groups of products:

Foods that are alive at the time of storage, distribution and sale e.g. fruits and vegetables,

Foods that are no longer alive and have been processed in some form e.g. meat and fish products, and

Commodities that benefit from storage at controlled temperature e.g. beer, tobacco, khandsari, etc.

Living foods such as fruits and vegetables have some natural protection against the activities of micro organism. The best method of preserving these items is to keep the product alive and at the same time retard the natural enzyme activity which will retard the rate of ripening or maturity.

Preservation of non-living foods is more difficult since they are susceptible to spoilage. The problem is to preserve dead tissues from decay and putrefaction. Long term storage of meat and fish product can only be achieved by freezing and then by storing it at temperature below -15oC. Only certain fruits and vegetables can benefit from freezing. However, for fruits and vegetables one should be very careful about the recommended storage temperature and humidity a deviation from which will have adverse effect on the stored product leading to even loss of the entire commodity.

Products such as apples, tomatoes, oranges, etc. cannot be frozen and close control of temperature is necessary for long term storage. Some product can also be benefited by storing under controlled atmosphere and modified atmosphere conditions.

Dairy products are produced from animal fats and therefore non living foodstuffs. They suffer from the oxidation and breakdown of their fats, causing rancidity. Packaging to exclude air and hence Oxygen can extend storage life of such foodstuffs