



# **ROHINI**

## **COLLEGE OF ENGINEERING & TECHNOLOGY**

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**(AUTONOMOUS)**

**AI3001 REFRIGERATION AND COLD STORAGE**

**UNIT V**

# Refrigerated Transport, Handling and Distribution (Cold Chain System)

## Introduction

Refrigerated transport, handling, and distribution together form the **cold chain system**, which maintains products at **controlled low temperatures** from the point of production to the final consumer. It is essential for **milk, meat, fruits, vegetables, poultry, and marine products**.

Refrigerated transport is the movement of perishable commodities using **temperature-controlled vehicles or containers** to prevent spoilage and quality loss. This could be defined as a method of **transporting goods that requires special temperature-controlled vehicles**.

The vehicle that transports the products to be shipped is equipped with a refrigeration system that maintains the products at the desired temperature during the entire transport process. For a wide variety of products, refrigerated transport is not an option, but an absolute necessity. It is a type of transport that complies with current and proper regulations both for transportation and to ensure the safety of the products.

Various types of transport can be used for the transport of refrigerated or frozen foods. All of them must have the relevant approved cooling system.

## Aerial

Air transport is one of the fastest growing modes of transport in the logistics sector in recent years. You have more information about this type of transport in:

- Types and characteristics of air transportation.
- Advantages of air transport.

**Airfreight can be used to transport goods that need to be refrigerated and frozen**, using different systems:

- Isothermal containers.
- Insulating Packaging.
- Cooling materials

## **Maritime**

**Maritime transport is the most widely used for the transportation of goods.** Refrigerated containers can be used to transport perishable foodstuffs that require a high level of preservation.

Specially designed containers are available to maintain the desired temperature of the goods.

You have more information about maritime transport in:

- Main characteristics of maritime transportation
- Advantages of maritime transport

## **Terrestrial**

As in the case of other means of transportation, land transportation **requires vehicles with refrigeration and freezing systems**. They are usually trucks designed for this task.

### **Types of vehicles for refrigerated transport**

#### **Isothermal Vehicle**

A type of vehicle designed with doors, roofs and walls with insulating material to prevent leaks and temperature changes between the interior and exterior.

#### **Refrigerated Vehicle**

This type of vehicle has a similar design to the isothermal models, but includes a cold source that provides the possibility of lowering the temperature to -20 degrees Celsius.

#### **Heating Vehicle**

Design similar to the isothermal type, but with a heat source that ensures that the temperature does not drop below 12 degrees.

#### **How they work**

In simple terms, we can explain that vehicles that can transport refrigerated or frozen cargo have a system designed for this purpose, independent of the vehicle's traditional energy.

These systems **have their own resources to maintain the temperature:** compressors, condensers or evaporators that are capable of lowering and maintaining the temperature.

In addition to this, certain considerations must be met, such as:

- The interior of the vehicle must be waterproof and airtight.
- The goods must be in special containers and never found at ground level.
- Goods must be isolated from the driver's cab.

## **REEFER TRUCKING**

Reefer trucks are essential in the transportation industry. They ensure that perishable goods reach their destination in optimal condition. Each type ensures that temperature-sensitive cargo is transported under optimal conditions.

## **REFRIGERATED TRAILERS**

Refrigerated trailers, or reefers, are essential in cold chain logistics, transporting perishable goods such as food, flowers, and pharmaceuticals. They are often equipped with small vent doors for ventilation.

By maintaining precise temperatures, they ensure products remain fresh over vast distances. This capability is crucial for grocery stores and pharmacies, making reefers indispensable in local and global supply chains.

## **CRYOGENIC REEFERS**

Cryogenic reefers represent a specialized segment of refrigerated transport, utilizing liquid nitrogen or carbon dioxide to maintain temperatures down to  $-150^{\circ}\text{C}$ . They're pivotal for shipping susceptible medical supplies, including vaccines and biological samples, across great distances without compromising their integrity.

## **HEATED TRUCKS**

Heated trucks are tailored for goods that require warmth to prevent freezing, such as certain chemicals, cosmetics, and food products sensitive to cold. These vehicles are vital during winter, ensuring that the cargo's temperature does not drop below a safe threshold, thus preserving the quality and efficacy of the transported goods.

## **REEFER TRUCK FEATURES**

Here are the top features of reefer trucks:

- **Temperature Monitoring System:** Ensures perishable goods are kept at safe temperatures throughout the journey, which is crucial for food safety and pharmaceutical transport.
- **Reliable Vehicle Mechanics:** Utilizes dependable trucks like Hino, Isuzu, and Toyota, minimizing the risk of breakdowns and ensuring timely deliveries.
- **Fiberglass Body:** Offers superior insulation and structural integrity, enhancing thermal efficiency by 20-30% compared to steel, crucial for maintaining temperature control.
- **Galvanized Steel Chassis:** Provides corrosion protection and durability, essential for withstanding heavy-duty tasks and adverse weather conditions.
- **Efficient Design Maximizing Space:** Optimizes cargo space, allowing for more products per delivery and reducing wasted space, which is key for profitability.
- **Dependable Refrigeration Units:** These are the core of reefer trucks, ensuring goods remain fresh. Brands like Carrier are preferred for their efficiency and reliability.

### **REFRIGERATED BOX TRUCKS AND VAN SIZES**

The range of refrigerated box trucks and vans caters to various cargo sizes and transportation needs. Some of the standard sizes are:

- **12'-14' Trucks:** Ideal for small-scale deliveries, these trucks can carry 4-6 pallets, supporting loads between 5,000 to 7,000 lbs. Perfect for local, urban deliveries of fresh produce or pharmaceuticals.
- **16'-20' Trucks:** This is a mid-size option capable of handling 6-8 pallets with a payload capacity of up to 13,000 lbs. It is suitable for medium-sized businesses distributing goods across regions.
- **22'-28' Trucks:** Designed for heavy-duty hauls, these trucks accommodate 10-12 pallets and payloads between 9,000 and 15,000 lbs. They are the go-to for large-scale, long-distance deliveries of frozen foods or temperature-sensitive cargo.

## **SIGNIFICANCE OF REFRIGERATED SHIPPING AND LOGISTICS**

Refrigeration in logistics revolutionizes the transportation of perishable items, ensuring they reach destinations fresh and safe. Reefer trucks and trailers are vital for maintaining the cold chain and crucial for food safety, pharmaceuticals, and other temperature-sensitive goods. This technology enables global trade, extending the market reach and consumer access to diverse products.

## **ADVANTAGES AND DISADVANTAGES OF REFRIGERATION TRUCK FLEETS**

Managing a fleet of refrigerated trucks is crucial for companies transporting perishable items, offering unique advantages and facing specific challenges.

Advantages:

- **Better shipping rates:** Specialized services allow refrigerated trucks to command higher rates, improving profitability.
- **Expanded market access:** These trucks transport diverse perishable items, opening up new markets.
- **Preservation of sensitive cargo:** Ensures the safe transport of food, pharmaceuticals, and other temperature-sensitive products.
- **Enhanced customer satisfaction:** Reliable delivery of fresh products builds customer trust and loyalty.

Disadvantages:

- **Higher initial cost:** Advanced cooling systems and insulation significantly increase the purchase price.
- **Maintenance complexity:** Requires specialized maintenance, increasing operational costs.
- **Insurance premiums:** High value and cargo sensitivity lead to higher insurance costs.

- **Deadhead miles:** Limited backhaul opportunities can result in non-revenue-generating miles.
- **Loading requirements:** Strict loading protocols to maintain temperature integrity can reduce flexibility and efficiency.

### Refrigerated food transportation logistics

The transport of refrigerated food is essential to respect and preserve the so-called cold chain of many of the goods used in different industries.

The logistics sector offers different vehicles adapted and designed to be able to control and maintain the desired temperature.

By air, land and sea it is possible to transport goods in a refrigerated environment with all the necessary guarantees and safety.

### Order Picking in Refrigerated Transport

Order picking in refrigerated transport refers to the process of selecting, assembling, and loading specific quantities of temperature-sensitive products from cold storage into refrigerated vehicles according to customer orders, while maintaining an unbroken cold chain.

It is a critical operation in cold storage warehouses, distribution centers, and refrigerated logistics.

### Objectives of Order Picking in Refrigerated Transport

- **Ensure** correct quantity and product mix
- **Maintain** required temperature and humidity
- **Minimize** product exposure to ambient conditions
- **Reduce** handling time and errors
- **Improve** delivery efficiency and product quality

### Order Picking Environments in Cold Chain

Area	Typical Temperature
Chilled zone	0 to 4°C
Frozen zone	-18 to -25°C
Ante room	8 to 12°C

# Types of Order Picking Methods Used in Refrigerated Transport

## 1. Discrete (Piece) Order Picking

- Individual items picked for each order
- Common in dairy, fresh produce, retail distribution

**Advantages:** Accurate, flexible

**Disadvantages:** Time-consuming in cold condition

## 2 Batch Order Picking

- Multiple orders picked simultaneously
- Sorted later

**Advantages:** Reduces travel time

**Application:** Medium-volume cold storage warehouses

## 3 Zone Picking

- Cold store divided into temperature zones
- Workers pick only in assigned zones

**Advantages:** Maintains temperature integrity

**Application:** Multi-commodity refrigerated warehouses

## 4 Wave Picking

- Orders picked in scheduled time windows
- Coordinated with vehicle dispatch

**Advantages:** Efficient truck loading

**Application:** Large refrigerated distribution centers

## 5 Pick-to-Vehicle (Cross Docking)

- Products moved directly from cold storage to reefer truck
- Minimal intermediate storage

**Advantages:** Reduces handling and temperature rise

**Application:** Milk, fresh fish, fruits

## Refrigerated display

A refrigerated display is a temperature-controlled cabinet used in retail outlets, supermarkets, dairies, meat shops and food service units to store, preserve and display perishable food products while maintaining product quality and safety.

# Objectives of Refrigerated Display

- Maintain **safe storage temperature**
- Enhance **product visibility and appeal**
- Prevent **spoilage and microbial growth**
- Reduce **moisture loss and dehydration**
- Ensure **food safety compliance**

## Types of Refrigerated Displays

### 1 Based on Temperature

Type	Temperature Range (°C)	Products
Chilled display	0 to 4	Milk, dairy, fruits, vegetables
Medium temp display	4 to 8	Beverages, processed foods
Frozen display	-18 to -25	Ice cream, frozen meat, poultry
Ice-cream cabinet	-20 to -30	Ice cream

### 2 Based on Design

#### (a) Open Refrigerated Display

- No front doors
- Uses **air curtain** for cooling

**Advantages:** Easy access, good visibility

**Disadvantages:** Higher energy loss

#### (b) Closed Refrigerated Display

- Glass doors or sliding doors

**Advantages:** Energy efficient, better temperature control

**Disadvantages:** Slightly reduced customer convenience

#### (c) Vertical Display Cabinets

- Upright shelves
- Used for beverages and packaged foods

#### **(d) Horizontal Display Cabinets**

- Chest-type freezers
- Used for frozen foods

#### **(e) Service Display Counters**

- Operated by staff
- Used for meat, fish, bakery items

#### **Main Components of Refrigerated Display**

- Compressor
- Condenser
- Expansion device
- Evaporator
- Air circulation fans
- Glass doors / air curtain
- LED lighting
- Temperature controller and sensors

#### **Sensors for cold storage management.**

Sensors play a vital role in **cold storage management** by continuously monitoring environmental and operational parameters to ensure:

- Product quality and safety
- Energy efficiency
- Prevention of spoilage and losses
- Compliance with food safety standards (HACCP, FSSAI)

#### **Importance of Sensors in Cold Storage**

- Maintain **required temperature and humidity**
- Detect **equipment failure** early
- Ensure **uniform cooling**
- Enable **automation and remote monitoring**
- Reduce **energy consumption**

#### **Types of Sensors Used in Cold Storage**

##### **1 Temperature Sensors**

Purpose:

Monitor and control storage temperature.

Common Types:

- **Thermocouples**
- **RTD (Pt100 / Pt1000)**
- **Thermistors**
- **Digital temperature sensors (DS18B20)**

Features:

- Range: +30°C to -40°C
- High accuracy ( $\pm 0.1$  to  $\pm 0.5^\circ\text{C}$ )

Applications:

- Storage chambers
- Evaporator and condenser
- Product core temperature
- Refrigerated transport

## **2 Humidity Sensors**

Purpose:

Maintain optimum **relative humidity (RH)** to avoid dehydration or condensation.

Types:

- Capacitive RH sensors
- Resistive humidity sensors

Range:

- 0–100% RH

Applications:

- Fruit and vegetable cold storages
- Ripening chambers

## **3 Gas Sensors**

#### (a) Oxygen (O<sub>2</sub>) Sensors

- Used in **Controlled Atmosphere (CA) storage**
- Monitor reduced oxygen levels

#### (b) Carbon Dioxide (CO<sub>2</sub>) Sensors

- Control respiration rate of fruits

#### (c) Ethylene Sensors

- Detect ripening gas
- Used for fruit storage and ripening chambers

### **4 Pressure Sensors**

Purpose:

Monitor refrigeration system pressure.

Applications:

- Compressor suction and discharge
- Detect refrigerant leakage
- System safety control

### **5 Door and Motion Sensors**

Door Sensors:

- Detect door opening/closing
- Prevent cold air loss

Motion Sensors:

- Detect human movement
- Improve safety and lighting control

### **6 Level Sensors**

Purpose:

Monitor:

- Refrigerant level

- Water level in humidifiers or defrost systems

## **7 Flow Sensors**

Purpose:

- Monitor refrigerant, brine, or chilled water flow
- Ensure proper heat transfer

## **8 Vibration Sensors**

Purpose:

- Monitor compressor and motor health
- Enable predictive maintenance

## **9 Ice/Frost Sensors**

Purpose:

- Detect ice buildup on evaporator coils
- Optimize defrost cycles