SCHEME :K

Name :_____
Roll No.:_____ Year : 20 ___ 20 __
Exam Seat No. :_____

LABORATORY MANUAL FOR

COLD CHAIN MANAGEMENT (316365)

MECHANICAL ENGINEERING GROUP

MAHARASHTRA STATE BOARD OF
TECHNICAL EDUCATION, MUMBAI
(Autonomous)(ISO21001:2018)(ISO/IEC27001:2013)

Maharashtra State
Board of Technical Education, Mumbai

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To ensure that the Diploma level Technical Education constantly matches the latest requirements of Technology and industry and includes the all-round personal development of students including social concerns and to become globally competitive, technology led organization.

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To provide high quality technical and managerial manpower, information and consultancy services to the industry and community to enable the industry and community to face the challenging technological & environmental challenges.

A Practical Manual for

Cold Chain Management
(316365)

Semester – VI

"K- SCHEME"

Diploma in Mechanical Engineering

Maharashtra State
Board of Technical Education, Mumbai
(Autonomous) (ISO 21001:2018) (ISO/IEC 27001:2013)

MAHARASHTRA STATE BOARD OF TECHNICAL EDUCATION

(Autonomous) (ISO 21001:2018) (ISO/IEC 27001:2013)

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MAHARASHTRA STATE

BOARD OF TECHNICAL EDUCATION

Certificate

This is to certify that Mr. / Ms .....Roll No…….of Sixth Semester of Diploma in …….of **Institute Name:** …….. (**Institute Code** :……..) has completed the term work satisfactorily in course **Cold Chain Management (316365)** for the academic year 20…… to 20…..... as prescribed in the curriculum.

Place: ……. Enrollment No.: ……

Date: …..... Exam Seat No.: ……....

Course Teacher **Head of the Department** **Principal**

Seal of the Institute

Preface

The primary focus of any engineering laboratory/ field work in the technical education system is to develop the much-needed industry relevant competencies and skills. With this in view, MSBTE embarked on this innovative 'K' Scheme curricula for engineering diploma programmes with National Education Policy 2020 (NEP-2020) and outcome-based education as the focus and accordingly, relatively large amount of time is allotted for the practical work. This displays the great importance of laboratory work making each teacher; instructor and student to realize that every minute of the laboratory time need to be effectively utilized to develop these outcomes, rather than doing other mundane activities. Therefore, for the successful implementation of this outcome-based curriculum, every practical has been designed to serve as a **'vehicle'** to develop this industry identified competency in every student. The practical skills are difficult to develop through 'chalk and duster' activity in the classroom situation. Accordingly, the 'I' scheme laboratory manual development team designed the practical to **focus** on the **outcomes**, rather than the traditional age old practice of conducting practical to 'verify the theory' (which may become a by product along the way).

This laboratory manual is designed to help all stakeholders, especially the students, teachers and instructors to develop in the student the pre-determined outcomes. It is expected from each student that at least a day in advance, they have to thoroughly read through the concerned practical procedure that they will do the next day and understand the minimum theoretical background associated with the practical. Every practical in this manual begins by identifying the competency, industry relevant skills, course outcomes and practical outcomes which serve as a key focal point for doing the practical. The students will then become aware about the skills they will achieve through procedure shown there and necessary precautions to be taken, which will help them to apply in solving real-world problems in their professional life.

This manual also provides guidelines to teachers and instructors to effectively facilitate student-centered lab activities through each practical exercise by arranging and managing necessary resources in order that the students follow the procedures and precautions systematically ensuring the achievement of outcomes in the students.

Understanding cold chain management is vital for diploma holders in mechanical, refrigeration, and allied disciplines, as it directly relates to food security, healthcare, sustainability, and logistics optimization. This course enables students to develop a strong foundation in refrigeration systems, insulation, product handling, and process monitoring, ultimately preparing them to contribute effectively to the cold chain industry.

The Lab Manual Development Team expresses sincere gratitude to MSBTE for initiating the curriculum and supporting the development of this manual. We also acknowledge the valuable contributions of the subject experts and educators who participated in designing and reviewing the practical to ensure alignment with industrial standards and academic objectives.

Lab Manual Development Team

Programme Outcomes (POs) to be achieved through Practical of this Course

Following POs are expected to be achieved through the practicals of the Heating Ventilation Air Conditioning course.

PO1. Basic and Discipline specific knowledge: Apply knowledge of basic mathematics, science and engineering fundamentals and engineering specialization to solve the mechanical engineering problems.

PO2. Problem analysis: Identify and analyze well-defined mechanical engineering problems using codified standard methods.

PO3. Design/ development of solutions: Design solutions for well-defined technical problems and assist with the design of systems components or processes to meet specified needs in mechanical engineering.

PO4. Engineering Tools, Experimentation and Testing: Apply modern mechanical engineering tools and appropriate technique to conduct standard tests and measurements.

PO5. Engineering practices for society, sustainability and environment: Apply appropriate technology in context of society, sustainability, environment and ethical practices.

PO6. Project Management: Use engineering management principles individually, as a team member or a leader to manage projects and effectively communicate about well defined engineering activities in diverse and multidisciplinary fields.

PO7. Life-long learning: Ability to analyze individual needs and engage in updating in the context of technological changes in mechanical engineering.

List of Industry Relevant Skills

The following industry relevant skills of the competency in 'cold chain management' through which industry are expected to be developed in students by undertaking the practical of this laboratory manual.

1. Use ICT-enabled tools to prepare technical feasibility reports considering local, national, and global factors.
2. Select suitable insulation materials for efficient cold storage and refrigeration systems.
3. Measure and record product characteristics using appropriate instruments in cold chain equipment.
4. Check and maintain cold chain systems to ensure proper operation and cost-effectiveness.
5. Identify modern technologies and government schemes like PMKSY related to sustainable cold chain management.

Practical- Course Outcome matrix

- CO1.Interpret the significance and components of the Cold Chain Management in various industries.
- CO2. Choose appropriate Cold Chain Packaging Techniques and Storage Systems for different applications.
- CO3. Create cost effective sustainable Cold Chain system as per client requirement.
- CO4. Apply appropriate Operations, Monitoring and Risk Management Strategies in Cold Chain.
- CO5.Use the regulatory frameworks, policies and best practices that ensure efficient and environmentally sustainable Cold Chain Management.

Sr. No.	Laboratory Practical Titles	CO 1	CO 2	CO 3	CO 4	CO 5
1	*****ICT enabled tools to prepare technical feasibility report based on Local factors.	√	-	-	-	-
2	ICT enabled tools to prepare technical feasibility report based on National & Global challenges affecting cold chain logistics.	√				
3	Insulation materials for Cold Room design.		√			
4	Measurement of different product characteristics of Cold Storage.		√			
5	*****Measurement of different product characteristics in Ice plant/ Water cooler/ Chiller/ Refrigerator.		√			
6	Different components used in Refrigerated vehicle.		√			
7	*Preparation of report on Data Logger & Simulation used in Block chain, Cold Chain.			√		
8	Strategies to optimize based on cost effectiveness using identified Cold Chain system.			√		
9	Inspection of a cold chain vehicle.				√	
10	Comparison of rotting of perishable food with and without refrigerator.				√	
11	*****Make use of Cold Chain Monitoring Tools.				√	
12	*Pradhan Mantri Kisan SAMPADA Yojana (PMKSY).					√
13	Retrofitting Older Cold Chain Infrastructure with Sustainable Technologies.	√	√	√	√	√
14	*****Cold Chain Technology in Medical Emergency – (Case Study of Covid-19 for Vaccine).	√	√	√	√	√
15	*****Model of "Subjee Cooler" – Case Study by IIT Bombay.	√	√	√	√	√
16	*****Preservation of Agricultural Products in Ancient India – (IKS).	√	√	√	√	√

Guidelines to Teachers

1. **Teacher needs to ensure that a dated log book** for the whole semester, apart from the laboratory manual is maintained by every student which s/he has to **submit for assessment to the teacher** in the next practical session.
2. There will be two sheets of blank pages after every practical for the student to report other matters (if any), which is not mentioned in the printed practical.
3. For difficult practical if required, teacher could provide the demonstration of the practical emphasizing of the skills which the student should achieve.
4. Teachers should give opportunity to students for hands-on after the demonstration.
5. Assess the skill achievement of the students and COs of each unit.
6. One or two questions ought to be added in each practical for different batches. For this teacher can maintain various practical related question banks for each course.
7. If some repetitive information like data sheet, use of software tools etc. has to be provided for effective attainment of practical outcomes, they can be incorporated in Appendix.
8. For effective implementation and attainment of practical outcomes, teacher ought to ensure that in the beginning itself of each practical, students must read through the complete write-up of that practical sheet.
9. During practical, ensure that each student gets chance and takes active part in taking observations/ readings and performing practical.
10. Teacher ought to assess the performance of students continuously according to the MSBTE guidelines.

Instructions for Students:

1. For incidental writing on the day of each practical session every student should maintain a **dated log book** for the whole semester, apart from this laboratory manual which s/he has to **submit for assessment to the teacher** in the next practical session.
2. For effective implementation and attainment of practical outcomes, in the beginning it of each practical, student needs to read through the complete write-up including the practical related questions and assessment scheme of that practical sheet.
3. Student ought to refer the data books, IS codes, Safety norms, Technical Manuals, etc.
4. Student should not hesitate to ask any difficulties they face during the conduct of practical

Content Page

List of Practical and Progressive Assessment Sheet

Sr. No.	Laboratory Practical Titles	Page No.	Date of Performance	Date of Submission	FA PR Marks (25)	Dated sign of teacher	Remarks (if any)
16	*****Preservation of Agricultural Products in Ancient India – (IKS).	89					

Note: To be transferred to Proforma of CIAAN-2023.

A suggestive list of LLOs is given in the above table. More such LLOs can be added to attain the COs and competency. A judicial mix of minimum 12 or more practical need to be performed, out of which, the practical marked as '*' are compulsory, so that the student reaches the 'Precision Level' of Dave's 'Psychomotor Domain Taxonomy' as generally required by the industry.

Practical No. 1

ICT enabled tools to prepare technical feasibility report based on Local factors.*

I. Practical Significance

Cold chain management ensures that perishable products such as food, dairy, and medicines are stored and transported under controlled temperatures. This practical helps student understand how ICT tools can be used to prepare a technical feasibility report based on local environmental and industrial factors.

II. Industry/Employer Expected Outcomes

The aim of this course is to help the students to attain the following industry identified outcomes through various teaching learning experiences: Perform activities related to Cold-Chain Management according to requirement such as products, quality, packaging and storage efficiently.

III. Course Level Learning Outcome (CO)

CO1 - Interpret the significance and components of the Cold Chain Management in various industries.

IV. Laboratory Learning Outcome(s)

LLO 1.1- Identify Real-World Cold Chain Applications.

LLO 1.2- Analyze Cold Chain Data as per Applications.

V. Relative Affective Domain Related Outcome(s)

- Student should develop a positive attitude towards using ICT tools.
- Collect valid data
- Follow ethical Practices.

VI. Minimum Theoretical Background

Introduction:

A cold chain is a system that maintains the required low-temperature range for perishable products such as food, dairy, meat, vaccines, and medicines. The aim is to keep products safe, fresh, and effective from the point of production until they reach the consumer. If the required temperature is not maintained, products may spoil, lose quality, or even become unsafe for use.

Components of a Cold Chain

1. **Cold Storage Facilities** – Warehouses where perishable items are stored at controlled temperatures before transport.
2. **Refrigerated Transportation** – Trucks, containers, or rail wagons with refrigeration systems that carry goods safely.
3. **Monitoring Systems** – ICT-based tools like temperature sensors, data loggers, GPS, and IoT devices to track and record temperature and humidity.
4. **Distribution Centers** – Local delivery points or retail outlets that ensure products reach consumers in fresh condition.

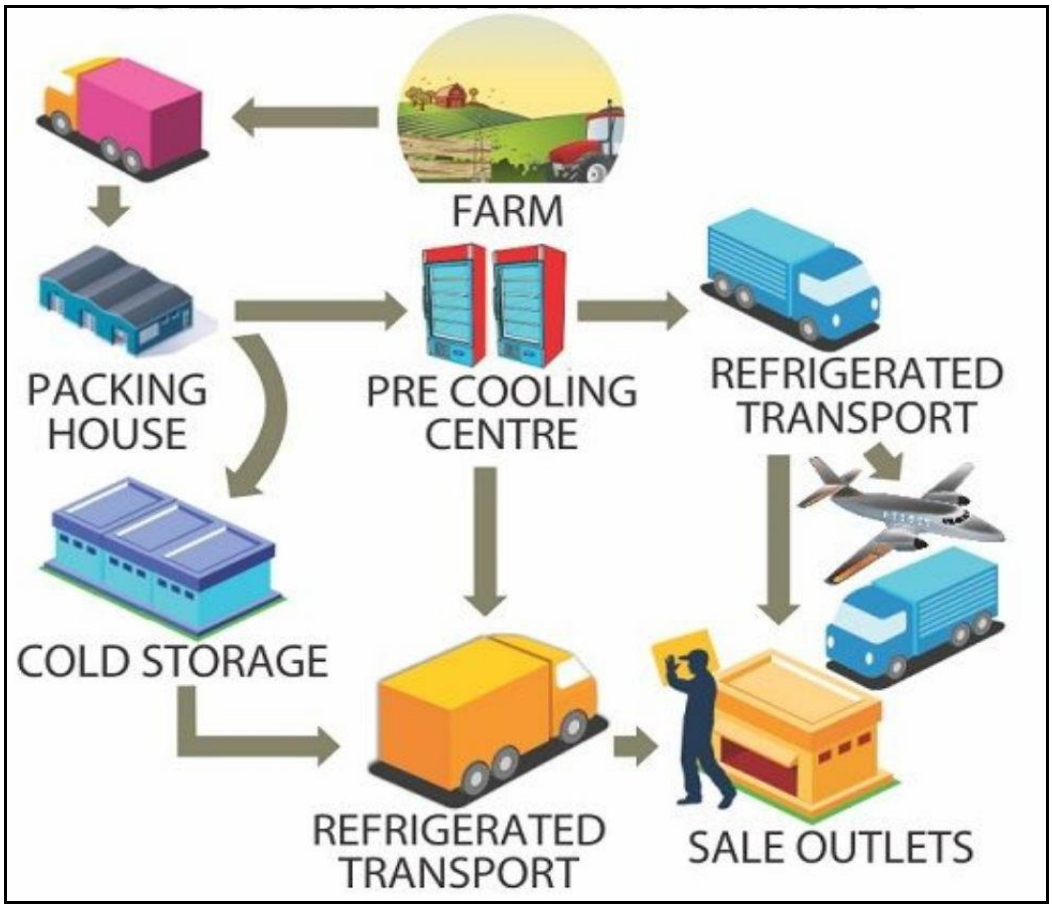


Fig. 1.1: Steps in Cold Chain Management

Role of ICT in Cold Chain Management

ICT (Information and Communication Technology) tools make cold chain management smarter and more reliable. They help in:

- **Data Collection:** Recording local temperature, humidity, and electricity availability.
- **GIS Mapping:** Locating markets, hospitals, farms, and cold storage facilities.
- **Monitoring:** Using IoT sensors and cloud storage for real-time data.
- **Decision Making:** Analysing feasibility reports and predicting future needs.

Factors Affecting Local Feasibility of Cold Chain

- **Ambient Temperature:** Higher temperature → higher cooling load.
- **Electricity Availability:** Power backup needed in case of outages.
- **Transport Connectivity:** Roads, distance to markets, fuel availability.
- **Demand Factors:** Local demand for dairy, fruits, vegetables, or vaccines.

VII. Experimental Set-up

Students will work in groups to prepare a technical feasibility report using ICT tools (GPS Maps, Excel, simulation software, or online cold chain calculators). Data regarding local temperature, electricity availability, transport connectivity, and market demand will be collected and analyzed.

VIII. Required Resources / Apparatus / Equipment

S. No.	Resource/Equipment	Specification	Quantity
1	Computer system	Minimum i3 Processor, 4GB RAM	1 per group
2	Internet Connection	10 Mbps or above	Shared
3	Weather Condition App	----	01
4	MS Excel	------	01

IX. Precautions to be Followed

- Ensure internet connectivity while using ICT tools.
- Use valid data.
- Save files regularly to avoid data loss.

X. Procedure (10–12 steps)

1. Form a group
2. Select any perishable local product (Farm Product/Industry Product)
3. Identify the local area for cold chain feasibility study.
4. Collect environmental data (temperature, humidity, electricity availability).
5. GPS to locate nearby markets, farms, or hospitals.
6. Select transportation routes and distances.
7. Enter collected data in Excel/Spreadsheet.
8. Use ASHRAE data

XI. Observations (Example Table)

Parameter	Data Collected	Remarks
Selected Local Product Name		
Current Location Name		
Current Location Avg. Ambient Temp.		
Current Location Humidity		
Nearest Market Avg. Ambient Temp.		
Nearest Market Avg. Humidity		
Distance Between current location and Market		
Type of transportation connectivity (Roadways/Railways/Airways etc.)		
Time Required to travel from current location to market		

XII. Results

XIII. Interpretation of Results

XIV. Conclusions

XIV. Practical Related Questions

1. State the role of ICT in cold chain management.
2. Explain feasibility report importance before setting up a cold storage facility.
3. Name two local products possible to supply using cold chain.
4. State the importance of temperature monitoring ensures product safety.

[Space for Answer]

XVI. References / Suggestions for Further Reading

1. https://www.youtube.com/watch?v=6TpXPhjRfXQ
2. https://www.youtube.com/watch?v=hC7hIMm-ysU
3. https://www.youtube.com/watch?v=Ioai2StDhFU
4. https://www.youtube.com/watch?v=Tuhv3n0zsOQ
5. https://www.youtube.com/watch?v=X6bg151CSj8
6. https://www.youtube.com/watch?v=mFnr1JJ8udo
7. https://www.ashrae.org/

XVII. Rubrics for Assessment Scheme

Performance Indicators		**Weightage**
Process Related (15 Marks)		**(60%)**
1	Proper Procedure and Use of ICT Tools	40%
2	Active Participation and Teamwork	20%
Product Related (10 Marks)		**(40%)**
3	Quality of Record Work	30%
4	Understanding and Results	10%
	Total	**100 %**

Marks Obtained			**Dated signature of Teacher**
Process Related (15)	**Product Related (10)**	**Total (25)**	

Practical No. 2
ICT Enabled Tools to Prepare Technical Feasibility Report Based on National & Global Challenges Affecting Cold Chain Logistics

I. Practical Significance

This practical helps student understands how information and communication technology (ICT) tools can be used to study the feasibility of cold chain systems while considering national and global challenges like energy shortage, climate change, and supply chain disruptions. It builds the ability to apply digital tools for problem-solving and decision-making in real-world logistics.

II. Industry/Employer Expected Outcome(s)

The aim of this course is to help the students to attain the following industry identified outcomes through various teaching learning experiences: Perform activities related to Cold-Chain Management according to requirement such as products, quality, packaging and storage efficiently.

III. Course Level Learning Outcome (CO)

CO1 - Interpret the significance and components of the Cold Chain Management in various industries.

IV. Laboratory Learning Outcome(s)

LLO 2.1 Identify Cold Chain Logistics Challenges.

LLO 2.2 Interpret the data based on key National & global factors affecting Cold Chain logistics.

V. Relative Affective Domain Related Outcome(s)

- Student should develop a positive attitude towards using ICT tools.
- Collect valid data
- Follow ethical Practices.

VI. Minimum Theoretical Background

Introduction:

Cold chain management is a process that maintains a controlled temperature environment for perishable goods such as food, dairy, medicines, and vaccines. It ensures that products remain safe, fresh, and effective from the point of production to the consumer. National and global challenges such as fluctuating energy prices, fuel shortages, temperature rise, and global trade delays directly affect cold chain logistics.

Components of Cold Chain

1. **Cold Storage Facilities** – These are temperature-controlled warehouses used to store perishable goods.

2. **Refrigerated Transport** – Vehicles with refrigeration systems that maintain required temperature ranges during transportation.
3. **ICT Monitoring Systems** – Tools like IoT sensors, GPS, and data loggers help monitor temperature, humidity, and route efficiency.
4. **Distribution Centers** – Facilities that manage the last-mile delivery of goods to local markets or hospitals.

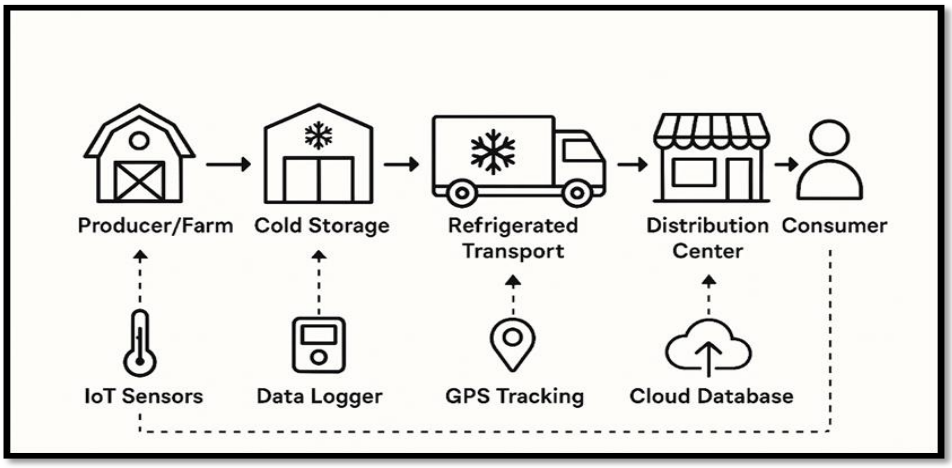
Role of ICT in Cold Chain Feasibility

ICT tools are essential for planning, monitoring, and evaluating cold chain operations.

ICT Tool	Function
Internet Connection	Helps map locations of warehouses, markets, and transport routes.
Data sheet	Used for data analysis, cost estimation, and preparing feasibility reports.
IoT Sensors	Measure and record real-time temperature and humidity data.

National and Global Challenges Affecting Cold Chain Logistics

Category	National Challenges	Global Challenges
Energy Supply	Irregular power supply and high energy cost	Rising fuel prices and global energy crises
Infrastructure	Poor rural connectivity	Port congestion and shipping delays
Environment	Hot climate, seasonal variation	Climate change and rising global temperature
Technology	Limited digital monitoring tools	Cyber security and data management issues
Economy	High investment cost	Inflation and international trade barriers



Fig, 2.1: Cold Chain System with ICT Tools

ICT systems collect real-time data from every stage, helping managers make decisions based on accurate and updated information.

VII. Experimental Setup

Students will work in groups to prepare a technical feasibility report for a selected product (such as milk, fruits, or vaccines). The analysis will be performed using ICT tools like GPS/GIS, Excel, and online simulation tools. Data regarding temperature conditions, transportation routes, electricity supply, and storage cost will be collected from both national and international cold chain case studies.

Each group will:

1. Identify local and global cold chain issues.
2. Compare national-level logistics with global standards.
3. Prepare and present a feasibility report highlighting improvements and solutions.

VIII. Required Resources / Apparatus / Equipment:

S. No.	Resource/Equipment	Specification	Quantity
1	Computer	Minimum i3 Processor, 4 GB RAM	1 per group
2	Internet Connection	Minimum 10 Mbps	Shared
3	GPS / GIS Tool	----	01
4	MS Excel	------	01

IX. Precautions to be Followed

- Before taking data, check whether data is valid or not.
- Save your work regularly to prevent data loss.
- Avoid changing system settings.

X. Procedure

1. Form groups of maximum 3 students
2. Select one product for cold chain feasibility study.
3. Identify local and national temperature and supply chain data.
4. Use GPS locate warehouses, markets, and transport routes.
5. Collect global data (for comparison) from government or industry reports.
6. Compare national and global data
7. Summarize findings and suggestions in a structured feasibility report.
8. Review on compared data.

Following are the list of product for observation and calculation

S. No.	Product	Focus Area	S. No.	Product	Focus Area
1	Mango	Climate-sensitive storage	**6**	Vegetables	Humidity control
2	Vaccine	Health cold chain logistics	**7**	Ice Cream	Deep freezing
3	Cheese	Food preservation	**8**	Flowers	Export logistics
4	Fish	High perishability	**9**	Blood Sample	Medical safety chain
5	Meat	Power backup needs	**6**	Vegetables	Humidity control

XI. Observations and Calculations

Name of Product- …….

Cooling Temperature Recorded at various locations				
Producer/Farm	**Cold Storage**	**Refrigerated Transport**	**Distribution centre**	**Consumer**
Time duration of storage in hours				
Producer/Farm	**Cold Storage**	**Refrigerated Transport**	**Distribution centre**	**Consumer**

Reference link- https://www.engineeringtoolbox.com/fruits-vegetables-storage-conditions-d_710.html

For selected product write national and Global data in following table using ICT tools

Parameter	National Data	Global Benchmark	Remarks
Cooling Temperature of product (°C)			
Electricity Cost (per unit)			
Transport Connectivity Score (Give rating from 1 to 10)			
Average Cold Storage Utilization in percentage			

XII. Results

XIII. Interpretation of Results

XIV. Conclusions and Recommendations

XV. Practical Related Questions

1. State the national and global challenges affecting cold chain logistics.
2. Explain importance of valid data in a feasibility report.
3. Explain the role of GIS in cold chain planning.
4. Explain the help of global standard improve local cold storage design.
5.

[Space for Answer]

XVI. References / Suggestions for Further Reading

1. https://www.youtube.com/watch?v=h_W9Z_AjW8A
2. https://www.youtube.com/watch?v=_DlIZ7GZtpQ
3. https://www.youtube.com/watch?v=inJB9wjlj78
4. https://www.youtube.com/watch?v=MJ8KObhhp24
5. https://www.youtube.com/watch?v=Fq9Y_xMEkM8
6. https://www.youtube.com/watch?v=RuBHhbkPYdY
7. https://www.ashrae.org/

XVII. Rubrics for Assessment Scheme

Performance Indicators		**Weightage**
Process Related (15 Marks)		**(60%)**
1	Proper Procedure and Use of ICT Tools	40%
2	Active Participation and Teamwork	20%
Product Related (10 Marks)		**(40%)**
3	Quality of Record Work	30%
4	Understanding and Results	10%
	Total	**100 %**

Marks Obtained			**Dated signature of Teacher**
Process Related (15)	**Product Related (10)**	**Total (25)**	

Practical No. 3
Insulation Materials for Cold Room Design

I. Practical Significance

Insulation helps maintain a constant temperature inside a cold room by preventing heat transfer. This practical helps student understand different insulation materials used in cold room design and their importance in saving energy and maintaining product quality.

II. Industry / Employer Expected Outcome(s)

The aim of this course is to help the students to attain the following industry identified outcomes through various teaching learning experiences: Perform activities related to Cold-Chain Management according to requirement such as products, quality, packaging and storage efficiently.

III. Course Level Learning Outcome(s) (CO)

CO2 - Choose Appropriate Cold Chain Packaging Techniques and Storage Systems for different applications.

IV. Laboratory Learning Outcome(s)

LLO 3.1 Identify the various insulation materials.
LLO 3.2 Select suitable insulation materials for Cold Room Design.

V. Relative Affective Domain Related Outcome(s)

- Follow safety practices
- Practice good housekeeping.
- Follow ethical Practices.

VI. Minimum Theoretical Background

Introduction:

A cold room is a specially designed temperature-controlled chamber used to preserve perishable items such as fruits, vegetables, dairy products, meat, and vaccines under specific temperature and humidity conditions. The insulation in a cold room plays a vital role in maintaining a stable internal temperature by preventing the entry of external heat and loss of internal cool air. Proper insulation also prevents condensation, maintains product quality, and increases the efficiency and lifespan of the cooling system. Hence, effective insulation design is essential for achieving energy-efficient, reliable, and cost-effective cold room operation.

Importance of Insulation

- Reduces heat flow into the cold room and minimizes temperature fluctuations.
- Maintains a uniform and stable internal temperature for stored products.
- Saves electrical energy by reducing the cooling load on refrigeration systems.
- Lowers the running cost and operational expenses of cold storage facilities
- Improves the overall efficiency and lifespan of refrigeration equipment.
- Prevents moisture condensation and mold formation on walls and ceilings.

Properties of Good Insulation Material

1. A good insulation material should have low thermal conductivity**.**
2. It must be resistant to moisture absorption.
3. The material should be light in weight.
4. It needs to be chemically stable and fire-resistant**.**

Factors Affecting Selection of Insulation

1. Type of product stored.
2. Temperature difference between inside and outside.
3. Humidity level.
4. Cost and availability of materials.
5. Life span and maintenance needs.

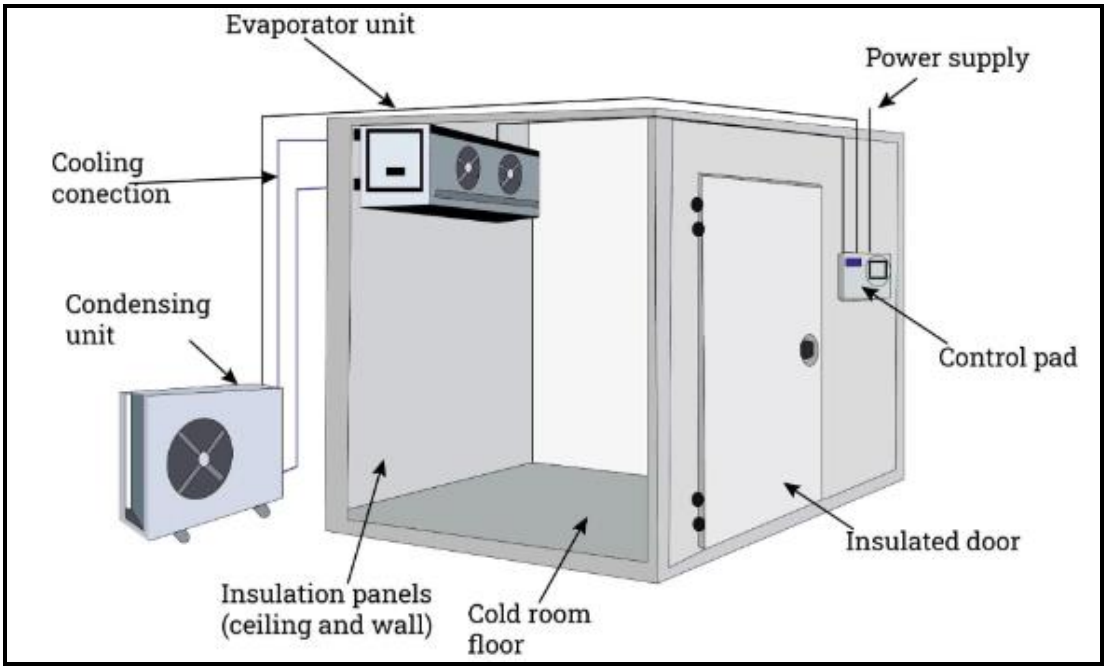


Fig. 3.1: Construction of cold storage

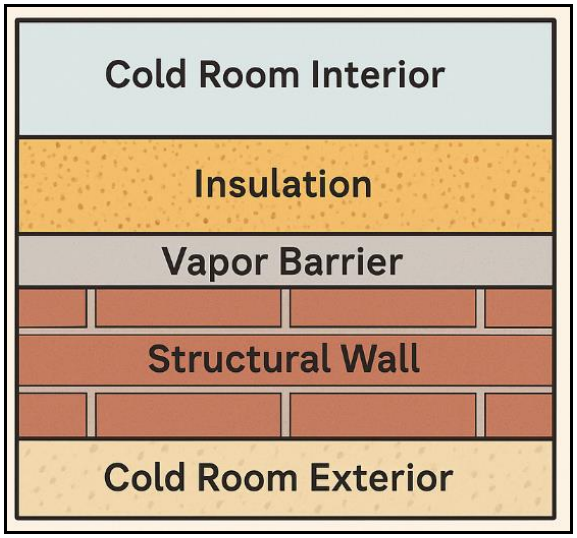
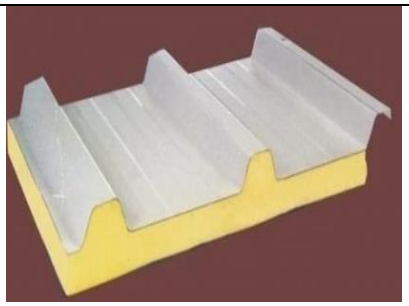
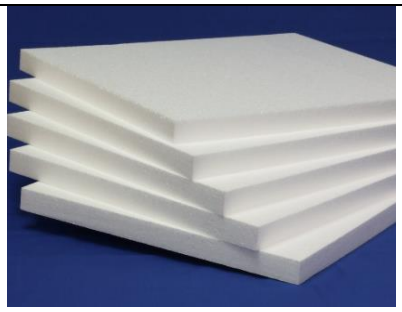
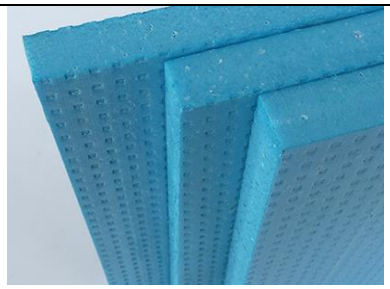


Fig. 3.2: Cold Room Cross-Section with Insulation Layers

VII. Experimental Setup:

Models or panels of different insulation materials.

Sr. No.	Material	Photographs
1	Polyurethane Foam (PUF)	
2	Expanded Polystyrene (EPS)	
3	Extruded Polystyrene (XPS)	
4	Glass Wool	
5	Cork Sheet	

VIII. Required Resources / Apparatus / Equipment

Sr. No.	Name of Resource	Specification	Quantity
1	Sample insulation panels	PUF, XPS, EPS, Glass wool	1 each

IX. Precautions to be Followed

1. Avoid touching insulation with wet hands.
2. Handle glass wool and sharp edges carefully.

X. Procedure

1. Understand the purpose of insulation in cold rooms, which is to reduce heat transfer and maintain low temperature efficiently.
2. List common insulation materials such as PUF, EPS, XPS, Glass Wool, and Cork used in cold room applications.
3. Observe physical samples or images of these materials to study their structure and texture.
4. Note key properties like thermal conductivity, density, and moisture resistance for each material.
5. Compare thermal conductivity values to find which material provides better insulation.
6. Study strength, durability, and flexibility to assess material performance in cold room conditions.
7. Learn basic installation methods like PUF panels or foam spray systems.
8. Check fire resistance and chemical stability for safety and reliability.
9. Prepare a short comparison table showing advantages and temperature ranges.
10. Conclude by selecting the most suitable insulation material based on cost, availability, and climate.

XI. Observations and Calculations

S. No.	Name of Insulation Material	Thermal Conductivity (W/m·K)	Density (kg/m^3)	Moisture Resistance (Poor/Good/Very good/Excellent)	Suitable Temperature Range (°C)
1	Polyurethane Foam (PUF)				
2	Expanded Polystyrene (EPS)				
3	Extruded Polystyrene (XPS)				
4	Glass Wool				
5	Cork Sheet				

XII. Results

S. No.	Name of Insulation Material	Applications
1	Polyurethane Foam (PUF)	
2	Expanded Polystyrene (EPS)	
3	Extruded Polystyrene (XPS)	
4	Glass Wool	
5	Cork Sheet	

XIII. Interpretation of Results

XIV. Conclusions and Recommendations

XV. Practical Related Questions

1. Name the manufacturer of insulations provided in practical.
2. List the desirable properties of insulation material provided.
3. State the types of insulation material provided.
4. Suggest the alternative insulations against material provided in practical.

[Space for Answer]

XVI. References / Suggestions for Further Reading

1. https://www.youtube.com/watch?v=9ZJjlua82Wo
2. https://www.youtube.com/watch?v=0tWAJB7IkUM
3. https://www.youtube.com/watch?v=XNDkbczkplk
4. https://www.youtube.com/watch?v=lTkkAIdf9Jg
5. https://www.youtube.com/watch?v=4PiMP7N_kvA
6. https://www.youtube.com/watch?v=AIPc1ui8WW0

XVII. Rubrics for Assessment Scheme

Performance Indicators		Weightage
Process Related (15 Marks)		**(60%)**
1	Proper Procedure and specifications of insulation materials	40%
2	Active Participation and Teamwork	20%
Product Related (10 Marks)		**(40%)**
3	Quality of Record Work	30%
4	Understanding and Results	10%
	Total	**100 %**

Marks Obtained			Dated signature of Teacher
Process Related (15)	**Product Related (10)**	**Total (25)**	

Practical No. 4

Measurement of Different Product Characteristics of Cold Storage

I. Practical Significance

The performance of a cold storage system depends on the physical and thermal characteristics of the products stored inside it. Measuring these characteristics helps in selecting suitable storage conditions, maintaining product quality, and reducing energy consumption.

II. Industry / Employer Expected Outcome(s)

The aim of this course is to help the students to attain the following industry identified outcomes through various teaching learning experiences: Perform activities related to Cold-Chain Management according to requirement such as products, quality, packaging and storage efficiently.

III. Course Level Learning Outcome(s) (CO)

CO2 - Choose Appropriate Cold Chain Packaging Techniques and Storage Systems for different applications.

IV. Laboratory Learning Outcome(s)

LLO 4.1 Use thermometers, data loggers, and hygrometers.

LLO 4.2 Measure temperature and relative humidity inside cold storage.

V. Relative Affective Domain Related Outcome(s)

- Follow safety practices.
- Practice good housekeeping.
- Maintain tools and equipment.
- Follow ethical Practices.

VI. Minimum Theoretical Background

Cold storage is a temperature-controlled facility used for preserving perishable items such as fruits, vegetables, dairy products, fish, meat and pharmaceuticals. Every product has its own temperature range, humidity level, and air circulation requirement for safe and effective storage. Measuring the product characteristics helps in deciding the correct design of cold rooms, energy use and shelf life of the products.

Fig. 4.1: Products stored in Cold Storage.

Key Product Characteristics in Cold Storage

Parameter	Description	Unit	Importance
Temperature	Temperature of product during storage	°C	Maintains freshness and prevents spoilage
Moisture Content	Percentage of water present in the product	%	Affects weight, quality, and energy requirement
Density	Mass per unit volume of product	kg/m³	Helps estimate storage space and capacity

Typical Storage Conditions for Common Products

Product	Storage Temperature (°C)	Relative Humidity (%)	Storage Life
Apple	0 to 1	90–95	4–6 months
Potato	3 to 5	90–95	4 months
Tomato	7 to 10	85–90	2–3 weeks
Fish	-18 to -20	95–100	6–8 months
Milk	2 to 4	85–90	3–4 days
Ice Cream	-20 to -25	90–95	6 months

Importance of Measuring Product Characteristics

- Ensures correct cold room design and operation.
- Prevents quality loss and economic wastage.
- Helps optimize energy consumption in refrigeration systems.
- Enables automation and control of cold chain systems.

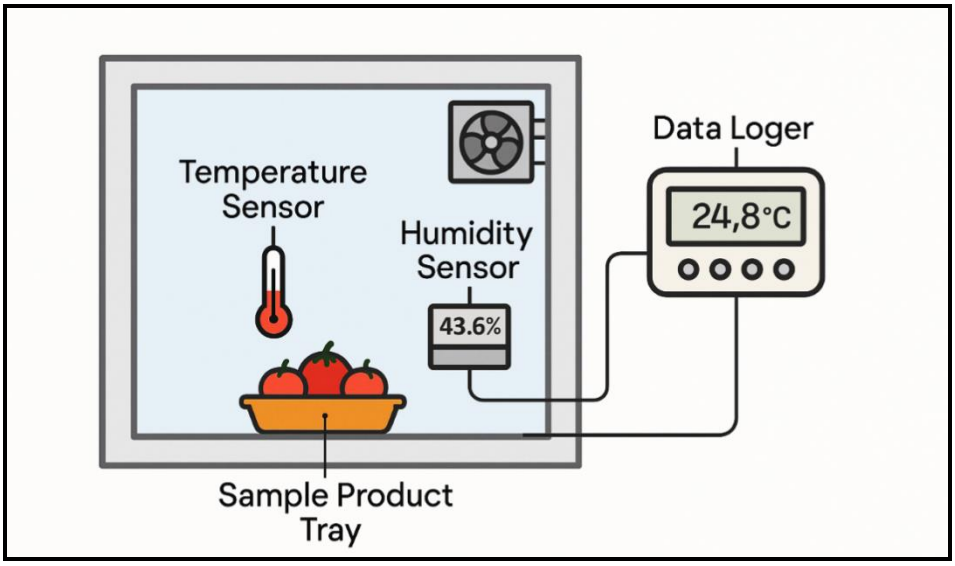


Fig. 4.2: Cold Storage Measurement System

VII. Experimental Setup

The experiment is performed using a mini cold storage/Refrigerator unit or simulation chamber equipped with measuring instruments such as thermometers, hygrometers, weighing scale, and moisture analyzer. Samples of products (like fruits or vegetables) are placed in the chamber. Readings of temperature, humidity, and weight change are recorded at fixed intervals.

VIII. Required Resources / Apparatus / Equipment:

Sr. No.	Name of Resource	Specification	Quantity
1	Cold Storage Chamber (Model)	Temperature range: -25°C to +10°C	01
2	Thermometer	Digital type, range: -30°C to +50°C	02
3	Hygrometer	Range: 0–100% RH	01
4	Digital Weighing Scale	Accuracy ±0.1 g	01
4	Sample Products	Fruits/vegetables/dairy items	As required

IX. Precautions to be followed:

1. Handle perishable products with care to avoid contamination.
2. Ensure sensors are properly calibrated before recording data.
3. Avoid opening the cold room door frequently during measurement.

X. Procedure

1. Select the product sample (e.g., tomato or apple).
2. Record initial weight, temperature, and moisture content.
3. Place the product in the cold storage chamber.
4. Set and maintain the required temperature and humidity.
5. Record readings of temperature and weight after 24 hrs.
6. Measure final moisture content after fixed time.
7. Calculate weight loss and temperature variation.

XI. Observations and Calculations

Name of Product-					
Time (min)	**Product Temp (°C)**	**Chamber Temp (°C)**	**Weight (g)**	**Moisture (%)**	**Remarks**
Initial					
After 24 Hr					

Calculations:

1. Weight Loss (%) = ((Initial Weight - Final Weight) / (Initial Weight))× 100
2. Humidity Loss (%) = ((Initial Humidity – Final Humidity) / (Initial Humidity)) × 100

XII. Results

1	Weight Loss (%)	
2	Humidity Loss (%)	

XIII. Interpretation of Results

XIV. Conclusions and Recommendations

XV. Practical Related Questions

1. State the effect of variation of temperature on product in cold storage.
2. Describe the effect of moisture content on product quality.
3. List factors affect weight loss in stored products.

[Space for Answer]

XVI. References / Suggestions for Further Reading

1. https://www.youtube.com/watch?v=junx5aB8eQQ
2. https://www.youtube.com/watch?v=i_i2kE8anxk
3. https://www.youtube.com/watch?v=0tWAJB7IkUM
4. https://www.youtube.com/watch?v=0tWAJB7IkUM
5. https://www.youtube.com/watch?v=CloudStorageDesign

XVII. Rubrics for Assessment Scheme

Performance Indicators		Weightage
Process Related (15 Marks)		**(60%)**
1	Proper Procedure and Use of Tools and Equipment	40%
2	Active Participation and Teamwork	20%
Product Related (10 Marks)		**(40%)**
3	Quality of Report/Record Work	30%
4	Understanding and Results/Conclusion	10%
	Total	**100 %**

Marks Obtained			Dated signature of Teacher
Process Related (15)	**Product Related (10)**	**Total (25)**	

Practical No. 5
Measurement of Different Product Characteristics in Ice Plant / Water Cooler / Chillers / Refrigerator*

I. Practical Significance

This practical helps student understand how temperature, pressure, cooling rate, and product conditions change in refrigeration systems such as an ice plant, water cooler, chiller, or refrigerator. It gives hands-on knowledge about the working of these systems and helps evaluate their cooling performance.

II. Industry / Employer Expected Outcome(s)

The aim of this course is to help the students to attain the following industry identified outcomes through various teaching learning experiences: Perform activities related to Cold-Chain Management according to requirement such as products, quality, packaging and storage efficiently.

III. Course Level Learning Outcome(s) (CO)

CO2 - Choose Appropriate Cold Chain Packaging Techniques and Storage Systems for different applications.

IV. Laboratory Learning Outcome(s)

LLO 5.1 Use thermometers, data loggers, and hygrometers.

LLO 5.2 Measure temperature distribution and fluctuations within the storage environment.

V. Relative Affective Domain Related Outcome(s)

- Follow safety practices.
- Practice good housekeeping.
- Maintain tools and equipment.
- Follow ethical Practices.

VI. Minimum Theoretical Background

Refrigeration systems play a crucial role in the cold chain by maintaining low temperatures required to preserve perishable goods such as food, dairy, fruits, vegetables, and medicines. Their main function is to remove heat from a product or enclosed space and transfer it to the surrounding environment, thus ensuring that the temperature remains below ambient conditions. Common refrigeration systems include ice plants, water coolers, chillers, and refrigerators, each serving specific applications within storage, transportation, and processing stages of the cold chain.

Basic Working Principle:

1. Compressor – Pressure and Temperature Booster

2. Condenser – Heat Rejection Unit

3. Expansion Valve – Pressure and Temperature Reducer

4. Evaporator – Cooling Producer

Product Characteristics:

Parameter	Description	Typical Range	Importance
Temperature	Product and ambient temperature	-20°C to +30°C	Determines cooling performance
Cooling Rate	Rate at which product temperature decreases	°C/min	Affects product quality
Pressure	Suction and discharge pressures	2–12 bar	Indicates system efficiency
Relative Humidity	Moisture level inside chamber	40–90%	Impacts freshness and dryness
Energy Consumption	Electrical power used	kWh	Measures operational efficiency

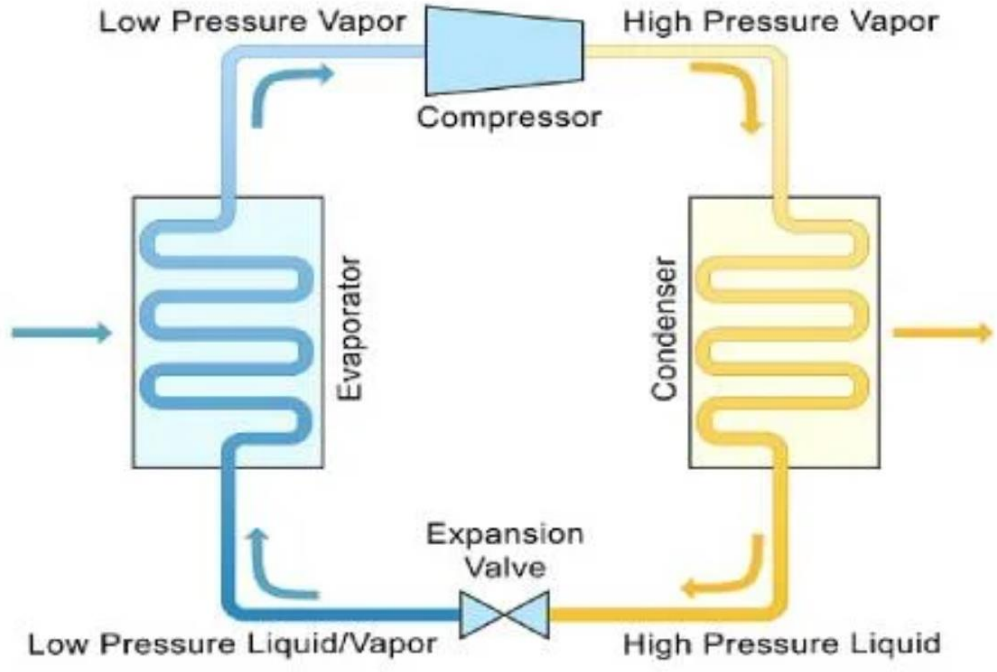


Fig. 5.1: Refrigeration System Layout

VII. Experimental Setup:

The experiment setup includes a small-scale working model of any refrigeration system (refrigerator, water cooler, or chiller). Thermometers gauges are fixed at key points such as compressor inlet/outlet, condenser, and evaporator. A product sample (like water or a bottle) is placed to observe cooling characteristics.

VIII. Required Resources / Apparatus / Equipment:

S. No.	Name of Resource	Specification	Quantity
1	Refrigerator / Chiller / Cooler Model	Capacity: 50–100 liters	01
2	Thermometer	Range: -30°C to +50°C	02–03
3	Stopwatch	Digital	01
4	Measuring Container	Volume: 1 liter	01

Fig. 5.2: Refrigeration Test Rig

IX. Precautions to be followed:

1. Do not open the refrigerator door frequently during measurement.
2. Handle temperature gauges and electrical connections carefully.
3. Take readings only after steady operation is achieved.

X. Procedure:

1. Start the refrigeration unit and allow it to run for 0 –60 minutes.
2. Measure and note the ambient temperature.
3. Record initial temperature of product (water or sample).
4. Measure temperature of evaporator and condenser.
5. Record temperature of product at regular intervals (every 30 minutes).
6. Continue until the product reaches desired cooling temperature.
7. Calculate cooling rate and average cooling rate
8. Prepare observation and result table.

XI. Observations and Calculations

Time (min)	Evaporator Temperature or Product Temp (°C) T_L		Condenser Temperature T_H	
	^oC	K	^oC	K
0				
30				
60				

Calculations-

1. Cooling rate of Product (K/min)

Cooling Rate = (Initial Temp of Product – Final Temp of Product) / Time

2. Average Cooling Rate (K/Min) = ----------

XII. Results

1	Cooling rate of Product	
2	Average Cooling Rate	

XIII. Interpretation of Results

XIV. Conclusions and Recommendations

XV. Practical Related Questions

1. List the main components of a refrigeration system.
2. State the factors affect the performance of a refrigerator.
3. State the function of the expansion valve.

[Space for Answer]

XVI. References / Suggestions for Further Reading

1. https://www.youtube.com/watch?v=p6GXJdRUz9E
2. https://www.youtube.com/watch?v=38lmWGZ85lc
3. https://www.youtube.com/watch?v=ok8j-1qx8II
4. https://www.youtube.com/watch?v=SOgFW9bdAiY
5. https://www.youtube.com/watch?v=vYUMymsvIAE
6. https://www.youtube.com/watch?v=9igK-PzIZ0w

XVII. Rubrics for Assessment Scheme

Performance Indicators		Weightage
Process Related (15 Marks)		**(60**%)
1	Proper Procedure and Use of Tools and Equipment	40%
2	Active Participation and Teamwork	20%
Product Related (10 Marks)		**(40**%)
3	Quality of Report/Record Work	30%
4	Understanding and Results/Conclusion	10%
	Total	**100 %**

Marks Obtained			Dated signature of Teacher
Process Related (15)	**Product Related (10)**	**Total (25)**	

Practical No. 6
Different Components Used in a Refrigerated Vehicle

I. Practical Significance

Refrigerated vehicles play an important role in maintaining the temperature of perishable goods such as milk, fruits, vegetables, meat, and medicines during transportation. Understanding their components helps students know how temperature is controlled and maintained in moving conditions.

II. Industry / Employer Expected Outcome(s)

The aim of this course is to help the students to attain the following industry identified outcomes through various teaching learning experiences: Perform activities related to Cold-Chain Management according to requirement such as products, quality, packaging and storage efficiently.

III. Course Level Learning Outcome(s) (CO)

CO2 - Choose appropriate Cold Chain Packaging Techniques and Storage Systems for different applications.

IV. Laboratory Learning Outcome(s)

LLO 6.1 Label different components used in Refrigerated vehicle.
LLO 6.2 Draw layout of refrigerant path flow diagram using CAD.

V. Relative Affective Domain Related Outcome(s)

- Follow safety practices.
- Practice good housekeeping.
- Maintain tools and equipment.
- Follow ethical Practices.

VI. Minimum Theoretical Background

A refrigerated vehicle is a specially designed transport system equipped with a mechanical refrigeration unit to carry perishable goods under controlled temperature conditions. These vehicles are used to transport food, dairy products, pharmaceuticals, seafood, meat, fruits, and vegetables that require specific temperature ranges, typically between -25°C and +5°C, depending on the product. The refrigeration system works on the vapor compression cycle and includes essential components such as a compressor, condenser, expansion valve, and evaporator to maintain the required cooling throughout transportation.

Refrigerated vehicles play a vital role in cold chain logistics by bridging the gap between producers, storage facilities, and markets. They minimize spoilage, reduce waste, and maintain product safety during long-distance or cross-regional transport. Efficient operation of these vehicles ensures that perishable commodities reach consumers in good condition, thereby supporting food security, public health, and overall supply chain efficiency.

Working Principle: The refrigeration system in a refrigerated vehicle works on the Vapour Compression Refrigeration Cycle, similar to the one used in home refrigerators but designed to operate efficiently while the vehicle is moving. The system mainly consists of four parts: a compressor, condenser, expansion valve, and evaporator.

Fig. 6.1: Refrigerated Vehicle

Main Components of a Refrigerated Vehicle:

S. No.	Component	Description
1	**Compressor**	Belt-driven or engine-mounted unit
2	**Condenser**	Air-cooled or water-cooled coil placed outside the cargo area
3	**Receiver-Drier**	Fitted after the condenser
4	**Expansion Valve**	Between receiver and evaporator
5	**Evaporator**	Located inside cargo compartment
6	**Refrigerant**	Commonly R-134a, R-404A, or R-290
7	**Blower Fan**	Fitted with evaporator
8	**Insulated Body**	Sandwich panels of PUF, XPS, or EPS
9	**Temperature Sensor & Controller**	Digital display system
10	**Power Source**	Engine-driven or electric standby unit

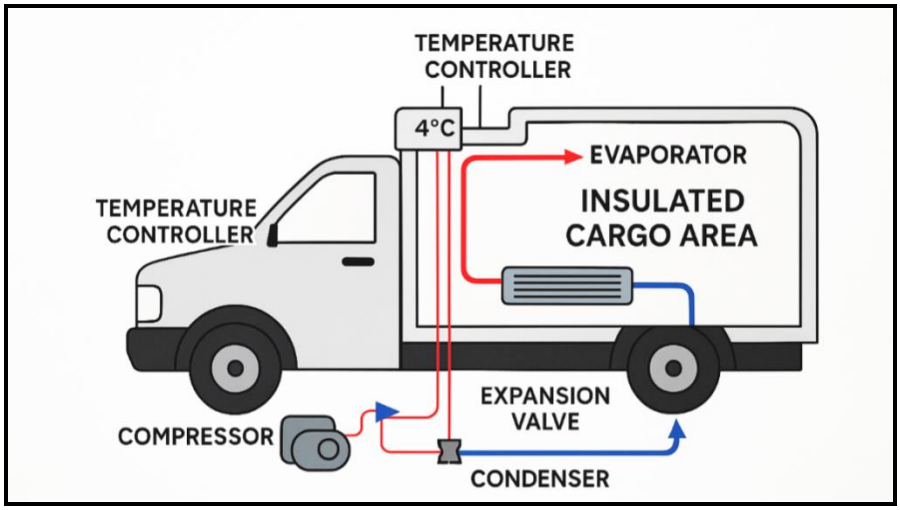


Fig. 6.2: Refrigerated Vehicle System Layout

VII. Experimental Setup

The setup consists of a model or schematic of a refrigerated truck or van. Students will identify each part, observe its location, and understand its function. The model may include a small compressor, condenser, evaporator, control unit, and insulation system.

VIII. Required Resources / Apparatus / Equipment:

S. No.	Name of Resource	Specification	Quantity
1	Model or Diagram of Refrigerated Vehicle	Medium-size or printed layout	01
8	Insulation Sample	PUF or EPS panel	01

X. Procedure:

1. Observe the layout of the refrigerated vehicle and identify key components.
2. Note the position of compressor, condenser, expansion valve and evaporator.
3. Trace the flow of refrigerant through the system.
4. Observe how air is cooled and circulated inside the compartment.
5. Study the insulation material and body structure.
6. Identify the type of refrigerant used.
7. Understand how power is supplied to the refrigeration unit.
8. Discuss the function of the temperature controller.

XI. Observations:

Component	Location	Function	Observation
Compressor			
Condenser			
Expansion Valve			
Evaporator			
Temperature Controller			

Give specification of Typical Refrigerated Vehicle

S. No.	Parameter	Specification / Description
1	Manufacturer	
2	Application	
3	Temperature Range	
4	Refrigeration System	
5	Body Length	
6	Insulation Type	
7	Insulation Thickness	

8	Insulation Density	
9	Structure Material	
10	Compartments	
11	Power Source	
12	Cooling Capacity	
13	Accessories	

XII. Results

XIII. Interpretation of Results

XIV. Conclusions and Recommendations

XV. Practical Related Questions

1. Name four main components of a refrigerated vehicle.
2. Name any four refrigerated vehicle manufacturer.
3. State the important of insulation in refrigerated vehicles.
4. Mention two refrigerants commonly used in vehicle refrigeration.

[Space for Answer]

XVI. References / Suggestions for Further Reading

1. https://www.youtube.com/watch?v=gqM0fAtqu5w
2. https://www.youtube.com/watch?v=gxSw3QysZEY
3. https://www.youtube.com/watch?v=wjt025E7eJg
4. https://www.youtube.com/watch?v=rpgy0BPFApA
5. https://www.youtube.com/watch?v=kAfsOOSXcWU
6. https://www.youtube.com/watch?v=s6WC_jrDEG8

XVII. Rubrics for Assessment Scheme

Performance Indicators		Weightage
Process Related (15 Marks)		**(60**%)
1	Proper Procedure and Use of Tools/Equipment	40%
2	Active Participation and Teamwork	20%
Product Related (10 Marks)		**(40**%)
3	Quality of Report/Record Work	30%
4	Understanding and Results/Conclusion	10%
	Total	**100 %**

Marks Obtained			Dated signature of Teacher
Process Related (15)	**Product Related (10)**	**Total (25)**	

Practical No. 7
Preparation of Report on Data Logger and Simulation Used in Block-chain-Based Cold Chain*

I. Practical Significance

Data loggers and block chain technology are now essential in modern cold chain systems. They help to continuously record, store and verify temperature, humidity, and other critical data for perishable goods. This practical teaches students how smart monitoring ensures product quality and transparency in supply chains.

II. Industry / Employer Expected Outcome(s)

The aim of this course is to help the students to attain the following industry identified outcomes through various teaching learning experiences: Perform activities related to Cold-Chain Management according to requirement such as products, quality, packaging and storage efficiently.

III. Course Level Learning Outcome(s) (CO)

CO3 - Create cost effective sustainable Cold Chain system as per client requirement.

IV. Laboratory Learning Outcome(s)

LLO 7.1 Interpret simulation results and proposes improvements in block chain-based cold chain systems.

LLO 7.2 Prepare a brief report using data obtained under proposed block chain-based improvements.

V. Relative Affective Domain Related Outcome(s)

- Follow safety practices.
- Practice good housekeeping.
- Maintain tools and equipment.
- Follow ethical Practices.

VI. Minimum Theoretical Background

A cold chain is a temperature-controlled supply system that ensures perishable goods like food, vaccines, and pharmaceuticals remain fresh and safe. Two key technologies improving cold chain performance are:

1. **Data Logger** – Measures and records parameters like temperature, humidity, and pressure.
2. **Block-chain Technology** – Provides a secure, tamper-proof digital ledger for sharing cold chain data among multiple stakeholders.

1. Data Logger in Cold Chain

A data logger is a small electronic device used in the cold chain to record important conditions such as temperature and humidity over time. It helps ensure that perishable products like food, medicines and vaccines are stored and transported under proper conditions. The device measures

and stores data automatically at regular time intervals for example every minute or every hour. Data loggers can have built-in sensors or use external probes placed inside cold rooms, refrigerated vehicles or storage boxes. The collected information can be seen on a display screen, downloaded to a computer, or uploaded to the cloud using wireless connections such as Wi-Fi or Bluetooth.

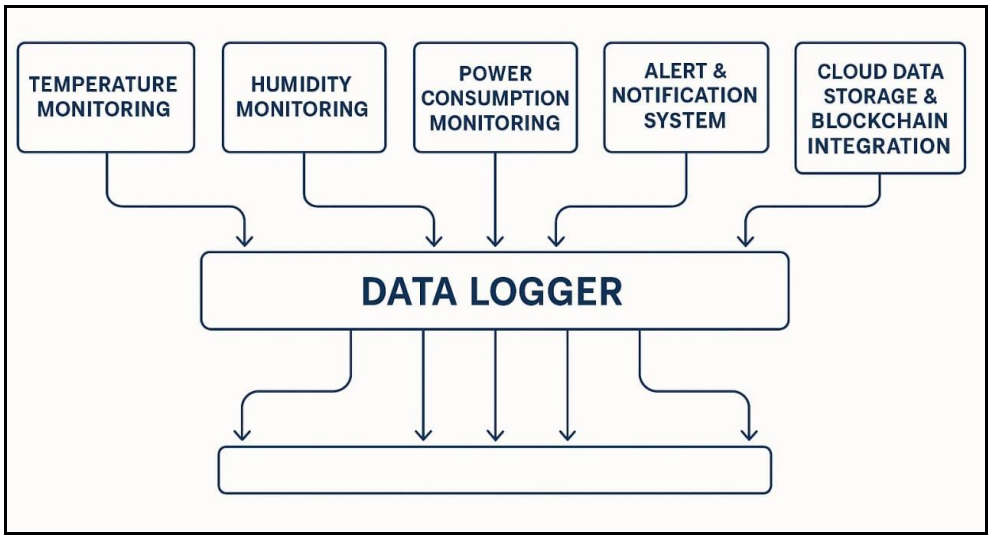


Fig. 7.1: Functions of Data Loggers in Cold Chain Management

2. Block chain in Cold Chain

Block-chain is a special type of digital record system used to store information safely and transparently. It works like an online notebook that everyone can see but no one can easily change. In block-chain, information is stored in small groups called "blocks." Each block contains data such as transactions, time, and a unique code (called a hash) that connects it to the previous block. All these blocks are linked together in a chain — this is why it is called a "block-chain."

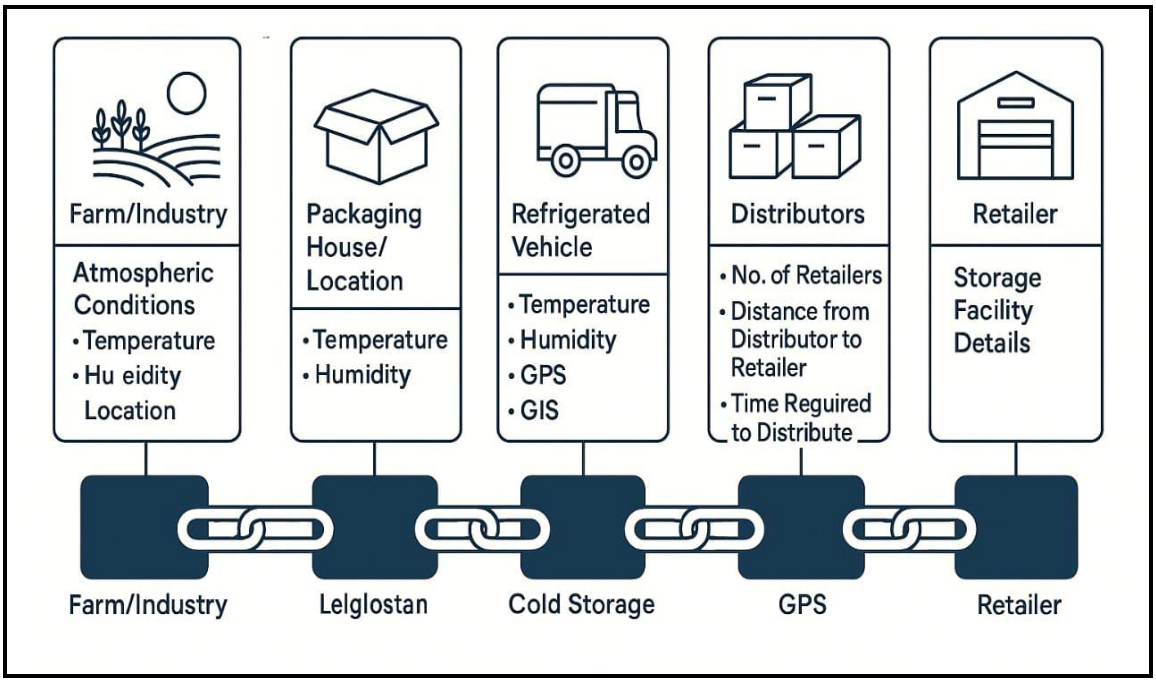


Fig. 7.2: Block-chain in cold chain management

In the **cold chain**, block chain is used to:

1. Verify temperature and humidity data recorded by data loggers.
2. Share verified data among suppliers, transporters and customers.
3. Prevent data manipulation or loss during shipment.

3. Simulation in Cold Chain

Simulation tools such as Thing Speak, Node-RED, IoTIFY IoT-based platforms can be used to model and analyze cold chain operations digitally. They allow virtual testing of sensors, refrigeration systems, and block-chain data transfer without physical setup.

Example Simulation Flow:

1. Input: Temperature and humidity data from sensors.
2. Processing: Data transferred to block-chain.
3. Output: Verified temperature history report.

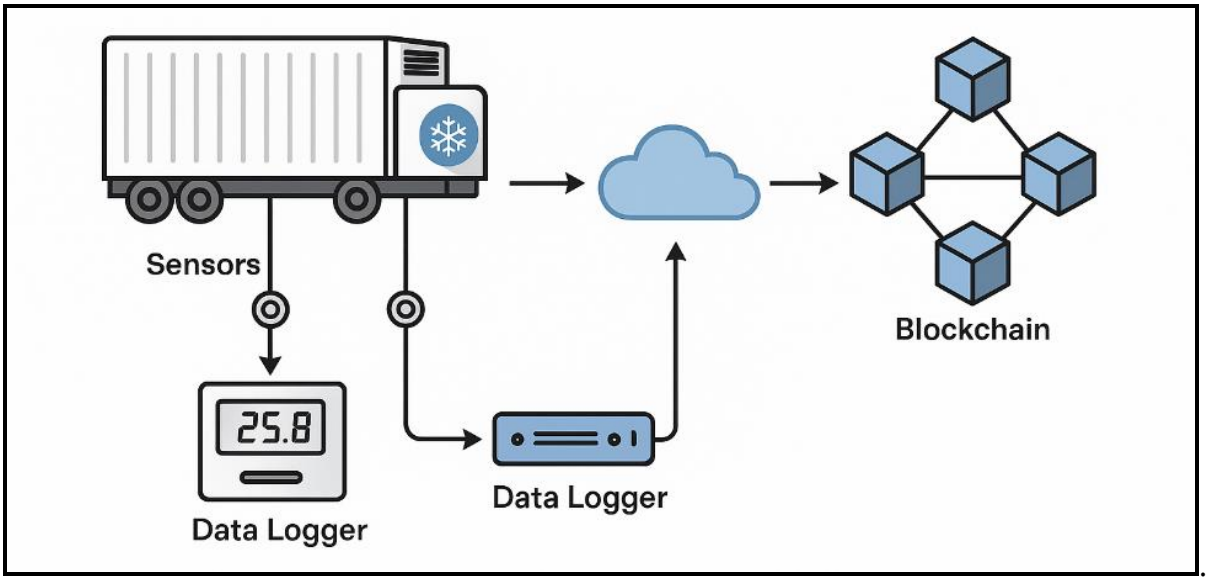


Fig. 7.3: Date Logger and Block-chain integration in cold chain management

VII. Experimental Setup

A small-scale model is used to show how data from sensors is collected, logged, and shared. It includes a temperature sensor, data logger device, and simulation setup. Students prepare a short report explaining data flow and block-chain connection.

VIII. Required Resources / Apparatus / Equipment

S. No.	Name of Resource	Specification	Quantity
1	Computer System	With simulation software (MATLAB / IoT platform)	01
2	Internet Connection	Stable, for cloud data upload	01

IX. Precautions to be Followed

Select the feasible case study to prepare a data logger and block chain diagram

X. Procedure

1. Select product – choose a temperature-sensitive product such as milk or (vaccine/fruits etc)
2. Identify supply chain stages – dairy farm → collection center → processing plant → cold storage → retail shop.
3. Decide monitoring parameters – mainly temperature and humidity.
4. Place sensors – install temperature sensors or data loggers at each stage.
5. Record data continuously – loggers measure temperature at regular time intervals.
6. Connect to IoT gateway – each logger connects through GSM or Wi-Fi.
7. Transmit data to cloud – data automatically uploaded to an online platform.
8. Integrate block chain network – cloud data stored securely in block chain ledger.
9. Create data blocks – each temperature record forms a block in the chain.
10. Ensure data security – block chain prevents alteration or deletion of data.
11. Provide real-time dashboard – managers can view live readings from all stages.
12. Set alert conditions – if temperature exceeds 6°C, automatic alert is sent.
13. Analyse historical data – block chain allows review of full temperature history.
14. Verify product quality – stable temperature ensures milk remains safe and fresh.
15. Draw the block diagram – show stages (farm → retail) with data loggers, IoT gateway, block chain cloud, and dashboard links.

XI. Observations and Calculations

Block diagram (show stages (farm → retail) with data loggers, IoT gateway, block chain cloud, and dashboard links.)

XII. Results

XIII. Interpretation of Results

XIV. Conclusions an d Recommendations

XV. Practical Related Questions

1. Describe the purpose of using data loggers in cold chain systems.
2. Explain – block-chain improve the safety of cold chain data.
3. State parameters are recorded by data loggers.
4. Define the term "data integrity" in the context of block-chain.
5. Name any one simulation tool used for cold chain analysis.

[Space for Answer]

XVI. References / Suggestions for Further Reading

1. https://www.youtube.com/watch?v=qYN7fOZw47s
2. https://www.youtube.com/watch?v=F6MRMpBIszg
3. https://www.youtube.com/watch?v=KSgTRM0AX38
4. https://www.youtube.com/watch?v=7S6rniaLPtQ
5. https://www.youtube.com/watch?v=YG4sp9EVgAew
6. https://www.blockchainappfactory.com/blog/blockchain-in-cold-chain-logistics/

XVII. Rubrics for Assessment Scheme

Performance Indicators		Weightage
Process Related (15 Marks)		**(60**%)
1	Proper Procedure and Use of Tools/Equipment	40%
2	Active Participation and Teamwork	20%
Product Related (10 Marks)		**(40**%)
3	Quality of Report/Record Work	30%
4	Understanding and Results/Conclusion	10%
	Total	**100 %**

Marks Obtained			Dated signature of Teacher
Process Related (15)	**Product Related (10)**	**Total (25)**	

Practical No. 8
Strategies to Optimize Based on Cost Effectiveness Using Identified Cold Chain System.

I. Practical Significance

Cold chain systems are essential for maintaining the quality of temperature-sensitive products such as food, vaccines, and medicines. This practical helps students understand how to design or select a cold chain system that gives maximum performance with minimum operating cost.

II. Industry / Employer Expected Outcome(s)

The aim of this course is to help the students to attain the following industry identified outcomes through various teaching learning experiences: Perform activities related to Cold-Chain Management according to requirement such as products, quality, packaging and storage efficiently.

III. Course Level Learning Outcome(s) (CO)

CO3 - Create cost effective sustainable Cold Chain system as per client requirement.

IV. Laboratory Learning Outcome(s)

LLO 8.1 Select relevant strategy for cost effectiveness of cold chain system using online data.
LLO 8.2 Use suitable strategy for cost effectiveness.

V. Relative Affective Domain Related Outcome(s)

- Follow safety practices.
- Practice good housekeeping.
- Maintain tools and equipment.
- Follow ethical Practices.

VI. Minimum Theoretical Background

A cold chain system is a temperature-controlled supply chain that includes all equipment and processes used to maintain a specific temperature range for perishable products. It consists of cold storage, refrigerated transport, and distribution systems.

Cost optimization in a cold chain means achieving maximum efficiency with minimum cost**,** without compromising product safety and quality.

Types of Cold Chain Systems

1. **Refrigerated Vehicles** – Used for transporting goods at controlled temperatures.
2. **Cold Storage Rooms** – For large-scale storage of food or pharmaceuticals.
3. **Portable Refrigeration Units** – For smaller consignments and short-term use.
4. **Hybrid or Solar-Powered Cold Chains** – For energy-efficient and sustainable operations.

Factors Affecting Cost in Cold Chain Systems:

S. No.	Factor	Description
1	Energy Consumption	Power required for compressors, fans, and lighting.
2	Insulation Quality	Better insulation reduces cooling losses and power cost.
3	Refrigerant Type	Eco-friendly refrigerants may reduce energy use but increase installation cost.
4	Equipment Efficiency	Use of inverter compressors or variable speed drives lowers cost.
5	Maintenance	Regular servicing prevents breakdowns and energy waste.
6	Transportation Distance	Longer routes increase fuel and cooling cost.
7	Product Load	Higher load requires more cooling energy.

Example of Cost Optimization Scenario:

Parameter	Before Optimization	After Optimization
Power Consumption (kWh/day)	150	110
Temperature Set-point	-20°C	-15°C
Fuel Used (litres/day)	20	15
Maintenance Cost (per month)	Rs. 8,000	Rs. 5,000
Product Wastage	5%	2%

Cost Saving: Approx. 25% reduction in total operating cost.

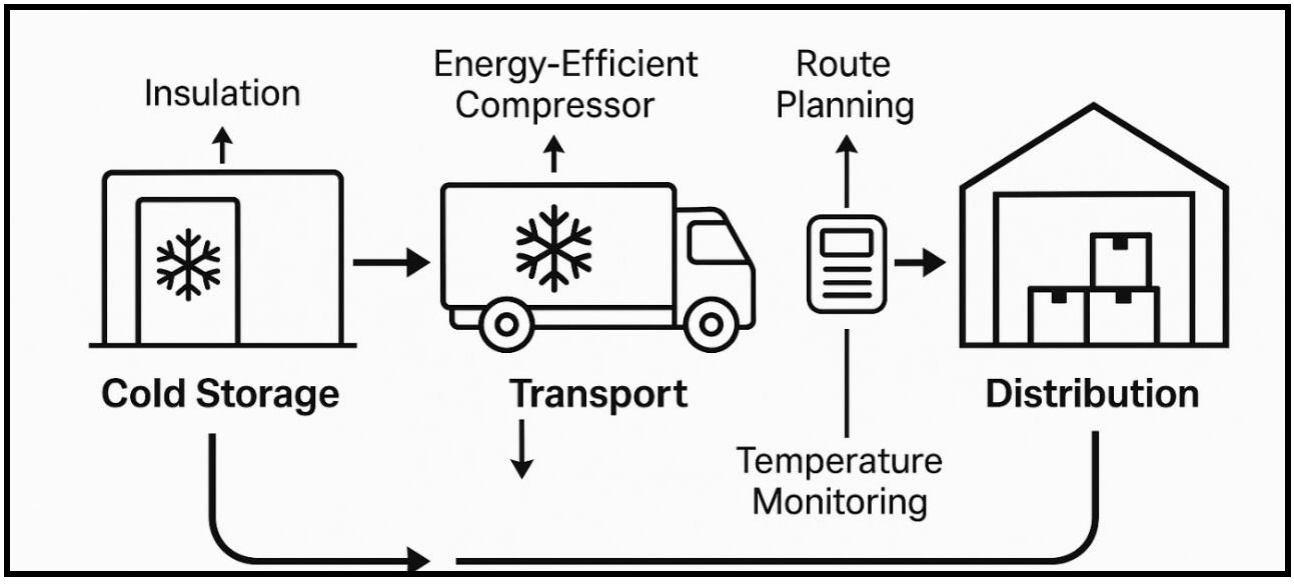


Fig. 8.1: Cold Chain System Cost Optimization Flow

VII. Experimental Setup

The experiment can be performed using a cold storage model or simulation software. Students analyze various cost components, identify areas of high energy use, and apply optimization strategies like improved insulation, temperature control, or use of energy-efficient devices.

As we know various costs optimization scenarios like quality of insulation, equipment efficiency, maintenance of system Product load, Refrigerant Type but here we are taking cost comparison using only effect of Product load on power consumption.

VIII. Required Resources / Apparatus / Equipment:

S. No.	Name of Resource	Specification	Quantity
1	Data of various temperature sensitive product	Use ASHRAE Data or any standard data	01

IX. Precautions to be followed:

1. Avoid overloading the storage unit.
2. Ensure doors are properly closed during operation.
3. Record data after stable temperature is achieved.

X. Procedure:

1. Selected milk as the product for study.
2. Observed the complete supply chain – from dairy farm to retail shop.
3. Noted the stages: collection → chilling → transportation → storage → retail.
4. Found that temperature should be maintained between 2°C to 6°C.
5. Identified equipment used: milk chiller, insulated tanker, cold room, display refrigerator.
6. Recorded energy source used – mainly electricity and diesel.
7. Collected approximate cost data for each stage (fuel, power, maintenance).
8. Observed that transport and storage consumed maximum power.
9. Suggested use of solar panels to reduce diesel cost.
10. Recommended using data loggers for automatic temperature monitoring.
11. Proposed IoT and GPS tracking to reduce product loss and fuel waste.
12. Compared present system cost with improved (optimized) system.
13. Found that energy-efficient compressors can save around 15–20% power.
14. Drew a block diagram showing the flow of milk and monitoring system.
15. Concluded that combining data monitoring, insulation improvement and renewable energy gives best cost-effective results.

XI. Observation Table

Stage	Temperature (^{O}C)	Main cost Source (Example- Electricity, Petrol, Diesel, Man power)	Alternative options main cost source OR Improvement in available main cost source
Collection center			
Transport vehicle			
Storage plant			
Retail outlet			

XII. Results:

XIII. Interpretation of Results:

XIV. Conclusions and Recommendations

XV. Practical Related Questions

1. List the main factors affecting cost in a cold chain system.
2. Explain the importance of insulation in energy efficiency.
3. Name two methods for cost optimization in cold chain operations.
4. Describe the role of data loggers in cost analysis.

[Space for Answer]

XVI. References / Suggestions for Further Reading

1. https://www.youtube.com/watch?v=_TWhbvCeK7M
2. https://www.youtube.com/watch?v=bckpGFFvD4U
3. https://www.ashrae.org/
4. https://www.blockchainappfactory.com/blog/blockchain-in-cold-chain-logistics/
5. https://www.youtube.com/watch?v=tz8Sx0QcgYE
6. https://www.youtube.com/watch?v=Jzc2jo0ypns
7. https://www.youtube.com/watch?v=a0fg0o6MCxE
8. https://www.youtube.com/watch?v=tVhxA9_TAAc

XVII. Rubrics for Assessment Scheme

Performance Indicators		Weightage
Process Related (15 Marks)		**(60**%)
1	Proper Procedure and Use of Tools/Equipment	40%
2	Active Participation and Teamwork	20%
Product Related (10 Marks)		**(40**%)
3	Quality of Report/Record Work	30%
4	Understanding and Results/Conclusion	10%
	Total	**100 %**

Marks Obtained			Dated signature of Teacher
Process Related (15)	**Product Related (10)**	**Total (25)**	

Practical no. 9
Inspection of a cold chain vehicle

I. Practical Significance:

This Practical helps students understand the working and inspection of cold chain vehicles. It develops skills to check refrigeration systems, insulation, and temperature control for safe transport of perishable goods.

II. Industry/Employer Expected Outcome(s):

Perform activities related to Cold-Chain Management according to requirement such as products, quality, packaging and storage efficiently.

III. Course Level Learning Outcome(s) (CO):

CO1 - Interpret the significance and components of the Cold Chain Management in various industries

IV. Laboratory Learning Outcome(s):

LLO 9.1: Prepare check list for inspection of cold chain vehicle.
LLO 9.2: Use check list for inspection of cold chain vehicle.

V. Relative Affective Domain related Outcome(s):

- Develop responsibility and safety awareness.
- Show teamwork and professional attitude.
- Take interest and care during inspection work.

VI. Relevant Theoretical Background with diagram (if required):

A cold chain vehicle is specially designed to transport temperature-sensitive products such as food, vaccines, and medicines. It is equipped with an insulated body and a refrigeration unit to maintain the required temperature during transport.

Main components:

a) Refrigeration unit – Provides cooling.
b) Insulated body – Prevents heat gain from outside.
c) Temperature sensors and data logger – Monitor and record temperature.
d) Power supply system – Runs the refrigeration unit (engine-driven or external).

Key Components Detail:

a) **Insulated Body:** The box or container is built with thick, non-metallic insulation (often foam or fibreglass panels) to minimize heat gain from the environment (Conduction).
b) **Refrigeration Unit (Reefer Unit):** Contains the compressor, condenser, and other components of the refrigeration system. It is powered by its own engine or the vehicle's engine.
c) **Evaporator:** Located inside the cargo area, this is where heat is absorbed from the air (cooling the space).

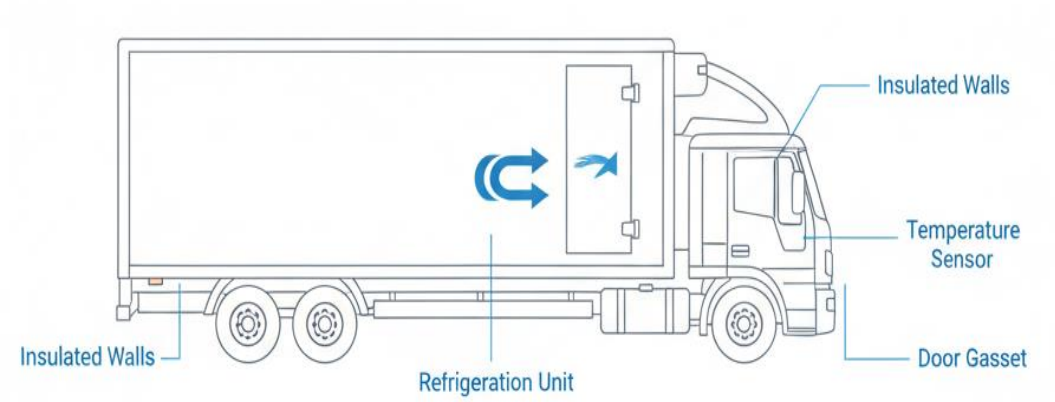


Fig. 9.1: Configuration of Cold Chain Vehicle

d) **Air Return & Supply Vents:** Ductwork and floor/wall channels designed to move cold air from the evaporator over the cargo and return warm air back to the evaporator, ensuring uniform temperature (Convection management).

e) **Temperature Sensor/Probe:** Installed inside the cargo area to continuously measure the air temperature.

f) **Data Logger & Telematics Unit:** Records temperature readings over the entire journey for quality assurance and regulatory compliance. It often includes GPS for real-time location and **temperature tracking.**

g) **Door** Seals and Latches: Essential for creating an airtight barrier to prevent ambient air intrusion when the doors are closed.

VII. Experimental setup:

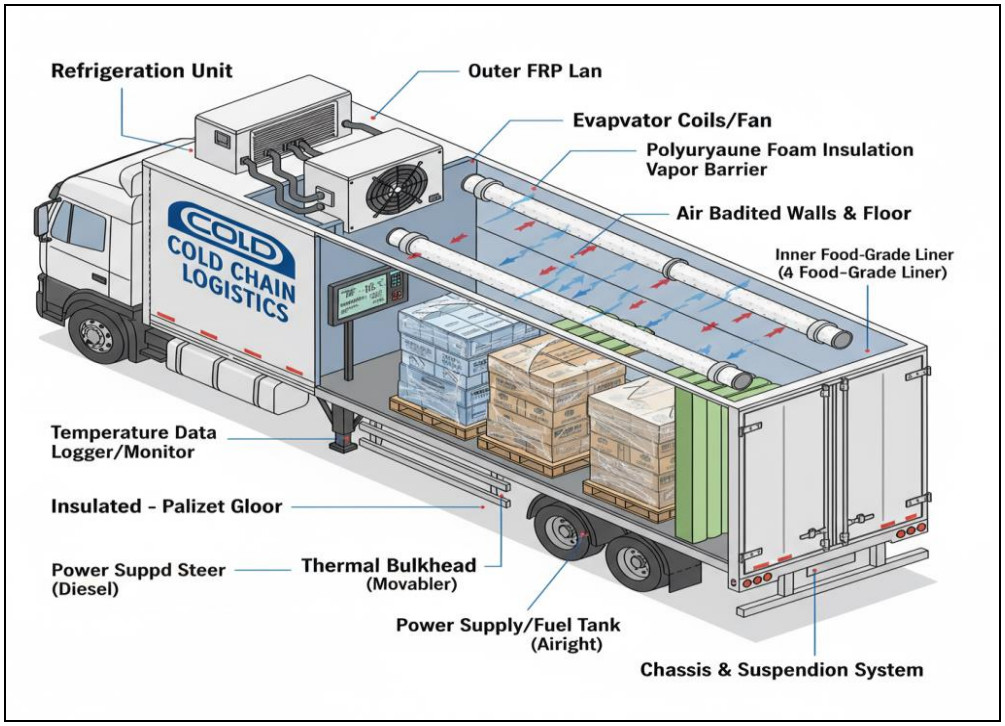


Fig. 9.1: Key Component Details of Cold Chain Vehicle

VIII. Required Resources /Apparatus/Equipment with specifications:

S. No.	Name of Equipment / Apparatus	Specification / Description	Quantity
1	Model or Cut-section of Cold Chain Vehicle	Shows insulated body and refrigeration unit	01
2	Refrigeration System Demonstration Unit	Compressor, condenser, evaporator, fan, and controls	01
3	Thermometer / Digital Temperature Sensor	Range: –20°C to +50°C, Accuracy: ±0.5°C	01
4	Data Logger / Temperature Recorder	Multi-channel, 0–50°C range	01
5	Sample Insulation Material	To study thickness and thermal properties	01
6	Tool Kit	Spanners, screwdrivers, pliers, etc.	01
7	Inspection Checklist	For recording observations and evaluation	01

IX. Precautions to be Followed:

a) Handle model or demo unit carefully.
b) Avoid damaging sensors or insulation samples.
c) Record observations accurately.
d) Follow safety instructions during demonstration or simulation.

X. Procedure:

Procedure to Prepare an Inspection Checklist for a Cold Chain Vehicle

1. Identify Key Components:
   a. Refrigeration unit (compressor, condenser, evaporator)
   b. Insulated body and doors
   c. Temperature sensors and data loggers
   d. Electrical connections and power supply
2. Define Inspection Parameters:
   a. Temperature at different points
   b. Pressure readings (suction/discharge)
   c. Condition of insulation and doors
   d. Cleanliness and hygiene
   e. Functioning of fans, alarms, and controls
3. Set Observation Format:
   a. Create columns for component, parameter, observed value, standard/expected value, and remarks.
4. Include Safety Checks:
   a. PPE usage, handling of refrigerants, and power supply safety
5. Number the Items Sequentially:
   a. Helps in systematic inspection and recording

6. Review and Finalize:
    a. Ensure all critical points are covered
    b. Make the checklist clear, simple, and easy to use during inspection

XI. Observations:

Note: Students refer above procedure points to mention different item to be checked in following observation table

Parameters	Items to be checked	Satisfactory condition	
		YES	NO
Key Components (components of Refrigeration system)	1.		
	2.		
	3.		
	4.		
	5.		
Inspection Parameters	1.		
	2.		
	3.		
	4.		
	5.		
Safety Checks points	1.		
	2.		
	3.		
	4.		
	5.		
FINAL RESULT:	SATISFACTORY FOR LOADING		
Remarks			

XII. Results:

XIII. Interpretation of Results

XIV. Conclusions and Recommendation

XV. Practical Related Questions

Note: Below given are few sample questions for reference. Teachers must design more such questions so as to ensure the achievement of identified CO.

1. Write the environmental impact of refrigerant leakage from cold chain vehicles.
2. Explain the role of insulation materials and their thermal conductivity in maintaining temperature.
3. State different types of refrigerants used in transport refrigeration.
4. Describe the maintenance schedule recommended for a cold chain vehicle.
5. Explain the importance of checklists in preventive maintenance.

[Space for Answer]

XVI. References / Suggestions for Further Reading

1. https://youtu.be/r_0mn1GLabE?si=DbHGHms2NtfO3ojv
2. https://youtu.be/CyIwn7qEoy0?si=f2d_wEot_fYIiwDq
3. https://youtu.be/HQA3Tk09mWs?si=gi9edXwkLUepxCH6
4. https://youtu.be/HQA3Tk09mWs?si=FbewvqD7jmX24YWt
5. https://youtu.be/oQyGXqVfBj8?si=f0OvvGzTBDdxLqpf

XVII. Rubrics for Assessment Scheme

Performance Indicators		Weightage
Process Related (15 Marks)		**(60**%)
1	Preparation of Check list	40%
2	Observation and use of checklist	20%
Product Related (10 Marks)		**(40**%)
3	Results	20%
4	Interpretation of result and conclusion	10%
5	Practical related questions	10%
	Total	**100 %**

Marks Obtained			Dated signature of Teacher
Process Related (15)	**Product Related (10)**	**Total (25)**	

Practical No. 10.
Comparison of rotting of perishable food with and without refrigerator.

I. Practical Significance:

This practical helps students understand the importance of refrigeration in slowing down food spoilage. It shows how low temperature preserves perishable items by reducing bacterial activity and maintaining food quality for a longer time.

II. Industry/Employer Expected Outcome(s):

Perform activities related to Cold-Chain Management according to requirement such as products, quality, packaging and storage efficiently.

III. Course Level Learning Outcome (CO):

CO1 - Interpret the significance and components of the Cold Chain Management in various industries.

CO2 - Choose appropriate Cold Chain Packaging Techniques and Storage Systems for different applications.

IV. Laboratory Learning Outcome(s):

LLO 10.1 Inspect the changes in texture, color and odor over time due to storage conditions.

LLO 10.2 Compare the spoilage process of perishable food in different storage conditions.

V. Relative Affective Domain Related Outcome(s):

- Develop awareness about food preservation and hygiene.
- Show responsibility while handling perishable items.
- Follow safety and cleanliness during practical work.

VI. Relevant Theoretical Background (with Diagram):

Perishable foods such as milk, fruits, and vegetables spoil quickly due to microbial activity (bacteria and fungi) and enzymatic reactions at normal room temperature. Refrigeration slows down these activities by lowering the temperature, thereby increasing the shelf life of food products.

At low temperatures (0–5°C):

1. Microbial growth slows down.
2. Chemical and enzymatic reactions occur more slowly.
3. Food retains its freshness, color, and texture longer.

At room temperature (25–30°C):

1. Microorganisms multiply rapidly.
2. Food spoils faster due to fermentation and decay.

VII. Experimental Setup:

With Refrigeration **Without Refrigeration**

Fig. 10.1: Comparison of rotting of perishable food with and without refrigerator

VIII. Required Resources / Apparatus / Equipment:

S. No.	Item / Equipment	Specification / Description	Quantity
1	Perishable food samples (e.g., milk, fruits, vegetables)	Identical type and quantity	02
2	Refrigerator	Maintains temperature around 4°C	01
3	Containers	Clean, airtight, identical for both samples	02
4	Thermometer / Digital temperature sensor	Range: 0°C to 50°C	01
5	Observation sheet / Record chart	For noting changes daily	01
6	Timer / Calendar	For tracking observation duration	01
7	Personal protective equipment (PPE)	Gloves, apron, mask	As required
8	Waste disposal bin	For safe disposal of spoiled food	01

IX. Precautions to be Followed

1. Use fresh and identical food samples for accurate comparison.
2. Keep containers clean and covered to avoid contamination.
3. Do not touch samples frequently during observation.
4. Maintain constant temperature in the refrigerator.
5. Record observations daily at the same time.
6. Dispose of rotten samples safely to prevent odor or infection.

X. Procedure:

1. Select a perishable food item such as milk, fruit, or vegetable.
2. Divide it into two equal samples of the same type and quantity.
3. Place one sample in the refrigerator (around 4°C).
4. Keep the second sample at room temperature (around 25–30°C).
5. Use identical containers for both samples to ensure fair comparison.
6. Observe both samples daily for changes in color, smell, texture, or mold formation.
7. Record all findings in the observation table.
8. Continue the observation until clear signs of spoilage or rotting appear.
9. Compare the number of days each sample takes to rot.
10. Conclude how temperature affects the rate of food spoilage.

XI. Observations:

S. No.	Parameter	Inside Refrigerator (≈4°C)	Outside Refrigerator (≈25–30°C)
1	Appearance		
2	Smell		
3	Texture		
4	Color		
5	Mold Growth		
6	Condition		
7	Overall Result		

XII. Results:

XIII. Interpretation of Results:

XIV. Conclusions and Recommendation:

XV. Practical Related Questions

Note: Below given are few sample questions for reference. Teachers must design more such questions so as to ensure the achievement of identified CO.

1. List the factors that influence the rate of food spoilage.
2. Explain refrigeration helps in extending the shelf life of food.
3. Discuss the importance of hygiene and cleanliness in food preservation.
4. Explain how frequent door opening affects cooling efficiency.
5. Write importance of this experiment relates to cold chain management in industry.

[Space for Answer]

XVI. References / Suggestions for Further Reading

1) https://youtu.be/ZkMaO-zUrf4?si=f0S58BA5QAhs8Moz
2) https://youtu.be/tuacmQVHnN4?si=B6nz3h-awAcm_wiB
3) https://youtu.be/M5qAR0FMGs0?si=nSpI96NccuL1EOqr
4) https://youtu.be/P5lu-dq7agI?si=JQZ7ouIg5y0eUyX1

XVIII. Rubrics for Assessment Scheme

Performance Indicators		Weightage
Process Related (15 Marks)		**(60**%)
1	Handling of the measuring Instruments	40%
2	Final Observations	20%
Product Related (10 Marks)		**(40**%)
3	Results	20%
4	Interpretation of result and conclusion	10%
5	Practical related questions	10%
	Total	**100 %**

Marks Obtained			Dated signature of Teacher
Process Related (15)	**Product Related (10)**	**Total (25)**	

Practical No. 11
Make use of Cold Chain Monitoring Tools*

I. Practical Significance

This practical helps students understand how cold chain monitoring tools are used to track and maintain temperature and humidity during the storage and transport of perishable goods. It highlights the importance of continuous monitoring for product safety and quality.

II. Industry/Employer Expected Outcome(s)

Perform activities related to Cold-Chain Management according to requirement such as products, quality, packaging and storage efficiently.

III. Course Level Learning Outcome (CO)

CO4 - Apply appropriate Operations, Monitoring and Risk Management Strategies in Cold Chain

IV. Laboratory Learning Outcome(s)

LLO 11.1 Identify Cold Chain Monitoring Tools.

LLO 11.2 Use Cold Chain Monitoring Tools.

V. Affective Domain Related Outcome(s):

- Develop responsibility for handling monitoring equipment carefully.
- Show accuracy and honesty while recording temperature data.
- Demonstrate awareness about maintaining product safety in the cold chain.

VI. Relevant Theoretical Background (with Diagram):

Cold chain monitoring tools are devices that record and display temperature and humidity of storage or transport environments. Common tools include data loggers, thermometers, and temperature indicators. These tools help detect deviations from required temperature ranges and prevent product spoilage.

VII. Experimental Setup:

Fig. 11.1: Data logger for Temperature and Humidity measurement

VIII. Required Resources /Apparatus/Equipment with specification

S. No.	Equipment / Tool	Description / Specification	Quantity
1	Digital Thermometer	Range: –20°C to +50°C	01
2	Data Logger	Multi-channel, USB/Bluetooth enabled	01
3	Temperature Indicator / RFID Sensor	Used for transport monitoring	01
4	Refrigerator / Cold Box	For maintaining low temperature	01
5	Hygrometer	Humidity measurement	01
6	Observation Sheet	For recording temperature data	01
7	PPE	Gloves, apron, safety shoes	01

IX. Precautions to be followed:

1. Handle all instruments carefully.
2. Ensure sensors are properly placed for accurate readings.
3. Calibrate devices before use.
4. Avoid opening the cold storage frequently.

X. Procedure:

1. Identify and understand the function of each monitoring tool.
2. Place sensors or data loggers inside the refrigerator or cold box.
3. Set desired temperature range on the device.
4. Record temperature and humidity readings at fixed intervals.
5. Observe any deviation from the set range.
6. Download and analyze the recorded data.
7. Write a result showing temperature trends and system performance.

XI. Observations:

Time	Set Temperature (°C)	Actual Temperature (°C)	Humidity (%)	Remarks
20 min				
40 min				
60 min				
80 min				

XII. Results

XIII. Interpretation of Results

XIV. Conclusions and Recommendation

XV. Practical Related Questions

Note: Below given are few sample questions for reference. Teachers must design more such questions so as to ensure the achievement of identified CO.

1. Mention importance of continuous monitoring in a cold chain.
2. State the function of sensors used in cold chain monitoring.
3. Write the importance of calibration in monitoring instruments.
4. State the role of insulation in maintaining cold chain efficiency.
5. Mention industries where cold chain monitoring is essential.

[Space for Answer]

XVI. References / Suggestions for Further Reading

1) https://youtu.be/F3aFndZaWZA?si=-RBfkDGWAZtB6TQC
2) https://youtu.be/mJrIyg8WtuM?si=DS6X0pvQtegMeYVN
3) https://youtu.be/XudeO8wYMt0?si=fHW8uQIpSnpr9rUa
4) Tools for Monitoring Cold-Chain Equipment Data

XVII. Rubrics for Assessment Scheme

Performance Indicators		Weightage
Process Related (15 Marks)		**(60%)**
1	Handling of the measuring Instruments	40%
2	Observations	20%
Product Related (10 Marks)		**(40%)**
3	Result	20%
4	Interpretation of result	10%
5	Practical related questions	10%
	Total	**100 %**

Marks Obtained			**Dated signature of Teacher**
Process Related (15)	**Product Related (10)**	**Total (25)**	

Practical No. 12
Pradhan Mantri Kisan Sampada Yojana (PMKSY)*

I. Practical Significance:

This practical helps students understand how the PM Kisan SAMPADA Yojana supports the development of food processing and cold chain infrastructure in India. It connects engineering applications with government initiatives for reducing food wastage and promoting entrepreneurship.

II. Industry/Employer Expected Outcome(s):

Perform activities related to Cold-Chain Management according to requirement such as products, quality, packaging and storage efficiently.

III. Course Level Learning Outcome (CO)

CO5 - Use the regulatory frameworks, policies and best practices that ensure efficient and environmentally sustainable Cold Chain Management

IV. Laboratory Learning Outcome(s)

LLO 12.1 Prepare report on relevant data from government reports, official websites, and research papers.

LLO 12.2 Analyze statistical data related to PMKSY funding, beneficiaries, and impact assessment.

V. **Relative Affective Domain related Outcome(s):**

- Develop awareness about national programs for farmers and industries.
- Show interest in applying technical knowledge for rural development.
- Demonstrate responsibility towards reducing food loss through technology.

VI. Relevant Theoretical Background (with Diagram):

The Pradhan Mantri Kisan SAMPADA Yojana (PMKSY) is a government initiative under the Ministry of Food Processing Industries (MoFPI) aimed at creating a modern infrastructure for food processing and cold chain management.

Key Components:

1. Mega Food Parks
2. Integrated Cold Chain and Value Addition Infrastructure
3. Creation/Expansion of Food Processing Units
4. Agro-Processing Clusters
5. Operation Greens
6. Food Testing Labs
7. Backward & Forward Linkages

VII. Experimental Setup (If Conducted as Study or Model-Based Practical):

Fig. 12.1: Salient Features of PMKSY

a) Refer report on relevant data from government reports, official websites, and research papers.
b) Analyze statistical data related to PMKSY funding, beneficiaries, and impact assessment.

VIII. Required Resources /Apparatus/Equipment with specification

S. No.	Equipment / Resource	Description / Use	Quantity
1	PMKSY Scheme Brochure /Document	For reference and study	01
2	Laptop / Projector	For presentation or data analysis	01
3	Chart / Model	To show cold chain process under PMKSY	01
4	Case Study / Report	Example of PMKSY-supported food park	01

IX. Precautions to be followed:

a) Use authentic government sources for scheme details.
b) Present data and facts accurately.
c) Avoid assumptions not supported by official references.
d) Ensure proper citation of sources.

X. Procedure:

1. Refer Website sampada-mofpi.gov.in
2. State the objectives of PMKSY.
3. Name the components of PMKSY.
4. Discuss about highlights of Cold Chain Unit and Mega Food Park.
5. Discuss the impact of PMKSY on food preservation and farmer income.
6. Describe the procedure applying for PMKSY.

XI. Observations:

S. No.	Component	Description
1	Mega Food Park	Cluster-based infrastructure
2	Cold Chain	Temperature-controlled storage
3	Agro Processing Units	Value addition
4	Operation Greens	Price stabilization

XII. Results:

S. No.	Component	Benefit to Industry/Farmers/society
1	Mega Food Park	
2	Cold Chain	

XIII. Interpretation of Results

XIV. Conclusions and Recommendation

XV. Practical Related Questions

Note: Below given are few sample questions for reference. Teachers must design more such questions so as to ensure the achievement of identified CO.

1. State the role of public–private partnership in PMKSY projects.
2. Write challenges faced in implementation of PMKSY.
3. Explain the procedure applying for PMKSY.
4. Mention the financial institutions involved in funding PMKSY projects.

[Space for Answer]

XVI. References / Suggestions for Further Reading

1) Welcome to MOFPI Scheme Management System (sampada-mofpi.gov.in)
2) https://youtu.be/bGC0TbjsZD0?si=j75TVrskTXcg_YIz
3) https://youtu.be/U5XQSrkBf54?si=OOY-5Nf7bEUkeFw1
4) https://youtu.be/-9u68mAxXuo?si=0jnlN4YVy_nanfxB

XVII. Rubrics for Assessment Scheme

Performance Indicators		Weightage
Process Related (15 Marks)		**(60%)**
1	Study of official Website PMKSY	40%
2	Observation of Key components of PMKSY	20%
Product Related (10 Marks)		**(40%)**
3	Result	20%
4	Interpretation of result	10%
5	Practical related questions	10%
	Total	**100 %**

Marks Obtained			Dated signature of Teacher
Process Related (15)	**Product Related (10)**	**Total (25)**	

Practical No. 13
Retrofitting Older Cold Chain Infrastructure with Sustainable Technologies

I. Practical Significance:

This Practical helps students understand how old cold chain systems can be upgraded using modern, energy-efficient, and eco-friendly technologies to improve performance, reduce power consumption, and lower environmental impact.

II. Industry/Employer Expected Outcome(s):

Perform activities related to Cold-Chain Management according to requirement such as products, quality, packaging and storage efficiently.

III. Course Level Learning Outcome (CO):

CO1 - Interpret the significance and components of the Cold Chain Management in various industries.

CO2 - Choose appropriate Cold Chain Packaging Techniques and Storage Systems for different applications.

CO3 - Create cost effective sustainable Cold Chain system as per client requirement.

CO4 - Apply appropriate Operations, Monitoring and Risk Management Strategies in Cold Chain.

CO5 - Use the regulatory frameworks, policies and best practices that ensure efficient and environmentally sustainable Cold Chain Management

IV. Laboratory Learning Outcome(s):

LLO 13.1: Use data loggers and sensors to monitor energy consumption and temperature stability before and after retrofitting in given situation.

LLO 13.2: Apply Sustainable Retrofitting Techniques in given situation.

V. Relative Affective Domain related Outcome(s):

- Develop a responsible attitude toward energy conservation.
- Show awareness about environmental sustainability in engineering applications.
- Demonstrate teamwork and interest in green technologies.

VI. Relevant Theoretical Background with diagram (if required):

Retrofitting means upgrading existing cold storage systems to enhance their efficiency and reduce carbon emissions.

Common sustainable retrofit technologies include:

a) Variable Frequency Drives (VFDs)
b) Energy-efficient compressors and fans
c) Natural refrigerants (like ammonia, CO_2 , or hydrocarbons)
d) Solar-assisted refrigeration systems
e) Advanced insulation materials.

VII. Experimental Setup (Study/Model-Based):

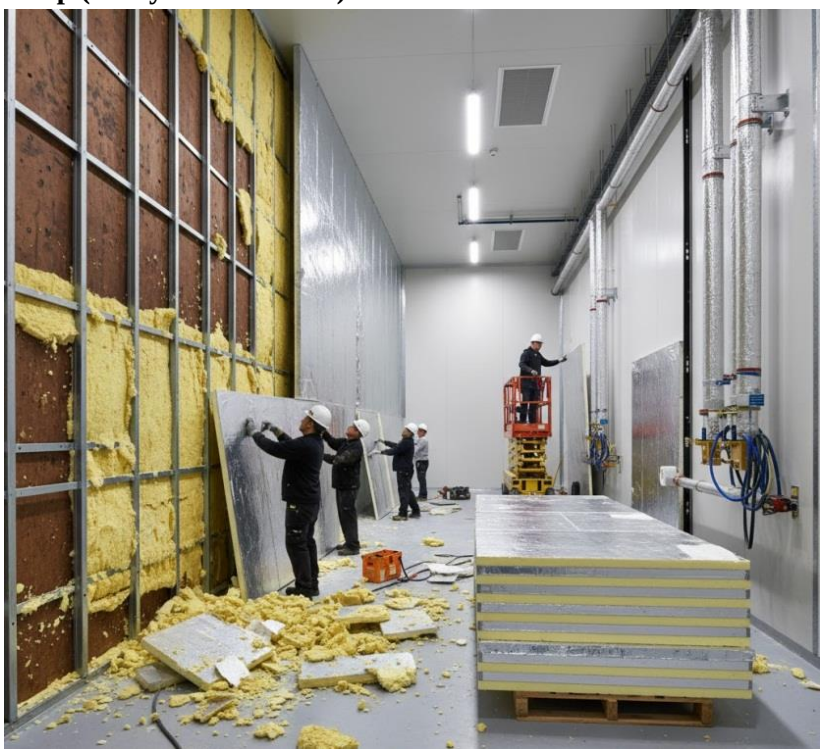


Fig. 13.1: Common sustainable retrofit technologies at a Glance

VIII. Required Resources /Apparatus/Equipment with specification:

S. No.	Equipment / Resource	Specification / use	Quantity
1	Thermometer / Digital Temperature Logger	Range: –40°C to +50°C, to note temperature readings	01
2	Hygrometer / Digital RH Meter (Optional)	Range: 0–100% RH, for humidity measurement	01
3	ICT Tools	For studying sustainable retrofit technologies after data collection	01
4	Measuring Tape	0–5 meter / 0–10 meter, for measuring room dimensions, wall thickness	01

X. Precautions to be followed:

1. Listen carefully to the instructions given by the teacher or plant supervisor.
2. Use instruments and tools carefully
3. Use eco-friendly materials and certified tools.
4. Follow all safety rules, signboards, and warning instructions.

IX. Procedure:

Students should study existing cold storage/ Ice plant/ any suitable refrigerating system and record technical and visual observations as per the following steps.

1. Facility details:
   a) Type of plant

b) Capacity (tonnes / m^3)
c) Age of plant (years)
d) Operating temperature
e) Operating hours per day

2. Insulation Condition
   a) Insulation material
   b) Thickness of insulation (if known)
   c) Condition of door seal (any gaps, moisture, fungus)
   d) Presence of air curtains
3. Type of system
   a) Compressor type and make
   b) Refrigerant used
   c) Evaporator coil condition
   d) Condenser condition
   e) Leakage signs
4. Operating Practices
   a) Door opening frequency
   b) Loading/unloading practices
   c) Lighting type

XI. Observations:

S. No.	Inspection Parameter	Observations (Present Condition)	Remark (Good/Average /Satisfactory)
1	Insulation condition		
2	Door gasket & sealing		
3	air curtain		
4	Evaporator coil cleanliness		
5	Condenser cleanliness		
6	Refrigerant leakage signs		
7	Lighting type		
8	Temperature variation inside room		
9	Humidity level		

X. Results:

S. No.	Area	Problem Noted	Suggested Retrofit
1	Insulation		
2	Door section		
3	Refrigeration compressor		
4	Condenser		
5	Evaporator		
6	Refrigerant		
7	Lighting		
8	Renewable		

XIII. Interpretation of Results:

XIV. Conclusions and Recommendation:

XV. Practical Related Questions

Note: Below given are few sample questions for reference. Teachers must design more such questions so as to ensure the achievement of identified CO.

1. Mention examples of sustainable technologies used in cold chain retrofitting.
2. State how insulation improvement affects energy efficiency.
3. Mention the importance of energy audits in retrofit planning.
4. Mention two safety measures to be followed during refrigerant replacement.
5. Mention two benefits of predictive maintenance in retrofitted systems.
6. Mention two challenges faced during retrofitting of old units.

[Space for Answer]

XII. **References / Suggestions for Further Reading**

1) 4 Emerging Innovations for Sustainable Refrigeration in Cold Chain Logistics - ISHRAE Refcold India
2) Cold Chain | Ministry of Food Processing Industries | GOI
3) https://www.mofpi.gov.in/en/Schemes/cold-chain
4) https://nccd.gov.in/

XIII. **Rubrics for Assessment Scheme**

Performance Indicators		**Weightage**
Process Related (15 Marks)		**(60%)**
1	Technical and visual data collection	40%
2	Observations and remarks	20%
Product Related (10 Marks)		**(40%)**
3	Result and Interpretation of result	30%
4	Practical related questions	10%
	Total	**100 %**

Marks Obtained			**Dated signature of Teacher**
Process Related (15)	**Product Related (10)**	**Total (25)**	

Practical No. 14
Cold Chain Technology in Medical Emergency-
(Case Study of Covid 19 for Vaccine)*

I. Practical Significance:

This practical helps students understand how cold chain technology ensures the safe storage, transportation, and distribution of temperature-sensitive medical products like vaccines. It highlights the crucial role of refrigeration, insulation, and monitoring systems during the COVID-19 pandemic.

II. Industry/Employer Expected Outcome(s):

Perform activities related to Cold-Chain Management according to requirement such as products, quality, packaging and storage efficiently.

III. Course Level Learning Outcome (CO):

CO1- Interpret the significance and components of the Cold Chain Management in various industries.

CO2 - Choose appropriate Cold Chain Packaging Techniques and Storage Systems for different applications.

CO3 - Create cost effective sustainable Cold Chain system as per client requirement.

CO4 - Apply appropriate Operations, Monitoring and Risk Management Strategies in Cold Chain.

CO5 - Use the regulatory frameworks, policies and best practices that ensure efficient and environmentally sustainable Cold Chain Management

IV. Laboratory Learning Outcome(s):

LLO 14.1 Prepare brief report about the risks of maintaining an intact cold chain in emergency situations.

LLO 14.2 List the measures to minimize the risk in cold chain system during emergency situations.

V. Relative Affective Domain related Outcome(s):

- Develop awareness about the role of engineers in healthcare systems.
- Show responsibility towards maintaining product safety and public health.
- Demonstrate interest in applying refrigeration knowledge to humanitarian needs.

VI. Relevant Theoretical Background (with Diagram):

Cold chain technology maintains the vaccine at a specific temperature range from production to administration. For COVID-19 vaccines, temperature requirements varied between –70°C (Pfizer), –20°C (Moderna), and 2–8°C (Covishield/Covaxin).

Key Cold Chain Components:

1. Cold storage rooms
2. Refrigerated transport vehicles
3. Vaccine carriers and cold boxes
4. Temperature monitoring devices (data loggers, sensors)

VII. Experimental setup:

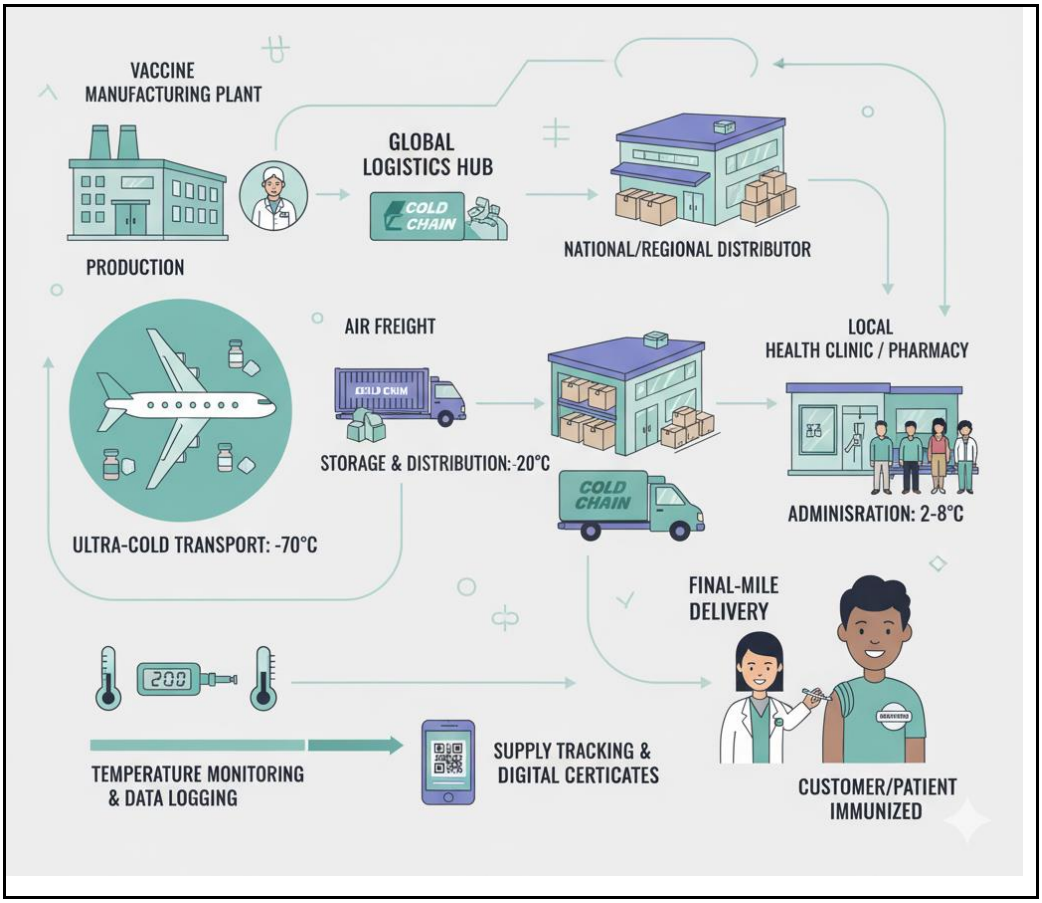


Fig. 14.1: Cold Chain cycle Medical Emergency

VIII. Required Resources /Apparatus/Equipment with specification:

S. No.	Equipment / Resource	Description / Use	Quantity
1	Vaccine Carrier / Cold Box	Maintains 2–8°C during short transport	01
2	Data Logger / Thermometer	Records and monitors temperature	01
3	Refrigerator or Model	For demonstrating cold storage	01
4	Insulation Material Sample	Used for maintaining temperature stability	01
5	Research Data/Case Study Report	Information on COVID-19 vaccine cold chain	01

IX. Precautions to be followed:

1. Avoid frequent opening of vaccine containers.
2. Maintain correct temperature range as per vaccine requirement.
3. Handle temperature sensors carefully.
4. Use calibrated thermometers or data loggers.
5. Keep cold boxes sealed properly during transport.

X. Procedure:

1. Study the vaccine cold chain process from manufacturer to vaccination site.
2. Identify different temperature requirements of various COVID-19 vaccines.
3. Study how cold boxes and carriers are designed for temperature maintenance.
4. Analyze a case study showing logistics and challenges during the COVID-19 vaccine distribution.
5. Record data on temperature variation, transportation distance and storage time.
6. Observe the effectiveness of cold chain management.

XI. Observations:

Parameter	Covishield	Covaxin	Pfizer
Required Storage Temp (°C)			
Transport Method			
Data Logger Used			
Deviation Observed			
Result			

XII. Results:

XIII. Interpretation of Results:

XIV. Conclusions and Recommendation:

XV. Practical Related Questions:

Note: Below given are few sample questions for reference. Teachers must design more such questions so as to ensure the achievement of identified CO.

1. Write effect of temperature variation on vaccine potency.
2. Mention the type of refrigerants suitable for ultra-low temperature freezers.
3. Mention the role of mechanical engineers in designing medical cold chains.
4. Write the use of PCM (Phase Change Materials) in cold boxes.
5. State the benefit of GPS tracking in vaccine transport.
6. State the importance of energy-efficient compressors in medical cold chains.

[Space for Answer]

References / Suggestions for Further Reading

1) https://youtu.be/FDXBOLW3UMI?si=dQtWi6-xgLZ33YqV
2) https://youtu.be/_wnt_3fkxBo?si=hUzCOg1quBpODbn7
3) https://youtu.be/c6tBYI7TMwE?si=p0NNJ82Vws7NMk7_
4) https://youtu.be/PAZjboKjPA8?si=PyFJGvUv7ynLL-pI
5) covid19dashboard.mohfw.gov.in/pdf/COVID19VaccineOG111Chapter16.pdf?utm

XVII. Rubrics for Assessment Scheme

Performance Indicators		Weightage
Process Related (15 Marks)		**(60**%)
1	Information collection from website	40%
2	Observations	20%
Product Related (10 Marks)		**(40**%)
3	results	20%
4	Interpretation of result and conclusion	10%
5	Practical related questions	10%
	Total	**100 %**

Marks Obtained			Dated signature of Teacher
Process Related (15)	**Product Related (10)**	**Total (25)**	

Practical No. 15
Model of "Subjee Cooler"–Case Study by IIT Bombay.*

I. Practical Significance:

This practical helps students understand the concept of non-electrical cold storage used for preserving fruits and vegetables in rural areas. The "Subjee Cooler," developed by IIT Bombay, demonstrates how evaporative cooling can be used as a low-cost and sustainable solution for short-term storage of perishable produce.

II. Industry/Employer Expected Outcome (s)

Perform activities related to Cold-Chain Management according to requirement such as products, quality, packaging and storage efficiently.

III. Course Level Learning Outcome (CO)

CO1 - Interpret the significance and components of the Cold Chain Management in various industries.

CO2 - Choose appropriate Cold Chain Packaging Techniques and Storage Systems for different applications.

CO3 - Create cost effective sustainable Cold Chain system as per client requirement.

CO4 - Apply appropriate Operations, Monitoring and Risk Management Strategies in Cold Chain.

CO5 - Use the regulatory frameworks, policies and best practices that ensure efficient and environmentally sustainable Cold Chain Management

IV. Laboratory Learning Outcome(s)

LLO 15.1 Design prototype to preserve Agriculture Products in given situation.

LLO 15.2 Test the prototype with operational parameters like temperature & humidity.

V. Relative Affective Domain related Outcome(s)

- Develop awareness about sustainable and affordable cooling technologies.
- Show responsibility towards minimizing food wastage.
- Demonstrate curiosity in applying engineering knowledge for rural development.

VI. Relevant Theoretical Background with diagram (if required)

The Subjee Cooler operates on the principle of evaporative cooling, where water evaporation from a porous surface absorbs heat from the stored produce, lowering the temperature inside the chamber. The cool and humid air reduces moisture loss and spoilage of vegetables, increasing their shelf life by 2–3 days compared to normal room conditions. It is made using locally available materials like sand, bricks, and jute cloth.

It is an eco-friendly**,** low-maintenance, and non-electric storage method, suitable for rural areas and small vendors**.**

VII. Experimental setup

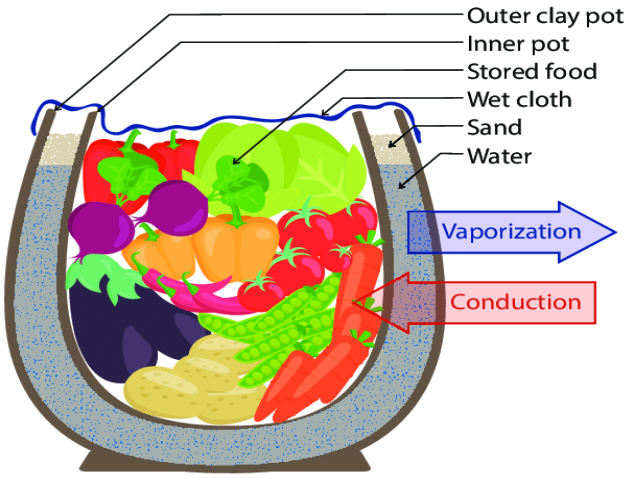


Fig. 15.1: Model of "Subjee Cooler

VIII. Required Resources /Apparatus/Equipment with specification

S. No.	Equipment / Material	Description / Use	Quantity
1	Two clay pots – one big, one small (matka type)	Demonstration of cooling concept	1 each
2	Sand (clean, fine)	Used to fill gap between pot, Clean river sand or silica sand	Enough to fill gap
3	Jute Cloth / Gunny Bag	For covering and water retention	01
4	Small lid / plate	To cover top opening	01
5	Weighing balance	Digital or mechanical; range: 0–1 kg,	01
6	Thermometer & Hygrometer	Range: 0°C to 50°C Range: 0–100% RH	01
7	Water	To wet sand and cloth	-
8	Vegetable Samples	Tomato, Brinjal or any fresh product	250 gm

IX. Precautions to be followed:

1. Keep sand moist all the time.
2. Do not keep in direct sunlight.
3. Maintain good ventilation.
4. Avoid excess water (no flooding).

X. Procedure:

1. Take a big clay pot and place a small clay pot inside it, keeping equal gap on all sides.
2. Fill the gap between the two pots with wet sand. Press lightly so the small pot sits firmly.
3. Pour water on the sand until it is fully wet (not flooded).
4. Cover the top of the pots with a jute/cotton cloth, and wet the cloth.
5. Place the setup in shaded, ventilated area for 10–15 minutes for cooling to start.
6. Now place vegetables inside the inner pot, close with cloth and then keep a lid/plate on top.

XI. Observations:

Time	Temp. in Cooler (°C)	Ambient Temp (°C)	RH in Cooler (%)	Weight of Vegetable (gm)	Weight of Vegetable (gm) (Ambient) (gm)	Freshness Observation
0 hr						
6 hr						
24 hr						

XII. Results:

XIII. Interpretation of Results:

XIV. Conclusions and Recommendation:

XV. Practical Related Questions:

Note: Below given are few sample questions for reference. Teachers must design more such questions so as to ensure the achievement of identified CO.

1. Write the effect of ambient humidity on cooler performance.
2. State the role of porosity of bricks in cooling efficiency.
3. Mention the materials used for constructing a Subjee Cooler.
4. State the benefit of using jute cloth instead of plastic.
5. Mention the impact of Subjee Cooler technology on rural economy.
6. Write the expected temperature difference achieved by the system.

[Space for Answer]

XVI. **References / Suggestions for Further Reading**

1) https://youtu.be/NlCK-wy2-54?si=tn8H_fFjSnbTvIHe
2) https://youtu.be/XMS4z8huLgI?si=4R6cFKUY7qHAIPP5
3) https://youtu.be/Pen2Qou8d4w?si=KkgOnGUXiMHyXerF
4) https://youtu.be/NlCK-wy2-54?si=lDuakEvVRjjPpNwi

XVII. **Rubrics for Assessment Scheme**

Performance Indicators		**Weightage**
Process Related (15 Marks)		**(70**%)
1	Model of Subjee cooler	40%
2	Reading and observations	30%
Product Related (10 Marks)		**(30**%)
3	Result and Interpretation of result	20%
4	Practical related questions	10%
	Total	**100 %**

Marks Obtained			**Dated signature of Teacher**
Process Related (15)	**Product Related (10)**	**Total (25)**	

Practical No. 16
Preservation of Agricultural Products in Ancient India- (IKS)*

I. Practical Significance:

This practical helps students understand the traditional methods used in ancient India for preserving agricultural products. It highlights Indigenous Knowledge Systems (IKS) and shows how natural and sustainable techniques were applied to extend the shelf life of grains, fruits, and vegetables before modern refrigeration.

II. Industry/Employer Expected Outcome(s):

Perform activities related to Cold-Chain Management according to requirement such as products, quality, packaging and storage efficiently.

III. Course Level Learning Outcome (CO)

CO1 - Interpret the significance and components of the Cold Chain Management in various industries.

CO2 - Choose appropriate Cold Chain Packaging Techniques and Storage Systems for different applications.

CO3 - Create cost effective sustainable Cold Chain system as per client requirement.

CO4 - Apply appropriate Operations, Monitoring and Risk Management Strategies in Cold Chain.

CO5 - Use the regulatory frameworks, policies and best practices that ensure efficient and environmentally sustainable Cold Chain Management

IV. Laboratory Learning Outcome(s)

LLO 16.1 Identify the techniques of preservation of Agricultural Products used in ancient India.

LLO 16.2 Prepare a report on components of preservation of Agricultural Products used in ancient India.

V. Relative Affective Domain Related Outcome(s)

- Show respect and interest in indigenous knowledge and traditional practices.
- Demonstrate responsibility towards reducing food wastage.
- Develop curiosity about combining ancient methods with modern technology.

VI. Relevant Theoretical Background (with Diagram):

In ancient India, agricultural products were preserved using natural techniques without electricity. Common methods included:

1. **Sun Drying:** Grains, pulses, and spices were dried under the sun to remove moisture And prevent microbial growth.
2. **Storage in Earthen Pots / Silos:** Grains and pulses were stored in porous containers, which provided natural cooling and moisture regulation.
3. **Oil Coating / Ash Layering:** Spices and seeds were coated with oil or layered with ash to prevent insect attack.
4. **Sand / Straw Layering:** Fruits and tubers were stored in sand or straw to slow respiration and delay spoilage.

VII. Experimental Setup:

Fig. 16.1: Agricultural products preserving by natural techniques

VIII. Required Resources / Apparatus / Equipment

S. No.	Equipment / Material	Description / Use
1	Earthen Pots / Clay Containers	Storage of grains and pulses
2	Straw / Sand	For layering and insulation
3	Oil / Ash	To prevent insect infestation
4	Samples of Grains / Pulses / Spices	For demonstration of preservation
5	Observation Sheet	To note changes in moisture, spoilage, or insects

IX. Precautions to be followed:

1. Use clean and dry containers to prevent contamination.
2. Keep storage area ventilated and shaded.
3. Avoid moisture accumulation in stored grains.
4. Record observations daily or at regular intervals.
5. Handle materials carefully to prevent spoilage during the study.

X. Procedure:

1. Select samples of grains, pulses, or spices.
2. Prepare storage using traditional methods (earthen pots, sand, straw, ash, or oil coating).
3. Place the stored samples in a cool, shaded, and dry area.
4. Observe and record changes over several days or weeks, including moisture content, insect attack, and spoilage.
5. Compare the effectiveness of different traditional methods.
6. Prepare a report summarizing which methods best preserved the products.

XII. Observations:

Method Used	Sample Stored	Moisture Change	Insect Attack	Spoilage / Shelf Life
Sun Drying				
Earthen Pot				
Oil Coating				
Sand Layer				

XII. Results

XIII. Interpretation of Results

XIV. Conclusions and Recommendation

XV. Practical Related Questions

Note: Below given are few sample questions for reference. Teachers must design more such questions so as to ensure the achievement of identified CO.

1. Write the effect of moisture on stored grains.
2. State two natural materials used for insulation in ancient storage.
3. Mention the benefit of straw layering for fruits.
4. State two limitations of sun drying.
5. Write the impact of ancient storage methods on food security.
6. State the relevance of IKS in modern sustainable agriculture.

[Space for Answer]

XVI. References / Suggestions for Further Reading

1) https://youtu.be/qXGF1Y2l174?si=y1kzFW13Rs4zqDKa
2) https://youtu.be/FLQ2XeMN6zc?si=6M_cQ8x0yo1zHUQ-
3) https://youtu.be/TrQ7Qh6mBbI?si=5_b6JTxrimWM_hsa
4) https://youtu.be/rvyRm9j__Do?si=rq8dYIO0rvVSFMdi
5) https://youtu.be/LmLG4Q7P0bE?si=uWCLJlMrAXDwG38C

XVII. Rubrics for Assessment Scheme

Performance Indicators		Weightage
Process Related (15 Marks)		**(60%)**
1	Collect information	40%
2	Observations	20%
Product Related (10 Marks)		**(40%)**
3	Result and Interpretation of results	30%
4	Practical related questions	10%
	Total	**100 %**

Marks Obtained			Dated signature of Teacher
Process Related (15)	**Product Related (10)**	**Total (25)**	