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NAME OF THE COURSE: INVENTORY & WAREHOUSING MANAGEMENT

SUBJECT CODE: 534EBC

SEMESTER: III ELECTIVE

BATCH: 2024-2026

VISION & MISSION STATEMENT

Vision: To be an oasis of knowledge to the seeker, to nurture one's creativity and research acumen, and to instil a unique blend of leadership, innovative spirit, and empathy in response to the ever-evolving business ecosystem.

Mission:

- Provide a pedagogy that blends academic rigor and experiential learning.
- Inculcate an entrepreneurial mindset through curated activities.
- Establish a conducive environment for research.
- Foster a culture of innovation and collaboration to progress in a dynamic business landscape.
- Promote humanistic values to produce socially responsible leaders.

Program Educational Objectives (PEOs)

PEO 1 – Employability:

To develop students with industry-specific knowledge & skills to meet the industry requirements, and also join a public sector undertaking through competitive examinations.

PEO 2 – Entrepreneur:

To create effective business service owners with a growth mindset by enhancing their critical thinking, problem-solving, and decision-making skills

PEO3 – Research and Development:

To instil and grow a mindset that focuses efforts towards inculcating and encouraging the students in the field of research and development

PEO 4 – Contribution to Business World

To produce ethical and innovative business professionals to enhance the growth of the business world

PEO 5 – Contribution to the Society:

To work and contribute towards the holistic development of society by producing competent MBA professionals

Program Outcomes

PO1:Problem Solving Skill

Application of tools & techniques relevant to management theories and practices in analysing & solving business problems

PO2: Decision-Making Skill

Fostering analytical and critical thinking abilities for data-based decision making

PO3: Ethical Value

Ability to develop value-based leadership attributes

PO4: Communication Skill

Ability to understand, analyse, and effectively communicate global, economic, legal, and ethical aspects of business

PO5: Individual and Team Leadership Skill

Ability to be self-motivated in leading & driving a team towards the achievement of organizational goals and contributing effectively to establish industrial harmony

PO6: Employability Skill

Foster and enhance employability skills through relevant industry subject knowledge

PO7: Entrepreneurial Skill

Equipped with skills and competencies to become a global entrepreneur

PO8: Contribution to Society

Strive towards becoming a global influencer and motivating future generations towards building a legacy that contributes to the overall growth of humankind

Inventory & Warehousing Management

COURSE OBJECTIVE

C1	To provide an in-depth understanding of Inventory Management and its impact on Logistics
C2	To analyze and evaluate the activities of various models, tools and techniques of Inventory control and inventory management
C3	To examine the dimensions of knowledge of various inventory ranking methods, and how to use technology in inventory control
C4	To appraise on the overview of basics of warehouse management, its location, layout and principles of warehouse design
C5	To appraise the various elements on knowledge about the standardization, codification, safety and security of inventory and the role of Information technology in warehouse management

SYLLABUS

UNIT-1 Introduction to Inventory – Definition, principles, role, functions and importance of Inventory, Types of Inventory, Inventory Policy, Costs Associated with Inventory, Inventory and Profitability, Impact of Inventory on total logical cost – Inventory management – objectives / importance, symptoms of poor inventory management, Improving effectiveness of inventory management.

UNIT-2 Inventory Control and models – Importance and scope of Inventory control, Selective Inventory control, Inventory Models – Economic Lot size, EOQ, Economic Batch Quantity [EBQ], ROL – reorder level, P model, Q model, two bin system, fair share allocation model, MRP, ABC analysis, Just in Time (JIT). Modern methods Kanban, DRP and ERP.

UNIT-3 Inventory Methods – Inventory ranking methods and Quadrant technique, FIFO. LIFC, Weighted average method, Inventory under certainly and uncertainly, Risk

Management, Work in progress inventories, Finished Goods Inventories, Spare parts inventories, Use of Computers in Inventory Management – RFID, EDI, Satellite tracking system.

UNIT-4 Warehouse Management – Definition, Principles, Roles, Importance of Warehouses, Need for Warehousing, Warehouse selection and planning, functions and operations of a warehouse, Warehouse location, Area of Warehouse, Factors affecting warehousing cost, Warehouse layout, Design principles.

UNIT-5 Planning – codification and standardization of the Materials, Incoming Materials Receipts, Retrieval and Transaction Processing System, Security and Loss Prevention, Consumption Based Planning – MRP and lot sixing procedure, Forecasting parameter and result, planned order planning file consolidation, Break bulk, Cross docking, Mixing, Assembly – competitive advantage, production support warehouse – ERP, Role of IT in warehousing.

Unit-1

Introduction to Inventory

Definition: Inventory represents the stock of materials, work-in-progress, and finished goods that a business holds to meet customer demand and support operations.

Key Principles (2024-2025):

Real-time tracking and visibility
Enables live monitoring of goods, inventory, and shipments, improving transparency and responsiveness across the supply chain.

Data-driven decision making
Utilizes analytics and actionable insights from data to guide strategic and operational choices, reducing errors and improving efficiency.

 Automation integration
Incorporates robotics, AI, and software to streamline repetitive tasks, minimize human error, and boost productivity in supply chain operations.

 Demand forecasting accuracy
Predicts future customer demand using historical data and trends, helping businesses manage inventory and reduce stockouts or overstock.

 Supply chain optimization
Enhances overall supply chain performance by improving cost-efficiency, delivery speed, and resource utilization through strategic planning.

Role and Functions of Inventory

Primary Functions:

- Buffer against demand variability

- Enables production smoothing
- Provides customer service continuity
- Facilitates economic production runs
- Hedge against supply uncertainties

Strategic Role: Inventory serves as a critical link between supply and demand, enabling businesses to maintain operational efficiency while meeting customer expectations.

Importance of Inventory Management

In 2024, inventory distortion—the imbalance of having too much or too little stock in relation to demand—was estimated to have cost retailers $1.7 trillion, according to IHL Group. This staggering figure underscores the critical importance of effective inventory management.

Key Benefits:

- Cost reduction through optimized stock levels
- Improved cash flow management
- Enhanced customer satisfaction
- Waste reduction and obsolescence prevention
- Better supplier relationships

Types of Inventory

By Stage of Production:

- Raw materials
- Work-in-progress (WIP)
- Finished goods
- Maintenance, Repair, and Operations (MRO)

By Function:

- Cycle stock (regular demand fulfillment)
- Safety stock (buffer for uncertainties)
- Seasonal stock (demand fluctuations)
- Speculative stock (price advantage)

Inventory Policy

Modern inventory policies emphasize:

- **Just-in-Time (JIT)** approaches
- **Vendor-Managed Inventory (VMI)** systems
- **ABC Analysis** for prioritization

- **Economic Order Quantity (EOQ)** optimization

The 80/20 inventory rule states that 20% of your inventory and product range should deliver 80% of your sales.

Costs Associated with Inventory

Four Main Categories:

1. **Purchase Costs**: Direct cost of acquiring inventory
2. **Ordering Costs**: Administrative costs of placing orders
3. **Holding Costs**: Holding costs, on the other hand, relate to expenses tied to storing inventory, including warehouse rent, insurance, and depreciation.
4. **Shortage Costs**: Shortage costs encompass the repercussions of running out of stock, such as lost sales, backorders, and potential damage to customer relationships. Inventory costs = Purchase costs + Ordering costs + Holding costs + Shortage costs

Inventory and Profitability

Current Performance Metrics (2024):

- The average inventory turnover rate across sectors in 2024 is 8.5.
- Financial sector leads with highest turnover at 227.67
- Retail maintains approximately 11.32 turnover rate

Profitability Impact:

- Reduced carrying costs improve margins
- Faster turnover enhances ROI
- Prevents obsolescence losses
- Optimizes working capital utilization

Impact on Total Logistics Cost

Inventory significantly affects total logistics costs through:

- Transportation frequency and batch sizes
- Warehouse space requirements and costs
- Insurance and security expenses
- Technology and system maintenance costs
- When companies maintain optimal inventory levels, they can minimize holding costs, which include storage, insurance, and taxes.

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Inventory Management Objectives

Primary Objectives:

- Minimize total inventory costs
- Ensure adequate stock availability
- Optimize cash flow
- Reduce waste and obsolescence
- Enhance customer service levels

Symptoms of Poor Inventory Management

Key Warning Signs:

- Frequent stockouts or overstock situations
- High carrying costs relative to sales
- Excessive obsolete inventory
- Poor inventory turnover ratios
- Customer complaints about availability
- Inaccurate inventory records
- Inefficient warehouse operations

Improving Inventory Management Effectiveness

2025 Best Practices:

1. **Technology Integration**: Implement real-time inventory tracking systems
2. **Automation**: Optimize retail inventory with best practices for 2025: embrace automation, real-time tracking, and strategic forecasting.
3. **Advanced Analytics**: Use AI and machine learning for demand forecasting
4. **Supplier Collaboration**: Develop VMI partnerships
5. **Continuous Monitoring**: Regular review of inventory metrics and KPIs

Modern Techniques:

- RFID and IoT integration
- Predictive analytics
- Cloud-based inventory systems
- Mobile inventory management
- Integrated ERP solutions

Key Performance Indicators:

- Inventory turnover ratio
- Days sales outstanding
- Fill rate percentage
- Carrying cost percentage
- Obsolescence rate

The landscape of inventory management continues to evolve with technology advancement, emphasizing the need for businesses to adopt integrated, data-driven approaches to optimize their inventory operations and maintain competitive advantage.

Vendor-Managed Inventory (VMI) Systems
Definition and Core Concept
Vendor-managed inventory (VMI) is an inventory management technique in which a supplier of goods, usually the manufacturer, is responsible for optimizing the inventory held by a distributor. It is a model approach where the supplier takes full responsibility for maintaining the inventory levels of their products at the customer's location. **How VMI Works**
With vendor managed inventory, a supplier actively manages a customer's inventory levels, aiming to improve efficiency and cut costs for both parties. The system operates through:
Key Components:

- Real-time data sharing between supplier and customer
- Supplier monitors inventory levels at customer locations
- Automated replenishment based on predetermined parameters
- Continuous communication and collaboration

Using automated data flows and advanced analytics, the VMI model improves order accuracy, reduces rework, and increases inventory turnover. **Benefits of VMI Systems**
For Retailers/Customers:

- **Cost Reduction**: The main benefit of VMI for retailers is a reduction in inventory costs. By transferring the responsibility of inventory management to the vendor, retailers reduce the amount of capital tied up in inventory and the costs associated with storing and managing it. **Improved Cash Flow**: This strategy offers benefits including reduced inventory costs, improved cash flow, and decreased stockouts. **Better Inventory Accuracy**: VMI offers vendors predictable demand and streamlined workflows, while retailers enjoy improved inventory accuracy and reduced operational complexity. **For Suppliers/Vendors:**
- **Enhanced Demand Forecasting**: VMI gives suppliers visibility into customer inventory and demand patterns, so better demand forecasting and alignment of production and inventory. **Predictable Demand**: Vendors gain better insight into customer consumption patterns
- **Streamlined Operations**: Reduced administrative burden and improved efficiency

Mutual Benefits:
This leads to cost-savings in planning, ordering, and storing products by both the vendor and the retailer. Vendor managed inventory offers a lot of benefits for both the supplier and the buyer,

like preventing excess stock, reducing costs, and guaranteeing a smooth flow of inventory.

Performance Improvements

By leveraging VMI, they can reduce lead times, optimize order size, and improve overall supply chain performance. Suppliers use real-time sales and demand forecast data to optimize shipments and maintain high in-stock rates, allowing them to respond quickly to market changes.

Challenges and Risks

Primary Disadvantages:

1. **Vendor Dependency**: One of the primary risks of VMI is the heavy reliance on vendor reliability. Since vendors are responsible for managing inventory levels, any inefficiencies, errors, or delays on their part can directly impact the retailer's operations. **Data Security Concerns**: Increased vulnerability from data exposure to a third party is possibly the most serious concern many have about VMI
2. **Loss of Control**: Companies may feel they lose direct control over their inventory management
3. **Implementation Complexity**: Transitioning from traditional inventory management to VMI requires changes in processes and systems. Companies must invest in technology and training to facilitate real-time data sharing and collaboration.

Implementation Requirements

Critical Success Factors:

- **Data Transparency**: This means you have to have transparency in sharing critical business information
- **Technology Investment**: Need for integrated systems enabling real-time data sharing
- **Clear Agreements**: A successful VMI system relies on shared data, clear agreements, and ongoing communication.
- **Performance Metrics**: Establishment of key performance indicators and monitoring systems

Planning Considerations:

Implementing VMI requires planning and collaboration. Organizations must address:

- Contractual terms and service level agreements
- Data sharing protocols and security measures
- Integration with existing systems
- Training requirements for staff

Current Trends and Future Outlook (2024-2025)

Technology Integration: Modern VMI systems increasingly incorporate:

- Advanced analytics and AI for demand forecasting
- IoT sensors for real-time inventory monitoring
- Cloud-based platforms for seamless data sharing
- Mobile applications for enhanced visibility

Industry Adoption: These companies rely on VMI to maintain efficient supply chains and ensure product availability VMI continues to gain traction across various industries, particularly in retail, manufacturing, and healthcare sectors.

Strategic Evolution: Reflecting on the strategic benefits of VMI and staying informed about future trends can help companies achieve greater efficiency and success in their supply chain operations

Best Practices for VMI Implementation

1. **Start with Pilot Programs**: Begin with select products or locations
2. **Establish Clear Communication Channels**: Regular review meetings and feedback loops
3. **Invest in Technology**: Ensure robust data sharing and analytics capabilities
4. **Define Performance Metrics**: Track inventory turnover, service levels, and cost savings
5. **Maintain Flexibility**: Allow for adjustments based on market conditions and performance

While this approach can be adapted to various industries, its core principles of collaboration, data sharing, and performance measurement remain constant.
VMI represents a significant shift from traditional inventory management approaches, offering substantial benefits when implemented correctly but requiring careful planning and strong vendor relationships to succeed.

UNIT-2

UNIT II: INVENTORY CONTROL AND MODELS

1. Importance and Scope of Inventory Control

Importance:
- Minimizes investment in inventory
- Ensures material availability
- Reduces carrying costs
- Improves operational efficiency
- Enhances profitability
- Better space utilization

Scope:
- Determining stock levels
- Setting reorder points
- Inventory classification
- Ordering quantities
- Monitoring and reporting
- Coordination with production and sales

2. Selective Inventory Control

ABC Analysis

Classification based on annual consumption value:

A-Items (70-80% value, 10-20% items)
- Tight control
- Frequent reviews
- Accurate records
- Close monitoring

B-Items (15-25% value, 30-40% items)
- Moderate control
- Periodic reviews
- Normal monitoring

C-Items (5-10% value, 40-50% items)
- Simple control
- Bulk ordering
- Minimal paperwork

VED Analysis (Vital, Essential, Desirable)
Based on criticality:
- **V (Vital)**: Critical for operations, cannot be substituted
- **E (Essential)**: Important but short delays acceptable
- **D (Desirable)**: Can be postponed without significant impact

FSN Analysis (Fast, Slow, Non-moving)
Based on consumption rate:
- **Fast Moving**: Regular consumption
- **Slow Moving**: Intermittent consumption
- **Non-Moving**: No consumption for specified period

HML Analysis (High, Medium, Low)
Based on unit price of items

SDE Analysis (Scarce, Difficult, Easily Available)
Based on availability

3. Inventory Models

A. Economic Order Quantity (EOQ)

Formula: $EOQ = \sqrt{(2DS/H)}$

Where:
- D = Annual demand
- S = Ordering cost per order
- H = Holding cost per unit per year

Assumptions:
- Demand is constant and known
- Lead time is constant
- No quantity discounts
- No stockouts allowed
- Instantaneous replenishment

Benefits:
- Minimizes total inventory cost
- Optimal order quantity
- Balances ordering and holding costs

B. Economic Batch Quantity (EBQ) / Economic Production Quantity (EPQ)

Formula: EBQ = $\sqrt{(2DS/H)} \times \sqrt{(P/(P-D))}$

Where:
- P = Production rate
- D = Demand rate
- S = Setup cost
- H = Holding cost

Used when items are produced internally rather than purchased.

C. Reorder Level (ROL)

Formula: ROL = Lead Time Demand + Safety Stock

ROL = (Average consumption × Lead time) + Safety stock

Point at which new order should be placed to avoid stockout.

D. P Model (Periodic Review System)

- Fixed review period
- Variable order quantity
- Order placed at regular intervals
- Order quantity = Target level - Current inventory
- Suitable for low-value items

E. Q Model (Continuous Review System)

- Fixed order quantity
- Variable review period
- Order placed when inventory reaches reorder point

- Continuous monitoring required
- Suitable for high-value items (A-class)

F. Two-Bin System

- Simple visual control method
- Inventory divided into two bins
- First bin used for normal consumption
- When first bin empty, order placed
- Second bin used during lead time
- Suitable for C-class items

G. Fair Share Allocation Model

Allocates limited inventory among multiple demand points based on:
- Demand history
- Priority
- Service level requirements
- Available stock

Formula: Allocation = (Location Demand / Total Demand) × Available Stock

H. Material Requirements Planning (MRP)

Components:
1. Master Production Schedule (MPS)
2. Bill of Materials (BOM)
3. Inventory Status File

Process:
- Determines what, when, and how much to produce
- Time-phased requirements planning
- Backward scheduling from due dates
- Considers lead times

Outputs:
- Planned order releases
- Order rescheduling notices
- Exception reports

I. Just-In-Time (JIT)

Principles:
- Zero inventory
- Pull system
- Elimination of waste

- Continuous improvement (Kaizen)
- Quality at source

Requirements:
- Reliable suppliers
- Short lead times
- Stable demand
- Quality materials
- Excellent coordination

Benefits:
- Reduced inventory costs
- Improved quality
- Faster response
- Better space utilization
- Reduced waste

4. Modern Methods

A. Kanban

- Japanese visual signal system
- Card-based pull system
- Signals when to produce/order
- Part of JIT philosophy

Types:
- Production Kanban (authorization to produce)
- Withdrawal Kanban (authorization to move)

Calculation: Number of Kanbans = (Average Demand × Lead Time × (1 + Safety Factor)) / Container Capacity

B. Distribution Requirements Planning (DRP)

- Time-phased planning for distribution
- Extends MRP logic to distribution network
- Plans inventory at multiple locations
- Coordinates transportation and warehousing

Benefits:
- Better inventory positioning
- Reduced safety stock
- Improved customer service
- Transportation optimization

C. Enterprise Resource Planning (ERP)

Integrated software system managing:
- Inventory
- Production
- Sales
- Finance
- Human Resources
- Supply Chain

Benefits:
- Real-time information
- Integrated processes
- Better decision-making
- Reduced redundancy
- Improved efficiency

UNIT III: INVENTORY METHODS

1. Inventory Ranking Methods

Purpose:
Prioritize inventory items based on multiple criteria for better control and resource allocation.

Common Ranking Criteria:
- Annual consumption value
- Criticality
- Lead time
- Supplier reliability
- Demand variability
- Shelf life

Multi-criteria Ranking:
Combines multiple factors with weights assigned to each criterion.

2. Quadrant Technique

Two-dimensional classification using two criteria simultaneously:

Example: Value vs. Criticality Matrix

```
High Value | A-Critical | A-Non-Critical
           |------------|----------------
```

Low Value | C-Critical | C-Non-Critical
Critical Non-Critical
```

**Management Strategy**:
- **A-Critical**: Tightest control, maximum attention
- **A-Non-Critical**: Cost focus, value analysis
- **C-Critical**: Ensure availability, safety stock
- **C-Non-Critical**: Simplest control, bulk ordering

### 3. Inventory Valuation Methods

#### A. FIFO (First-In-First-Out)

**Principle**: First items purchased are first to be issued/sold

**Advantages**:
- Reflects actual physical flow (especially perishables)
- Ending inventory at current prices
- Simple to understand

**Disadvantages**:
- Issues at older prices (may not reflect current costs)
- Higher profits in inflation (higher tax liability)

**Example**:
```
Purchase 1: 100 units @ $10 = $1,000
Purchase 2: 100 units @ $12 = $1,200
Issue: 150 units
Cost = (100 × $10) + (50 × $12) = $1,600
```

#### B. LIFO (Last-In-First-Out)

**Principle**: Last items purchased are first to be issued/sold

**Advantages**:
- Issues at current prices
- Matches current costs with revenue
- Lower profits in inflation (tax benefit)

**Disadvantages**:
- Doesn't match physical flow
- Ending inventory at older prices
- Complex record-keeping
```

Example:
```
Purchase 1: 100 units @ $10 = $1,000
Purchase 2: 100 units @ $12 = $1,200
Issue: 150 units
Cost = (100 × $12) + (50 × $10) = $1,700
```

C. Weighted Average Method

Principle: Average cost of all units available

Formula: Weighted Average Cost = Total Cost of Inventory / Total Units Available

Advantages:
- Smooths price fluctuations
- Simple to calculate
- Acceptable for tax purposes

Disadvantages:
- Doesn't reflect actual cost of specific units
- Requires recalculation after each purchase

Example:
```
Purchase 1: 100 units @ $10 = $1,000
Purchase 2: 100 units @ $12 = $1,200
Total: 200 units @ Average $11 = $2,200
Issue: 150 units @ $11 = $1,650
```

4. Inventory Under Certainty

Characteristics:
- Demand is known and constant
- Lead time is fixed
- No uncertainty in supply
- Standard EOQ models applicable

Models Used:
- Basic EOQ
- EBQ
- Quantity discount models

5. Inventory Under Uncertainty

Types of Uncertainty:
- Demand variability
- Lead time variability
- Supply uncertainty
- Price fluctuations

Management Approaches:

Safety Stock Calculation:
$SS = Z \times \sigma \times \sqrt{LT}$

Where:
- Z = Service level factor
- σ = Standard deviation of demand
- LT = Lead time

Service Level:
Probability of not running out of stock

90% service level: Z = 1.28
95% service level: Z = 1.65
99% service level: Z = 2.33

6. Risk Management in Inventory

Strategies:
- **Diversification**: Multiple suppliers
- **Safety Stock**: Buffer against uncertainty
- **Flexible Contracts**: Options for quantity changes
- **Hedging**: Financial instruments for price risk
- **Insurance**: Coverage for inventory losses
- **Postponement**: Delay final customization
- **Information Sharing**: Better demand visibility

Risk Types:
- Demand risk
- Supply risk
- Price risk
- Obsolescence risk
- Quality risk
- Lead time risk

7. Work-in-Progress (WIP) Inventories

Definition: Partially completed goods in production process

Management Considerations:
- Minimize cycle time
- Balance production lines
- Reduce setup times
- Improve process flow
- Eliminate bottlenecks

WIP Calculation:
WIP = Production Rate × Cycle Time

Reduction Strategies:
- Lean manufacturing
- Process improvement
- Better scheduling
- Quality improvement

8. Finished Goods Inventories

Purpose:
- Meet customer demand
- Buffer against demand variability
- Enable production leveling
- Support marketing programs

Management:
- Demand forecasting
- Production planning
- Distribution planning
- Promotion coordination

Optimization:
- Make-to-stock vs. make-to-order decisions
- Postponement strategies
- Modular design
- Flexible manufacturing

9. Spare Parts Inventories

Characteristics:
- Intermittent demand
- Critical for operations
- High variety
- Long shelf life

Classification:

- **Capital spares**: Expensive, long lead time
- **Insurance spares**: Critical items
- **Rotable spares**: Repairable items
- **Consumable spares**: Regular replacement

Management Strategies:
- Criticality analysis (VED)
- Reliability-centered approach
- Vendor-managed inventory
- Cannibalization policy
- Repairable pool management

10. Use of Computers in Inventory Management

A. Radio Frequency Identification (RFID)

Technology: Uses radio waves to identify and track items

Components:
- RFID tags (active/passive)
- RFID readers
- Antenna
- Software system

Benefits:
- Real-time visibility
- Automatic data capture
- No line-of-sight required
- Bulk reading capability
- Reduced manual errors
- Faster operations

Applications:
- Inventory tracking
- Asset management
- Supply chain visibility
- Anti-theft systems

B. Electronic Data Interchange (EDI)

Definition: Computer-to-computer exchange of business documents

Common Documents:
- Purchase orders
- Invoices
- Advance ship notices

- Inventory reports
- Payment advice

Benefits:
- Faster transactions
- Reduced paperwork
- Lower costs
- Fewer errors
- Improved accuracy
- Better coordination

C. Satellite Tracking System

Technology: GPS-based real-time tracking of shipments

Features:
- Location tracking
- Route monitoring
- Temperature monitoring
- Security alerts
- Delivery confirmation

Benefits:
- Real-time visibility
- Better planning
- Improved security
- Exception management
- Customer updates
- Route optimization

UNIT IV: WAREHOUSE MANAGEMENT

1. Definition of Warehouse

A warehouse is a planned space for the storage and handling of goods and materials. It serves as a link between production and consumption, providing time and place utility.

2. Principles of Warehousing

1. **Planning Principle**: Systematic planning of operations
2. **Flow Principle**: Minimize handling and movement
3. **Space Utilization**: Maximize cubic space usage
4. **Standardization**: Uniform processes and equipment
5. **Flexibility**: Adaptable to changing needs

6. **Accessibility**: Easy access to all stored items
7. **Safety**: Protection of goods and personnel
8. **Economy**: Cost-effective operations

3. Roles of Warehouses

- **Storage**: Holding inventory until needed
- **Consolidation**: Combining small shipments
- **Break-bulk**: Breaking large shipments
- **Cross-docking**: Direct transfer without storage
- **Value-added services**: Labeling, packaging, assembly
- **Buffering**: Managing supply-demand variations
- **Mixing**: Creating assortments for customers

4. Importance of Warehouses

- Ensures continuous supply
- Enables economies of scale
- Supports just-in-time delivery
- Facilitates distribution
- Provides price stabilization
- Enables seasonal production
- Supports marketing activities
- Risk reduction through insurance

5. Need for Warehousing

Business Needs:
- Time gap between production and consumption
- Seasonal production/consumption patterns
- Bulk purchasing economies
- Market expansion
- Customer service requirements

Operational Needs:
- Production smoothing
- Transportation economics
- Order fulfillment
- Emergency stock
- Work-in-progress storage

6. Warehouse Selection and Planning

Selection Criteria:

Location Factors:

- Proximity to customers/suppliers
- Transportation infrastructure
- Labor availability and cost
- Land cost
- Utility availability
- Tax regulations
- Expansion potential

Facility Factors:
- Building specifications
- Material handling capability
- Storage capacity
- Technology infrastructure
- Security features
- Environmental conditions

Planning Process:
1. Demand analysis
2. Network design
3. Capacity planning
4. Technology selection
5. Layout design
6. Process design
7. Resource planning

7. Functions and Operations of a Warehouse

Primary Functions:

A. Receiving
- Unloading vehicles
- Checking quantities
- Quality inspection
- Documentation
- Putaway to storage

B. Storage
- Organized placement
- Stock maintenance
- Inventory management
- Space optimization

C. Order Picking
- Order processing
- Item retrieval
- Batch picking

- Zone picking

D. Packing
- Order assembly
- Packaging
- Labeling
- Documentation

E. Shipping
- Loading vehicles
- Route planning
- Dispatch documentation
- Tracking

Supporting Functions:
- Inventory control
- Quality control
- Returns processing
- Value-added services
- Information management
- Equipment maintenance

8. Warehouse Location

Location Strategies:

A. Centralized Warehouse
- Single large facility
- Lower facility costs
- Higher transportation costs
- Longer delivery times

B. Decentralized Warehouses
- Multiple regional facilities
- Higher facility costs
- Lower transportation costs
- Faster delivery times

Location Methods:

1. Center of Gravity Method
- Weighted average of customer locations
- Minimizes transportation costs

2. Grid Method
- Systematic evaluation of grid points

- Considers multiple factors

3. Factor Rating Method
- Multiple criteria evaluation
- Weighted scoring system

9. Area of Warehouse

Space Requirements:

A. Storage Area
- Primary storage space for inventory
- Typically 50-70% of total area

B. Receiving Area
- Unloading and inspection
- 10-15% of total area

C. Shipping Area
- Order assembly and dispatch
- 10-15% of total area

D. Aisles
- Movement corridors
- 15-25% of total area

E. Support Areas
- Offices, restrooms, break rooms
- 5-10% of total area

Area Calculation:
Total Area = (Storage Requirements / Storage Height) + (Aisles + Receiving + Shipping + Support)

10. Factors Affecting Warehousing Cost

Fixed Costs:
- Building depreciation/rent
- Property taxes
- Insurance
- Security systems
- Management salaries

Variable Costs:
- Labor (handling, picking, packing)
- Utilities

- Equipment operation
- Maintenance
- Packaging materials
- Technology costs

Cost Drivers:
- Inventory turnover
- Order frequency
- Product characteristics
- Service level requirements
- Technology level
- Location

11. Warehouse Layout

Layout Objectives:
- Maximize space utilization
- Minimize handling costs
- Optimize material flow
- Ensure safety
- Facilitate supervision
- Allow flexibility

Layout Types:

A. U-Shaped Layout
- Receiving and shipping at same end
- Efficient material flow
- Good supervision

B. Flow-Through Layout
- Receiving at one end, shipping at other
- Straight-line flow
- Suitable for cross-docking

C. L-Shaped Layout
- Receiving and shipping at adjacent sides
- Space efficient
- Flexible operations

Storage Methods:

1. Floor Storage
- Direct stacking on floor
- Low cost
- Limited height

2. Rack Storage
- Pallet racks
- Maximum height utilization
- Easy access

3. Mezzanine Storage
- Multi-level structure
- Increased capacity
- Suitable for small items

12. Design Principles

Key Principles:

1. One-Way Flow
- Materials move in one direction
- Reduces congestion
- Improves efficiency

2. Straight-Line Movement
- Minimize distance traveled
- Reduce handling time
- Lower costs

3. Use of Gravity
- Gravity-fed systems where possible
- Reduces energy consumption
- Improves efficiency

4. Maximum Space Utilization
- Vertical space usage
- Narrow aisles with proper equipment
- Efficient storage systems

5. Flexibility
- Adaptable to changing needs
- Modular systems
- Scalable design

6. Accessibility
- Easy access to all items
- Consider turnover rates
- Fast movers near shipping

7. Product Grouping

- Compatible products together
- Hazardous items separated
- Temperature requirements

8. Safety
- Fire protection systems
- Emergency exits
- Safe equipment operation
- Proper lighting

9. Ergonomics
- Reduce physical strain
- Proper equipment height
- Comfortable working conditions

10. Technology Integration
- Automation where beneficial
- WMS implementation
- RFID systems
- Barcode scanning

UNIT V: PLANNING AND ADVANCED WAREHOUSE OPERATIONS

1. Codification and Standardization of Materials

Codification

Definition: Systematic assignment of codes to materials for identification and classification.

Objectives:
- Unique identification
- Easy retrieval
- Prevent duplication
- Facilitate automation
- Simplify communication

Coding Systems:

A. Numerical Code
- Uses only numbers
- Simple and clear
- Example: 001-050-1234

B. Alphabetical Code

- Uses letters
- Mnemonic advantages
- Example: RAW-STE-001

C. Alphanumeric Code
- Combination of letters and numbers
- Maximum flexibility
- Example: RM-STL-001-25

D. Decimal Code
- Hierarchical classification
- Example: 10.20.30 (Category.Group.Item)

E. Mnemonic Code
- Memory-aid codes
- Example: BOLTM10 (Bolt, Mild steel, 10mm)

Standardization

Definition: Establishing uniform specifications and procedures

Benefits:
- Reduces variety
- Lowers inventory costs
- Simplifies procurement
- Improves interchangeability
- Facilitates quality control
- Economies of scale

Types:
- **Simplification**: Reducing unnecessary variety
- **Specification**: Defining precise requirements
- **Unification**: Common standards across organization

2. Incoming Materials Receipts

Receipt Process:

Step 1: Pre-Receipt
- Advance ship notice (ASN) review
- Dock scheduling
- Resource preparation

Step 2: Physical Receipt
- Vehicle arrival
- Unloading

- Quantity verification
- Damage inspection

Step 3: Documentation
- Receipt note preparation
- Purchase order matching
- GRN (Goods Receipt Note) generation
- System updating

Step 4: Quality Inspection
- Visual inspection
- Sampling
- Testing (if required)
- Accept/reject decision

Step 5: Putaway
- Storage location assignment
- Material movement
- System update
- Bin card update

Documentation:
- Delivery challan
- Purchase order
- Goods receipt note
- Inspection report
- Bin cards
- Stock ledger

3. Retrieval and Transaction Processing System

Retrieval Process:

Order Processing Flow:
1. Order receipt and validation
2. Inventory availability check
3. Picking list generation
4. Material retrieval
5. Verification
6. Packing
7. Dispatch
8. Documentation

Retrieval Strategies:

A. Discrete Picking

- One order at a time
- Simple but less efficient
- Suitable for low volume

B. Batch Picking
- Multiple orders together
- Higher efficiency
- Requires sorting

C. Zone Picking
- Different zones for pickers
- Reduces travel
- Requires coordination

D. Wave Picking
- Scheduled picking waves
- Optimizes resources
- Better vehicle utilization

Transaction Processing:

Types of Transactions:
- Receipts
- Issues
- Returns
- Adjustments
- Transfers
- Cycle counts

System Requirements:
- Real-time updates
- Accuracy
- Audit trail
- Integration with ERP
- Reporting capabilities

4. Security and Loss Prevention

Security Measures:

Physical Security:
- Perimeter fencing
- Access control systems
- CCTV surveillance
- Security guards
- Lighting

- Alarm systems

Inventory Security:
- Stock verification
- Cycle counting
- Sealed storage areas
- Limited access
- Two-person rule for high-value items

Cyber Security:
- System access controls
- Data encryption
- Backup systems
- Firewall protection
- Regular audits

Loss Prevention:

Types of Losses:
- Theft (internal/external)
- Damage
- Obsolescence
- Deterioration
- Errors in record-keeping
- Natural disasters

Prevention Strategies:
- Employee training
- Background checks
- Inventory audits
- Proper storage conditions
- FIFO implementation
- Insurance coverage
- Fire protection systems
- Pest control

5. Consumption-Based Planning

Material Requirements Planning (MRP)

Inputs:
1. Master Production Schedule (MPS)
2. Bill of Materials (BOM)
3. Inventory Status File
4. Lead Time Data

Process:
- Gross requirements calculation
- Net requirements calculation
- Lot sizing
- Time phasing
- Order release

MRP Logic:
```
Gross Requirements
- On-hand Inventory
- Scheduled Receipts
= Net Requirements
```

Lot Sizing Procedures

A. Lot-for-Lot (L4L)
- Order exactly what's needed
- Minimizes holding cost
- Higher ordering cost

B. Economic Order Quantity (EOQ)
- Fixed optimal quantity
- Balances ordering and holding costs
- May not match requirements exactly

C. Fixed Period Requirements (FPR)
- Orders cover fixed time period
- Simple to implement
- Varying order quantities

D. Part Period Balancing (PPB)
- Minimizes total cost
- Balances ordering and holding
- Complex calculation

E. Least Unit Cost (LUC)
- Minimum cost per unit
- Considers future requirements
- Good for variable demand

F. Silver-Meal Heuristic
- Minimizes average cost per period
- Look-ahead approach
- Effective for lumpy demand

6. Forecasting Parameters and Results

Forecasting Parameters:

Time Horizon:
- Short-term (< 3 months)
- Medium-term (3-12 months)
- Long-term (> 1 year)

Demand Patterns:
- Level (constant)
- Trend (increasing/decreasing)
- Seasonal
- Cyclical

Forecast Accuracy Measures:

MAD (Mean Absolute Deviation):
$MAD = \Sigma|Actual - Forecast| / n$

MSE (Mean Squared Error):
$MSE = \Sigma(Actual - Forecast)^2 / n$

MAPE (Mean Absolute Percentage Error):
$MAPE = \Sigma|(Actual - Forecast)/Actual| \times 100 / n$

Tracking Signal:
TS = RSFE / MAD
(RSFE = Running Sum of Forecast Errors)

Common Forecasting Methods:

Qualitative:
- Expert opinion
- Delphi method
- Market research

Quantitative:
- Moving average
- Exponential smoothing
- Trend analysis
- Regression analysis

7. Planned Order Planning File Consolidation

Purpose: Integrate planned orders from different sources and time periods

Process:
1. Collect planned orders from MRP
2. Group by item and time period
3. Consider constraints (capacity, materials)
4. Consolidate compatible orders
5. Generate final production/purchase schedule

Benefits:
- Reduced setup costs
- Better resource utilization
- Simplified scheduling
- Lower transaction costs

Considerations:
- Capacity constraints
- Material availability
- Lead times
- Priority rules
- Cost trade-offs

8. Break-Bulk Operations

Definition: Breaking large shipments into smaller quantities for distribution

Process:
1. Receive large shipment
2. Verify quantity and quality
3. Sort and segregate
4. Create smaller shipments
5. Redistribute to multiple destinations

Applications:
- Import distribution
- Regional distribution centers
- Retail distribution

Benefits:
- Transportation economies on inbound
- Faster local delivery
- Reduced inventory at destinations
- Better customer service

9. Cross-Docking

Definition: Direct transfer from receiving to shipping with minimal or no storage

Types:

A. Pre-distributed Cross-Docking
- Sorted at origin
- Direct transfer
- Fastest method

B. Consolidation Cross-Docking
- Items from multiple suppliers
- Consolidated for single destination
- Requires sorting

Requirements:
- Advanced information systems
- Accurate demand forecasting
- Reliable suppliers
- Efficient handling equipment
- Good coordination

Benefits:
- Reduced inventory holding
- Faster throughput
- Lower handling costs
- Reduced storage space
- Improved cash flow

10. Mixing/Assembly Operations

Mixing:
Creating customized assortments from standard items

Examples:
- Retail assortments
- Promotional packages
- Customer-specific combinations

**Assembly Operations