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Supply Chain Network Design: A Strategic Centralization of Hazardous Commodity

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Supply Chain Network Design: A Strategic Centralization of Hazardous Commodity

Mustafa Hashem M. Al-Naser

Abstract- **Supply Chain Management field presents its management, consultants, and professionals with a set of various decisions to be made at the strategic, tactical and operational phases. One critical component of these decisions is the supply chain network design. Each firm, during the establishment phase, is required to properly design its network by strategically positioning its distribution facilities to optimize the overall cost of its supply chain. This paper illustrates the importance of such decision; specifically, in relation to the storage of hazardous commodity while covering strengths, weaknesses, opportunities, and threats associated with this decision. Furthermore, the paper presents a potential model for managing hazardous materials that can lead to a significant reduction in the warehousing cost; if executed properly.**

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I. Introduction

Within every organization, supply chain management plays an essential role to the success of its core functions; whether that organization is in the manufacturing or services industries. To gain a better understanding of this, a common definition classifies supply chain management as the design, planning, execution, control, and monitoring of supply chain activities with the ultimate goal of creating net value, establishing a competitive infrastructure, leveraging worldwide logistics, alignment of supply and demand, and measuring performance globally [1]. Supply chain management requires multiple sets of decisions to be made across the different phases. Such decisions can be looked at as strategic, tactical, or operational; depending on the area of concern they are set to address. One crucial strategic decision pertains to the design of the organization's supply chain network. This refers to the geographical positioning of its inventory to better support the core functions through the allocation of storage facilities. The site selection for a storage facility is dependent on several factors; such as the suppliers' locations, the production sites, and the types of materials to be stored.

When considering such a significant decision, the type of materials plays a major role; especially with the decision to centralize the hazardous commodity. Occupational Safety and Health Administration defines the hazardous materials as any substance or chemical, which is hazardous to people's health or is physically hazardous [2]. Health hazards include skin irritation and damage to the breathing system, while physical hazards include flammability and reactivity with other materials. Despite the hazards associated with such materials, chemicals and gases are crucial for organizations in the energy, manufacturing, and health industries. Therefore, it is important to carefully mange such materials in order maintain safe and reliable supply chain. This paper will address insights required to make such strategic decision of central storage for hazardous materials.

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II. Hazard Identification

The first step in developing a central storage strategy for hazardous commodity is to identify the specific types of materials that are considered for storage as inventory. National Fire Protection Association (NFPA) underlines the challenge of determining and classifying hazardous materials due to the lack of consistent definition and classification approach [3]. However, these are some of the commonly classified hazardous materials that are being used globally:

- Chemicals
- Gases
- Radioactive materials
- Explosives

Each class of hazardous material poses unique risks and dangers. For instance, chemicals can lead to fires, explosions or chemical reactions if mishandled, while radioactive materials require a special handling using appropriate personal protective equipment to avoid exposure to radiations.

III. Regulatory Framework

The storage of hazardous materials is subject to a complex set of regulations at the local, national, and international levels. These regulations aim to safeguard human health, protect the environment, and ensure public safety. Examples of such regulations include OSHA (Occupational Safety and Health Administration) regulations in the United States, the European Union's REACH (Registration, Evaluation, Authorization, and Restriction of Chemicals) legislation, and international agreements like the Basel Convention on the Control of Transboundary Movements of Hazardous Wastes and Their Disposal [4].

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Compliance with these regulations is not optional, but rather mandatory. Failure to adhere to regulatory requirements can result in severe penalties, legal liabilities, and reputational damage for organizations. In fact, compliance incorporates storage facility design, safety protocols, record-keeping, as well as other reporting requirements.

IV. Centralized Storage Strategy

Central storage refers to the consolidation of hazardous commodity storage in a single, strategically located facility. This approach contrasts with decentralized storage, where materials are stored at multiple sites, such as individual production facilities or regional warehouses. This means that all customers that utilize such hazardous materials will be served from a single storage point. The centralized storage strategy offers several compelling benefits including:

- Cost Savings, where economies of scale can lead a significant reduction in the storage cost, allow for bulk purchasing, and ensure optimized resource utilization
- Logistics Optimization as centralization streamlines transportation, making it more efficient and environmentally friendly
- Enhanced Safety since a single, well-designed facility can implement advanced safety measures; thus, reducing the risk of accidents
- Full compliance to internal and external regulations, since it is easier to monitor and audit the compliance level of one facility rather than multiple facilities.

V. Site Selection

Choosing the right location for a central storage facility is critical and these factors shall be considered and addressed [5]:

- *Proximity:* The site should be close to production facilities to minimize the cost of transportation and the required time for delivery
- *Transportation Networks:* accessibility to highways, railways, and ports is essential for efficient inbound and outbound logistics flows
- *Emergency Response:* The site must have access to emergency response resources, such as fire departments and medical facilities
- *Environmental Impact:* Assess the environmental impact of the site, including potential effects on ecosystems and nearby communities

Performing an environmental impact assessment is a crucial step prior to the site selection, as it evaluates the potential environmental effects of a project, helping to mitigate negative impacts and ensure full compliance with environmental regulations.

VI. Facility Design

The design of the central storage facility should prioritize safety and efficiency. Key elements of consideration include:

- *Layout:* Efficient material flow and segregation of hazardous materials
- Infrastructure: Adequate storage capacity, containment systems, and ventilation
- *Fire Suppression:* Vigorous fire suppression systems, including water and foam sprinklers and alarm systems
- *Security:* Access restrictions and controls, surveillance, and intrusion detection systems

Containment systems, such as secondary containment structures and bunds, are vital to prevent leaks and spills from escaping the storage area [6]. In addition, effective ventilation systems help manage air quality within the facility, particularly when dealing with volatile or toxic materials.

VII. Inventory Management

Inventory control is essential for the efficient management of hazardous materials. The longer hazardous materials are stored, the higher chance that their physical properties change over time; resulting in waste and additional expenses. Key strategies to overcome this include:

- *First-In-First-Out (FIFO):* Helps ensure older materials are used or disposed of first in order to minimize waste
- *Just-In-Time (JIT):* An approach of maintaining minimal on-site inventory to reduce storage costs
- *Regular Audits:* Conducting frequent audits to track inventory levels, expirations dates, and overall compliance

In addition to the above strategies, advanced technologies, such as RFID (Radio-Frequency Identification) and barcode systems, can improve inventory tracking accuracy. Real-time monitoring systems help prevent unauthorized access and monitor environmental conditions. With the evolution of Artificial Intelligence, several technologies have emerged, such as smart sensors measuring the temperature and humidity of a certain point within a warehouse to help maintain appropriate storage environment.

VIII. Safety Measures

Establishing comprehensive safety protocols is a paramount when handling hazardous materials. These protocols should cover, at minimum:

- *Material Handling:* Providing guidelines for safe handling, loading, and unloading of hazardous materials

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- *Emergency Response:* A set of procedures for responding to accidents, including spills, fires, and chemical exposures
- *Personal Protective Equipment (PPE):* Listing all requirements for personnel to minimize exposure risks

Moreover, ensuring that the assigned personnel are well-trained in safety procedures is critical. It is essential to develop and regularly update emergency response plans, conduct emergency drills, and provide ongoing safety training to all employees

IX. Risk Assessment and Mitigation

Risk assessment involves identifying potential hazards, evaluating their likelihood and consequences, and prioritizing them based on their risk levels [7]. This step helps in determining the critical risks that must addressed. As a result, risk mitigation strategies need to be implemented to reduce the likelihood and impact of identified risks. This may include:

- Installation of safety barriers to separate hazardous materials.
- Implementing strict safety protocols and monitoring.
- Creating backup systems to prevent critical failures.

Furthermore, it is crucial to develop contingency plans for responding to accidents or incidents. These plans should include immediate actions to contain and mitigate the incident, as well as long-term recovery efforts.

X. SWOT Analysis

SWOT (Strength, Weakness, Opportunities, Threats) analysis is a key tool utilized in supply chain management for making strategic decisions while considering all the internal and external factors. For the optimum centralization of hazardous materials, below are major areas of interest to keep in mind:

a) Strengths

- Advanced safety measures and protocols; thus, reducing the risk of accidents and incidents involving hazardous materials.
- Cost savings resulting from economies of scale through bulk purchasing and inventory management.
- Efficient logistics by streamlining transportation logistics, making it more environmentally friendly and cost-effective.
- Higher compliance rate to local, national, and international regulations governing the storage of hazardous materials.

b) Weaknesse

- Initial Capital Investment for the construction or retrofitting of existing facility
- Higher operational cost for personnel, maintenance, and utilities
- Greater environmental impact in case of accidents and incidents

c) Opportunities

- Technological advancements, such as advanced inventory tracking systems and environmental sustainability measures
- Sustainability focus for making the storage facility more environmentally friendly by reducing waste and energy consumption

d) Threats

- Severe consequences of storage related incidents for hazardous materials
- Continuous changes of regulations and compliance requirements in case of failure to adapt to these changes
- Competitive pressures to reduce costs; thus, impacting the feasibility of centralized storage
- Impact of economic uncertainties and fluctuations on the cost-effectiveness of central storage

XI. Conclusion

In conclusion, a well-planned central storage strategy for hazardous materials is a critical component of supply chain management across various industries. However, it is important to consider key aspects associated with central storage, including hazard identification, facility design, and safety measures.

Centralized storage of hazardous materials offers substantial benefits, including cost savings, enhanced safety, logistics optimization, and higher compliance rate.

However, as industries continue to evolve and regulations become more stringent, organizations must adapt their storage strategies to ensure the safe and efficient handling of hazardous materials. Furthermore, sustainability considerations are increasingly important, urging businesses to find ways to reduce their environmental impact.

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