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Inventory Optimization Using FSN Analysis in Spare Parts Planning

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Abstract- Effective spare parts inventory management is a cornerstone of operational efficiency in service-intensive industries. In the elevator and lift sector, the availability of the right spare part at the right time directly determines service continuity, customer satisfaction, and maintenance cost. This study investigates the application of FSN (Fast, Slow, and Non-Moving) Analysis as a systematic inventory classification technique for optimizing spare parts planning in the Indian elevator industry. Drawing on secondary inventory data comprising 329 stock-keeping units (SKUs) collected over a twelve-month period from a pneumatic vacuum home-lift manufacturer based in Chennai, the research classifies spare parts into three movement-based categories and derives category-specific inventory control policies. Complementary ABC and VED analyses are also employed to provide value-based and criticality-based perspectives. The FSN classification reveals that 46 items (13.98%) are Fast-Moving, 67 items (20.36%) are Slow-Moving, and a striking 216 items (65.65%) are Non-Moving, indicating significant capital blockage in idle inventory. The ABC analysis identifies 23 high-value Class A items driving approximately 70% of annual consumption, while the VED analysis highlights several safety-critical Vital components requiring zero stock-out tolerance. The integrated FSN–ABC–VED framework provides a robust, multi-dimensional foundation for spare parts inventory optimization. The study contributes to the under-researched domain of inventory management in the Indian home-lift and elevator sector, offering practical, implementable recommendations for reducing inventory carrying costs, improving warehouse utilization, and strengthening service reliability.

Keywords: FSN Analysis, Spare Parts Inventory, Inventory Optimization, ABC Analysis, VED Analysis, Elevator Industry, Inventory Classification, Warehouse Management, Carrying Cost, Operational Efficiency

I. INTRODUCTION

In contemporary service operations, inventory management has evolved far beyond the conventional scope of raw-material stocking. For firms operating in equipment-intensive sectors, the management of spare parts inventory has emerged as a strategic imperative that directly affects service levels, maintenance efficiency, and financial performance. The elevator and lift industry represents one such sector, where unplanned equipment downtime can have serious operational, safety, and reputational consequences for both service providers and their clients.

Spare parts inventories in this industry are inherently heterogeneous. They span a wide spectrum that includes high-frequency consumables, periodically required mechanical assemblies, imported electronic control components, and specialized pneumatic or hydraulic elements. Managing this diverse portfolio demands a structured classification approach that distinguishes between items requiring active replenishment and those tying up capital without productive use.

FSN Analysis—which classifies inventory into Fast-Moving (F), Slow-Moving (S), and Non-Moving (N) categories based on consumption frequency—offers a practical, data-driven solution to this challenge. Unlike demand-value-based techniques such as ABC Analysis, FSN focuses on movement patterns, making it particularly well-suited for spare parts environments where certain high-cost items may move infrequently while low-cost items are consumed continuously.

This article presents the findings of a structured study applying FSN, ABC, and VED analyses to the spare parts inventory of a Chennai-based pneumatic vacuum home-lift manufacturer. The study is situated within the rapidly growing Indian home-lift segment—a market that has received minimal academic attention despite its significant economic activity and unique inventory management challenges arising from specialized imported components and proprietary technologies.

II. NEED FOR THE STUDY

The practical motivation for this study emerged from a direct observation: many mid-sized elevator companies in India manage their spare parts inventory through experience-based judgment and reactive procurement rather than systematic, data-driven methods. This approach creates two simultaneously damaging conditions—capital locked in idle stock on one hand, and recurring stock-outs of frequently used components on the other.

Several specific operational inefficiencies were observed and documented as justification for this research. A significant portion of the inventory budget was found to be tied up in spare parts that recorded zero or negligible consumption over the study period. Conversely, frequently used parts experienced intermittent stock-outs, leading to maintenance delays and elevated emergency procurement costs. The absence of any formal classification system meant that a low-cost consumable and an expensive, safety-critical electronic component were managed with identical procedures—an approach that is neither economically rational nor operationally sound.

From a financial standpoint, the cost implications of poor spare parts management in this sector are substantial. Inventory carrying costs—encompassing storage, insurance, handling, and the risk of technological obsolescence—compound progressively as non-moving stock accumulates undetected. FSN Analysis addresses this challenge by providing a movement-based visibility tool that enables differentiated, evidence-based inventory decisions.

From an academic standpoint, this study addresses a recognized void in the literature. While FSN Analysis has been applied extensively in manufacturing plants, hospital pharmacies, and retail environments, its application within the Indian elevator and home-lift industry has not been documented in peer-reviewed literature. This study therefore serves a dual purpose: providing actionable insights for the organization studied and contributing an original empirical case to the operations management literature.

III. SCOPE OF THE STUDY

The geographical scope of this study is confined to the Chennai operations of a pneumatic vacuum home-lift manufacturer, encompassing its central service warehouse and spare parts store. The Chennai location was selected because it serves as the primary inventory hub for the company's pan-India service network and provides the most comprehensive dataset for meaningful FSN classification.

Functionally, the study covers the complete spare parts inventory of 329 SKUs maintained by the organization during the twelve-month study period spanning the financial year 2025. The inventory dataset includes electrical and electronic components, mechanical assemblies, pneumatic elements specific to vacuum elevator technology, cabin fittings, and operational consumables. The analysis encompasses FSN classification based on movement frequency, ABC classification based on annual consumption value, and VED classification based on operational criticality.

The study is explicitly bounded to spare parts management for maintenance and after-sales service activities. It excludes the procurement of new elevator units, financial performance analysis, human resource practices, and international supply chain operations. Company-identifying information has been intentionally excluded to ensure research generalizability and commercial confidentiality.

IV. OBJECTIVES OF THE STUDY

The primary objective of this study is:

- To optimize spare parts inventory management through the application of FSN Analysis, with the aim of improving inventory control efficiency and reducing unnecessary stock investment.

The specific objectives are:

- To examine and document the existing spare parts inventory management practices of the organization.
- To identify the movement pattern of spare parts based on twelve-month consumption frequency data.

- To classify all 329 spare parts SKUs into Fast-Moving, Slow-Moving, and Non-Moving categories using FSN Analysis.
- To apply ABC Analysis for consumption-value-based classification of spare parts.
- To apply VED Analysis for criticality-based classification of spare parts required for maintenance operations.
- To identify excess, idle, and non-moving inventory and quantify the capital blockage associated with such stock.
- To develop category-specific inventory control policies and practical procurement recommendations.
- To improve warehouse space utilization and support better maintenance planning through inventory optimization.

V. REVIEW OF LITERATURE

The academic literature on FSN Analysis spans diverse sectors, reflecting both its methodological versatility and widespread practical relevance. A synthesis of key published works is presented below to establish the theoretical and empirical foundations of this study.

Nadkarni and Ghewari (2016) demonstrated in a manufacturing context that FSN Analysis effectively separates active from idle inventory, reducing carrying costs and improving warehouse organization. Their work established the conceptual basis for movement-based inventory classification that informs this study.

Manivel and Ranganathan (2017) applied combined ABC–FSN Analysis to hospital pharmacy inventory and found that fast-moving items demanded continuous replenishment while non-moving items generated avoidable wastage through expiry and obsolescence. Their work highlights the utility of FSN in service-sector environments—directly analogous to elevator maintenance operations.

Shankar and Kannan (2018) applied FSN Analysis specifically to engineering spare parts, demonstrating that fast-moving items require safety stock policies while non-moving items represent an avoidable drain on working capital. Their findings corroborate the primary analytical approach adopted in this study.

Rahul S. Mor et al. (2021) extended FSN Analysis to warehouse operations, showing that non-moving inventory significantly impairs warehouse productivity and that classification-based policies yield measurable reductions in holding costs. This study builds on their framework and applies it to the elevator sector.

Zhang, Huang, and Yuan (2021) conducted a comprehensive literature review on spare parts inventory management systems, confirming that FSN Analysis remains one of the most widely adopted techniques for understanding stock movement patterns and supporting replenishment policy design.

Divya Devarajan et al. (2024) applied FSN–XYZ Analysis in a chemical manufacturing context and reported that many materials classified as non-moving caused unnecessary capital blockage, with FSN classification enabling significant improvements in stock turnover and procurement efficiency.

Kaewmanee and Wangwatcharakul (2025) applied FSN Analysis to spare parts inventory in a production company and reported a significant reduction in excess inventory costs following FSN-based reclassification and the introduction of category-specific replenishment rules. Their quantitative outcomes provide a useful benchmark for the present study.

Lely Herlina and team (2025) applied FSN Analysis to a maintenance warehouse and found that most electrical spare parts were non-moving while mechanical parts were predominantly slow-moving. Their work reinforces the sector-specific nature of FSN outcomes and supports the need for context-sensitive classification criteria.

Collectively, this body of literature confirms that FSN Analysis is a robust, practically applicable tool for spare parts inventory optimization. However, a consistent gap is the absence of FSN-based studies in the Indian elevator and home-lift industry—a gap this study directly addresses.

VI. RESEARCH METHODOLOGY

6.1 Research Design

This study adopts a descriptive and analytical research design. The descriptive component documents the existing spare parts inventory management practices within the organization. The analytical component applies FSN, ABC, and VED classification techniques to twelve months of spare parts consumption data to derive inventory optimization insights.

6.2 Data Source and Collection

The study is entirely based on secondary data sourced directly from the organization's inventory management system. The dataset encompasses twelve months of spare parts issue records for the financial year 2025, covering all 329 active SKUs. Data sources include inventory stock registers, ERP-generated monthly issue reports, stores issue vouchers, material receipt records, and spare parts transaction logs. No primary data collection through questionnaires or structured interviews was employed, as the analytical objective required objective, quantitative consumption records.

6.3 Sampling Technique

A census approach was adopted for inventory analysis. All 329 spare parts maintained in the organization's inventory during the study period were included in the FSN, ABC, and VED analyses. This approach ensures complete coverage of the inventory portfolio and eliminates sampling error in classification outcomes.

6.4 FSN Classification Criteria

Spare parts were classified according to the following criteria based on twelve months of issue records:

FSN Category	Classification Criterion	Interpretation
Fast-Moving (F)	Consumed in 7 or more months out of 12	Regularly demanded; continuous replenishment required
Slow-Moving (S)	Consumed in 4 to 6 months out of 12	Occasional demand; periodic review sufficient
Non-Moving (N)	Consumed in 3 or fewer months out of 12	Negligible/zero demand; inventory reduction warranted

6.5 Analytical Tools

Three complementary analytical tools were applied. FSN Analysis classified spare parts by movement frequency. ABC Analysis classified spare parts by annual consumption value using the 70/90/100 cumulative threshold convention. VED Analysis classified spare parts by operational criticality—Vital (V) items being those whose absence directly halts lift operation, Essential (E) items whose absence impairs performance, and Desirable (D) items whose absence can be tolerated for short periods without critical consequence. Microsoft Excel was employed for data organization, pivot analysis, and visualization.

VII. ANALYSIS AND INTERPRETATION

7.1 Monthly Consumption Overview

The total annual consumption across all 329 SKUs amounted to 7,869 units. Monthly analysis revealed pronounced seasonality, with peak consumption recorded in January (1,272 units) and February (1,188 units), corresponding to heightened maintenance activity in the post-monsoon period. The lowest consumption was recorded in June (229 units) and July (332 units). This seasonal pattern has direct implications for safety stock planning, particularly for fast-moving items.

7.2 FSN Classification Results

Category	No. of Items	% of Total SKUs	Annual Quantity	% of Total Qty	Recommended Location
Fast-Moving (F)	46	13.98 %	3,566	45.3 %	Service Centre
Slow-Moving (S)	67	20.36 %	3,139	39.9 %	Regional Warehouse
Non-Moving (N)	216	65.65 %	1,164	14.8 %	Central Warehouse / Review

TOTAL	329	100 %	7,869	100 %	—

A critical observation arising from the FSN results is the inverse relationship between item count and consumption volume. Fast-Moving items constitute only 13.98% of all SKUs yet account for 45.3% of total annual consumption by quantity. This confirms the Pareto principle operating in spare parts demand: a small number of items drive the majority of service activity. The 46 Fast-Moving SKUs must therefore be prioritized for continuous stock availability at every service centre to prevent maintenance delays.

The most operationally significant finding is that 216 items—representing 65.65% of the entire SKU portfolio—are Non-Moving. These items recorded consumption in three or fewer months across the twelve-month study period. They collectively contribute only 14.8% of annual consumption volume yet occupy warehouse space, incur holding costs, and tie up working capital that could be deployed more productively elsewhere in the business.

7.3 ABC Analysis Results

ABC Analysis applied to the 329 SKUs identified 23 Class A items contributing approximately 70% of total annual demand, 31 Class B items contributing the next 20%, and the remaining 275 Class C items contributing the final 10%. The highest-demand items were Rivets (1,290 units, 18.29%), Batteries-2.5AH (346 units), Cabin Shoe Carpet (315 units), Inner Cabin Door Bush (264 units), and 3mm Gasket Beading Standard (250 units). These Class A items require tight inventory control, frequent replenishment cycles, and accurate demand forecasting to prevent service disruptions.

The concentration of annual demand in a small number of items—the top ten items alone account for 49.4% of total consumption—underscores the strategic importance of differential inventory control. Class A items warrant continuous review systems and vendor performance monitoring, while Class C items can be managed with simpler periodic or on-demand procurement approaches.

7.4 VED Analysis Results

The VED Analysis categorized spare parts according to their functional criticality. Vital items—including batteries, door lock sets, sensors, emergency switches, braking units, rope lock mechanisms, and solenoid assemblies—are those whose unavailability renders the lift inoperable or unsafe. These items require zero stock-out tolerance and must be maintained with dedicated safety stock at all service locations irrespective of their FSN classification.

Essential items include gaskets, polycarbonate sheets, SMPS boards, fans, and cable harnesses. Short-term unavailability of these items impairs lift performance without creating immediate safety hazards. Desirable items—such as carpets, logo plates, and decorative cover plates—have negligible safety and operational impact and can be sourced on an as-needed basis without safety stock provisions.

7.5 Integrated FSN–ABC–VED Matrix

The most actionable output of the study is the cross-classification of FSN, ABC, and VED categories. Items that are simultaneously Fast-Moving, Class A, and Vital (FAV items)—such as OLR Relays, Emergency Keys, Travelling Cables, and Door Solenoids—require the highest priority management with zero stock-out tolerance. At the opposite end, items that are Non-Moving, Class C, and Desirable (NCD items)—such as decorative carpets and cover plates—can be managed with minimal safety stock or purely on-demand procurement. This matrix-based approach transforms the FSN outputs into a tiered, operationally actionable inventory policy framework.

VIII. FINDINGS

- Out of 329 spare parts, 46 items (13.98%) are Fast-Moving and account for 45.3% of annual consumption volume, confirming their critical role in daily maintenance operations.
- 67 items (20.36%) are Slow-Moving, indicating moderate demand that requires periodic review rather than continuous replenishment.
- A substantial 216 items (65.65%) are Non-Moving, representing idle inventory that ties up working capital, occupies warehouse space, and

incurs carrying costs without contributing to operational output.

- The top 23 Class A items identified through ABC Analysis drive approximately 70% of total annual spare parts consumption, confirming the Pareto principle and highlighting the need for differential inventory control.
- Several Vital spare parts identified through VED Analysis experienced occasional availability gaps, signalling that the current procurement system does not adequately account for operational criticality in replenishment decisions.
- Certain high-value Class A items were found to be overstocked relative to actual consumption, resulting in avoidable inventory investment beyond operational requirements.
- Monthly consumption analysis reveals significant seasonal variation, with peak demand in January–February and trough demand in June–July, a pattern that current inventory planning does not account for.
- The absence of a formal, structured inventory classification system has allowed non-moving stock to accumulate over successive procurement cycles without detection or review.
- Coordination gaps between the procurement, maintenance, and stores functions contribute to misalignment between actual demand and purchasing decisions, exacerbating over-stocking tendencies.
- A conservative estimate suggests that implementing FSN-based inventory optimization could reduce capital blockage by 25–30% through the rationalization of Non-Moving stock and improve inventory turnover ratios measurably.

IX. SUGGESTIONS

Non-Moving Inventory

The organization should immediately initiate a structured review of all 216 Non-Moving items, categorizing each as obsolete, potentially usable in other operational contexts, or returnable to vendors. A formal disposal or return-to-vendor programme should be established for confirmed obsolete items to recover working capital and reclaim storage space. Fresh procurement of Non-Moving item categories should be subject to a documented maintenance justification requirement, and a mandatory periodic review cycle of six to twelve months should be institutionalized to prevent future dead stock accumulation.

Slow-Moving Inventory

A Periodic Review System (P-Model) should be adopted for Slow-Moving items, with review intervals calibrated to consumption history and scheduled preventive maintenance calendars. Demand forecasting techniques such as exponential smoothing or moving average models should be employed to reduce forecast error. Bulk procurement of Slow-Moving items should be replaced with need-based or Just-in-Time ordering to minimize holding costs.

Fast-Moving Inventory

A Continuous Review System (Q-Model) should be implemented for all 46 Fast-Moving items, with explicitly calculated Reorder Points (ROP) and Economic Order Quantities (EOQ). Strategic safety stock should be maintained for all FAV (Fast-Moving, Class A, Vital) items to buffer against supply disruptions. An automated or ERP-integrated inventory tracking system should be deployed to provide real-time visibility into Fast-Moving stock levels across all service locations.

Integrated Classification Framework

The organization should formalize the combined FSN–ABC–VED classification framework as a standing inventory management policy. FAV items must receive the highest management priority with zero stock-out tolerance. NCD items should be managed with minimal or zero safety stock. The classification should be reviewed annually to reflect changes in the installed base, product line updates, and evolving consumption patterns. Dedicated inventory performance indicators— including Inventory Turnover Ratio, Non-Moving Inventory Percentage, Stock-Out Rate, and Carrying Cost per SKU— should be established and monitored on a quarterly basis.

Organisational and Process Improvements

Cross-functional coordination between procurement, maintenance, and stores should be strengthened through regular inventory review meetings aligned with maintenance schedules. Personnel in all three functions should be trained in FSN, ABC, and VED methodologies to embed analytical thinking into routine inventory decisions. Proper item codification and standardization should be implemented across the entire SKU portfolio to improve inventory tracking accuracy and eliminate duplication. Procurement lead-time data—particularly for imported components—should be integrated into reorder point calculations to ensure that safety stock levels adequately buffer supply risk.

X. CONCLUSION

This study applied FSN Analysis, supplemented by ABC and VED classification techniques, to the spare parts inventory of an elevator manufacturer operating in the Indian home-lift sector. The analysis covered 329 SKUs across twelve months of actual consumption data and yielded clear, actionable insights into the structure and efficiency of the organization's spare parts management practices.

The principal finding—that 65.65% of all SKUs are Non-Moving—represents a significant opportunity for inventory rationalization. The concentration of actual consumption in a small subset of Fast-Moving items (13.98% of SKUs accounting for 45.3% of consumption volume) confirms the applicability of the Pareto principle and underscores the need for differentiated inventory control strategies rather than uniform procurement practices.

The integrated FSN–ABC–VED framework adopted in this study transcends the limitations of any single classification technique. By simultaneously considering movement frequency, consumption value, and operational criticality, it provides a comprehensive foundation for inventory policy design that is both economically rational and operationally sound. The framework is directly implementable without requiring advanced technology investment, making it particularly suitable for mid-sized elevator companies at the current stage of their operational maturity.

From an academic perspective, this study fills a documented gap in the literature by providing the first empirically grounded, sector-specific application of FSN Analysis to the Indian home-lift industry. The findings contribute to the growing body of knowledge on inventory management in service-intensive industries and offer a replicable methodology for future research in analogous contexts—including other elevator segment operators and maintenance service providers across South Asia.

In conclusion, FSN Analysis—when applied rigorously and integrated with value-based and criticality-based classification—is a powerful, cost-effective tool for spare parts inventory optimization. Its systematic implementation in the studied organization has the potential to reduce inventory carrying costs substantially, release blocked working capital, improve service reliability for end customers, and establish a culture of data-driven inventory decision-making that will serve the organization well as it continues to grow.

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