A Case Study on Location-Based Inventory Management: QR Labelling and Digital Integration in Warehouse Operations

N.H. Mohd Fadzil[1]* and H.N. Abu Bakar[1]

Politeknik Ungku Omar,
31400 Ipoh, Perak, Malaysia.

*Corresponding Author's Email: hasliza@puo.edu.my
Article History: Received 15 August 2025; Revised 1 October 2025;
Accepted 28 October 2025;

Abstract
Efficient warehouse management is essential to ensure accuracy, reduce operational costs, and enhance supply chain performance. However, in the case study warehouse located in Rawang which operates using the ZOHO Warehouse Management System (WMS), the absence of location-based tagging led to significant inefficiencies including delayed retrieval, stock misplacement, poor space utilization, and error-prone audits. This study conducted with warehouse staff and supervisors from XYZ Manufacturing Sdn. Bhd. aimed to address these issues through the design and implementation of a structured location-based inventory management system. The methodology was organized into four phases: (1) problem identification through system observation and performance benchmarking, (2) system design using rack, slot, and area identifiers combined with QR code labelling, (3) system implementation involving physical tagging and integration of location data into ZOHO WMS and (4) performance evaluation using key performance indicators (KPIs). The results demonstrated substantial improvements, with retrieval time reduced by 58%, stock movement error rate decreased from 15% to 4%, space utilization efficiency increased from 65% to 85%, and audit accuracy improved from 70% to 95%. These outcomes substantiate those low-cost interventions themselves, if incorporated into computerized warehouse systems, can yield considerable performance gains. The study further recommends the use of advanced technologies such as RFID, IoT sensors and indoor positioning systems, as well as the incorporation of green logistics practices, to sustain and scale these improvements. The study overall offers a practical framework integration of physical and digital systems to achieve scalable, robust and sustainable warehouse operations.

Keywords: Inventory Control; Location-Based Tagging; Operational Efficiency; QR Code; Warehouse Management System.

1.0 Introduction
Warehouse management has been made more complex with the rise in range of inventories, variability in demand and growing expectations of operations, necessitating efficient inventory control systems with low delays, minimal cost and excellent accuracy (Osman et al., 2024a). Recent studies emphasize that the performance of warehouses can be improved through the integration of technologies such as QR code, IoT, RFID and digital tagging (Anggara et al., 2024; Jarašūnienė et al., 2023). The use of warehouse management systems (WMS) has been established to streamline inventory operations and enhance operational outcomes, particularly when supplemented with lean practices and digitalization (Osman et al., 2024b; Tubis & Rohman, 2023).

Digital innovations also play a key role in enabling more accurate inventory tracking. For instance, Vaccari et al., (2024) highlighted the high potential of indoor positioning systems (IPS) such as UWB, Wi-Fi and Bluetooth to enhance logistics visibility and Zhang et al., (2024) demonstrated their feasibility in warehouse environments despite cost and deployment concerns. Furthermore, Shanmugamani & Mohamad, (2023) reported that WMS implementation in B2B environments directly impacts productivity and accuracy. Similarly, Yılmaz et al., (2025) noted that warehouse design and product clustering as a strategy can improve supply chain feasibility through the optimization of storage and retrieval systems.

Future directions also point to the addition of artificial intelligence and high-performance computational capabilities to warehouse operations. Rad et al., (2025) examined the use of AI-based order picking, with noteworthy improvements in efficiency and accuracy, while Shanmugamani & Mohamad, (2023) proposed clustering and GPU-based routing as approaches to warehouse storage and retrieval optimization. Collectively, these studies demonstrate the growing significance of bringing physical warehouse infrastructure into alignment with digital harmony to improve performance, visibility and sustainability.

In the warehouse under study, which employs ZOHO Warehouse Management System (WMS) a cloud-based inventory management platform that enables real-time tracking, order processing and stock control, the stock location field is not utilized for over 400 items. This has resulted in significant inefficiencies such as increased retrieval time, increased labour costs, stock movement errors, disorganized storage and difficulty in conducting audits and replenishment. To meet these challenges, this project aims to create and implement a location-based inventory tagging system of rack, slot and area labels attach QR code and area labels for faster and more precise identification, input the location into the ZOHO WMS for real-time visibility and compare the results on retrieval times, error rates, space usage and audit accuracy.

This is a method that was used as location-based tagging of stock provides a structured and traceable setting for keeping inventory within the warehouse, minimizing retrieval times and preventing item misplacement. The use of rack, slot and area identifiers ensures systematic storage and supports efficient space utilization while QR code and area labels offer a low-cost yet highly reliable method for real-time data capture and synchronization with the ZOHO WMS. Previous studies have demonstrated that combining physical location identifiers with QR enables systems can substantially improve inventory visibility, tracking accuracy and overall warehouse performance (Anggara et al., 2024; Tubis & Rohman, 2023). The limits of this study are all the packaging materials and raw materials in the warehouse of the case study, focusing on the physical structuring, labelling systems and computer integration in ZOHO and performance improvement measured over a defined post-implementation period. By bridging the gaps between physical tagging and digital syncing, this research provides a unified framework for warehouse performance enhancement and obtains actionable insights into large-scale WMS enhancement approaches (Perera et al., 2023; Villegas-Ch et al., 2024).

2.0 Methodology

This study is a case study with focus on the implementation of an inventory management system based on location within a currently operational warehouse that is presently managed using the ZOHO Warehouse Management System (WMS). The methodological process was structured into four main stages, adopted from current warehouse process improvement structures (Osman et al., 2024b; Tubis & Rohman, 2023).

Phase 1 : Problem Identification

The first phase involved direct observation and inspection of the existing ZOHO WMS. Inventory records were checked to determine lack of the location tagging that caused inefficiencies in the form of slow picking, stock loss and ineffective space utilization. Warehouse workers and supervisors were interviewed to determine data for operations challenges, while retrieval time, error and auditing accuracy were measured as baseline performance indicators. This approach is consistent with best practice in warehouse research where the identifying of functional gaps is the first step to digitalization (Zhang et al., 2024).

Phase 2 : System Design

A systematic warehouse design was developed in this phase to address the identified inefficiencies. Products were sorted by product type, how often they move, and storage requirements. Rack, slot and area identifiers were developed and mapped to develop a systematic storage system. QR code labels were then designed to encompass item description, location code and part number with well-defined separation of floor/area-based from rack-based items. The application of QR codes as electronic identifiers is consistent with studies by Anggara et al., (2024), which indicated that QR-based systems enhanced traceability of inventory and reduced human error.

Phase 3 : System Implementation

The newly established location codes and QR codes were deployed in the warehouse configuration. Individual identifiers and QR tags were assigned to each rack and specific storage location to enable quick scanning and live traceability. Concurrent with libelling, the ZOHO WMS was modified to include the corresponding location fields. This ensured digital synchronization between the warehouse management system and the physical warehouse. As suggested by Vaccari et al., (2024), combining physical layout design and digital integration gives a more robust and durable warehouse management system.

Phase 4: Performance Evaluation

Following implementation, the comparative analysis was done to evaluate between pre- and post-implementation environments. The measurement focused on quantitative performance measures, i.e., four important performance measures (KPIs): average retrieval time per item (minutes), error rate in stock movement (%), space efficiency utilization (%) and accuracy of inventory audits (%). These were measured for the three-month period after implementation to ensure stability and reliability in results. Parallel to this, qualitative data were gathered through staff comments and provided information about the usability of the system, ease of use and overall adoption by warehouse personnel. This mixed assessment approach that brings together quantitative KPIs and qualitative commendation provides insights into current trends in warehouse performance research (Jarašūnienė et al., 2023).

3.0 Results and Discussion

This section illustrates the results of the study and discusses the outcome of every implementation phase against the study objectives. The results are arranged chronologically by the four main phases of the methodology; problem identification, system design, system implementation and performance evaluation. All stages present the recorded improvement, supporting evidence and analysis of performance of the location-based inventory management system in conjunction with the ZOHO Warehouse Management System (WMS). Comparative outcomes are provided to present the impact of the new system on retrieval time, stock movement accuracy, space utilization and inventory audit performance.

3.1 Phase 1: Problem Identification

The absence of location-based tagging in the warehouse management system (WMS) was found to be among the primary drivers of inefficiency. As shown in Table 1 (Appendix), the absence of location data in the original warehouse management system (WMS) caused inventory retrieval, restocking and tracking issues leading to inefficiencies in operation and extra labour costs. This finding is supported by previous research studies which observed that the lack of systematized location data has the propensity to cause disorganization and reduced productivity in warehouse operations (Zhang et al., 2024).

3.2 Phase 2: System Design

Based on the inefficiencies defined in Phase 1, a planned warehouse layout was designed to establish a systematic way of managing inventory. As shown in Figure 1, the warehouse was divided into separate zones and racks and each marked with a different location code. This structured design made it possible for raw materials, packaging material and non-moving stock to be stored in designated spaces, thereby reducing the likelihood of misplaced products and facilitating easy pick-up. This has also been highlighted by Yılmaz et al., (2025), who demonstrated that product grouping and planned warehouse design increase supply chain feasibility by maximizing storage and retrieval.

To support this layout, Figure 1 shows the organized location codes, which encompass rack numbers, slots and designated zones. This structured code not only enhances retrieval and resupply speeds but also minimizes the chances of misplaced inventory. Through assigning individual rack and slot numbers such as R1–R5 for package and component materials, F1–F3 for carpets and NMS for non-moving storage, the warehouse now has greater visibility and traceability of stock.

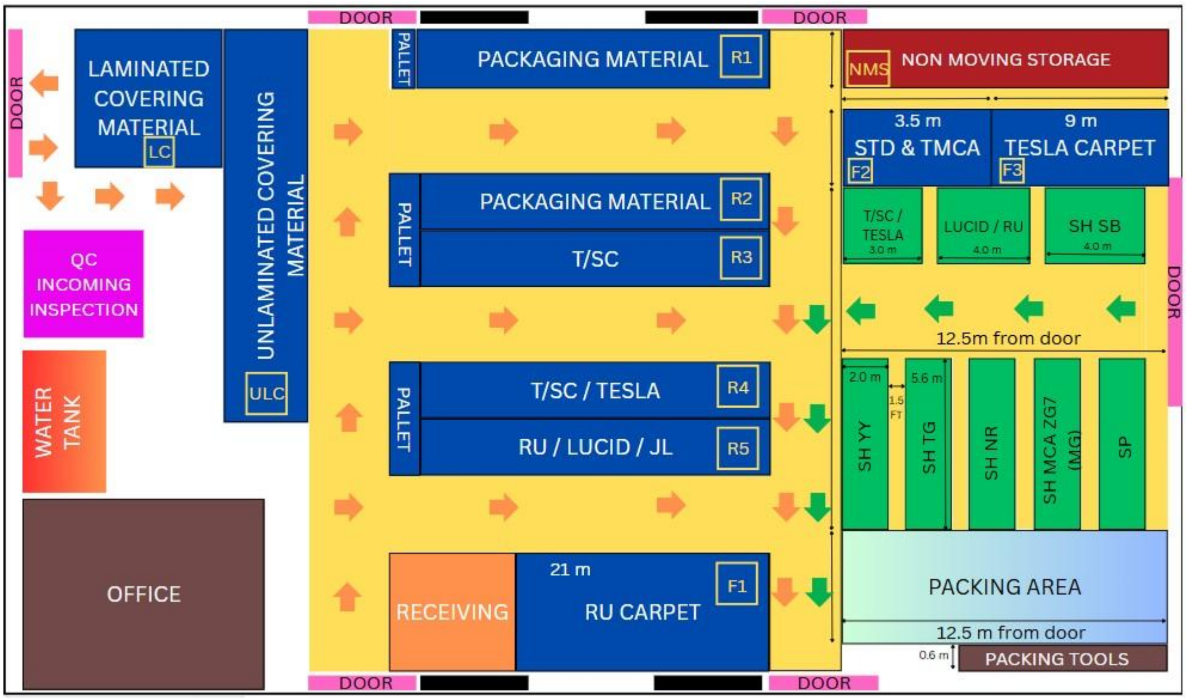

Figure 1: Warehouse Layout with Location Tagging.

Further details of these location identifiers are presented in Table 2 which outlines the designated codes for each material type and rack level. These identifiers were then combined with QR labels for digital integration during the implementation process. This model of coding not only improved visibility but also gave a foundation for tracing in real-time once synchronized with the ZOHO WMS. Anggara et al., (2024) emphasized that QR-based identification, when augmented with well-designed layout, helps to reduce manual handling errors and improve speed in operations.

Table 2: Location Identifiers

Description	Location
Laminated Covering Material	LC 1 (The number shows which rack)
Unlaminated Covering Material	ULC1 (The number shows which rack)
Packaging Material Racks	R1 – 45 slots Bottom Rack – slots B1-B15 Middle Rack – slots M16 –M30
	Top Rack – slots T31-T45 R2 – 45 slots Bottom Rack – slots B1-B15 Middle Rack – slots M16 –M30 Top Rack – slots T31-T45
T/SC and TESLA Racks	R3 – 45 slots Bottom Rack – slots B1-B15 Middle Rack – slots MF16 –M30 Top Rack – slots T31-T45 R4 –45 slots Bottom Rack – slots B1-B15 Middle Rack – slots M16 –M30 Top Rack – slots T31-T45
RU / LUCID / JL Racks	R5 – 45 slots Bottom Rack – slots B1-B15 Middle Rack – slots M16 –M30 Top Rack – slots T31-T45
RU Carpet	F1
STD & TMCA	F2
TESLA CARPET	F3
Non-Moving Storage	NMS

Overall, the system design phase created a solid physical and logical structure that acted in direct response to the disorganization that was evidenced in the baseline system. By the union of organized location codes and redesigned warehouse layout, this phase set the groundwork for associating physical tagging with digital systems based on intelligent warehouse design principles (Tubis & Rohman, 2023).

3.3 Phase 3: System Implementation

The new system was also established by physical tagging and digital incorporation into the warehouse infrastructure. Figure 2 shows that each QR label contains essential information such as item description, part number and location code. The labels are physically placed directly onto racks to indicate the precise location of inventory items to enable fast and reliable identification. For those items stored in locations not on racks there are area tags employed to ensure consistent traceability.

Figure 2: Location Identifier QR Label.

In parallel with the physical tagging, the ZOHO WMS was updated to incorporate the newly developed location codes (R. Ruthramathi & Dr. V. Sivakumar, 2023). Table 3 (Appendix), illustrates the updated raw material inventory records with an additional Location column, which allowed for faster item recognition and improved stock visibility. Moreover, as shown in Table 4 (Appendix),, synchronizing physical location tags with electronic records established a seamless workflow between warehouse processes and the WMS. Integration allowed replenishment with improved accuracy, reduced retrieval time, and streamlined inventory audits. Vaccari et al., (2024) highlighted that such synchronization between physical tagging and digital systems strengthens supply chain visibility and improves decision-makingOverall, the execution phase constituted a fundamental change from a disorganized, manually controlled system to an integrated system that aligns structured physical layouts with digital technologies. The approach captures the essence of intelligent warehouse management, where hybrid solutions combining location-based tagging, QR coding and WMS integration provide scalable and sustainable efficiency gains (Tubis & Rohman, 2023).

3.4 Phase 4: Performance Evaluation

Following the implementation of the location-based inventory system, a comparative study was conducted to quantitatively measure the benefits achieved. Performance was assessed based on of four key performance indicators (KPIs): stock retrieval time, stock movement error rate, space utilization efficiency and audit accuracy. As shown in Table 5, one can observe that there were indeed significant improvements in operational performance.

Average retrieval time per item reduced from 12 minutes to 5 minutes, an improvement of 58%. Error rates on stock movement reduced from 15% to 4%, reflecting the effectiveness of QR code marking and systematic location identifiers in curbing human error. Space utilization efficiency improved from 65% to 85% because the products were assigned to the racks and designated areas in a methodical way, thus preventing chaos and maximizing used space. Audit accuracy also increased from 70% to 95%, thanks to the increased visibility and real-time traceability of combining location data into ZOHO WMS. These improvements are consistent with findings by Jarašūnienė et al. (2023), who reported that IoT-enabled solutions significantly improve warehouse accuracy and reduce errors.

Table 5: Key Performance Indicators Before and After Implementation

Bil	Key Performance Index	Before Implementation	After Implementation
1	Average retrieval time per item (minutes)	12	5
2	Stock movement error rate (%)	15	4
3	Space utilization efficiency (%)	65	85
4	Accuracy inventory audits (%)	70	95

The results also agree with current trends in smart warehouse systems, where hybrid solutions that include structured configurations, digital identification and WMS integration offer measurable advantages in operations (Tubis & Rohman,2023). Furthermore, such studies have shown that strategic planning for warehouses and clustering initiatives can significantly contribute to supply chain robustness and space utilization (Yılmaz et al., 2025).

Overall, the evaluation confirms that the implementation of organised location tagging, QR codes, and digital synchronization into ZOHO WMS is a cost-effective, scalable platform for warehouse improvement. These results not only indicate to the effectiveness of the system but also highlight the potential of implementing it as a future platform for improvement with RFID, IoT sensors and indoor position technologies.

4.0 Conclusion

This study demonstrated that the implementation of a formal location-based inventory management system supported by QR code marking and incorporation in the ZOHO WMS significantly improved warehouse performance by reducing retrieval time, stock movement error discrepancies, space utilization maximization, and audit error minimization. The findings confirm that with low-cost initiatives, significant performance gains are achievable when physical warehouse infrastructures are methodically synchronized with electronic systems. Similar evidence was reported by Anggara et al., (2024), who demonstrated that QR-based warehouse systems enhance traceability and minimize human error and by (Jarašūnienė et al., 2023), who emphasized that IoT solutions can significantly improve warehouse visibility and efficiency.

To further bolster these results, several recommendations are proposed. Future research should comprise the use of cutting-edge technologies such as RFID, IoT sensors and indoor positioning systems to facilitate automatic tracking (Vaccari et al., 2024; Zhang et al., 2024). In addition, the development of dashboards for real-time analytics on ZOHO to support faster and data-based decision-making, continuous employee training to ensure system standardization and sustainability for a longer duration and scalability of the framework to other warehouses to test its adaptability across different operating scenarios. In addition, the synchronization of location tagging with green logistics procedures will provide opportunities for reducing energy consumption and enabling sustainable supply chain management in line with recent studies on sustainable warehouse practices (Tubis & Rohman, 2023).

The evaluation period of three months post implementation may not fully reflect the long-term sustainability of the improvement. Future research should address these limitations by including longer evaluations periods and the integration of automated data collection methods such as RFID, IoT sensors for more comprehensive analysis. Collectively, these initiatives will not only sustain the improvements achieved but also position the warehouse for long-term scalability, resilience and competitiveness.

Acknowledgements
The author would like to express his gratitude to the management and staff of XYZ Manufacturing Sdn. Bhd for their cooperation and to all team members involved in the implementation of this project. The author would also like to express his gratitude to the Politeknik Ungku Omar and Jabatan Pendidikan Politeknik dan Kolej Komuniti who have made significant contributions to various parts of this research effort.

Author Contributions
N.H. Mohd Fadzil: Conceptualization, Abstract, Introduction, Discussion, Conclusion, Methodology, Result and Editing; **H.N. Abu Bakar**: Result, Discussion and Writing-Reviewing.

Conflicts of Interest

This manuscript is an original work and is not currently submitted to any other journal. All contributing authors have reviewed and approved the final version and declare no conflict of interest in the manuscript.

References

Anggara, B., Anshor, A. H., & Hadikristanto, W. (2024). Implementation Web-Based Qr-Code Information System Design in Warehouse Inventory Management System Using Rapid Application Development (RAD) Method at PT Dharma Precision Parts. *Formosa Journal of Computer and Information Science*, *3*(2), 81–90. https://doi.org/10.55927/fjcis.v3i2.10117

Jarašūnienė, A., Čižiūnienė, K., & Čereška, A. (2023). Research on Impact of IoT on Warehouse Management. *Sensors*, *23*(4), 2213. https://doi.org/10.3390/s23042213

Osman, M. K., Mohamad, E., Kamarudin, N., & Rahman, A. A. (2024a). Warehouse operations optimisation through the implementation of lean methodology: A comprehensive review. *Multidisciplinary Reviews*, *8*(4), e2025110. https://doi.org/10.31893/multirev.2025110

Osman, M. K., Mohamad, E., Kamarudin, N., & Rahman, A. A. (2024b). Warehouse operations optimisation through the implementation of lean methodology: A comprehensive review. *Multidisciplinary Reviews*, *8*(4), e2025110. https://doi.org/10.31893/multirev.2025110

Perera, S., Pinto, A., Sewmini, H., Ulugalathenne, A., Thelijjagoda, S., & Karunarathna, N. (2023). *Influence of IoT on Warehouse Management Performance in the Global Context: A Critical Literature Review*. 118–132. https://doi.org/10.54389/MLEP9597

R. Ruthramathi, & Dr. V. Sivakumar. (2023). Digital Technology Advancement and Innovations in Warehouse Operations. *International of Emerging Knowledge Studies*, *2*(4), 87–98.

Rad, F. F., Oghazi, P., Onur, İ., & Kordestani, A. (2025). Adoption of AI-based order picking in warehouse: benefits, challenges, and critical success factors. *Review of Managerial Science*. https://doi.org/10.1007/s11846-025-00858-1

Shanmugamani, K., & Mohamad, F. (2023). The Implementation of Warehouse Management System (WMS) To Improve Warehouse Performance in Business to Business (B2B). *International Journal of Industrial Management*, *17*(4), 231–239. https://doi.org/10.15282/ijim.17.4.2023.10091

Tubis, A. A., & Rohman, J. (2023). Intelligent Warehouse in Industry 4.0—Systematic Literature Review. *Sensors*, *23*(8), 4105. https://doi.org/10.3390/s23084105

Vaccari, L., Coruzzolo, A. M., Lolli, F., & Sellitto, M. A. (2024). Indoor Positioning Systems in Logistics: A Review. *Logistics*, *8*(4), 126. https://doi.org/10.3390/logistics8040126

Villegas-Ch, W., Navarro, A. M., & Sanchez-Viteri, S. (2024). Optimization of inventory management through computer vision and machine learning technologies. *Intelligent Systems with Applications*, *24*, 200438. https://doi.org/10.1016/j.iswa.2024.200438

Yılmaz, Ö. F., Yılmaz, B. G., Yeni, F. B., & Bal, A. (2025). Investigating the impact of strategic warehouse design and product clustering on supply chain viability: A unified robust stochastic programming approach. *International Journal of Production Economics*, *285*, 109621. https://doi.org/10.1016/j.ijpe.2025.109621

Zhang, X., Tan, Y. C., Tai, V. C., & Hao, Y. (2024). Indoor positioning system for warehouse environment: A scoping review. *Journal of Mechanical Engineering and Sciences*, 10350–10381. https://doi.org/10.15282/jmes.18.4.2024.9.0815

Appendix

Table 1: Raw Material Inventory in ZOHO system

Section	External Provider	Part Number	Part Description	Closing Stock	UOM	Unit Price in MYR	Stock Value	Minimum Stock	Maximum Stock
TESLA	OPS	8-1597TE	MAP POCKET PACC	450.00	EA	19.43	8743.00	10.00	0.00
RU	OPS	8-1595RU	MAP POCKET VINY1	0.00	EA	12.85	0.00	0.00	0.00
LUCID	OPS	8-1573LV	PACKAGING BOX 84	570.00	EA	10.40	5928.00	25.00	250.00
JL	OPS	8-1544JV	W40-019RR	370.00	EA	9.54	3529.80	43.00	300.00
LUCID	ELTETE	8-1582LV	Lucid-Paper Pallet	24.00	EA	35.00	843.00	25.00	250.00

Table 3: Raw Material Inventory with the new location column included

Section	External Provider	Part Number	Part Description	Closing Stock	UOM	Unit Price in MYR	Stock Value	Minimum Stock	Maximum Stock
RU	CYCEL	6-4379RU	PP Sheet Stiffener (338x25x0.7mm)	-4200.00	EA	0.45	-1890.00	0.00	0.00
RU	OPS	8-1592RU	PNL FRT SEAT BACK CARPET BLACK PACKAGING BOX	-40.00	EA	12.90	-516.00	0.00	0.00
RU	CYCEL	6-4376RU	PP Sheet Clip Retainer (338 X 30MM)	-50.00	EA	0.64	-32.00	0.00	0.00
T/SC	MASTRADA	4-7077T	Slide front plastic extrusion 370mm RH (152025-901 PZQ)	-26.00	EA	3.66	-95.16	300.00	600.00
T/SC	CHANGTAI	4-7007G	BLACK BINDING SLIT AT 18MM CUT AT 18MM	-59.96	COIL	20.16	-1208.79	100.00	100.00

Table 4: Location added into ZOHO system

Section	External Provider	Part Number	Part Description	Closing Stock	UOM	Unit Price in MYR	Stock Value	Minimum Stock	Maximum Stock	Location
JL	WANSERN	9-0095JV	LIMINATED PUR NAPPA GRAIN TX7	-4200.00	EA	0.45	-1890.00	0.00	0.00	WF1