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An analysis of human errors in the receiving process of raw material warehouses in the automotive industry using HEART and SHERPA methods

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ABSTRACT

The development of industrial manufacturing automation drives the need for efficiency, but the majority of part receiving processes in the automotive warehouse department are still traditional, making them prone to human error. This research aims to identify the causes of human error in receiving, analyze its impact on warehouse accuracy and efficiency, and provide recommendations for improvement. Periodic data from July-December 2024 shows that 43.27% of warehouse errors occurred during receiving. The quantitative method Human Error Assessment and Reduction Technique (HEART) was applied to 6 main activities and 12 sub-tasks, resulting in the highest error probability (HEP) for the sub-task of checking the physical condition of the part (HEP = 12.085). The qualitative approach Systematic Human Error Reduction and Prediction Approach (SHERPA) identified the dominance of action errors and checking errors, particularly in part checking, data input, material handling, and document verification. The combination of findings from HEART-SHERPA reveals that human error slows down the receiving process, disrupts actual stock, and delays production flow. Recommendations for improvement include: (1) Technical training and routine briefings to enhance operator competency, (2) implementing a buddy system and double verification using checklists, and (3) re-layouting the transit area with tag labels and structured archiving.

1. Introduction

The development of automation in the manufacturing industry has brought significant changes to companies' operational processes in Indonesia. According to the Central Bureau of Statistics (BPS), approximately 30% of jobs in the manufacturing sector are potentially impacted by automation (Suhandoko, 2024). Globally, the International Federation of Robotics (2021) report shows an increase in the use of industrial robots, reaching 3 million units in 2021, up 10% from the previous year (Frankfurt, 2021) . The application of automation has proven capable of increasing efficiency and reducing errors caused by human intervention (Woods et al., 2017). A McKinsey study shows that implementing automation can increase manufacturing industry productivity by up to 20% (Suhandoko, 2024). In this context, the automotive sector is one of the industries that is highly driven to innovate in work systems in order to maintain efficiency, precision, and competitiveness.

The increasing demand for two-wheeled vehicles in Indonesia, particularly the Honda brand, creates new challenges in the supply chain and warehouse management. One critical point in this

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system is the receiving process, which marks the beginning of the internal logistics flow (Frazelle, 2002). Based on company observations and data, the receiving process frequently experiences errors such as incorrect specifications, mismatched quantities, and part rejections due to material handling errors. Internal company data for the period from July to December 2023 recorded 74 cases of receiving errors, which contributed the most to overall warehouse issues (43.27%), making it a critical point that needs improvement.

Various studies have examined the application of HEART (Human Error Assessment and Reduction Technique) and SHERPA (Systematic Human Error Reduction and Prediction Approach) in the manufacturing context. The study successfully identified 18 types of human error in the ceramic production process using both methods (Utama et al., 2020). Another study utilized HEART to predict human error in the assembly department and provide control solutions (Aliabadi et al., 2024; Octaviani & Arifin, 2024; Pradipta & Susanto, 2023; Rammadaniya & Mahbubah, 2022). However, there haven't been many studies that specifically examine the application of this method in the warehouse context, particularly in the receiving process of automotive parts, which is characterized by high volume pressure and complex manual work systems.

This study proposes a combination of the HEART and SHERPA methods as an approach to identify, evaluate, and mitigate human error risks in the receiving process at an automotive warehouse. HEART was chosen for its ability to quantitatively measure the probability of errors quickly and simply (Bell & Holroyd, 2009). Meanwhile, SHERPA was used to systematically analyze errors based on task activities and provide practical improvement recommendations (Alatas & Putri, 2017; Cahyani et al., 2022).

This research aims to identify the root causes of human error in the part receiving process at an automotive industry warehouse and to evaluate its impact on operational effectiveness. The main motivation for this study is the high contribution of receiving errors to production disruptions and logistical inefficiencies. The innovation of this research lies in the specific application of the combined HEART and SHERPA methods in a warehouse environment that still relies on manual systems and has limitations in investing in automation technology. This research is expected to provide practical contributions in reducing human error rates and improving the accuracy of logistics processes in the automotive manufacturing industry.

2. Methods

This study uses a sequential mixed-methods approach that combines quantitative and qualitative methods sequentially. The analysis was conducted using two approaches: the Human Error Assessment and Reduction Technique (HEART) to quantitatively calculate the probability of human error, and the Systematic Human Error Reduction and Prediction Approach (SHERPA) to systematically evaluate potential human errors based on work activities. The research focus is directed towards the goods receiving process in the automotive company's warehouse, with the assumption that the still-manual working system contributes to errors in part specifications and quantities.

Data Collection

This research uses two types of data. Primary data was obtained through direct observation of receiving activities in the warehouse department and semi-structured interviews with warehouse operators and staff. Secondary data consisted of internal company documentation, including part error reports, and a literature review of scientific journals related to human error analysis.

Procedure

The initial step begins with identifying the main problems in the inventory receiving process, followed by a literature study to formulate the appropriate method. Next, field observations are conducted to directly observe the types and frequency of errors, and in-depth interviews are carried out to explore potential causes. After the data is collected, the analysis process is divided into two methods: HEART and SHERPA.

The HEART method is used to calculate the probability of human error occurring (Williams, 1986). The procedure begins with: Classifying activities into Generic Task Types (GTTs), Identifying Error

Producing Conditions (EPCs) according to the reference table. After that, calculate the Assessed Effect (AE) using the formula:

$$\text{AE} = ((Max\ Effect - 1)\ \text{x}\ \text{APOA}) + 1 \quad (1)$$

Finally, calculate the Human Error Probability (HEP) value using the formula:

$$\text{HEP} = Nominal\ Human\ Unreliability\ \text{x}\ AE_1\ \text{x}\ AE_2\ \text{x}\ AE_3\ \dots\ \text{x}\ \text{AE (n)} \quad (2)$$

This method provides a quantitative value indicating the extent of error risk in a specific activity (Pradipta & Susanto, 2023).

The SHERPA method aims to evaluate potential errors based on task structure (Stanton & Baber, 2002). The steps taken include, first, developing a Hierarchical Task Analysis (HTA), second, identifying potential human errors (Human Error Identification/HEI), then conducting an ordinal analysis of consequences and probabilities with categories: low, medium, high, and finally, designing mitigation strategies for the identified errors. This method helps identify error-prone points and develop preventive measures based on task analysis (Alatas & Putri, 2017; Rizky & Nugraha, 2022).

Data validity is maintained through source triangulation (observation, interviews, and documentation) and expert triangulation to assess the suitability of the approach used. HEART validation is conducted through expert judgment to ensure that GTT and EPC classifications are appropriate for the field context (Arya et al., 2023). The results of the HEART analysis are presented as HEP values per activity, while the results of SHERPA are visualized in an error matrix and mitigation strategies (Pamuka & Susanto, 2018; Tahapary & Saptadi, 2022). Quantitative descriptive analysis was used to identify the proportion of error types, as well as a significance test using a comparative statistical approach to error frequency to provide recommendations for improvement.

3. Results and Discussion

The observation results obtained by the researcher through direct observation in the warehouse department to observe the part receiving process for 14 days, and the interview results from 2 warehouse receiving operator informants, yielded data from the memo summarizing the requests for missing parts submitted to the logistics team, which showed that the receiving team, through warehouse controller employees, made part requests 320 times during the 2024 period.

As for the results of the component receiving process identification in the warehouse area, there are 6 main activities consisting of a total of 12 interconnected sub-activities. HTA serves as an important initial step in both methods that will be used.

Human Error Assessment and Reduction Technique (HEART)

Hierarchical Task Analysis (HTA) is expressed in the form of a task structure or hierarchy of operational activities. HTA is a step to break down the activities or tasks performed by workers in the part receiving process, as shown in Fig. 1.

Based on Fig 1, each subtask in the HTA was identified for Human Error Probability (HEP) using the HEART method for each subtask in the warehouse receiving process. Each subtask was assigned a code number and classified based on the Generic Task Type (GTT) table according to the HEART categories, which determined the initial Nominal Human Error Probability (NHEP) value. Next, the Assessed Error-Producing Conditions (EPCs) were identified by the warehouse foreman as expert judgment, which was then converted into the Assessed Proportion of Effect (AE).

The Assessed Effect (AE) value can be calculated:

$$\text{AE} = ((Max\ Effect - 1)\ \text{x}\ \text{APOA}) + 1 \quad (1)$$
$$AE_{1.1} = \left((Max\ Effect - 1)\text{x}\ \text{APOA}\right) + 1$$
$$AE_{1.1} = \left((4 - 1)\ \text{x}\ 0{,}5\right) + 1$$
$$AE_{1.1} = 2{,}5$$

Calculation to obtain the HEP value:

$$\text{HEP} = Nominal\ Human\ Unreliability\ \text{x}\ AE_1\ \text{x}\ AE_2\ \text{x}\ AE_3\ \dots\ \text{x}\ \text{AE (n)} \quad (2)$$
$$HEP_{1,1} = Nominal\ Human\ Unreliability\ \text{x}\ AE_1\ \text{x}\ AE_2\ \text{x}\ AE_3\ \dots\ \text{x}\ \text{AE (n)}$$
$$HEP_{1,1} = 0{,}02\ \text{x}\ 2{,}5\ \text{x}\ 2\ \text{x}\ 9$$
$$HEP_{1,1} = 0{,}900$$

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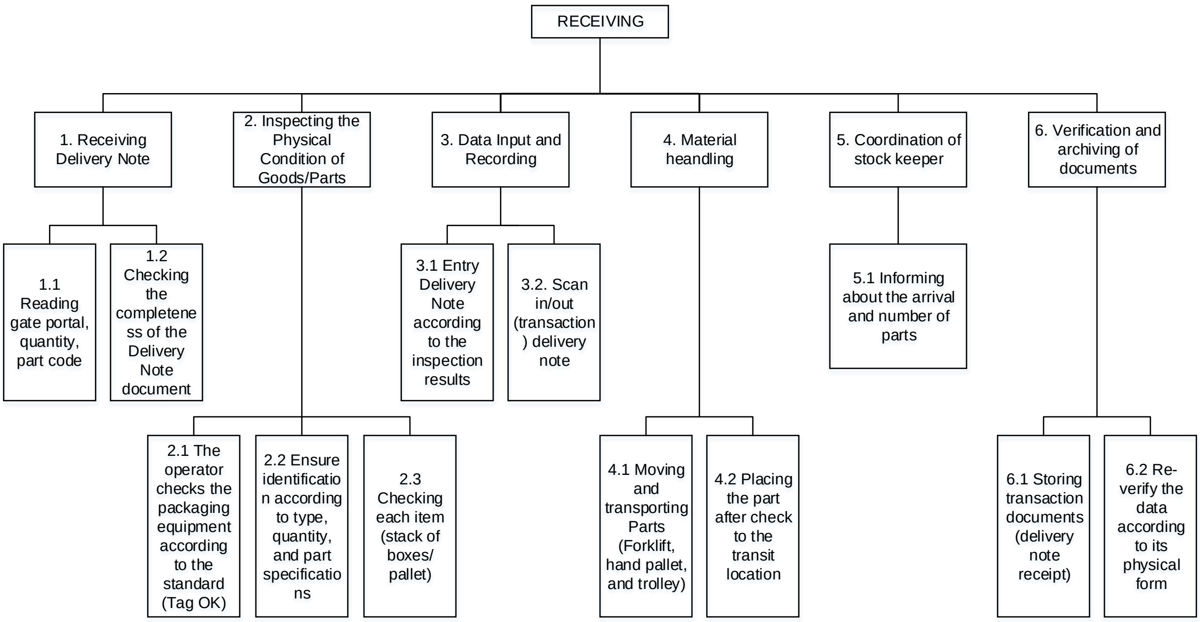

Fig. 1 Hierarchical Taks Analysis (HTA) process of receiving parts in the warehouse.

The value of the HEP means that for the sub-task of reading the gate portal, the number, and the part code, the probability of error is 0.900. The results of the overall assessment and calculation summary are shown in Table 1.

Table 1 Recapitulation of EPCs, APoA, AE, and HEP Receiving Process Assessments

Potential Error	1.1 Operator misreads Delivery Note (location, quantity, part code)		
Generic Task Types (GTTs)	Routine, very practical, fast operator with relatively low skill involved.		
Nominal Human Error Probability [r]	0,02		
Error Producing Conditions (EPCs)	**Total HEART Effect**	**Assessed Proportion**	**Assessed Effect**
No.15	4	0,5	2,5
No.16	3	0,5	2
No.2	11	0,8	9
Human Error Probability (HEP)	0,900		
Potensial Error	1.2 Delivery Note documents received are incomplete		
Generic Task Types (GTTs)	Restoring or replacing a system to its original form or, by following a procedure with multiple checks.		
Nominal Human Error Probability [r]	0,003		
Error Producing Conditions (EPCs)	**Total HEART Effect**	**Assessed Proportion**	**Assessed Effect**
No.15	4	0,7	3,1
No.17	3	0,5	2
Human Error Probability (HEP)	0,0186		

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Table 1 Continue

Potential Error	2.1 Parts noted and damaged (rusty) not detected by the operator		
Generic Task Types (GTTs)	Complex operators/tasks that require a high level of understanding and skill.		
Nominal Human Error Probability [r]	0,16		
Error Producing Conditions (EPCs)	**Total HEART Effect**	**Assessed Proportion**	**Assessed Effect**
No.16	3	0,8	2,6
No.17	3	0,6	2,2
No.2	11	0,5	6
No 25	1,6	0,5	1,3
Human Error Probability (HEP)	7,139		
Potential Error	2.2 Operators lack thorough identification of types, quantities and specifications of parts		
Generic Task Types (GTTs)	Complex operators/tasks that require a high level of understanding and skill.		
Nominal Human Error Probability [r]	0,16		
Error Producing Conditions (EPCs)	**Total HEART Effect**	**Assessed Proportion**	**Assessed Effect**
No.10	5,5	0,7	4,15
No.16	3	0,8	2,6
No.2	11	0,6	7
Human Error Probability (HEP)	12,085		
Potential Error	2.3 The operator checks the parts just for sampling		
Generic Task Types (GTTs)	Simple clear operation is done quickly or with little attention.		
Nominal Human Error Probability [r]	0,09		
Error Producing Conditions (EPCs)	**Total HEART Effect**	**Assessed Proportion**	**Assessed Effect**
No.9	6	0,7	4,5
No.11	5	0,6	3,4
No.2	11	0,6	7
Human Error Probability (HEP)	9,639		
Potential Error	3.1 Operator incorrect data input (typo, wrong part code, incorrect number)		
Generic Task Types (GTTs)	Simple operation that is clearly done quickly or with little attention.		
Nominal Human Error Probability [r]	0,09		
Error Producing Conditions (EPCs)	**Total HEART Effect**	**Assessed Proportion**	**Assessed Effect**
No.2	11	0,5	6
No.16	3	0,6	2,2
Human Error Probability (HEP)	1,188		

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Table 1 Continue

Potential Error	**3.2 Operator forgets to scan in/out (transaction) of road letter**		
Generic Task Types (GTTs)	Simple clear operation is done quickly or with little attention.		
Nominal Human Error Probability [r]	0,09		
Error Producing Conditions (EPCs)	**Total HEART Effect**	**Assessed Proportion**	**Assessed Effect**
No.2	11	0,8	9
No.15	4	0,6	2,8
No.11	5	0,8	4,2
Human Error Probability (HEP)	9,526		
Potential Error	4.1 Parts drop/bump when loading parts		
Generic Task Types (GTTs)	Complex operators/tasks that require a high level of understanding and skill.		
Nominal Human Error Probability [r]	0,16		
Error Producing Conditions (EPCs)	**Total HEART Effect**	**Assessed Proportion**	**Assessed Effect**
No.24	1,6	0,8	1,48
No.17	3	0,6	2,2
No.16	3	0,8	2,6
No.11	5	0,8	4,2
Human Error Probability (HEP)	5,689		
Potential Error	4.2 Operator receives misplaced after check		
Generic Task Types (GTTs)	Routine, very practical, fast operator with relatively low skill involved		
Nominal Human Error Probability [r]	0,02		
Error Producing Conditions (EPCs)	**Total HEART Effect**	**Assessed Proportion**	**Assessed Effect**
No.15	4	0,7	3,1
No.11	5	0,6	3,4
Human Error Probability (HEP)	0,211		
Potential Error	5.1 Misinformation about other carriers regarding the arrival and number of parts		
Generic Task Types (GTTs)	Routine, very practical, fast operator by involving relative skill		
Nominal Human Error Probability [r]	0,02		
Error Producing Conditions (EPCs)	**Total HEART Effect**	**Assessed Proportion**	**Assessed Effect**
No.10	5,5	0,6	3,7
No.15	4	0,6	2,8
No.17	3	0,6	2,2
Human Error Probability (HEP)	0,456		

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Table 1 Continue

Potential Error	**6.1 Documents of road letters transactions are lost, making them difficult to trace in times of urgency**		
Generic Task Types (GTTs)	Routine, very practical, fast operator with relatively low skill involved.		
Nominal Human Error Probability [r]	0,02		
Error Producing Conditions (EPCs)	**Total HEART Effect**	**Assessed Proportion**	**Assessed Effect**
No.29	1,4	0,7	1,28
Human Error Probability (HEP)	0,026		
Potential Error	6.2 Incorrect verification so that the data does not match the physical		
Generic Task Types (GTTs)	Routine, very practical, fast operator with relatively low skill involved.		
Nominal Human Error Probability [r]	0,02		
Error Producing Conditions (EPCs)	**Total HEART Effect**	**Assessed Proportion**	**Assessed Effect**
No.15	4	0,6	2,8
No.13	4	0,6	2,8
Human Error Probability (HEP)	0,157		

The results in Table 1 show that the highest probability value was found in sub-task 2.2 with an HEP value of 12.085, and the lowest in sub-task 1.2, supported by the conditions that caused the error. After obtaining the HEP results, the SHERPA approach was used to re-evaluate the overall process in matrix form to verify the previous findings.

Systematic Human Error Reduction and Prediction Approach (SHERPA)

This SHERPA refers to the pre-arranged task mapping during the application of the HEART method, which begins with constructing a Hierarchical Task Analysis (HTA) based on Fig 1, followed by assessment using the Human Error Identification (HEI) table, and then performing a consequences and ordinal probability analysis with categories: low, medium, high, as presented in Table 2.

Table 2 Human Error Identification (HEI)

No Task	Mode Error	Error Description	Consequences
1.1	A1	Operator misreads Delivery Note (location, quantity, part code)	Part received incorrectly
1.2	C2	Delivery Note documents received are incomplete	The part received according to the quantity on the delivery note only and the more part (rejected) or returned to the suppier
2.1	C1	Parts noted and damaged (rusty) not detected by the operator	Damaged parts pass to the next process (production)
2.2	C2	Operators lack thorough identification of types, quantities and specifications of parts	Parts do not meet the required specifications (delivery orders) and have the potential to damage the delivery components if they are installed on the production line
2.3	C2	The operator checks the parts just for sampling	Parts received are less than quantity
3.1	A7	Incorrect operator data input (typo, wrong part code, incorrect amount)	Inaccurate inventory data: there is a difference between the actual physical goods and the recording in the application system and product in data processing (SAP) in the warehouse
3.2	A8	Operator forgets to scan in/out (transaction) of road letter	Delivery note transaction history is not recorded
4.1	A5	Parts drop/bump when loading parts	Physical damage to parts, Operator potential injury
4.2	A6	Operator receives misplaced after check	Other operators have difficulty finding parts

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No Task	Mode Error	Error Description	Consequences
5.1	I2	Misinformation about other carriers regarding the arrival and number of parts	Parts stacking in transit area and parts stock mismatch
6.1	A5	Documents of road letters transactions are lost, making them difficult to trace in times of urgency	Difficult to track goods
6.2	C4	Incorrect verification so that the data does not match the physical	Inaccurate data and potentially erroneous operational decisions

Based on Table 2, the analysis of error modes shows that Action errors occur most frequently in tasks 3, 4, and sub-tasks 1.1 and 6.1. This is followed by Checking Errors in task 2 and sub-tasks 1.1 & 6.2, and Communication Errors only in task 5. After the error modes were identified, a subsequent analysis was conducted to examine the related problems and the impact of operator or worker errors through consequence analysis. The results of the two approaches used can be seen in Table 3.

Table 3 Comparison of HEART and SHERPA results

No Task	Sub-Task	HEP HEART	Category SHERPA	Recommended Improvements
2.2	Ensure identification according to type, quantity, and part specifications	12,085	High (Action, Checking)	Provide follow-up training and monitoring on a regular basis
2.3	Checking each item (stack of boxes/pallet)	9,639	High (Checking)	Provide follow-up training and monitoring on a regular basis
3.2	Scan in/out (transaction) delivery note	9,526	Medium (Action)	Implementation of a buddy system where each operator is responsible for reminding his colleagues
2.1	The operator checks the packaging equipment according to the standard (Tag OK)	7,139	Medium (Checking)	Provide follow-up training and monitoring on a regular basis
4.1	Moving and transporting Parts (Forklift, hand pallet, and trolley)	5,689	Low (Action)	Provide regular appeals and preventive actions
3.1	Entry Delivery Note according to the inspection results	1,188	Medium (Action, Checking)	Conduct a thorough check and check the DO document after checking
1.1	Reading gate portal, quantity, part code	0,900	Medium	Carefully checking the documents of every order
5.1	Informing about the arrival and number of parts	0,456	Medium	Implementation of a buddy system where each operator is responsible for reminding his colleagues
4.2	Placing the part after check to the transit location	0,211	Low	Temporary tagging and re-layout of transit areas that make it easier for operators to
6.2	Re-verify the data according to its physical form	0,157	Medium	Conducting regular communication and double verification of check results
6.1	Storing transaction documents (delivery note receipt)	0,026	Low	Archive documents every time after a transaction
1.2	Checking the completeness of the Delivery Note document	0,019	Low	Double verify documents physically

Based on Table 3, the sub-tasks with the highest error probability are "Ensure identification according to type, quantity, and part specifications" (HEP: 12,085) and "Checking each item" (HEP: 9,639), which fall under the category of checking. The high value indicates that manual verification activities are the most prone to errors, particularly due to cognitive load and time pressure. Other sub-tasks such as document scanning (HEP: 9,526) and package inspection (HEP: 7,139) also have a medium-high risk, even though they fall under the action and checking categories. Conversely,

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physical activities such as part movement (HEP: 5,689) and inspection result entry (HEP: 1,188) show a lower risk. Some administrative subtasks have very low HEP (<1), but it is still important to ensure the continuity of the process. This finding indicates that the manual inspection process is a top priority in mitigating human error in the automotive goods receiving warehouse.

Recommendations for Improvement

To improve accuracy and efficiency in the warehouse part receiving process, and to reduce error rates caused by previously identified human factors, several strategic steps are recommended:

1. Strengthening human resource competencies through mandatory technical training programs and regular briefings is essential, especially for new personnel or those who have experienced job rotations, with a focus on physical goods inspection procedures, document understanding, and systematic record-keeping.
2. Implementing double verification of documents and the physical condition of goods, supported by manual checklists and the "buddy system," is crucial to minimize errors.
3. The transit area rearrangement (re-layout) is aimed at optimizing distribution flow and minimizing work overlap between operators, complemented by temporary transit labeling to expedite part identification and periodic transaction archiving and reconfirmation of inspection results to ensure data traceability and accuracy.

4. Conclusion

This study reveals that the receiving process in the raw material warehouse of the automotive company is highly susceptible to human error, particularly in activities requiring high concentration and quick decision-making. Based on the HEART-SHERPA method, six main activities consisting of twelve sub-tasks have been identified. The sub-task with the highest potential for errors is 2.2, with a Human Error Probability (HEP) value of 12.085 (action error), followed by sub-tasks 2.3 and 3.2, each with an HEP value above 9. These three activities involve part inspection processes with time pressure, high part type variation, and visual similarity between components, which can lead to perceptual errors and incorrect decision-making. Conversely, subtasks 1.2 and 6.1, which are routine and have low complexity, show the smallest HEP values, namely 0.0186 and 0.026.

Human error in the receiving process not only impacts the accuracy of material data but can also disrupt production flow and operational stability. Therefore, this study recommends three main strategies: periodic training and briefings to improve compliance with SOPs, implementing a double-check system and a Buddy System for critical activities, and redesigning the transit area with a more organized marking and filing system. Additionally, it is recommended to conduct a workload analysis to ensure a balance between the number of employees and operational demands. Further research can be expanded to other warehouse phases to comprehensively assess the risk of human error.

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