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Analysis of Work Posture with Revised NIOSH Lifting Equation (RNLE) and Mental Workload with Subjective Scale of Mental Workload (ESCAM) in Employees (CV Gajah Printing)

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Abstract. *Human resources are one of the main elements that need to be considered because of their limited abilities. The limited ability of humans to perform various kinds of physical and non-physical activities is usually influenced by work postures that are less ergonomic and excessive workload. The purpose of this study is to identify the risk of skeletal muscle injury of shopping bag plastic manufacturing operators using NIOSH Lifting, measure the mental workload of shopping bag plastic manufacturing operators using the ESCAM method, and provide suggestions for improvement using the NIOSH Lifting and ESCAM methods. Based on the results of measuring workers' work posture with the RWL and LI equations, it is known that manual handling activities at the printing, blowing, and mixing machine workstations have an LI> 3 value, where these activities have a risk level for skeletal muscle injury. While the results of measuring employee mental workload, 2 factors can affect employee performance, namely the consequences for health and task characteristics.*

Keywords: *work posture, NIOSH lifting, mental workload, ESCAM*

I. INTRODUCTION

Human resources in a company are one of the important elements that need to be considered in developing a business. (Priyono & Marnis, 2008). In the manufacturing industry, the production process needs to be involved with human resources to compete in an increasingly competitive era. Human resources have a major contribution in carrying out the production process through their role in completing each job. (Priyono & Marnis, 2008). Human resources can affect the productivity of a company (Mahyarni & Meflinda, 2011). The higher the level of motivation of natural resources in doing work, the higher the productivity of individuals and companies. (Djuhara, 2014). HR productivity will tend to increase if employees feel cared for by management. (Sururin et al., 2020). The productivity of an organization or company can be improved through effective human resource planning to produce efficient work activities. (Novera, 2010).

One of the efforts in human resource planning is to reorganize the workload given equally to each operator. According to Ayuba et al. (2019), workload is the amount of effort required to complete the overall task demand imposed on workers and is a measure of the limited ability or capacity of the human body to perform certain tasks. From an ergonomics point of view, the workload that can be performed by the human body must be appropriate and balanced with physical abilities, mental capacity, and other limitations. Employee workload occurs in three conditions, namely normal workload (fit), underload, and overload. (Tridoyo, 2014). Employee workload should be given evenly to prevent employees who have excessive tasks and employees who are idle (Sutarto, 2006). If the workload is light, it indicates that there is excess labor. Too much labor can lead to cost inefficiencies where the company needs to pay more workers who have the same level of productivity. (Novera, 2010). In addition, the workload must be designed in such a way as to

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produce an optimal workload, because if the workload is too little, boredom will arise and vice versa if the workload is too excessive, it will cause physical and psychological fatigue, resulting in a decrease in work performance (Iridiastadi & Yassierli, 2019). So it is necessary to analyze and regulate workload by all industries, both manufacturing and service industries.

CV Gajah Printing is one of the manufacturing companies engaged in the plastic industry and is located in Purbalingga, Central Java. CV Gajah Printing produces 3 main products, namely kresek, plastic shopping bags, and HD plong. The company produces at most 450 kg of plastic shopping bags per day. Currently, the products produced by CV Gajah Printing have been marketed to banyumas areas such as Purwokerto, Ajibarang, Sokaraja, and surrounding areas. This results in the high-quality standards used by CV Gajah Printing so that the process must be done well from start to finish. In the process of making plastic shopping bags, several jobs have manual material handling activities such as pouring raw materials into the mixing machine, pouring plastic seeds into the blowing machine, lifting plastic from the printing machine, lifting plastic to the cutting machine, and some jobs are done manually such as the soft handle process (providing plastic handles), the checking process, and finally the packing process.

Based on the results of interviews with the foreman of CV Gajah Printing, there are suspected problems with operator workload and employee work posture in manual handling activities. Employees at CV Gajah Printing stated that the operator's workload is high because the operator has a very flexible task, then the work posture experienced by the operator in carrying out manual handling activities is not ergonomic so when lifting the operator gets tired easily. Excessive workload causes employees to experience stress and physical and psychological fatigue (Novera, 2010; Pratama, 2022) and work postures that are performed repeatedly over a long period and material loads that are greater than the normal lifting limit of employees can be fatal if not given serious attention (Mohammadi et al., 2013). Therefore, this study subjectively measured mental workload to determine how much influence the mental workload of employees has on their work and measured work posture to determine the level of risk of skeletal muscle injury in manual handling activities.

The research of Cecilia et al. (2022) using the ESCAM method aims to determine the mental workload of civil servants (PNS) and to identify factors that affect work performance using the ESCAM method, the results in this study indicate that the workload value with a high category is in factor 1 (Task Demands and Task Complexity) with a value of 4.09 and control is done by resetting the rest schedule that has been set. In research by Herwanto et al., (2016) using the NIOSH Lifting method which aims to improve employee work attitudes to reduce skeletal muscle disorders in employees, the results in this study indicate that the lifting index value in the chemical liquid pouring process is not good with a lifting index value> 1.0 or the chemical liquid pouring process carried out by employees has a risk that can result in spinal cord injury and the lifting work is not safe to do. Another study Bastuti (2022) using the NIOSH Lifting method which aims to measure the level of danger of manual material handling flexion using the NIOSH Lifting method found that the Lifting Index (LI) value for the five employees was 3.35, 3.17, 3.45, 3.08, 3.25, 3.08 or the lifting index value> 1 in other words the lifting process carried out by the five employees has several risks that can result in spinal cord injury and the work is not safe to do. This study aims to apply two types of measuring instruments using the NIOSH and ESCAM methods. The NIOSH method measures the lifting load from lifting activities, where the respondent will carry out the lifting process and measure the variable value based on the load lifted by the respondent. The ESCAM method measures mental workload with a subjective approach, where respondents will provide an assessment of 5 dimensions, based on what the respondent feels when doing his job.

Based on the above problems, it is necessary to measure the workload of CV Gajah Printing employees to determine the effect of the mental workload of shopping bag plastic manufacturing

operators on employee work productivity, which are all employees at CV Gajah Printing. Then it is necessary to measure the work posture of employees who do manual handling activities, to determine the level of risk of skeletal muscle injury from the activities carried out. The results of the study are expected to be a consideration for the company in conducting evaluations and improvements to the company.

II. RESEARCH METHOD

The data needed to measure work postures are workers who are active in manual handling and measure lifting variables to 3 workers such as horizontal distance (H), vertical distance (V), displacement distance (D), asymmetry angle (A), type of coupling (C), and number of lifts/minute (F). The method used in this study is the NIOSH method through the RWL and LI equations to identify the level of risk of skeletal muscle injury.

Meanwhile, primary data collection was carried out by making a mental workload questionnaire in hardcopy form and then distributing it to all employees of CV Gajah Printing, totaling 28 respondents. Technically, respondents were allowed to fill out the questionnaire freely by giving a score between 1 (very low) to 5 (very high) based on the burden experienced by each employee. The method used is the ESCAM method to evaluate mental workload which is subjective and to determine the effect of mental workload of shopping bag plastic manufacturing operators on employee work productivity.

III. RESULT AND DISCUSSION

Appointment Variables

Based on direct data collection, the lifting variables are the horizontal distance between the center point of the body or the midpoint of the ankle and the position of the hand holding the load (H), the vertical distance between the floor and both hands holding the load (V), the vertical distance between the starting point before the load is lifted to the intended lifting point (D), the angle of asymmetry (turning angle when moving goods) (A), the frequency of lifting or the number of lifts performed per minute (F), and the clutch classification (hand grip) (C) of the plastic shopping bag making process at several work stations as shown in Table 1.

The lifting variable data can be used to calculate the risk level of skeletal muscle injury using the RWL and LI equations.

RWL and LI calculation of shopping bag plastic manufacturing process

RWL and LI calculations are only carried out in jobs that have manual handling activities, jobs that require lifting are found at several workstations, such as mixing, blowing, cutting, and printing machines. Then the body distance to the point of lifting objects can be seen in the table. Calculations of multipliers, RWL, and LI can be seen in Table 2 and Table 3.

An example of calculating the multiplier factor at the work station of mixing machine in the origin position is as follows:

$$\mathbf{LC} = \mathbf{23kg}$$

$$\mathbf{HM} = \frac{\mathbf{25}}{\mathbf{52}} = \mathbf{0,48}$$

Table 1. Data on manual handling activity variables for making plastic shopping bags

Respondents	Work Station	Weight (kg) (L)	Hand Location (cm)				Vertical Distance (cm)	Asymmetric Angle		Average Frequency	Duration	Object Coupling
			Origin		Destination			Origin	Destination			
			H	V	H	V	D	A	A	F		C
A	Mixing Machine	25	52	57	44	74	17	0	0	14	2 min	*Poor*
	Cutting Machine	20	30	24	34	37	13	0	0	4	2 min	*Good*
B	Blowing Machine	30	30	60	40	120	60	0	0	1	1 min	*Poor*
C	Printing Machine	45	40	89	40	37	52	0	0	1	1 min	*Good*

Table 2. Multiplier, RWL, and LI calculation results (Origins)

Respondents	Work Station	Weight (kg) (L)	Value	*Recommended Weight Limit* (***Origin***)							RWL	LI	Category
				LC	HM	VM	DM	AM	FM	CM			
A	Mixing Machine	25	Variables	23	52	57	17	0	14 lift/2 min	*Poor*	7,15	3,5	*Very High Risk*
			Multiplier Factor	23	0,48	0,95	1,08	1,00	0,70	0,90			
	Cutting Machine	20	Variables	23	30	24	13	0	4 lift/2 min	*Good*	17,23	1,16	*Low Risk*
			Multiplier Factor	23	0,83	0,85	1,17	1	0,91	1			
B	Blowing Machine	30	Variables	23	30	60	60	0	1 lift/min	*Poor*	13,86	2,16	*High Risk*
			Multiplier Factor	23	0,83	0,96	0,90	1	0,94	0,90			
C	Printing Machine	45	Variables	23	40	89	52	0	1 lift/min	*Good*	11,74	3,83	*Very High Risk*
			Multiplier Factor	23	0,63	0,96	0,91	1	0,94	1			

Table 3. Multiplier, RWL, and LI calculation results (Destination)

Respondents	Work Station	Weight (kg) (L)	Value	*Recommended Weight Limit* (***Destination***)							RWL	LI	Category
				LC	HM	VM	DM	AM	FM	CM			
A	Mixing Machine	25	Variables	23	44	74	17	0	14 lift/2 menit	*Poor*	8,9	2,81	*High Risk*
			Multiplier Factor	23	0,57	1,00	1,08	1	0,7	0,9			
	Cutting Machine	20	Variables	23	34	37	13	0	4 lift/2 menit	*Good*	15,9	1,26	*Low Risk*
			Multiplier Factor	23	0,74	0,89	1,17	1	0,91	1			
B	Blowing Machine	30	Variables	23	40	120	60	0	1 lift/menit	*Poor*	9,41	3,19	*Very High Risk*
			Multiplier Factor	23	0,63	0,87	0,90	1	0,94	0,9			
C	Printing Machine	45	Variables	23	40	37	52	0	1 lift/menit	*Good*	10,85	4,15	*Very High Risk*
			Multiplier Factor	23	0,63	0,89	0,91	1	0,94	1			

$$\mathbf{VM} = \mathbf{1} - (\mathbf{0,003} \times |\mathbf{57} - \mathbf{75}|) = \mathbf{0,95}$$

$$\mathbf{DM} = \mathbf{0,82} + \left(\frac{\mathbf{4,5}}{\mathbf{17}}\right) = \mathbf{1,08}$$

$$\boldsymbol{AM} = \mathbf{1} - (\mathbf{0,0032} \times \mathbf{0}) = \mathbf{1}$$

$$\mathbf{FM} = \frac{\mathbf{14}}{\mathbf{2}} = \mathbf{7\ sacks\ per\ minute} = \mathbf{0,7}$$

$$\mathbf{CM} = \boldsymbol{Poor} = \mathbf{0,90}$$

After calculating the multiplier factor, RWL, and LI calculations can then be made. The following is an example of the calculation of RWL and LI at the mixing machine workstation at the origin position as follows:

1. Recommended Weight Limit

$$\mathrm{RWL}_{\boldsymbol{Origin}} = 23 \times 0,48 \times 0,95 \times 1,08 \times 1 \times 0,7 \times 0,90 = \mathbf{7,15}\ \mathrm{kg}$$

2. Lifting Index

$$\mathbf{LI}_{\boldsymbol{Origin}} = \frac{\mathbf{25}}{\mathbf{7,15}} = \mathbf{3,50}$$

Work Posture Analysis with the National for Occupational Safety and Health (NIOSH) Method

Based on the results of data processing in Table, it can be seen that the manual handling

activity that has the highest value is at the printing machine workstation when the destination position with an LI value of 4.15 which means it falls into the very high-risk category, in this activity workers must lower the load from a height of 52 cm with a load lifted by 45 kg once, where the manual handling activity in the printing machine has a very high-risk level of spinal cord injury.

Then the activity at the mixing machine workstation has an LI value of 3.50 at the origin position, where in this activity the worker lifts a load of 25 kg with a height of 17 cm for 14 lifts, based on the activity and the LI value that the lifting done by the worker has a very high risk of spinal cord injury.

In manual handling activities the blowing machine workstation has an LI value of 3.19 at the destination position where in this activity workers have to lift a load of 30 kg with a height distance of 60 cm for one lift, based on the LI value in the blowing machine shows that the LI value> 3 which is the risk of spinal cord injury in manual handling activities in the mixing machine is very high.

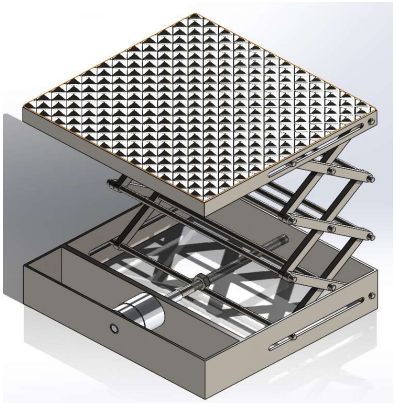

Figure 1. Design of small scissor lift

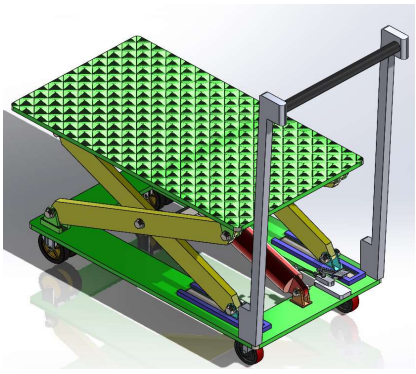

Figure 2. Design of scissor lift table

Improvement Implementation

Improvements are given to manual handling activities in blowing and printing machines by providing tools in the form of small scissor lifts. The following is a picture of the small scissor lift design which can be seen in Figure 1.

The proposal that can be given to the mixing machine is to provide a scissor lift table. The scissor lift tool assists in raising and lowering an item or object. The design of the scissor lift table image which can be seen in Table 2.

With the existence of tools in the form of a scissor lift, workers no longer need to use their energy in lifting manually. The scissor lift tool can assist workers in lifting goods or objects, by only using a machine or hydraulic jack, the tool will move according to the desired height.

ESCAM Questionnaire

The ESCAM method is a mental workload measurement questionnaire consisting of 5 factors, namely cognitive demands and task complexity, consequences for health, task characteristics, time organization, and work speed (Evelyn et al., 2022). The ESCAM questionnaire is addressed in Table 4.

Calculation of Mental Workload

Based on the results of distributing questionnaires to employees of CV Gajah Printing, 28 respondents varied in assessing the perceived mental workload. The following is a table of recapitulation results of the ESCAM questionnaire addressed in Table 5.

After obtaining the ESCAM questionnaire data, the validity and reliability of the data are tested, from the calculation results using SPSS software, it is obtained that the data used is correct and consistent so that it can be continued to the next stage, namely the calculation of the weight of each question item.

The following is an example of a calculation to find the weight value on question item number 1 as follows:

Weight Value P1

$$NB_1 = (5 \times 5) + (4 \times 20) + (3 \times 2) + (1 \times 1)$$

$$NB_1 = 25 + 80 + 6 + 1$$

$$NB_1 = 112$$

Table 6. ESCAM questionnaire factors and items

No	Question
Factor 1	**Cognitive Demands and Task Complexity**
P1	What level of effort or concentration does your work require?
P2	How many instructions need to be memorized and what materials are needed for your work?
P3	What is the level of complexity of the instructions you have to use in your work?
P4	What level of mental effort is required to avoid mistakes in your work?
P5	What is the level of decision-making uncertainty in your job?
P6	In general, in your position/role, how many decisions do you have to make?
Factor 2	**Health Consequences**
P7	Do you feel tired at the end of the workday?
P8	Do you feel tired when you wake up in the morning, making you lazy to work?
P9	How much fatigue is generated in my work?
P10	Do you find it hard to relax after work?
Factor 3	**Task Characteristics**
P11	How many interruptions (phone calls, delivery services, requests from colleagues, etc.) occurred during my work?
P12	What level of difficulty do you experience when doing your job?
P13	In your job, do you have to do more than one task at a time?
P14	Do the tasks you perform require a lot of concentration because there are many distractions or noise in your work environment?
Factor 4	**Time Organization**
P15	How often are you given a target time for each task you perform?
P16	How much time do you take to complete your work?
P17	How much time do you have to make decisions from your work?
Factor 5	**Working Speed**
P18	Is it possible that being lazy or slowing down my work could affect the work of my colleagues or productivity in your sector/unit?
P19	Are you able to take breaks during your work, in addition to your designated break time?
P20	In my work, can I make mistakes without affecting the final result?

Table 4. The result of the sum of the weight values and the average weight value

Factors	Total	Question Item	Average Weight
Cognitive Demands and Task Complexity	629	6	104,83
Health Consequences	453	4	113,25
Task Characteristics	450	4	112,5
Time Organization	152	3	50,67
Working Speed	160	3	53,33

Table 5. Recapitulation of ESCAM questionnaire data

Questions	Qualification					Weight
	VH (5)	H (4)	M (3)	L (2)	VL (1)	
P1	5	20	2		1	112
P2	9	16	2	1		117
P3	7	19	1	1		116
P4	4	19	4	1		110
P5	10	4	2	6	6	90
P6	3	9	7	3	6	84
P7	11	14	1	2		118
P8	7	19	2			117
P9	5	18	3	2		110
P10	4	18	5		1	108
P11	4	21	2		1	111
P12	3	20	4	1		109
P13	5	19	3	1		112
P14	7	20	1			118
P15	8	18	2			50
P16	9	19				47
P17	8	14	5	1		55
P18	6	18	4			54
P19	9	15	3	1		52
P20	7	18	2		1	54

After getting the weight value on each question item in each dimension, the next step is to add up the weight values and calculate the average weight value for each dimension. The following are the results of the summation of the weight value and the average weight value of each dimension addressed in Table 6.

The next step is to calculate the mental workload score and categorize the mental workload of each dimension as shown in Table 7.

Based on the table of mental workload score calculation results and mental workload classification for all employees, the factors that can affect employee performance and are

Table 7. Mental workload score calculation results

Factors	Average Weight	Total Respon-dents	Mental Workload Score	Category
Cognitive Demands and Task Complexity	104,83	28	3,74	Moderate
Health Consequences	113,25		4,04	High
Task Characteristics	112,50		4,02	High
Time Organization	50,67		1,81	Low
Working Speed	53,33		1,9	Low

categorized as high, namely the health consequences factor with a mental workload score of 4.04 and the task characteristics factor of 4.02, while the factors categorized as moderate are cognitive demands and task complexity factors with a mental workload score of 3.74, and factors categorized as very low are time organization factors with a mental workload score of 1.81 and a work speed factor of 1.90.

Mental Workload Analysis

Mental workload analysis is conducted using mental workload scores to determine what factors can affect employee performance at work. The following is a graph of the mental workload score of each dimension addressed in Figure 3.

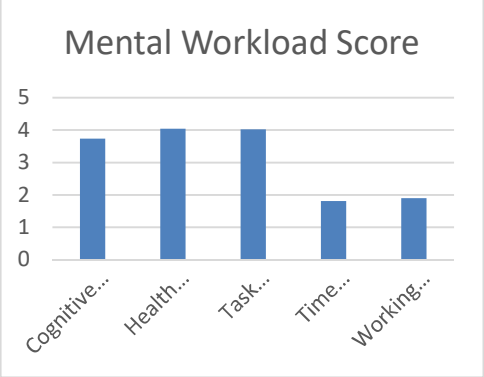

Figure 3. Mental workload score graph

Based on the calculation results in Table 7, it can be seen that the factors that tend to affect employee performance are in factor 2, namely the health consequences which are categorized as high where employees after completing their tasks feel tired due to too many tasks and little rest time, as a result, employees feel fatigued at the end of their work. This can occur due to the abundance of work for employees and the lack of rest time for employees, so the proposal to equalize the workload and reset the rest time is needed.

Then the next highest value is in factor 3, namely task characteristics which are categorized as high where this factor explains the disturbances in the workplace from the work environment to the many requests from coworkers asking for help with their work. This can occur because the workplace is too noisy and the lack of employee confidence in carrying out their duties leads to requests for help from coworkers and excessive workload, so proposals for the work environment and education are needed.

Furthermore, factors can affect employee performance in factor 1, namely cognitive demands and task complexity, where this problem occurs because there is no work SOP for each part from how to use the machine, adjusting the thickness of the plastic desired by the orderer, to packaging and the tasks given to the average employee are quite complicated and require high memory. This happens because the education taken by workers only reaches the high school and vocational level, so training and making SOPs in each part of the work is needed.

Proposed Improvements to Mental Workload

Proposals that can be given to factor 2 with high workload, it would be better if the proposed improvements are made to management and employees. Proposals can be made for management by providing adjustments related to employee work schedules, providing annual leave for workers, providing nutrition every morning, providing recreational vacations, and providing work incentives on national holidays. Then proposals for workers by stretching after a few hours and changing routines and healthy lifestyles.

Then the proposal that can be given to factor 3 with a high workload is to make improvements to management and workers. The proposal for management is to give clear tasks based on the number of employees available, provide additional training to support and improve employee performance, and provide earplugs in

every job to overcome the noise that arises in the workplace. The suggestion that can be given by workers is to follow the training properly and use the ear protection equipment provided to maintain ear health from noise.

Suggestions that can be given to factor 1 with moderate workload, can be made improvements to its management by providing clear SOPs (Standard Operating Procedures) so that workers can work optimally and can reduce errors that occur, evaluate SOPs regularly, and socialize SOPs thoroughly and clearly to employees. Then the proposal for all employees is to pay attention and understand the SOP thoroughly and obey the SOP that has been provided.

IV. Conclusion

Based on direct observation and interviews with workers who have lifting activities, workers often experience complaints at the waist and back due to the continuous lifting of heavy objects. RWL and LI calculations on manual handling activities show that all movements performed by workers at blowing, printing, and mixing machine workstations have an LI> 3 value, meaning that workers who are active at these workstations are at high risk of spinal cord injury. Improvements are made by proposing changes in work posture when picking up and placing plastic seeds or semi-finished plastic.

Improvements are made by providing small scissor lift tools at blowing and printing machine workstations and changing tools from hand pallets to scissor lift tables at mixing machine workstations to lift sacks or take screen printing results that have a high enough height. After the improvement, employees no longer need to use extra energy in lifting the sacks or screen printing results because, with the tone of the scissor lift tool, there is no longer a variable value of load weight (L), vertical distance (V), and displacement distance (D) on activities in blowing, printing and mixing machines.

Furthermore, based on the calculation of mental workload that has been carried out, it can be concluded that several factors affect employee performance, such as consequences for health, task characteristics, cognitive demands, and task complexity that have a mental workload score> 3, meaning that employees feel tired due to giving too many tasks and little rest time, employees also have disturbances in the workplace such as noise and many requests for help from colleagues, and the difficulty of employees in understanding the tasks they do due to the many instructions that need to be memorized and remembered so that improvements need to be made by giving proposals to management and workers.

Recommendations for improvements to management related to health consequences can be made by providing adjustments related to employee work schedules, providing annual leave for workers, providing nutrition every morning, providing recreational vacations, and providing work incentives on national holidays. Then improving task characteristics can be done by providing clear tasks based on the number of employees available, providing additional training to support and improve employee performance, and providing earplugs in each section to stay focused and minimize noise arising in the workplace. Furthermore, improvements related to cognitive demands and task complexity can be made by providing clear SOPs (Standard Operating Procedures) so that workers can work optimally and reduce errors that occur, evaluating SOPs regularly, and socializing SOPs thoroughly and clearly with employees.

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