

# **Maintenance Model Based on 5s and TPM to Increase Productivity in an SME in the Food and Beverage Sector**

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## **Abstract**

The food and beverage sector in Peru faces significant challenges related to demand variability, rising costs, and the need to guarantee food safety. In this context, low productivity and high levels of waste and rejects in manufacturing processes represent an obstacle to competitiveness. The objective of this research is to design and implement an improvement model based on the 5S methodology and preventive maintenance, aimed at increasing productivity in an oil manufacturing company, with emphasis on the production line of 1-liter presentations. The proposed model was developed in three phases: diagnosis of the current situation, design of the improvement proposal, and evaluation of results. In the first phase, the main causes of inefficiency were identified through tools such as the Ishikawa diagram and indicator analysis. Subsequently, the 5S methodology was applied to organize and standardize the work environment, and a preventive maintenance plan was implemented to ensure equipment reliability and reduce unplanned stoppages. The results obtained show significant improvements in productivity indicators, reduction of waste, and decrease in rejected products, confirming the effectiveness of the model in increasing operational efficiency. In conclusion, the integration of 5S and preventive maintenance constitutes a viable strategy to optimize production processes in small and medium-sized companies in the food sector, strengthening their competitiveness in the market.

## **Keywords**

TPM, 5S, food industry, and productivity.

## **1. Introduction**

The food and beverage sector faces multiple challenges derived from fluctuations in supply and demand, climate change, and food safety, all of which affect price stability. According to ILO (2023), oil prices have fallen in recent months due to factors such as seasonal soybean harvesting in Brazil and the abundant global supply available for export. Despite these difficulties, the sector maintains a strategic position within the Peruvian economy, contributing

26.3% to the manufacturing GDP and 3.3% to the national GDP (Ministry of Economy and Finance, 2022). Likewise, its exports reached 1,429 million dollars, consolidating its relevance in the trade balance.

In this context, Total Factor Productivity (TFP) emerges as a key indicator to measure the efficiency of resource use. In Peru, its average growth until 2010 was 2.6% (BCRP). The relationship between productivity and GDP is close, given that GDP reflects the monetary value of goods and services produced in a given period (Ministry of Economy and Finance, 2022). However, compared to countries such as Chile and Spain, Peru shows a disadvantage: while in Chile the food sector represents 4.7% of GDP, in Spain it grew 18.4% in 2022 compared to the previous year (Ministry of Foreign Affairs of Chile, 2023; Interempresas Sector Reports, 2023). This research is conducted in a soybean oil manufacturing company, a relevant product in the food industry that in Peru grew 14.4% between 2019 and 2021 (PRODUCE, 2021). In this sector, resource optimization is essential, considering that it generates approximately 420,000 direct jobs (MEF, 2022). However, there are issues associated with process efficiency, such as 2% waste and rejection rates between 1% and 3%, which reduce productivity and raise costs (University of Antioquia, 2016). For this reason, it is essential to implement improvement strategies that optimize processes and strengthen competitiveness. This study proposes a maintenance model based on the 5S methodology and preventive maintenance, aimed at increasing productivity in a small and medium-sized enterprise (SME) in the food and beverage sector, thus helping reduce waste, minimize machine downtime, and ensure more efficient use of available resources.

## **1.1 Objectives**

The objective of this study is to demonstrate that implementing a model based on the 5S methodology and preventive maintenance increases productivity in a food manufacturing company. The 5S methodology will be applied to organize the work environment and reduce waste, while preventive maintenance will ensure equipment reliability and decrease machine stoppages. Together, these tools aim to optimize resources and improve the efficiency of the 1-liter soybean oil production line.

## **2. Literature Review**

### **2.1 5s in the food sector**

The 5S methodology is recognized as a continuous improvement tool that seeks to create orderly, clean, and safe work environments, directly impacting productivity. Although it was conceived in the Japanese automotive industry, its implementation in the food sector has proven to be highly effective in ensuring food safety, reducing waste, and improving response times (Hernández, 2023; García Manríquez, 2022).

In warehouses, processing plants, and restaurants, the application of 5S enables the elimination of non-value-added activities, reduces contamination risks, and strengthens worker discipline (InduAlimentario, 2023; SoftExpert, 2024). Recent studies confirm that proper implementation contributes to reducing losses and waste, promotes food safety, and optimizes operational efficiency (Checklist Fácil, 2023). Additionally, Full Audits (2023) states that this methodology encourages worker motivation and consistency, creating a stronger organizational culture.

The use of digital tools and standardized templates, such as those developed by MyMap.AI (2023), has facilitated structured implementation, maintaining high hygiene standards and reducing cross-contamination. Research presented at international conferences (LACCEI, 2023) highlights that 5S also positively affects food logistics, improving delivery speed and customer satisfaction. In summary, the literature shows that 5S not only improves productivity but also increases the competitiveness of companies in the food and beverage sector by ensuring more efficient and safer processes.

### **2.2 TPM en el sector alimentario**

Preventive maintenance focuses on planned scheduling of activities to preserve equipment operability and reduce unexpected failures. In the food industry—where machinery availability is crucial for maintaining production continuity—this practice is indispensable. Proper application helps decrease unplanned stoppages, reduce corrective costs, and extend asset life (Checklist Fácil, 2024; SYDLE, 2024).

Various studies have demonstrated the benefits of this strategy. García et al. (2020) indicate that implementing preventive programs in food plants significantly reduces product rejection and waste, while success cases such as Tetra Pak in Asia confirm that this methodology improves overall equipment efficiency and reduces market complaints (Tetra Pak, 2016). Additionally, preventive maintenance has a positive impact on sustainability, as it reduces

workplace accidents, quality defects, and the environmental footprint of production processes (Revista Alimentaria, 2023).

Although more comprehensive methodologies such as Total Productive Maintenance (TPM) exist, the literature indicates that the preventive approach is a practical and viable alternative for small and medium-sized enterprises where resources are limited (La Estrella, 2017). In this sense, its implementation not only improves equipment reliability but also strengthens operational continuity and competitiveness in demanding markets such as food and beverages.

### **2.3 Integración de 5S y mantenimiento preventivo**

The joint application of the 5S methodology and preventive maintenance has been shown to generate synergies that enhance productivity and efficiency. While 5S contributes to maintaining organized work environments and facilitates the early detection of anomalies, preventive maintenance ensures that equipment operates reliably, avoiding unexpected interruptions. Research in the industrial sector shows that this combination not only reduces downtime but also improves key indicators such as Overall Equipment Effectiveness (OEE) and product quality (Velásquez-Costa, 2022).

In the food sector, the integration of these tools is especially relevant, since order, cleanliness, and machinery reliability are critical factors for both productivity and food safety. Thus, the literature supports that the joint adoption of 5S and preventive maintenance is an effective strategy to improve the competitiveness of manufacturing companies in this sector.

## **3. Methods**

The methodology used in this research was organized into three main stages. This structure was designed based on previous studies but adapted to the real characteristics of the analyzed production line. The objective was to understand the problem from its origin, propose a solution aligned with the plant's reality, and finally verify whether the proposed improvements truly generated an impact.

In the first stage, the goal was to understand what was happening in the one-liter bottle production line. To achieve this, different types of information were combined: direct observations on the shop floor, conversations with operators, and the review of production and failure records. Using these data, indicators such as cycle times, productivity levels, and equipment availability were calculated, providing a clear view of the current functioning.

In addition, analysis tools such as Value Stream Mapping, the Problem Tree, and Root Cause Analysis were used. These instruments helped organize the information and identify which factors were generating constant stoppages in the line. Among the most frequent problems were material shortages, failures in the filler machine, and the presence of defective inputs.

The second component corresponds to the design of the solution. Once the root causes were identified, an intervention model was proposed to directly address these issues. The proposal combines two approaches: the 5S methodology (aimed at improving order and organization in critical areas) and a preventive maintenance plan that anticipates failures and ensures equipment availability when needed.

During this phase, the necessary formats were also defined, along with the specific activities to be carried out and the goals to be achieved. The intention was to clearly establish what would be changed, how it would be implemented, and which indicators would allow evaluating whether the model was working.

The third component involves implementation and evaluation. A pilot test was conducted on the one-liter production line. After implementing the changes in the plant, times and key indicators—such as productivity and MTBF—were measured again. The comparison between the values obtained before and after the intervention made it possible to determine the real impact of the proposal.

This evaluation was essential to verify whether the application of 5S and preventive maintenance contributed to reducing stoppages, improving workflow, and, overall, increasing the productivity of the line. A graphical representation summarizing the proposed model is presented below in Figure 1.

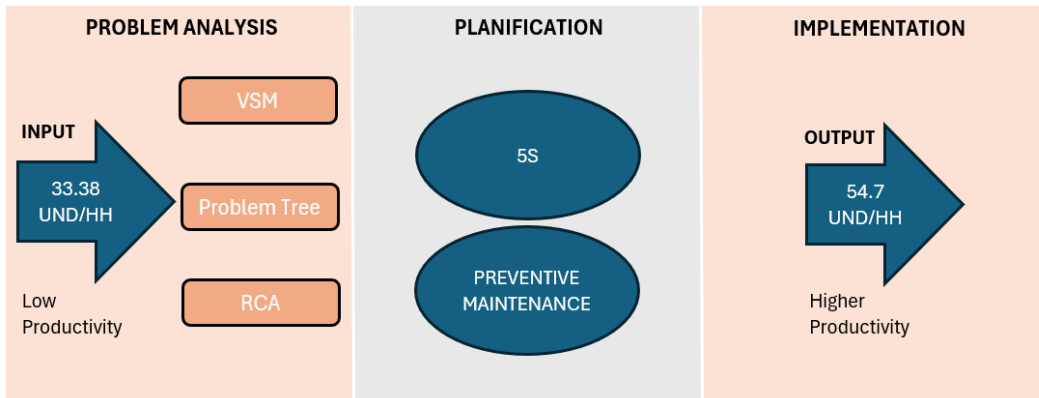


Figure 1. Designed model

#### 4. Data Collection

Data collection for this research was based on the gathering, organization, and analysis of information from an SME dedicated to soybean oil production, with the purpose of determining the main factors that affect its productivity. The process was carried out considering the stages of diagnosis, measurement, and indicator analysis, which made it possible to establish the root causes of the identified problem and validate the relevance of the proposed model based on the 5S tools and preventive maintenance.

This section details the procedure followed to collect the information, the instruments applied, the variables analyzed, and the validation criteria used for the design and implementation of the proposal.

#### 4.1 Implementación de 5S y Mantenimiento Preventivo

The data collection process was structured into three main phases:

##### Phase 1: Situational diagnosis.

In this stage, industrial engineering tools such as the Process Operations Diagram (DOP), the Pareto diagram, and the Ishikawa diagram were applied, which allowed identifying the factors contributing to low productivity. Based on this information, the problem tree was constructed, summarizing the causal relationships and enabling the establishment of intervention axes (Figure 2).

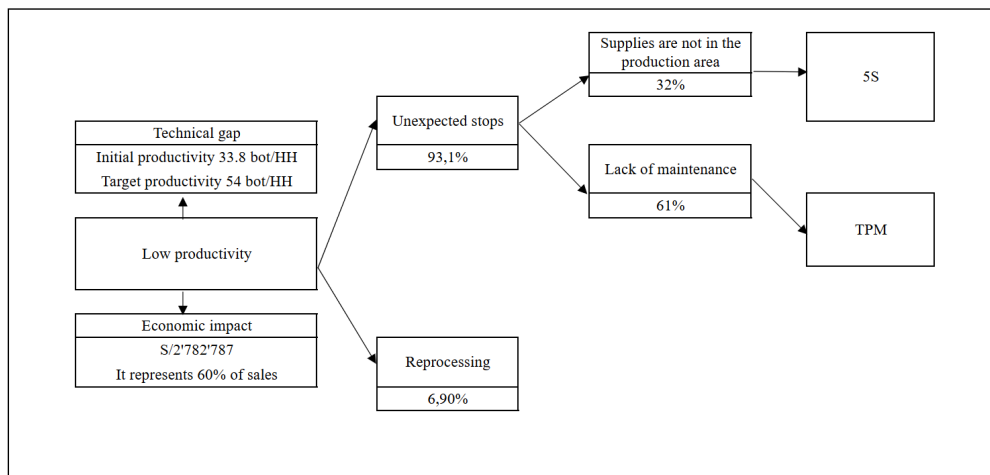


Figure 2. Problem tree

### Phase 2: Measurement and data collection.

Measurements were carried out by previously defining the sample size and the data collection procedure to calculate cycle time, Takt Time, standard time, equipment isolation time, changeover time, number of machines, operators, shifts, and maintenance-related stoppages. The information was classified using the following criterion: if the information was related to product production, it would be used to develop the VSM. Thirty-five time studies were conducted over three days (Figure 3).

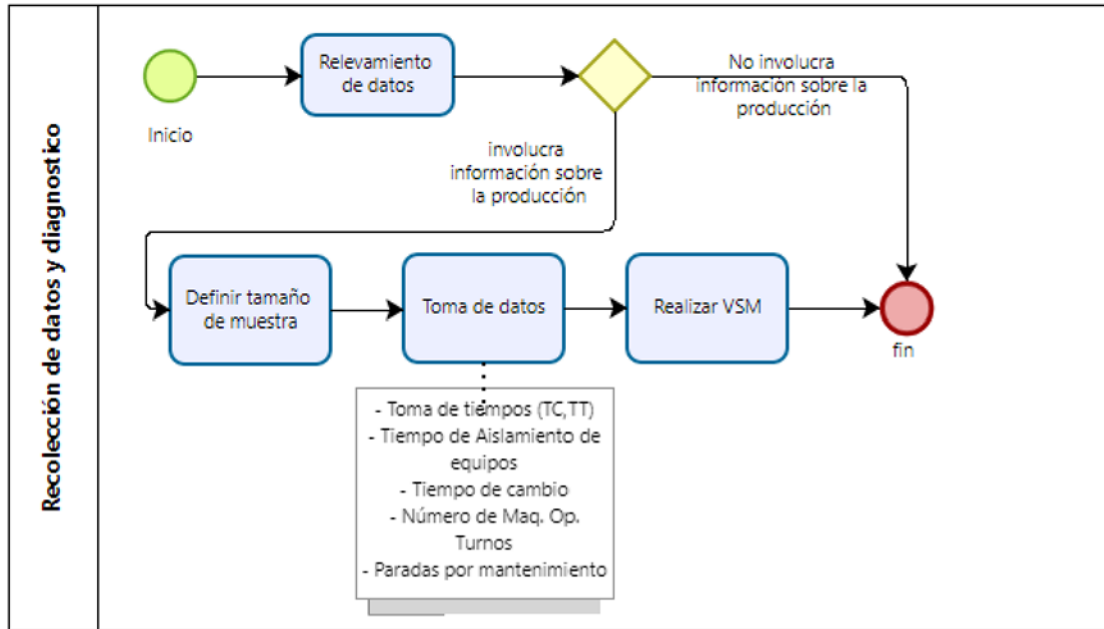


Figure 3. Data collection flowchart

### Phase 3: Indicator analysis.

With the collected data, productivity indicators, OEE (Overall Equipment Effectiveness), the Preventive Maintenance Compliance Index (ICMP), and MTBF (Mean Time Between Failures) were calculated. The results were used to establish a baseline, which was later compared with the values obtained after implementing the model in Table 1.

Tabla 1. Indicadores

Variable	Indicator	Formula / Unit	Objective
Productivity	Units produced per man-hour (Units/HH)	Total units produced / worked HH	Determine productivity efficiency level
Cycle time	Sum of minutes from the first operation to the last	Min/unit	Time required to produce one unit from start to finish
Preventive Maintenance Compliance (ICMP)	% of activities executed / planned × 100	%	Evaluate maintenance management
Mean Time Between Failures (MTBF)	Total operating hours / number of failures	Hours	Measure equipment reliability

### Processing and validation of information

Once the information was collected, it was validated through a comparative analysis between field measurements and the historical records provided by the company. Data coherence was verified by applying consistency checks and calculating weighted averages to reduce the effect of outliers. Additionally, basic statistical tools were used to

represent failure frequencies and time distributions, allowing for a comprehensive overview of equipment performance.

## 5. Results and Discussion

After the implementation of the proposed improvements, a comparison was made between the initial VSM and the VSM constructed after applying the 5S methodology on the 1-liter production line. This comparison made it possible to observe significant changes in several points of the process. The greatest progress occurred in the injection and labeling processes, where cycle times decreased by 39.3% and 62.96%, respectively. These reductions were mainly associated with the elimination of unnecessary searches, better arrangement of tools and inputs, and a smoother internal workflow. Below is a summary of the initial and final times (seconds) obtained (Table 2):

Table 2. Initial and Final Time per Process Operation

Operation	Initial Time (s)	Final Time (s)
Filling	112.83	68.5
Capping	8.18	3.96
Labeling	40.79	15.11
Case Packing	7.15	5.25

The analysis of the initial and final VSM showed reduction in cycle times:

- Injection: reduction of 39.3%
- Labeling: reduction of 62.96%

Overall, the total cycle time of the process decreased by 44.44%, approaching what had been projected during the design phase of the model. This reduction had a direct effect on the line's productivity, which increased by 35.08% compared to the initial value measured in boxes per man-hour. Although this increase did not reach the theoretical goal of 53.4 boxes/HH, it still represents a significant improvement over the state prior to intervention.

Regarding preventive maintenance, the introduction of the preventive plan helped increase the Mean Time Between Failures (MTBF) and reduce the recurrence of unplanned stoppages. However, because the pilot test was carried out over a relatively short period, the impact did not fully manifest in indicators such as MTBF or equipment availability. This suggests that with a longer and more consistent application, the benefits could be even greater (Figure 4).

### AREA: ENVASADO

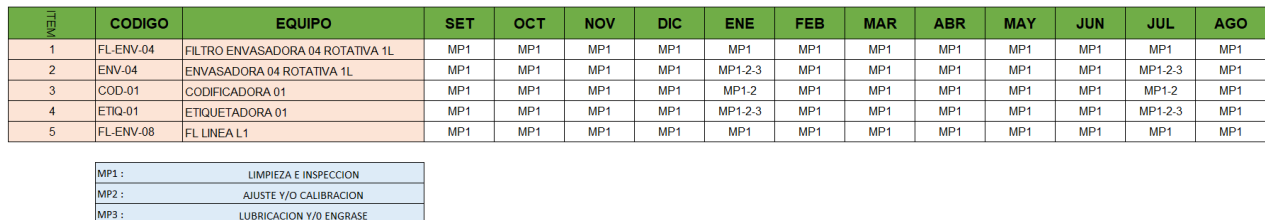


Figure 4. Cronograma de mantenimientos preventivos

### 5.1 Numerical Results

After conducting the pilot test, the following indicator results were obtained. Below, the calculation procedure for each indicator is presented.

$$\bullet \quad T_c = \frac{(68.5+3.96+15.11+5.25)}{60} = 1.55 \frac{\text{min}}{\text{caja}}$$

- $MTBF = \frac{8 \text{ hrs}}{8 \text{ fails}} = 1 \text{ hr/failure}$
- $ICMP = \frac{14 \text{ maintenance completed}}{15 \text{ scheduled maintenance}}$
- $Productivity = \frac{533'930 \text{ boxes}}{1'480 \text{ HH} \cdot 8 \text{ op}} = 45.10 \text{ boxes/HH}$

## 5.2 Graphical Results (11 font)

Below, we present the graphs obtained from the implementation of the two tools. For the case of 5S, the following compliance percentages (initial and final) were obtained (Figure 5 and Table 3)

Table 3. Initial and Final 5S Results

5s	Initial Results	Final Results
Seiri	40%	93.30%
Seiton	50%	80%
Seiso	30%	90%
Seitketsu	13.30%	93.30%
Shitsuke	0%	86.60%

Spider charts were obtained

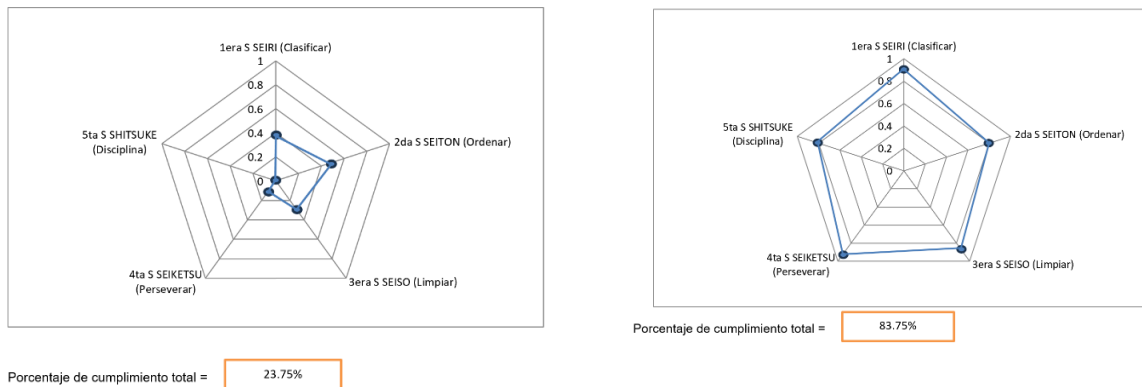


Figure 5. Comparison of initial and final 5S implementation

For the VSM, the process was graphed with the initial and final times shown below in Figure 6.

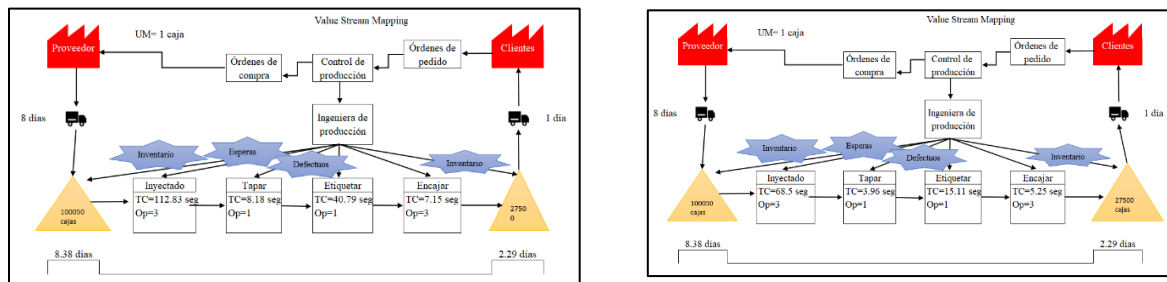


Figure 6. Comparison of initial and final VSM

### 5.3 Validation

The time measurements and calculation of the indicators after the time study allowed us to obtain results that we interpret in the following indicators, which demonstrate the effectiveness of the tools applied to each previously identified problem (Table 4).

Table 4. Indicator Validation

Indicator	As Is	To Be	Obtained	% Expected Increase	% Obtained Increase
Cycle time (min/unit)	2.7	1.3	1.5	-51.85%	-44%
MTBF (hours/failure)	0.25	3	1	11	3
Compliance index (%)	43.7	80	93.3	0.8	1.14
Productivity (boxes/HH)	33.3	54.7	45.1	0.6	0.35

The results of the study show that the joint application of the 5S methodology and a preventive maintenance plan can significantly improve productivity in an SME in the food and beverage sector. The reduction in cycle times in the main processes and the increase in overall productivity align with what various studies on continuous improvement and Lean approaches indicate.

However, certain limitations were also identified. The first relates to the short duration of the preventive maintenance plan, which made it difficult to observe its full impact on indicators such as MTBF or equipment availability. The second concerns the sustainability of the improvements, which depend greatly on employee commitment and continuous management support for maintaining 5S practices in the long term.

Additionally, external factors such as fluctuations in demand or input availability can influence productivity results. Future studies should incorporate these variables into broader operations management models.

In general, the results show that the implemented model is a viable alternative for strengthening the operational performance of manufacturing SMEs in the food and beverage sector. Its effectiveness depends on having adequate implementation time and ongoing organizational commitment to continuous improvement practices.

### 6. Conclusion

The research made it possible to develop, implement, and evaluate a maintenance model that combines the 5S methodology with preventive maintenance practices, with the objective of improving productivity in an SME in the food and beverage sector. The initial diagnosis revealed problems related to disorder, lack of standardization, and the prevalence of a reactive maintenance approach, factors that directly affected the efficiency of the 1-liter oil production line.

The application of 5S and the improvements related to order and workplace organization generated significant reductions in the cycle times of the most critical processes, which was reflected in a 35.08% increase in productivity. Although the preventive maintenance plan did not achieve all the expected results within the established pilot period, the evaluated indicators show a positive trend, especially in MTBF and the reduction of unplanned stoppages.

Overall, the results show that the implemented model is a viable alternative to strengthen the operational performance of manufacturing SMEs in the food and beverage sector. However, its effectiveness depends on having an adequate implementation timeframe and ongoing organizational commitment to continuous improvement practices.

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## Biographies

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