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Determination of Safety Stock and Reorder Point Using Spreadsheet Simulation for Inventory Control of Packaging Materials

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ABSTRACT

Effective inventory control is essential in make-to-order (MTO) flexible packaging operations, where packing materials often exhibit irregular and highly variable usage patterns. This study proposes an integrated inventory control model that combines probabilistic Safety Stock (SS) and Reorder Point (ROP) calculations with a spreadsheet-based Traffic Light System (TLS) as a practical, low-cost monitoring tool. Using historical consumption and supplier lead-time data, the analysis determines demand variability and applies a 90% service level (Z = 1.28) to calculate buffer stock requirements. Results show that high usage variability substantially increases SS and ROP values. For the key item examined, SS is calculated at 265 units and ROP at 1,380 units, highlighting the importance of statistical methods compared to manual estimation. The TLS simulation applied across all materials improves early detection of low-stock risks and enhances PPIC responsiveness. Sensitivity testing indicates that raising the service level to 95% increases SS by about 28%, demonstrating the trade-off between reliability and inventory costs. This study contributes by integrating SS–ROP computation, usage classification, and real-time visual monitoring into a unified operational framework. The model strengthens data-driven decision-making and reduces stockout risk in flexible packaging manufacturing.

Keywords: *Inventory Control, Safety Stock, Reorder Point, Traffic Light System*

Introduction

Inventory control is a critical function in manufacturing companies, particularly those adopting a make-to-order (MTO) production system in which material availability must align with fluctuating customer demand. Ineffective inventory management may lead to stockout conditions that disrupt production or excessive stock that increases storage costs. In flexible packaging industries, packing materials are essential components that require strict monitoring due to highly varied consumption and irregular ordering patterns. These conditions reinforce the importance of implementing systematic inventory control mechanisms supported by accurate calculations of safety stock (SS) and reorder point (ROP) [1], [2]. For example, [3] examined raw material procurement for plastic waste in pallet production and showed how EOQ calculations can determine order quantity, timing, and total inventory costs, ultimately reducing the frequency of reorders compared to conventional methods.

However, the PPIC division of the studied company currently uses a simple stock monitoring approach that does not incorporate service level analysis, demand variability, or probabilistic considerations. Historical consumption data also show significant month-to-month fluctuations, indicating that the current method is insufficient to prevent inventory shortages. Similar studies highlight that fluctuating demand requires more sophisticated inventory control models integrating buffer stock determination, forecasting, and replenishment planning [4]. [5] propose analytical formulations for safety lead time (LT) under fluctuating demand and lead time, while [6] present closed-form solutions for optimal ROP calculations that incorporate safety stock and uncertainty during lead time.

From a theoretical standpoint, inventory functions as a buffer between supply and demand to maintain operational continuity. Safety stock mitigates uncertainty caused by demand variability and lead-time deviations [7], while ROP determines the point at which replenishment must occur to avoid stockout [8]. Numerous studies emphasize structured approaches such as using standard deviation, service level targets, and probabilistic methods to reduce operational risk and improve supply reliability [9], [10]. [11] further reinforce the practical application of SS and ROP calculations in chemical procurement. More advanced models by [12], [13], [14], and [15] address the impacts of uncertainty, lead-time variability, and inventory risks in complex supply chain environments.

Despite extensive research, previous studies primarily focus on calculating SS and ROP without integrating them into a visual monitoring system capable of providing early warnings or supporting real-time decision-making. Existing literature also relies heavily on static or manual approaches and does not incorporate material classification (regular, periodic, rare) to differentiate monitoring priorities. These limitations create a clear research gap, particularly for companies that use spreadsheet tools as a low-cost alternative to ERP systems.

This gap is also evident in the studied company, where a simple visual monitoring method is used but is not supported by quantitative computation. As a result, procurement decisions are reactive rather than data-driven, leading to inefficiencies in scheduling and potential stockout risks. A spreadsheet-based simulation equipped with a traffic-light indicator (green–yellow–red) offers a practical solution by providing real-time visibility, early warning signals, and automated assessment of inventory conditions. Additionally, the fluctuating nature of packing material consumption indicates that inventory behavior aligns with discrete-event dynamics that change periodically. Simulation methods enable more accurate modeling of these conditions and provide advantages over deterministic approaches when uncertainty exists [4], [2].

Based on these conditions, the problem statement of this study is as follows:
The company does not have an integrated, quantitative, and visual inventory control system; SS–ROP calculations are not conducted using probabilistic methods; stock monitoring remains manual and non-predictive; and there is no material classification framework to identify items with different usage risks.
Therefore, this study aims to: Calculate optimal Safety Stock and Reorder Point values based on historical consumption, demand variability, and a predetermined service level, Classify packing materials based on usage frequency to differentiate monitoring and control priorities, Develop a spreadsheet-based simulation integrated with a Traffic Light System to enhance visibility, provide early warning signals, and support timely replenishment decisions.

The combination of quantitative SS–ROP modeling, material usage classification, and spreadsheet-based visual monitoring represents the novelty of this research and contributes to a practical, low-cost solution for inventory control in flexible packaging operations.

Research Methods

The quantitative method is used in this study to objectively measure demand variability and lead time uncertainty using historical data, resulting in more accurate and data-driven inventory control decisions [2], [16]. Spreadsheet-based calculation and simulation are selected as the primary analytical tools due to their transparency, flexibility, and suitability as a low-cost alternative to ERP systems in medium-sized manufacturing environments. Previous research [5] and [6] demonstrates that analytical and closed-form models provide reliable estimates for Safety Stock (SS) and Reorder Point (ROP) even under volatile demand, reinforcing the relevance of quantitative modeling for this study.

Research Design

The research design involves processing historical consumption and lead time data to calculate key inventory parameters. This approach facilitates the identification of demand patterns, variability, and stockout risks during the supplier lead time. The use of historical data reflects actual operational conditions, making it suitable for estimating future needs [17].

A spreadsheet model is employed to compute average usage, standard deviation, safety stock, and reorder point. Spreadsheet modeling provides transparency, adaptability, and the flexibility to simulate multiple scenarios efficiently [18], [19]. The methods align with international practices, where safety stock models consider demand fluctuations and lead-time ambiguity to determine optimal inventory levels [12], [15].

Flowchart of research Method

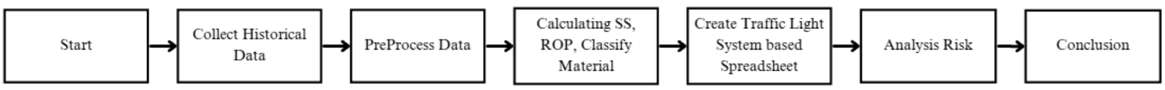

Figure 1. Flow Chart Research Procedure

The flowchart in Figure 1 the overall research procedure, starting from the collection and preprocessing of historical data, followed by the calculation of Safety Stock (SS) and Reorder Point (ROP). Materials are then classified based on usage frequency, and a spreadsheet-based simulation is developed to model inventory behavior. The Traffic Light System (TLS) is applied to visually identify stock conditions, which are subsequently analyzed to assess risks and support final conclusions and recommendations.

Data Collection

a. Material Usage Data

Daily or weekly consumption data are used to calculate average demand and standard deviation. Demand variability is a critical factor influencing safety stock levels because inconsistent usage patterns increase the risk of shortage [9]. Assumption**:** 1 month = 30 working days.

b. Lead Time Data

Lead time represents the duration needed for materials to arrive after a purchase order is issued. Variations in lead time increase the probability of stockout, making this variable essential for SS and ROP calculations [1], [20]. [13] emphasize that incorporating lead time uncertainty is crucial in developing realistic safety stock models.

c. Service Level Requirement

The predetermined service level determines the Z-score, which indicates the probability of avoiding stockout during lead time. [14] highlight that integrating service level targets into inventory calculations ensures alignment with organizational risk tolerance.

The company applies a 90% service level, corresponding to Z = 1.28. Justification:

1. Based on company PPIC policy to maintain moderate safety levels,
2. Materials are low–medium critical,
3. Higher service levels (≥95%) increase holding costs [21].

d. Initial Inventory Data

Initial stock levels provide the baseline for simulation and allow observation of how SS and ROP function within real stock movement patterns. [6] illustrates that accurate initial stock inputs improve predictive reliability of ROP models, particularly under stochastic demand conditions.

Table 1 summarizes the total material usage, lead time, and service level for each adhesive tape variant. The total column represents the cumulative consumption during the observation period, while the lead time (LT) is standardized at 14 days for all items.

Before performing the Safety Stock and Reorder Point calculations, the historical usage data for each material must first be organized to provide a clear overview of consumption patterns and lead-time conditions. Table 1 summarizes the total usage of each adhesive tape variant over the observation period, along with the standardized lead time of 14 days applied across all items. A service level value of 1.28 (corresponding to a 90% target service reliability) is used consistently to ensure uniformity in the subsequent SS and ROP calculations. This dataset serves as the foundational input for determining demand variability, buffer stock requirements, and the replenishment thresholds applied in the following analysis.

Tabel 1. Monthly Usage

Material Description	1	2	3	4	5	6	7	8	Total
Adhesive Tape Double 1inc	2,320	2,142	2,688	1,820	2,400	2,620	2,720	2,400	19,110
Adhesive Tape Double 1inc 3M Type R4	20	12	6	16	25	12	15	36	142
Adhesive Tape Double 1inc A	1.520	1.040	160	400	240	360	1.200	240	5.160
Adhesive Tape Double 2inc 3M Type 907	16	24	84	8	36	25	35	28	256
Adhesive Tape Bening 1inc	228	348	264	276	330	342	492	408	2.688
Adhesive Tape Bening 2inc	60	96	240	349	168	42	67	30	1.052
Adhesive Tape Bening 2inc	144	72	144	144	72	1092	72	144	1.884
Adhesive Tape Bening 3inc	240	114	248	244	192	226	163	240	1.667
Adhesive Tape Coklat 1inc	444	564	864	564	738	720	632	612	5.138
Adhesive Tape Coklat 2inc	993	754	918	876	876	839	984	786	7.026
Adhesive Tape Coklat 2inc	360	384	216	216	360	912	864	216	3.528
Adhesive Tape Coklat 2inc	92	198	89	84	168	89	150	96	966
Adhesive Tape Coklat 3inc	48	192	368	452	419	399	572	228	2.678

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Table 2. Usage per Materials

Material Description	Total	LT	Service Level
Adhesive Tape Double 1inc	19.110	14	1.28
Adhesive Tape Double 1inc 3M Type R4	142	14	1.28
Adhesive Tape Double 1inc	5.160	14	1.28
Adhesive Tape Double 2inc 3M Type 907	256	14	1.28
Adhesive Tape Bening 1inc	2.688	14	1.28
Adhesive Tape Bening 2inc	1.052	14	1.28
Adhesive Tape Bening 2inc	1.884	14	1.28
Adhesive Tape Bening 3inc	1.667	14	1.28
Adhesive Tape Coklat 1inc	5.138	14	1.28
Adhesive Tape Coklat 2inc	7.026	14	1.28
Adhesive Tape Coklat 2inc	3.528	14	1.28
Adhesive Tape Coklat 2inc	966	14	1.28
Adhesive Tape Coklat 3inc	2.678	14	1.28

Data Processing

a. Calculation of Average Demand and Standard Deviation

Average consumption indicates expected daily usage, while standard deviation measures demand variability. Higher variability results in higher safety stock requirements [17], [9].

b. Safety Stock Calculation

Safety Stock (SS) is the minimum buffer inventory held to protect against demand and lead time uncertainties. Maintaining an adequate safety stock helps prevent stockout events, ensures production continuity, reduces emergency procurement, and improves service reliability (Pratama et al., 2023; Roni et al., 2023), this formula is commonly used in inventory management where both demand and lead time [21], [22]. The formula used is:

$$SS = Z \times \sigma \times \sqrt{LT} \quad (1)$$

c. Reorder Point Calculation

This ensures materials arrive before inventory reaches zero, accounting for usage and safety stock [1], [2]. Reorder Point indicates when a new purchase order must be placed.

$$ROP = (\text{Average Daily Demand} \times LT) + SS \quad (2)$$

d. Definition of Effective Stock

To simulate inventory behavior and categorize stock status, Effective Stock is defined as:

$$\text{Effective Stock} = \text{Daily Stocks} + \text{Pending PO} + \text{In Quality Inspection} \quad (3)$$

e. Spreadsheet Traffic-Light Simulation

A spreadsheet simulation is developed to validate SS and ROP values by visualizing daily inventory levels and identifying stockout events. This simulation allows:

- Testing multiple demand scenarios
- Evaluating lead time variations
- Observing when ROP triggers replenishment
- Monitoring inventory trends using a traffic-light system

This method follows inventory monitoring approaches used by [23], [24] and [25]. Justification for Spreadsheet-Based Modeling, spreadsheets provide:

1. Low-cost implementation without ERP investment,
2. High transparency for PPIC operators,
3. Real-time visibility via conditional formatting,
4. Ease of scenario simulation,
5. Practical adoption in small–medium manufacturing environments (Sarkar & Giri, 2022).

Results and Discussion

Safety Stock Calculation

Safety Stock (SS) serves as a buffer to protect the company from stockout risk due to demand fluctuations and lead time uncertainty [26]. The company applies a 90% service level, corresponding to Z = 1.28. The calculation is demonstrated using the material *Adhesive Tape Double 1 inch*.
First, the monthly average usage was calculated from January to August:

$$\text{Avg} = \frac{19.110}{8} = 2388.75 \approx 2.389 \qquad (4)$$

Next, the variance and standard deviation were obtained from deviations of each monthly value from the mean:

$$\text{Variance} = 91.585{,}14 \qquad (5)$$

$$SD = \sqrt{91.585{,}14} = 302{,}63 \approx 303 \qquad (6)$$

The daily standard deviation was computed as:

$$SD_{\text{daily}} = \frac{303}{\sqrt{30}} = 55{,}30 \approx 55 \qquad (7)$$

Before calculating the Safety Stock, the average monthly usage and the variability of demand must first be determined. The average consumption is obtained by dividing the total usage over the observation period by the number of months. Subsequently, the variance and standard deviation are calculated based on the deviation of each monthly consumption value from the mean.

To align the calculation with the daily-based SS formula, the monthly standard deviation is then converted into a daily standard deviation by dividing it by the square root of the number of days in a month. These steps provide the fundamental parameters required to compute the Safety Stock.

$$SS = 1{,}28 \times 55 \times \sqrt{14} = 265 \qquad (8)$$

The result of safety stock calculation can be found on the table 3 below.

Table 3. Safety Stock Calculation

Material Description	Total	LT	Service Level	SS
Adhesive Tape Double 1inc	19,110	14	1,28	265
Adhesive Tape Double 1inc 3M Type R4	142	14	1,28	8
Adhesive Tape Double 1inc	5,160	14	1,28	460
Adhesive Tape Double 2inc 3M Type 907	256	14	1,28	20
Adhesive Tape Bening 1inc	2,688	14	1,28	74
Adhesive Tape Bening 2inc	1,052	14	1,28	99
Adhesive Tape Bening 2inc	1,884	14	1,28	304
Adhesive Tape Bening 2inc	742	14	1,28	449
Adhesive Tape Bening 3inc	1,667	14	1,28	42
Adhesive Tape Coklat 1inc	5,138	14	1,28	113
Adhesive Tape Coklat 2inc	7,026	14	1,28	75
Adhesive Tape Coklat 2inc	3,528	14	1,28	249
Adhesive Tape Coklat 2inc	966	14	1,28	39
Adhesive Tape Coklat 3inc	2,678	14	1,28	146

Table 3 presents the Safety Stock (SS) calculation results for various types of Adhesive Tape. In the probabilistic framework applied in this study, Safety Stock (SS) is a monotonic function of variability primarily the standard deviation of daily demand and the variance of lead time multiplied by the Z-value corresponding to the target service level. Since ROP is calculated as the sum of average demand during lead time and SS, any increase in demand variability or lead-time uncertainty directly raises SS and consequently increases ROP. Prior research in inventory management also shows that reducing lead-time variability generally lowers SS at common service-level ranges, although this behavior depends on the assumed distribution of demand during lead time [28].

Reorder Point Calculation

Reorder Point (ROP) represents the minimum inventory level at which the company must place a new order to prevent stockout. The formula used is:

$$ROP = (80 \times 14) + 55 = 1{,}380 \qquad (9)$$

The result of safety stock and reorder point calculation can be found below on table 4.

Table 4. Calculation Safety Sock and Reoder Point

Material Description	Grand Total	Lead Time	Service Level	SS	ROP
Adhesive Tape Double 1inc	19.110	14	1,28	265	1,380
Adhesive Tape Double 1inc 3M Type R41	142	14	1,28	8	16
Adhesive Tape Double 1inc	5,160	14	1,28	460	761
Adhesive Tape Double 2inc 3M Type 907	256	14	1,28	20	35
Adhesive Tape Bening 1inc	2,688	14	1,28	74	231
Adhesive Tape Bening 2inc	1.052	14	1,28	99	160
Adhesive Tape Bening 2inc	1.884	14	1,28	304	414
Adhesive Tape Bening 2inc	742	14	1,28	449	492
Adhesive Tape Bening 3inc	1.667	14	1,28	42	140
Adhesive Tape Coklat 1inc	5,138	14	1,28	113	413
Adhesive Tape Coklat 2inc	7,026	14	1,28	75	485
Adhesive Tape Coklat 2inc	3,528	14	1,28	249	455
Adhesive Tape Coklat 2inc	966	14	1,28	39	95
Adhesive Tape Coklat 3inc	2,678	14	1,28	146	303

For all materials, the ROP value is never lower than the Safety Stock (SS), because ROP is calculated as the sum of daily demand × lead time plus SS. Mathematically, ROP will always be greater than SS, because ROP is calculated as the sum of daily demand × lead time plus SS. Mathematically, ROP will always be greater than SS.

The differences in Safety Stock (SS) and Reorder Point (ROP) among the three materials are primarily driven by variations in average consumption levels, usage patterns, and demand variability. Adhesive Tape Double 1 inch shows the highest total usage (19,110 units) with the most irregular consumption pattern, resulting in a larger demand deviation and therefore a high SS (265 units) and a large ROP (1,380 units). In contrast, Adhesive Tape Double 1 inch 3M Type R41 has very low and relatively stable usage (142 units), leading to a minimal buffer requirement (SS 8 units) and a very small ROP (16 units). Meanwhile, the second variant of Adhesive Tape Double 1 inch falls in the middle (SS 460 units; ROP 761 units) because its consumption level is moderate lower than the first item but still fluctuating enough to require a considerable buffer. Overall, higher average usage combined with greater demand variability leads to larger SS and ROP values, as more inventory is needed to maintain the service level and prevent stockouts [27].

A ROP set too low raises the risk of stockouts and production disruptions, while a ROP set too high causes excess inventory and higher holding costs. Empirical studies show a clear trade-off: higher service levels or uncertain lead times require more inventory, while lower levels increase stockout risk. Therefore, managers should (1) apply probabilistic SS/ROP calculations, (2) perform routine sensitivity checks on service level and lead time, and (3) reduce lead time or demand variability for critical items to lower SS needs without harming service levels [29].

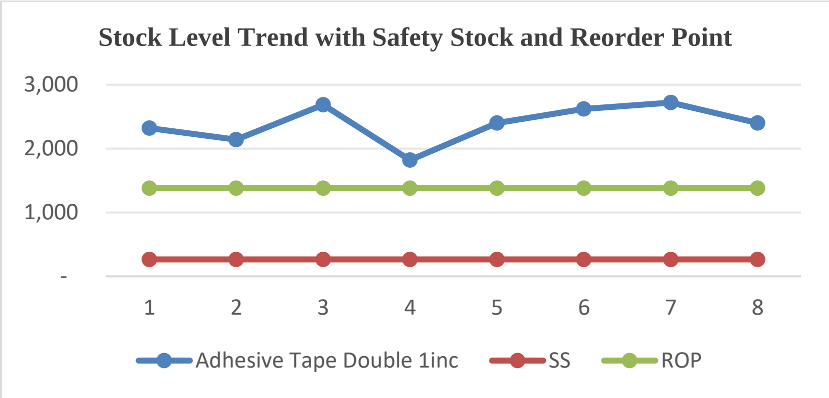

Figure 2. Stock Level Trend

As shown in Figure 2, the stock level fluctuates each month while the SS and ROP remain constant, allowing for a clear comparison between actual stock movements and the established control limits. Below down is the interpretation of this analysis

1. Items with high consumption but low variability (e.g., AT Coklat 2 inch) have small SS but large ROP, reflecting predictable but high-speed usage.
2. Items with low consumption but high variability (e.g., AT Bening 2 inch – 742 total usage) show high SS relative to demand because uncertainty is more dominant than volume.
3. Items with very low demand (e.g., AT Coklat 3 inch – 44 units) have minimal SS and ROP, indicating limited risk exposure and low business impact.

Material Categorization Based on Usage Frequency

Material classification based on usage frequency helps determine which items require tighter monitoring, Three categories are applied can be found on table 5.

- Regular: Used > 6 months/year
- Periodical: Used 2–6 months/year
- Rare: Used < 2 months/year

Table 5. Category of Packing Material Usage

Material Description	Months of Usage	Category
Adhesive Tape Hitam 2inc	January – August	Regular
Adhesive Tape Hitam 2inc	January – August	Regular
Adhesive Tape Merah 2inc	January – August	Regular
Adhesive Tape Teraoka	January – February, May – July	Periodic
Adhesive Tape Teraoka	July	Rare
Adhesive Tape Teraoka	February	Rare

The usage classification presented in the table shows clear differences in consumption patterns across the various packing materials. Adhesive Tape Hitam 2 inch and Adhesive Tape Merah 2 inch fall into the *Regular* category because they were used consistently from January to August. This indicates that these materials have stable and continuous demand, making them operationally critical and requiring close monitoring to prevent stockout. In contrast, Adhesive Tape Teraoka demonstrates irregular usage behavior. One variant appears in the *Periodic* category, with usage occurring only in January–February and May–July, suggesting that its demand is tied to specific production schedules or customer orders. Meanwhile, the other two Teraoka entries are classified as *Rare*, used only in a single month (July and February). These rare items represent low-frequency demand and carry minimal operational risk, but they may require special attention related to storage, shelf life, or procurement planning due to their infrequent consumption.Overall, this categorization helps prioritize monitoring efforts: Regular items require tighter control, Periodic items need schedule-based review, and Rare items can be managed with minimal safety stock to avoid unnecessary inventory accumulation**.**

Monitoring of Packing Material

Monitoring is essential for maintaining stock stability, The monitoring framework involves:

1. Determining monitoring criteria (monthly usage, SS, ROP)
2. Collecting historical usage data
3. Classifying materials
4. Applying a traffic light system
5. Conducting stock analysis
6. Making replenishment decisions
7. Evaluating and adjusting monitoring parameters
8. Reporting inventory performance

The traffic light system enhances visibility:

- Green: Stock safe
- Yellow: Approaching ROP
- Red: Critical, requires immediate ordering

This system improves decision-making efficiency and prevents production delays,

Traffic Light System Simulation

To improve the monitoring and decision-making process related to packing material inventory, a Traffic Light System (TLS) was implemented, TLS provides a visual classification of inventory status based on Effective Stock, Reorder Point (ROP), and Safety Stock (SS), Farisan et al. (2025) employed Monte Carlo simulation to model spare parts inventory, integrating ROP and safety stock, which aligns closely with the methodology applied in this study. This system allows planners to quickly identify risk levels and determine appropriate ordering actions, The traffic light indicators show:

- Green: operational continuity is safe
- Yellow: attention required; ordering should be planned
- Red: immediate replenishment required

As shown in Figure 3, the Excel formula used for the traffic light classification automates the categorization of each material’s stock status based on Effective Stock, Safety Stock, and the Reorder Point.

```
=IF(Effective_Stock > (ROP + Safety_Stock), "Green",
    IF(Effective_Stock >= ROP, "Yellow",
        "Red"))
```

Figure 3. Traffic Light Criteria Excel Formula

Green — Stock is Safe

A material is categorized as Green when the Effective Stock exceeds (ROP + SS), This indicates that the inventory level is stable and no immediate ordering action is required,
Condition:

- Effective Stock > (ROP + Safety Stock)

Yellow — Replenishment Should Be Considered

The Yellow category appears when Effective Stock is equal to or above the ROP but does not exceed ROP + SS, This serves as an early warning signal indicating that stock is approaching a critical threshold,
Condition:

- Effective Stock ≥ ROP

Red — Critical / Stockout Risk

A material falls under the Red category when the Effective Stock is below the ROP, This condition indicates a high risk of stockout and requires immediate replenishment,
Condition:

- Effective Stock < ROP

As can be seen in Figure 4 below, the simulation output displays the traffic light classification for each material, indicating whether the stock level falls into Green, Yellow, or Red status based on the defined inventory thresholds. Material classification (regular/periodic/rare) following usage logic.

Group	Material Description	Grand Total	Lead Time	Service Level	SS	ROP	Effective Stock	Traffic Light	Status
ADH	Adhesive Tape Double 1inc	19110	14	1.28	265	1380	4480	Hijau	REGULER
	Adhesive Tape Double 1inc 3M Type R410	142	14	1.28	8	16	220	Hijau	REGULER
	Adhesive Tape Double 1inc A	5160	14	1.28	460	761	960	Kuning	REGULER
	Adhesive Tape Double 2inc	53	14	1.28	29	32	47	Kuning	PERIODIK
	Adhesive Tape Double 2inc 3M Type 9075I	256	14	1.28	20	35	140	Hijau	REGULER
	Adhesive Tape Double 2inc 3M Type 9075I	32	14	1.28	6	8	63	Hijau	PERIODIK
	Adhesive Tape Bening 1inc	2688	14	1.28	74	231	756	Hijau	REGULER
	Adhesive Tape Bening 1inc E	216	14	1.28	26	39	39	Kuning	PERIODIK
	Adhesive Tape Bening 2inc	1052	14	1.28	99	160	953	Hijau	REGULER
	Adhesive Tape Bening 2inc A	1884	14	1.28	304	414	702	Kuning	REGULER
	Adhesive Tape Bening 2inc E	742	14	1.28	449	492	960	Hijau	PERIODIK
	Adhesive Tape Bening 3inc	1667	14	1.28	42	140	578	Hijau	REGULER
	Adhesive Tape Coklat 1inc	5138	14	1.28	113	413	1242	Hijau	REGULER
	Adhesive Tape Coklat 2inc	7026	14	1.28	75	485	1914	Hijau	REGULER
	Adhesive Tape Coklat 2inc A	3528	14	1.28	249	455	402	Merah	REGULER
	Adhesive Tape Coklat 2inc E	966	14	1.28	39	95	346	Hijau	REGULER
	Adhesive Tape Coklat 3inc	2678	14	1.28	146	303	1348	Hijau	REGULER
	Adhesive Tape Coklat 3inc E	44	14	1.28	7	10	328	Hijau	PERIODIK

Figure 4 Traffic Light System Simulation

Sensitivity Analysis (Service Level 90% vs 95%)

Z-values:

- 90% SL → Z = 1.28
- 95% SL → Z = 1.645

Example effect on SS:

Untuk material AT Double 1 inch:

$$SS_{95\%} = 1.645 \times 55 \times 3.74 = 337 \qquad (10)$$

Changes:

- Safety Stock increases from 265 → 337 (+27%)
- Reorder Point (ROP) automatically increases
- Total stock investment rises

Higher service level = higher capital cost but lower stockout risk.

Sensitivity Analysis (LT 20%, 30%)

- LT 20% = 17
- LT 30% = 18

$$SS = 1.28 \times 55 \times \sqrt{17} = 290 \qquad (11)$$

$$SS = 1.28 \times 55 \times \sqrt{18} = 299 \qquad (12)$$

$$ROP = (80 \times 17) + 290 = 1.650 \qquad (13)$$

$$ROP = (80 \times 18) + 299 = 1.739 \qquad (14)$$

Table 6. Increase SS & ROP with LT 20%,30%

LT	Days	ROP	Increase ROP	Increase SS
20%	17	1360	21.40%	10.20%
30%	18	1440	28.60%	13.40%

Based on the scenario where Lead Time (LT) increases by 20% and 30%, the Reorder Point (ROP) shows a significant rise of approximately 21,4% and 28,6%, while Safety Stock (SS) also increases by about 10,2% and 13,4% in table 6. This demonstrates that ROP and SS are highly sensitive to changes in LT, and any increase in LT automatically drives higher safety stock requirements. It is important to emphasize, however, that the effect of lead time, daily usage increase or decreases and stock out has already been fully incorporated into the calculations of Safety Stock and Reorder Point through the formulas. Therefore, the SS and ROP values used in the Traffic Light System (TLS) already represent the actual lead time conditions.

Conclusion

This study successfully developed an integrated inventory control model combining Safety Stock (SS), Reorder Point (ROP), material usage classification, and a spreadsheet-based Traffic Light System (TLS) to improve packing material management in the flexible packaging industry. The results demonstrate that probabilistic SS–ROP calculations generate differentiated buffer levels in accordance with demand variability and lead-time uncertainty, thereby enhancing the accuracy of replenishment decisions. The implementation of the TLS with three visual status indicators (green, yellow, and red) significantly improves inventory visibility and accelerates monitoring and decision-making processes compared to manual evaluation methods. In addition, the classification of materials into regular, periodic, and rare categories enables more efficient planning by aligning monitoring priorities with actual consumption patterns. Sensitivity analysis indicates that increases in lead time substantially affect SS and ROP values. However, as demand variability and lead-time uncertainty are already embedded in the SS and ROP formulations, the TLS provides reliable and accurate inventory control signals under varying operational conditions. Overall, the proposed model enhances planning accuracy, reduces stockout risk, and supports the transition from judgment-based to data-driven inventory management practices.

Theoretical Contributions

This study contributes to inventory management theory by empirically validating the use of probabilistic SS–ROP calculations for items with heterogeneous and highly variable usage patterns. The findings reinforce the theoretical principle that safety stock must adjust proportionally to demand variability and lead-time uncertainty, while demonstrating that such methods remain effective even when implemented through spreadsheet-based models. Furthermore, the study supports prior findings that probabilistic models outperform deterministic assumption-based models when demand or lead time is stochastic [30], [31].

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