International Journal of Scientific Advances
ISSN: 2708-7972
Volume: 3 | Issue: 2 | Mar - Apr 2022 Available Online: www.ijscia.com
DOI: 10.51542/ijscia.v3i2.17

Design of Lean Six Sigma to Reduce Waste in Aerophile Line Production Processes in The Chemical Industry Using DMAIC And VSM Approach

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ABSTRACT
This research was conducted on companies engaged in the chemical industry which are manufacturers of household products such as: air freshener, baby care products, food plastic wrappers, metal polishers, mouse glue, insecticides, lpg cans, car care products, insect repellent, and many more. many other products. The product chosen to be used as research material this time is an aerosol insect repellent product. This research was carried out in the production department of an aerophile line that produces aerosol insect repellents. This study aims to determine the defects and waste that occur in the aerophyll line so that it can improve quality and increase the amount of production in order to meet customer desires. The method used in this research is descriptive which is done by analyzing the production process of one type of product on the aerophile line by observing for 3 months. The results of this study were carried out using the DMAIC (Define, Measure, Analyze, Improve, Control) and VSM (Value Stream Mapping) methods identified 5 types of defects, namely dented cans, missing batch numbers, reject caps, leaks, and low weight. From the calculation results, the average DPU is 0.05, the average DPO is 0.01, the average DPMO is 10278.14, the average production yield is only 68.59% and the level of sigma value is at level 2. Improvements made with Lean Sigma by expanding the capacity of the waterbath and accelerating the process of immersion and raising the temperature in the waterbath, scheduling machine inspections, making checksheets, and work instructions and SOPs. So that we get a decrease in production cycle time from 88 minutes to 83 minutes which has an impact on increasing the production target from 72 pallets/day to 78 pallets/day, and has an impact on the actual number of production from 1,875 pallets/month to 2,028 pallets/month.

Keywords: Lean Six Sigma; DMAIC; VSM; Defect; Wasting

INTRODUCTION

In the face of many diseases caused by insects and germs, which can cause various conditions such as dengue fever, diarrhea, and other viruses transmitted through insects. So, one chemical company created an insect repellent product with different aroma variants, which can make us avoid insects and germs. The problem of competition in the chemical industry, especially insect repellent products, is that consumer comfort and safety are certainly very important. To fulfil this, the company must regulate the quality of the product to meet customer needs because this is the right step for industrial operations and is a key factor for every industrial company to be able to compete competitively [1-4]. Efforts that can be made to support this are by planning and designing the right production system so that the production process can run smoothly, precisely and accurately, where the balance of this path is influenced by several factors such as operator performance and proper layout, and queues. A company engaged in the chemical industry, one of the producers of insect repellent and several other products such as wet wipes, cosmetics, insect repellent, hair dye, and several other products. With an average production of 1,875 pallets of insect repellent per month, with consumer demand that continues to increase every month for the request for insect repellent, the production of insect repellent exceeds aerophile line must increase production capacity.

Improvements can be made by adding overtime hours, adding shifts, adding employees, modifying the layout, changing the work order process, and line balancing. The following is a comparison chart of consumer demand for insect repellent products from March 2020 - to February 2021.

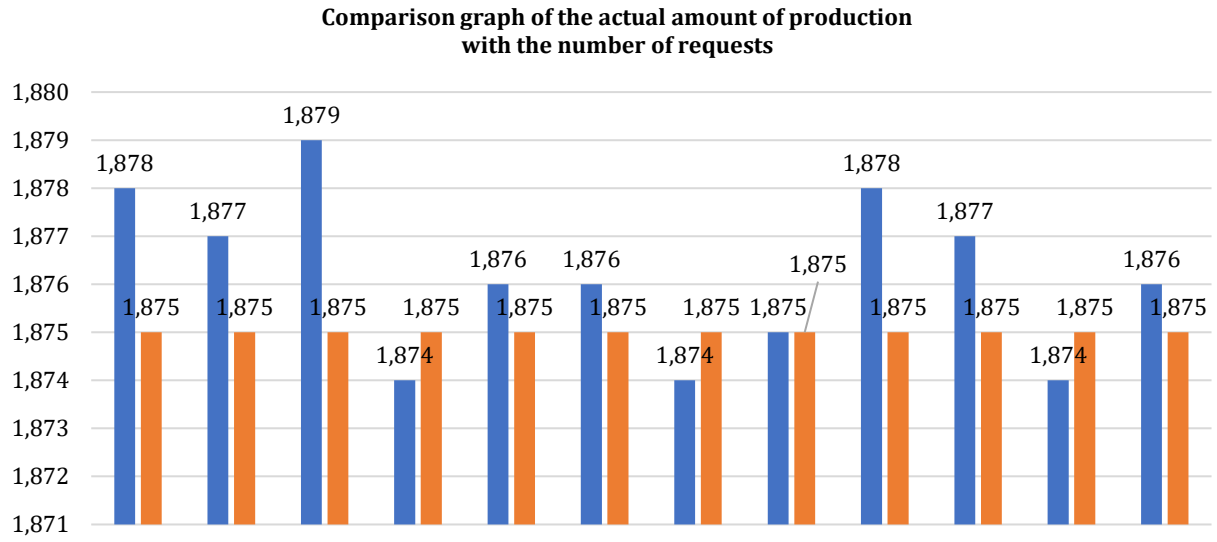

FIGURE 1: Comparison graph of the actual amount of product with the number of requests

The graph above shows that the problem is that the number of requests is higher than the number of available product stocks, namely the average number of requests for 1,876 pallets. In contrast, the available inventory is 1,875 units, so this can affect the level of customer interest. This happens because the cycle time is too high, and backorders occur because of an imbalance between production output and demand.

This happens because of an imbalance in the production line due to the unequal workload distribution at each work station. This impacts the performance of the track balance to be less good. Following are the cycle time conditions in the production process of insect repellent products:

TABLE 1: Details of the Process and Cycle Time of the Production Process of Aerosol Insect Control Products

No.	Activity	Time(minutes)
1	Lifting the can onto the conveyor	2
2	premix filling	1
3	premix weighing	1
4	Gas filling	1
5	Print batch number	1
6	Soaking (Water Bath)	10
7	Cap Installation	1
8	Packaging (Packing)	1
9	Weighing	1
10	Arrange boxes on pallets	15
11	QC Check	5
12	Transfer to finished goods warehouse	5
	Total	**44**

The current condition of the aerophile line is shown in the table above; the largest cycle time is in the process of preparing boxes on pallets of 15 minutes. With a total cycle time of 44 minutes, it can produce 2.5 pallets; if converted in a matter of production per day, it makes 75 pallets of insect repellent products.

The company's policy targets 85% of the number of units per hour for each production within 25 working days. The problem faced by the company that is the object of this research is waste. According to Bester field [5-11], there are 7 types of waste: Defect, Waiting, Unnecessary Inventory, Inappropriate Processing, Unnecessary Motion, Transportation, and Over Production. The problem experienced by producers is the occurrence of Defects and Waiting or waste of time in the production process; this occurs in several functions that take quite a long time due to the operation of several factors. These problems can cause a decrease in the amount of production so that the production target is not met, so it is necessary to carry out inspections and maintenance on the production process. The next problem is the need to improve product quality, seen from the defects, namely missing batch numbers, dented cans, leaks, less weight, and damaged caps (spray caps). With this problem, the best improvement will be held for the company.

To overcome this problem, the company needs to balance the production line. One method that can be used in production line optimization is the Lean Six Sigma method used to minimize the waste that occurs. Several methods will optimize the production line balance, namely DMAIC (Defince, Measure, Analyze, Improve, and Control) and VSM (Visual Stream Mapping).

Based on research conducted by [11-16]. there are problems that occur, namely not achieving the production yield target due to the high number of defective products resulting from the machine quality inspection process. An analysis is carried out using the Lean Six Sigma method to solve the problems that occur so that the research is relevant as a reference in determining the research method.

DMAIC is an application of the Six Sigma concept. This method implements continuous improvement to create product quality that meets the target [17-20]. The DMAIC method consists of five main stages, define, measure, analyze, improve, and control. VSM is a method that describes all existing processes in a company [21-22]. The whole process is depicted with certain symbols on a piece of paper. The production process in question is from raw materials to products in the hands of consumers. The purpose of VSM is to identify the production process so that materials and information can run without interruption, increase productivity and competitiveness, and assist in implementing the system [16-24]. Therefore, VSM helps in finding waste in the production process. This method is expected to provide a solution as an alternative to improve the performance of the production line's balance so that the motorcycle frame's production process becomes more efficient, effective, and productive. A balanced workload between work stations will impact work efficiency with the production line and is expected to meet production targets and customer needs.

RESEARCH METHODOLOGY

Problems that occur such as defects by identifying production and the types that happen, then the next step is making VSM (Current State) find out the current state and calculate production quality using DPMO calculations and in the next stage, analysis using Fishbone so that improvements are obtained according to the problem and for the final step, namely by making improvements using the VSM (Future State) image.

The following are some steps of data processing:

(1) Define

Define is the first stage, focusing on problem identification, determining process objectives, and identifying internal and external customer needs. Several tools such as SIPOC and CTQ are used in the define step.

(1.1) SIPOC (Supplier, Input, Process, Output, Customer)

SIPOC identification is usually used before the process improvement begins. In the Six Sigma methodology, SIPOC is used to identify and select problems to be resolved along with costs, benefits and impacts on customers. The SIPOC steps are as follows:

(a) S (Supplier) is a company or organization that provides the resources needed by the company to produce goods and services.
(b) I (Input) are materials, information and other resources provided by suppliers for consumption or transformation in the production process.
(c) P (Process / Process) is a series of actions and activities that convert Input into Output.
(d) O (Output) are goods or services produced by the process.
(e) C (Customer) is a person who uses goods or services produced by the company.

(1.2) CTQ (Critical to Quality)

CTQ is a tool used to describe consumer desires related to product quality quantitatively and qualitatively. To make a CTQ tree diagram, three things are needed: identification of important needs, identification of quality drivers, and identification of performance requirements (Six Sigma).

Identify important needs, namely identifying the main conditions that the product or service must own. At this stage, a very extensive discussion is required as it helps to ensure that nothing is missed. Next is the identification of quality drivers. What has been identified initially requires a specific quality identification process from the driver. What must be remembered are the factors consumers refer to and think that the product is high quality. This process must be done carefully because it is closely related to consumer needs. Finally, identify the requirements needed to meet the specifications.

(2) Measure

Measurement is the measurement stage of the problems that have been identified to be resolved. In this stage, data collection then measures the characteristics and capabilities of the current process to determine the steps that must be taken to make improvements and further improvements.

(2.1) Pareto chart

A Pareto chart is a bar graph that shows problems in order of several occurrences. The order starts from the number of the issues that occur the most to those that occur the least. In the Graph, it is shown by the highest bar graph (far left) to the lowest graph (far right). Before making a Pareto diagram, data related to the problem or event we want to analyze must be collected first.

(2.2) DPMO (Defects Per Million Opportunities)

DPMO stands for Defects Per Million Opportunities, namely Defects per One Million Opportunities. DPMO is one of the Process Capability assessments to measure how good a production process is. Other Process Capability Assessments include DPU (Defects Per Unit) and Z-score (Sigma Level).

(2.3) VSM (Current State Mapping)

Value Stream Mapping (VSM) is a hand-drawn map where other people can see and understand processes, materials, and information flow, from the arrival of raw materials to the production process until the finished goods are sent to the customer. In making VSM, there are 2 steps, namely Current State Mapping and Future State Mapping:

- Current State Mapping

At this early stage, data analysis and calculations were carried out to find out where the problems occurred, at this stage, 30 observations were made and the calculation of the adequacy test and data uniformity test to determine whether the data used was good for research.

- Data Uniformity Test

In this data analysis, it is carried out using a support application, namely the MINITAB application to facilitate calculations as according to (Moelong, 2010), data analysis techniques are the process of categorizing data sequences, organizing them into a pattern, category and basic description unit where data analysis begins by examining all data. Available from various sources. After reviewing, the next step is to carry out data reduction, which is carried out using a core summary. The next step is to arrange them in units. The categories are created while coding. The final stage of this data analysis is to check the validity of the data. After this stage, start the stage of data interpretation in processing temporary results into substantive theory using certain methods.

- Future State Mapping

Future State Mapping or future maps can be the basis for improvements in real work areas. This map was made by considering the findings obtained during mapping on Current State Mapping. From the results of observations of current conditions, there will be problems that can be said

as waste or waste in production activities. Therefore, it will determine or design the Future State Map. In conditions like this, we have been able to create or develop a Future State Map by eliminating waste or including improvements in new techniques or technologies.

(3) Analyze
The analysis phase isolates the main causes of the CTQ that the team focuses on. There are usually no more than three causes that must be controlled for success in some cases. If too many reasons are identified, the team is not isolating the main problem, or the project goals are too high to be achieved with just one project. The determinant of the success of this phase is the main cause that must be proven, not only relying on fishbone diagrams.

Speed and results are critical factors for building Six Sigma momentum. Projects undertaken must be sized to ensure team success and closure within a reasonable time.

(4) Improve
The improvement phase focuses on a full understanding of the main causes identified in the analysis phase, with the intention of either controlling or eliminating the causes of these problems to achieve maximum performance.

(5) Control
The control phase of the DMAIC approach is about maintaining the changes made in the improvement phase. Its purpose is to maintain profits, monitor improvements to ensure continued success, create control plans, and update documents, business processes and training records. The critical factor for the success of the control phase is that if a control phase is required, the company must have a strong internal audit division to ensure long-term compliance.

RESULT AND DISCUSSION
This section discusses the previous chapter's results and discussions on data processing. The following are the results and discussion of this research.

(1) Define
In the Define stage, two tools are used, namely SIPOC and CTQ. SIPOC is a process flow that shows activity in a business process consisting of Supplier, Input, Process, Output and Customer. After knowing the production process flow for the insect repellent product, the next step is to analyze the CTQ to find out what customer desires have not been realized. Here are the results of the analysis:

(1.1) SIPOC (Supplier, Input, Process, Output, Customer)
This SIPOC analysis is useful for identifying and knowing who is the main supplier for input and how the process reaches the customer.

- Supplier

The raw materials used as the first step in the insect repellent production process are obtained from various suppliers who have collaborated to get the raw materials needed. These are obtained from 3 suppliers who have provided all the raw materials required.

- Input

The raw materials for insect repellent products, there are several raw materials for making them. Still, the main raw materials for insect repellent products can be categorized, namely premix consisting of aromatics, gas, cans and other stamps.

- Process

Process steps must be passed for insect repellent products, namely sorting raw materials, taking, raising, filling premix, filling gas, weighing, batch numbering, soaking, stamping, packaging, weighing, preparation, and inspection.

- Output

The results obtained are insect repellent with various aroma variants available, namely lily blossom, orange, green forest, and others. And also available in 200 ml, 400 ml, 600 ml, and 675 ml sizes.

- Customers

Customers of this insect repellent product are consumers who use insect repellent products who care about the health of their families.

(1.2) CTQ
Before this analysis, interviews were held with production operators and QC for any defects that often occur that can lead to a decrease in the level of customer confidence, and the interview results show that the defects that often occur are dented cans, missing batch numbers, reject caps, leaks, and weight. Less content.

(2) Measure
At this stage, it is used to measure the sigma value by calculating DPMO (Defect per Million Opportunities) and creating the initial phase of VSM or commonly called Current State Mapping. This stage has a very important role in improving product quality and reducing waste because by measuring and calculating, it will be able to know how the company's current performance is.

(2.1) Pareto chart
At this stage, the Pareto diagram is a tool used to find the cause of the problem and focus on solving it. In this insect repellent product, several defects often occur, namely dented cans, missing batch numbers, reject caps, leaks, and low weight.

(2.2) DPMO
At this stage, the sigma value measurement is carried out by calculating DPU, DPO and DPMO, and the Yield on these products. In this stage, it is useful to measure the company's performance and get the following results:

TABLE 2: DPMO Results

No	Month	Total Demand	Total Defect	DPU	DPO	DPMO	Yield%	Sigma
1	March	1,878	98	0.05	0.01	10436.63	68.59%	3.81
2	April	1,877	99	0.05	0.01	10548.75	68.60%	3.81
3	May	1,879	91	0.05	0.01	9686.00	68.59%	3.84
4	June	1,874	85	0.05	0.01	9071.50	68.60%	3.86
5	July	1,876	100	0.05	0.01	10660.98	68.60%	3.80
6	August	1,876	89	0.05	0.01	9488.27	68.60%	3.85
7	September	1,874	103	0.05	0.01	10992.53	68.60%	3.79
8	October	1,875	106	0.06	0.01	11306.67	68.60%	3.78
9	November	1,878	98	0.05	0.01	10436.63	68.59%	3.81
10	December	1,877	92	0.05	0.01	9802.88	68.60%	3.83
11	January	1,874	99	0.05	0.01	10565.64	68.60%	3.81
12	February	1,876	97	0.05	0.01	10341.15	68.60%	3.81
Average		**1876**	**96**	**0.05**	**0.01**	**10278.14**	**68.60%**	**3.82**

Based on the table above, the sigma results are obtained with an average of 3.82. If seen from the sigma level conversion above, it is at the 2-sigma level, which means it is on the average for the Indonesian industry.

(2.3) VSM (Current State Map)
At this stage it contains an analysis of the activities of the insect repellent production process which aims to find or find problems in the form of waste, what happens and in what part of the waste occurs based on the activation process the result is that there is a waste of time at the immersion stage. which at this stage requires quite a long time.

(3) Analyze
At this Analyze stage, the 5 why and Fishbone tools are used to get the Fishbone results, it must be based on what has been described in the 5 whys. This stage is carried out to find out the cause of the problems and find out what improvements are good to apply.

(3.1) Cans Dent
• Human Factor
The human factor that occurs is the condition of the workers not understanding how to raise the cans to the conveyor then, causing the cans to fall scattered and then causing a loss of concentration in workers.

• Method Factor
The method factor is that there is no good procedure for raising cans to the conveyor because the company has not done training on how to raise cans to the conveyor properly and correctly.

• Engine Factor
The machine factor that occurs is the operator setting the conveyor speed too high and when setting the starwill it is not by the SOP, and there is no routine inspection schedule.

• Environmental factor
Environmental factors that occur are a narrow and inadequate placement area so that the placement and arrangement are too high and can cause cans to fall, the production area is noisy, making it difficult to communicate. Human Factors

(3.2) Missing Batch Number
• engine factor
The machine factor that occurs is that there is no routine ink replacement check schedule, the ink machine is exposed to premix so it cannot function properly.

• Method Factor
The method factor is that the company calculates the ink change time, and has not used the correct method in the ink change process.

• Environmental factor
Environmental factors that occur are slippery conveyor conditions so that many cans are missed before entering the batch number printing process.

• human factor
The human factor that occurs is that the operator does not understand when to change ink and how to install it, so they have to call a mechanic to install the ink.

(3.3) Cap Reject
• Environmental factor
Environmental factors that occur are that the installation space is too narrow so many are missed, and the condition of the room is crowded and noisy.

• Method Factor
The method factor is that there is no standard hydraulic machine height so it is still done by guessing. And there is no training on how to install a good and correct stamp.

• Engine Factor
The engine factor that occurs is the quality of the stamp itself is still relatively standard, and the hydraulic engine is very old.

• Human Factor
The human factor that occurs is that workers do not understand how to put the correct stamp because there is no training. And there is often a loss of concentration due to the conveyor running too fast.

(3.4) Leaking

- Material Factor

The material factor is the condition of the material is too thin, causing the can to leak easily and the material quality is not good.

- Method Factor

The method factor that occurs is that there is no special understanding regarding the installation of startwill so new workers find it a little difficult to install. There is no understanding of the procedure for raising cans to the conveyor, so cans often fall onto the production floor, resulting in dents and leaks.

- Engine Factor

The engine factor is that the starwill setting does not fit so that the can is squeezed. And the conveyor speed is too high, resulting in the movement of the starwill not being synchronized.

- Human Factor

The human factor that occurs is that workers do not understand how to raise cans to the correct conveyor because there is no training. And there is often a loss of concentration due to the conveyor running too fast.

(3.5) Less Filling Weight

- Environmental factor

Environmental factors that occur are where the condition of the machine is dirty and slippery so that in the process of filling the premix the device is difficult to grip, and the condition of the room is crowded and noisy.

- Method Factor

The method factor that occurs is that there is no additional premix capacity to increase the amount of production. And the condition of the scales is old and worn so it can't work properly.

- Engine Factor

The engine factor is that the premix storage capacity is still limited, and the weighing machine error can result in the weight of the contents not being by existing standards in the company.

- Human Factor

The human factor is that workers lack concentration during the premix and gas filling process.

(3.6) Waste

- Engine Factor

The machine factor that occurs is inefficient production time, where the machine runs for 23 hours a day and is only turned off when changing products, making the machine work with poor performance.

- Method Factor

The method factor that occurs is that there is no routine machine inspection schedule. The machine is only repaired when damage occurs.

And there is no machine maintenance training so to restore the machine you have to rely on technicians.

- Human Factor

The human factor that occurs is a high workload that occurs in workers where each worker carries out various activities. This is because the number of employees is still lacking.

(4) Improve

The next stage is Improve, which aims to propose improvements to overcome problems such as waste and defective products by making improvements through 5W + 1H and repairing waste through VSM (Future State Mapping).

(4.1) 5W+1H

Based on the analysis of repairs carried out using 5W + 1H tools, the results obtained are:

- Cans Dent

In this problem, improvements were found, namely making SOPs and work instructions for employees, changing cans material and making SOPs for installation and replacing starwill.

- Missing Batch Number

The proposed improvement for this problem is to make improvements by making an ink change schedule and creating a batch ink change instruction SOP.

- Cap Reject

The suggested improvement for this problem is to apply the SOP and correct stamp installation instructions and provide input to employees regarding work instructions.

- Leaking

The suggested improvement for this problem is to apply SOP and can packaging instructions and replace the can material with thicker material to reduce the risk of leakage.

- Less Filling Weight

Suggested improvements for this problem are implementing SOPs and changing the scales to increase production quality. As well as adding capacity for premix storage.

- Waste

For further problems, it can be suggested that by providing machine maintenance training and adding the number of employees so that workloads are evenly distributed. So that it can improve the performance of workers and enhance the quality of product.

(4.2) VSM (Future State Mapping)

In the VSM (Future State Mapping) analysis, improvements were found by reducing the immersion time and increasing the temperature during immersion so that there is no long waiting time and can shorten the time, and the results of the comparison of production times are obtained as below:

TABLE 3: Comparison After Repair

No.	Activity	Cycle time (Minutes)	
		Before	After
1	Sort raw materials	45	45
2	Lifting the can onto the conveyor	2	2
3	premix filling	1	1
4	premix weighing	1	1
5	Gas filling	1	1
6	Print batch number	1	1
7	Soaking (Water Bath)	10	5
8	Cap Installation	1	1
9	Packaging (Packing)	1	1
10	Weighing and drafting	15	15
11	QC Check	5	5
12	Transfer to finished goods warehouse	5	5
	Total	**88**	**83**

(5) Control

Control phase is a proposal for companies that are used as research which is the last stage of the DMAIC method, which contains suggestions or recommendations to eliminate waste and reduce defects. At this Control stage, a Check sheet and SOP are made.

CONCLUSION

From the results of processing and analysis that has been carried out on the production process of aerosol insect repellent products, it can be concluded as follows:

(1) It is known that several defects occurred, namely dented cans, missing batch numbers, reject caps, leaks, and low weight of contents. The cause of this defect is that there is no training for workers and there is no SOP for the production process, there are no work instructions, and there is no maintenance and improvement on the machine.

(2) There is waste in the production process activities, precisely in the immersion activity, this occurs because the water bath capacity is not large enough and the clamping machine on the water bath is running slowly therefore, a proposed improvement is given according to the analysis of VSM, namely by increasing the speed of the immersion process and raising the temperature at water bath, and the results of the comparison time were obtained where before the repair was carried out the cycle time was 88 minutes and after the repair was accepted it was about 83 minutes.

(3) The proposed improvements are based on the DMAIC analysis that has been carried out, namely by accelerating the immersion process to eliminate waste that occurs, repairing the weighing machine, making SOPs for production activities, making work instructions, conducting briefings before the start of work activities and making checksheets to help control the process. Maintenance.

SUGGESTIONS

Suggestions are given from the results of this study both for the application of the company and for further research, namely:

(1) To improve quality, it is hoped that the company can apply this method because the results of this analysis can answer problems in the production process of aerosol insect repellent products.

(2) This study only discusses one product type among several products produced by chemical companies. It is hoped that further research can discuss all kinds of products made by chemical companies.

(3) It is hoped that further research can discuss other methods that are still related to more widespread improvements and relevant to future conditions.

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