

Reduction of Visual Defects Dented in Valve Seat Products Using the Failure Mode and Effect Analysis (Fmea) Method and Kaizen Seven Tools at PT. XYZ

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PT. XYZ is one of the manufacturing companies that produces precision spare parts for automotive and electronic components. One of the automotive component spare parts is the Valve Seat. In the production process, there are NG (Not Good) valve seat products that are delivered to customers, resulting in frequent customer claims. This research aims to describe and analyze work process improvements so that quality can be maintained using the Seven Tools Method and to identify the factors causing the delivery of non-conforming products. Furthermore, the Failure Mode and Effect Analysis method is used to identify the highest failure risks, followed by kaizen implementation. Based on these results, an analysis of work process improvements is required to maintain product quality before delivery to customers by creating work instructions and adding work process methods during handling. Based on the pareto defect diagram, the most frequent defect in the last 3 months was the dented part, accounting for 95,91%. The contributing factors were: Human factors, where operators did not yet fully understand handling requirements; machine factors, where components and cutting oil circulation were dirty; method factors, where handling was not in accordance with SOP; and material factors, where the material made of stainless steel was easily scratched. By implementing FMEA and Kaizen, it was found that the Valve Seat production process at PT XYZ was already quite good, with a defect reduction of 0.87%, from the previous defect rate of 2.75% to 1.88%.

Keywords: Product Defect, Seven Tools, FMEA, Quality Control

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1. Introduction

PT. XYZ is a manufacturing company that produces components for the automotive, electronics, audio equipment, and office automation sectors. The company has been operating since 1997 in the Delta Silicon 1 Industrial Park, Lippo Cikarang, Bekasi Regency. PT. XYZ specializes in the production of precision parts using CNC milling machines and secondary processes.

The parts produced include *shafts*, *metal inserts*, *pulley levers*, and *valve seats*. A *valve seat* is a ring-shaped component that functions as a sealing surface. It ensures that the valve closes tightly, prevents fluid (gas or liquid) leakage, and maintains compression. The continuously increasing demand from customers requires the company to maintain the quality of its products. Maintaining product quality is essential to ensure customer satisfaction and prevent defective products from being delivered to customers. However, *valve seat* production still experienced *dented* defects, totaling 83,393 pieces out of a total production of 3,032,462 pieces (2.75%) during the July–September 2025 period. This condition requires the company to evaluate the defective products in order to reduce the defect rate. The most prevalent defect was *dented valve seat*, which resulted in poor part quality and high costs. Therefore, this study aims to control the product defect ratio from 2.75% to 0% and achieve zero cases of product defects.

The defects occurring during the last three months were classified into two categories: visual defects and dimensional defects. Visual defects included *dented valve seat*, *cracked valve seat*, and *burr on valve seat*, while dimensional defects consisted of *out-of-specification dimensions* and *short-cut parts*. Defective parts that are delivered to customers may cause various potential and serious problems during the assembly process. Visual defects such as *dented valve seat*, *cracked valve seat*, and *burr on valve seat* can prevent the valve from closing properly. These microscopic gaps may cause fluids, gases, or vapors to leak from the system. Such leakage can reduce operating or compression efficiency and result in power loss and increased fuel or energy consumption. Leakage at the valve seat can also cause backfire (*misfire*) and lead to *overheating*. If *overheating* is allowed to persist, the *valve seat* may wear out and eventually fracture. The resulting fragments may enter the combustion chamber or flow passages and damage other components. Dimensional defects, such as *short-cut parts* and *out-of-specification dimensions*, can have serious consequences if delivered to customers because the *valve seat* may fail to assemble properly (*mismatching*) due to an excessive *gap* or clearance. To address these defects, the FMEA approach is applied.

The Failure Mode and Effects Analysis (FMEA) method was formally introduced in the aerospace industry in the mid-1960s, with a particular focus on safety issues. Shortly thereafter, FMEA became a key tool for improving safety, particularly in the chemical process industry. FMEA continues to be used to prevent accidents and safety incidents. [1] The object of FMEA is the overall process or product that may experience potential failures.

Previous studies on quality control have applied FMEA, Seven Tools, or their combination to identify product defects and determine their causes. However, several studies primarily emphasize defect identification, root-cause analysis, and risk prioritization, while the linkage between risk analysis and direct process improvement with measurable defect reduction remains less emphasized. This creates a research gap for an integrated approach that not only identifies the causes of defects but also translates the highest-priority risks into practical improvement actions and evaluates their impact on the defect rate. In this study, Seven Tools is used to identify the dominant defect and its potential causes through Pareto and Fishbone analysis, while FMEA prioritizes the causes based on their Risk Priority Number (RPN). The prioritized causes are then addressed through Kaizen using the 5W+1H approach, creating a systematic link between problem identification, risk prioritization, and process improvement. This approach is particularly relevant because the *dented* defect reached 83,393 pieces, equivalent to 2.75% of 3,032,462 production units during July–September 2025, and accounted for 95.91% of all identified defects.

The novelty of this study lies in integrating Seven Tools, FMEA, and Kaizen into a continuous improvement framework specifically for *dented* defects in *valve seat* production. FMEA identified *disorganized handling* as the highest-priority cause, with an RPN of 256, exceeding the RPN values of the other identified causes. This priority was subsequently addressed through a Kaizen improvement involving the addition of a plastic container to the production rack to improve handling practices. Therefore, the research contribution extends beyond identifying the causes of *dented* defects by demonstrating a measurable quality-improvement objective: reducing the initial defect rate of 2.75% to a maximum of 2% through targeted corrective action.

The purpose of Failure Mode and Effects Analysis (FMEA) is to identify and analyze potential failures in products, systems, or processes. This method is used to determine the root causes of quality problems. Various forms of errors, design deficiencies, conditions that do not conform to specified requirements, and product modifications that may lead to failure are examples of failures that can be analyzed using this technique.[1] Therefore, this study aims to identify the causes of defects in *valve seat* products and provide improvement recommendations to achieve the goal of *zero defect/zero claim*.

2. Methods

This study employed a quantitative descriptive approach with a case study design to identify the causes of defects in *valve seat* products at PT. XYZ and to develop improvement actions for reducing the defect rate. The research object was the *valve seat*, a precision ring-shaped component that functions as a sealing surface and supports valve performance. Primary data consisted of production defect data collected during July–September 2025, direct observations of the production and handling processes, and semi-structured interviews with informants from the Production, QC/QA, *Warehouse*, and Engineering departments. Informants were selected based on their direct involvement in the *valve seat* production, quality inspection, material handling, or technical support processes and their understanding of the occurrence and handling of *dented* defects. Secondary data were obtained from company records and relevant literature.

The research procedure consisted of several sequential stages. First, production and quality data for July–September 2025 were collected and classified according to defect type. Second, the Pareto diagram, as one of the Seven Quality Control Tools, was used to determine the dominant defect based on its frequency and proportion. The analysis identified *dented* as the dominant defect, accounting for 95.91% of all recorded defects. Third, a Fishbone Diagram, another of the Seven Quality Control Tools, was used to identify potential root causes according to the 4M+1E categories: *Man*, *Machine*, *Method*, *Material*, and *Environment*. The analysis identified disorganized handling, unsmooth cutting-oil circulation, non-compliance with SOPs, and easily scratched material as the main potential causes.

Fourth, Failure Mode and Effects Analysis (FMEA) was applied to prioritize the identified causes according to their associated risks. Each potential failure cause was evaluated using three parameters: Severity (S), Occurrence (O), and Detection (D). The *Severity* score represented the seriousness of the effect of the failure on product quality or subsequent processes, *Occurrence* represented the likelihood or frequency of the failure cause occurring, and *Detection* represented the ability of the existing control system to detect the failure before the defective product proceeded to the next process or customer. The ratings were determined based on [insert the actual company/FMEA rating scale and assessment basis used in the study] through evaluation by the relevant Production, QC/QA, Warehouse, and Engineering personnel. The Risk Priority Number (RPN) was then calculated as $RPN = S \times O \times D$, and the causes were ranked according to their RPN values. The highest RPN was obtained for disorganized handling, with a value of 256.

Fifth, the highest-priority cause identified through FMEA was subjected to Kaizen improvement. The Kaizen implementation consisted of: (1) identifying the improvement target based on the highest FMEA priority; (2) defining the *What*, *Why*, *Where*, *When*, *Who*, and *How* using the 5W+1H approach; (3) developing and implementing the corrective action; (4) assigning responsibility to the relevant departments; and (5) conducting a trial period to evaluate the effectiveness of the improvement. In this study, the improvement was implemented by the Engineering and QA teams through the addition of a plastic container to the production rack to improve handling and prevent contact-related damage to the *valve seat*.

Finally, the effectiveness of the improvement was evaluated by comparing the defect rate before and after implementation during the trial period. The initial defect rate of 2.75% was used as the baseline, while the improvement target was set at a maximum of 2%, corresponding to the company's allowable defect rate. Thus, the research procedure did not stop at identifying the causes of *dented* defects but continued through risk prioritization, implementation of corrective action, and evaluation of its potential contribution to reducing the defect rate.

This study employs a quantitative descriptive approach based on a case study to identify the causes of defects in *valve seat* products at PT. XYZ and to provide improvement recommendations for reducing the defect rate through the application of Failure Mode and Effects Analysis (FMEA) and Kaizen. The research

object is the *valve seat*, a precision ring-shaped component that functions to prevent leakage, withstand high pressure and temperatures, and support the performance of the valve mechanism. The research data consist of primary data in the form of production defect data collected over the most recent three-month period (July–September 2025) through observations and interviews with personnel from the Production, QC/QA, *Warehouse*, and *Engineering* departments, as well as secondary data obtained from journals, books, and company archives. Data processing was conducted by identifying the dominant defects using a Pareto diagram, analyzing their root causes using a 4M+1E Fishbone Diagram (*Man, Machine, Method, Material*, and *Environment*), and subsequently determining the Risk Priority Number (RPN) using the FMEA method based on *Severity, Occurrence, and Detection*. The causes with the highest RPN values were then prioritized for improvement using the Kaizen approach. The research stages consisted of observing the production and quality processes, collecting defect data, conducting a literature review, analyzing the causes of defects, determining improvement priorities, and developing recommendations to reduce the defect rate in *valve seat* products.

3. Result And Discussion

Data Collection and Processing

Primary Data

Sampling was conducted by collecting defect data from the most recent three-month period. The following table presents the *Valve Seat* part defect data for July–September 2025.

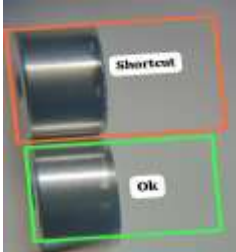
Table 1. Defect Data for July–September 2025

No	Defect	Month			Total (pcs)	% NG
		July	Agst	Sept		
1	Dented	27.401	26.246	29.746	83.393	2.75%
2	Burry	313	253	344	2730	0.0009%
3	Outspec Dimensi	167	149	170	486	0.0016%
4	Crack	103	96	105	304	0.0001%
5	Shortcut	10	9	12	31	0.00001%
TOTAL DEFECT					86.944	2.867%
TOTAL PRODUCTION					3.032.462	

Based on Table 1, a total of 86,944 defective parts were identified during the three-month period, consisting of five types of defects: *dented*, *burry*, *crack*, *shortcut*, and *out-of-specification dimensions*. The total defect rate was 2.867%, compared with the *Zero Defect* standard. The following table presents the characteristics of each type of product defect.

Table 2. Product Defects

No	Defect	Figure	Description
1	<i>Dented</i>		Deformation or indentation on the part area, particularly around the <i>chamfer</i> , body, upper surface, and lower surface.
2	<i>Burry</i>		Improper or uneven residual material on the upper cut, lower cut, and <i>chamfer</i> areas.

No	Defect	Figure	Description
3	Crack		Cracks occurring on the <i>valve seat</i> body.
4	Shortcut		Defective or incomplete cutting of the part.
5	Outspec dimensi		Absence of the required <i>chamfer</i> cut.

Analysis and Discussion

Pareto Diagram

A Pareto diagram was used to determine the distribution and percentage of product defects occurring during the three-month period from July to September 2025. The cumulative percentage of product defects is presented in Table 3.

Table 3. Cumulative Percentage of Product Defects

No	Defect	Total (pcs)	% defect	Cumulative Percentage
1	Dented	83.393	95,91%	95,91%
2	Burry	2730	3,14%	99,05%
3	Outspec Dimensi	486	0,56%	99,61%
4	Crack	304	0,35%	99,96%
5	Shortcut	31	0,04%	100%
TOTAL DEFECT		86.944		

After calculating the cumulative percentage of product defects, the dominant defect requiring improvement could be identified. The results of the defect analysis are presented in the Pareto diagram shown in Figure 1.

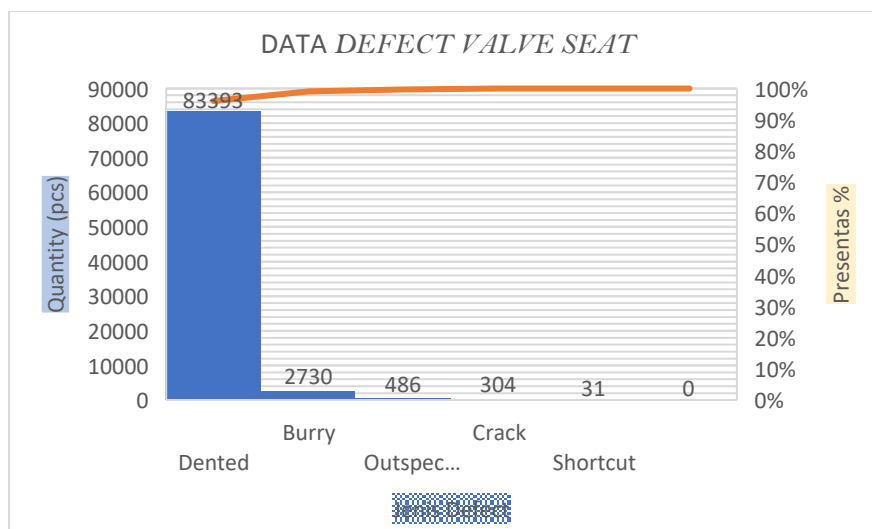


Figure 1. Pareto Diagram of Defects for Three Months (July–September 2025)

Based on the results of the Pareto diagram, it can be seen that the *Dented* defect has the highest frequency. Therefore, among the five types of defects identified, the analysis was narrowed down to the most prevalent defect, namely *Valve Seat Dented*, for further investigation and improvement. This was done to focus the improvement efforts on the defect with the highest level of importance and occurrence.

Fishbone Diagram

In the *Fishbone Diagram*, the analysis focused on the *Valve Seat Dented* defect to identify its underlying causes. The results of the *Fishbone Diagram* analysis for the Dented component are presented in Figure 2.

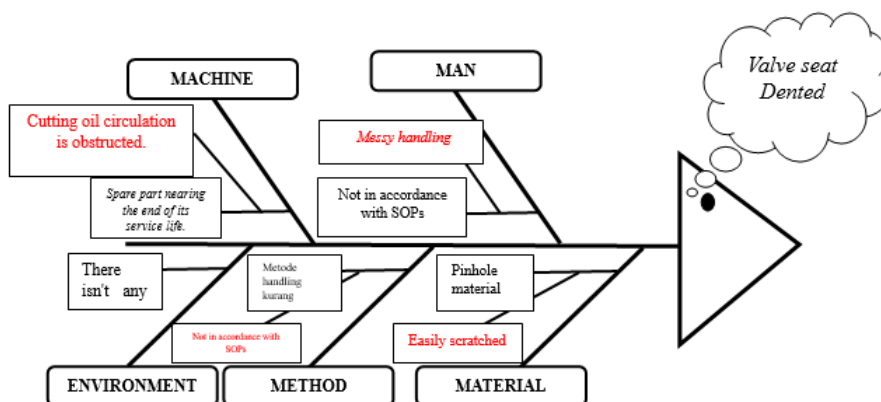


Figure 2. Fishbone Diagram

The Fishbone *Diagram* analysis identified one *root cause* for each factor, except for the *Environment* factor. The identified root causes are presented in Table 4.

Table 4. Root Causes Identified from the Fishbone Diagram

Factor	Root Cause
<i>Man</i>	Disorganized <i>handling</i>
<i>Machine</i>	Unsmooth or obstructed <i>cutting oil</i> circulation
<i>Method</i>	Non-compliance with the SOP
<i>Material</i>	Material is easily scratched
<i>Environment</i>	No problems identified

FMEA

In the data processing stage, the researcher employed the Failure Mode and Effects Analysis (FMEA) method. FMEA was used to analyze the relationship between potential failure modes and their effects, with the aim of determining the severity of defects and their potential impact. This approach involves identifying and mapping potential causes of failure and determining appropriate corrective actions.

The Risk Priority Number (RPN) was then calculated by multiplying the *Severity (S)*, *Occurrence (O)*, and *Detection (D)* ratings. The results were subsequently ranked based on the highest RPN values. The highest-priority corrective action was assigned to the failure cause with the highest RPN, indicating that the issue required the most immediate attention. The results of the FMEA calculation are presented in Table 5.

Table 5. Failure Mode and Effects Analysis (FMEA)

Failure Mode	Failure Cause	S	O	D	RPN
Valve Seat Dented	Disorganized <i>handling</i>	8	4	8	256
	Non-compliance with SOP	5	3	4	60
	Unsmooth <i>cutting oil</i> circulation	4	3	3	36
	Material is easily scratched	7	3	3	63

Source: Processed Data, 2025

RPN : *Severity (S) x Occurrence (O) x Detection (D)*

Description :

S : *Severity*

O : *Occurre*

D : *Detection*

RPN : *Risk Priority Number*

Based on Table 5, data processing was carried out, and the Risk Priority Number (RPN) values were determined for each potential cause of failure. These causes included disorganized handling, improper circulation of cutting oil, methods that did not comply with the SOP, and materials that were easily scratched. The FMEA analysis showed that the Man factor had a higher risk of failure compared with the other factors.

Kaizen

To reduce the defect rate of *Valve Seat* products, the Kaizen method was implemented using the 5W+1H analysis approach. This method was used to further investigate potential causes of failure based on the data obtained from the RPN (*Risk Priority Number*) analysis. Through this analysis, the main causes could be identified more specifically, particularly those related to machine factors. Based on the analysis results, several solutions were developed to address problems originating from the machine aspect that contributed to the occurrence of defects. The proposed solutions are presented in the following table.

Table 6. Proposed Improvements Using 5W+1H Analysis

Main Cause Factor	5W+1H	Description	Action	Remarks
Valve Seat Dented	What	What is the purpose of implementing the improvement?	To reduce defects	–
	Why	Why is the improvement necessary?	Because the potential for failure is high	–

Main Cause Factor	5W+1H	Description	Action	Remarks
	Where	Where will the improvement be implemented?	On the machine in the <i>Valve Seat</i> production area	–
	When	When will the improvement be implemented?	The improvement will be implemented starting October 15, 2025	–
	Who	Who will implement the improvement?	Engineering and QA Teams	–
	How	How will the improvement be implemented?	Adding a plastic container to the rack	

The improvement or *Kaizen* presented in Table 3 involved the Engineering and QA departments. The improvement activities were documented in the form of a *Kaizen Report*, as presented in Figure 3 below.



Figure 3, Kaizen Report

Following the implementation of the *Kaizen* documented in the *Kaizen Report*, a one-month trial was conducted on the production line where the improvements had been implemented. The target defect rate was set at a maximum of 1.8% by the researcher, or a maximum of 2% based on the maximum allowable defect rate for *Valve Seat* parts at PT. XYZ. If the defect rate during the trial period remained below 2% of total

production, the *Kaizen* aimed at reducing defects in *Valve Seat* products would be considered successful, particularly in addressing the failure mode with the highest RPN, namely disorganized or improper handling.

Relationship Between Defect Data, Root Causes, FMEA, and Kaizen Improvement

The defect data for July–September 2025 indicate that the *dented* defect was the dominant quality problem in the *valve seat* production process. A total of 83,393 *dented* parts were recorded from 3,032,462 production units, resulting in a defect rate of 2.75%. This defect represented 95.91% of the total 86,944 defective parts, substantially exceeding the other defect categories. Therefore, the Pareto analysis provided a clear basis for focusing the improvement effort on the *dented* defect as the most significant quality problem. The Fishbone analysis was subsequently conducted to identify the potential causes of the *dented* defect. Four contributing factors were identified: *Man*, *Machine*, *Method*, and *Material*. The *Man* factor was associated with disorganized handling, the *Machine* factor with unsmooth or obstructed cutting-oil circulation, the *Method* factor with non-compliance with the SOP, and the *Material* factor with material that was easily scratched. No significant problem was identified for the *Environment* factor. These findings indicate that the *dented* defect was not attributed to a single general condition but to several potential causes that required further prioritization.

FMEA was then applied to determine the priority of the identified causes. The results show that disorganized handling had the highest RPN of 256, based on Severity = 8, Occurrence = 4, and Detection = 8. The other causes had considerably lower RPN values, namely 63 for easily scratched material, 60 for non-compliance with SOP, and 36 for unsmooth cutting-oil circulation. Muh Rosyid (Esaprom S4) The high RPN of disorganized handling indicates that this factor represented the most critical combination of potential impact, occurrence, and difficulty of detection among the identified causes. Consequently, the *Man* factor was selected as the primary target for improvement.

The FMEA results also provide the basis for correcting the interpretation of the Kaizen improvement. Since disorganized handling under the *Man* factor was the cause with the highest RPN, the Kaizen action should be interpreted as an improvement to the handling process rather than primarily as a Machine-related improvement. The Kaizen action involved adding a plastic container to the production rack to improve the handling arrangement of *valve seat* components. The improvement was implemented by the Engineering and QA teams in the *valve seat* production area using the 5W+1H approach.

Thus, the analytical sequence of this study can be clearly established as defect identification → defect prioritization → cause identification → risk prioritization → corrective action. The Pareto analysis identified *dented* as the dominant defect, the Fishbone analysis identified its potential causes, FMEA determined that disorganized handling had the highest risk with an RPN of 256, and Kaizen translated this priority into a practical handling improvement. This sequence demonstrates that the corrective action was derived from the results of the preceding analyses rather than being selected independently.

Quantitative Evaluation of the Improvement

The initial production data show that the *dented* defect rate was 2.75%, corresponding to 83,393 defective parts from 3,032,462 production units. After the Kaizen improvement, the study reports a defect rate of 1.88%, representing a reduction of 0.87 percentage points from the initial condition.

Table 7. Reduction of Kaizen

Condition	Dented Defect Rate	Reduction
Before Kaizen	2.75%	-
After Kaizen	1.88%	0.87 %

The relative reduction in the defect rate was:

$$\frac{2.75 - 1.88}{2.75} \times 100\% = 31.64\%$$

Therefore, based on the defect-rate data reported in the study, the Kaizen improvement was associated with a 0.87 percentage-point reduction, equivalent to a 31.64% relative reduction in the *dented* defect rate. The resulting defect rate of 1.88% was also below the company's maximum allowable defect rate of 2%, which was established as the criterion for successful improvement during the one-month trial. This result demonstrates that the contribution of the study extends beyond identifying the causes of the *dented* defect. The integration of Pareto, Fishbone, FMEA, and Kaizen provided a structured improvement sequence in which the dominant defect was identified, its potential causes were investigated, the highest-risk cause was prioritized quantitatively, and a targeted corrective action was implemented. The reported reduction from 2.75% to 1.88% indicates that the improvement contributed to lowering the defect rate and achieving the company's maximum allowable defect target.

4. Conclusion

1. The *dented* defect was the most dominant defect in the *valve seat* production process, with 83,393 defective parts or 2.75% of total production, accounting for 95.91% of all recorded defects during July–September 2025. The Pareto analysis therefore established *dented* as the primary defect requiring improvement.
2. The Fishbone analysis identified four potential causes of the *dented* defect: disorganized handling (*Man*), unsmooth cutting-oil circulation (*Machine*), non-compliance with SOP (*Method*), and easily scratched material (*Material*). FMEA was then used to prioritize these causes based on *Severity*, *Occurrence*, and *Detection*. Disorganized handling obtained the highest RPN of 256, with Severity = 8, Occurrence = 4, and Detection = 8, making it the highest-priority cause for improvement.
3. The Kaizen improvement was directed at the highest-priority cause, namely disorganized handling, through the addition of a plastic container to the production rack. Following the improvement, the reported *dented* defect rate decreased from 2.75% to 1.88%, representing a reduction of 0.87 percentage points or 31.64% relative to the initial defect rate. The resulting defect rate of 1.88% was below the company's maximum allowable defect rate of 2%, indicating that the reported improvement result achieved the predetermined target.

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