Cost of quality system in passenger car plant: a methodology of implementation

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Abstract. The purpose of this research is to provide methodological adjustments or procedures for installation steps and the implementation of a quality cost system, including adjusting the quality cost calculation model for the automotive manufacturing industry, especially passenger car factories. A literature review approach is used and pilot studies are chosen for empirical aspects of research to enrich the mix of qualitative and quantitative data. Although the literature review shows that many experts write similar research, adjusting the quality cost model is still recommended. The results of the pilot study explain that the implementation of quality costs at an early stage is considered sufficient until reporting. Further research is advised to practice tracking quality costs. Research starts from preparation to reporting on quality costs. The scope of research is limited to quality costs in the operational area (production). The methodology for implementing a quality cost system can guide organizations to get an internal view of quality costs. This research confirms that organizations do need to modify the available quality cost models according to the organization's goals, needs, and environment. Thus, the simple models offered in this research are both valuable and contribute to quality economic literature.

1. Introduction

A highly competitive global business environment, forces producers to design and produce quality products and services and focus on meeting customer needs and expectations with costs that represent value for customers [1; 2]. Products that are well designed and produced correctly without errors may not be considered as quality products by customers if they do not meet their requirements [3]. This does not mean that there is no need to produce products or services that far exceed customer expectations, but that optimal production costs are always needed to meet these expectations [2]. Anyone who runs a company knows that these costs exist, but what they may not realize is how much of their expenses are directly related to quality costs [4]. Managers who are aware of expenses related to quality, make decisions that are different from managers who are not aware of expenses related to quality [5]. This has made quality cost reporting a useful tool in identifying potential areas for quality improvement, monitoring quality, and achieving optimal production costs so that businesses remain competitive [6].

However, previous research data shows that many industries around the world have not yet adopted quality cost reporting [7; 8; 9; 10]. For example, quality costs have not been widely adopted in Australia [11]. While 67% of companies in America and 66% of companies in Northeast England also have not yet implemented a quality cost system [12]. There are 85-90% of automotive manufacturing organizations in India not yet implementing quality cost systems [13]. 51 out of 84 or 60.71% of
organizations in Malaysia have not yet implemented a quality cost system [14]. Data in the field shows that seven out of eight countries producing passenger car factories with the same production (brand X) have not yet installed and implemented a quality cost system. While the requirements of the ISO 9001 quality management system, ISO Technical Specification (ISO / TS) and International Automotive Task Force (IATF) 16949, clause 5.6 regarding management review that during management review an organization must monitor quality objectives, and report and evaluate the cost of poor quality regularly. It was found to be lacking in literature research that there is no quantitative evidence that shows an increase where ISO 9000 or IATF reduces quality costs. This makes there is a need to develop a quality cost system to complement the quality management system more significantly through quality cost training. In addition, to determine whether the quality management system is effective in improving the quality of work in the most profitable way, there is a need to test it through quality cost training.

Various reasons are cited for not adopting quality cost reporting and the most common reason is the lack of awareness and understanding of quality cost principles [10; 14; 11]. A number of reasons made the previous authors do a lot of related research regarding the steps of the installation procedure and the implementation of a quality cost system, including international standards. The process of installing and implementing a quality cost system is not always easy. Difficulties encountered during the process of installing and implementing quality costs one of which is the lack of literature sources regarding the methodology of installation and implementation of quality cost systems that approach the business practices of each organization. It is clear that each industry is required to modify the model or adjust the implementation model according to the needs and ease of application, which results in various quality cost structures [15; 16]. Likewise, to calculate the total quality cost, BS 6143-2 [17] has identified a list of quality cost elements under the categorization of Prevention-Appraisal-Failure. The list of elements only acts as a guideline for quality costing. Most quality experts say that a quality cost system must be tailored to each organization. Organizations that decide to manage their quality costs, must choose the appropriate model, which contains their quality cost elements and categories [18].

Therefore, this research proposes adjusting the model in the area of quality costs. One of them is the adjustment of steps or procedures in implementing a quality cost system and the second is the adjustment of categories and elements in estimating or measuring quality costs at passenger car factories.

2. Literature review
2.1. Literature related to research issues
The process of installing and implementing a quality cost system is not always easy. This process met with resistance from those involved because of the additional workload and from top management who might not be convinced of its usefulness. Many quality experts have realized this. Table 1 summarizes the research problems of some of the previous researchers. These problems require solutions so that the quality cost system can be widely applied to various industries throughout the world.

| Researchers          | Research Issues                                                                                     |
|----------------------|------------------------------------------------------------------------------------------------------|
| Beamon [19] and Schmahl et al [20] | • Slow improvement.                                                                                  |
|                      | • Bureaucracy or complexity in a manner that maintains to deteriorate.                                 |
|                      | • Changes in a single location generally tend to have large negative results in one or extra areas.   |
|                      | • Management is in person concerned in quality problems solely throughout a significant crisis.       |
|                      | • Management is coming up short on thoughts regarding how to reduce expenses further.                |

(continued)
| Researchers                              | Research Issues                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                     |
|------------------------------------------|------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| Beamon [19] and Schmahl et al [20]      | • Not all personnel are actively and in person concerned in pushing the organization's mission forward.  
• Many people and departments disagree concerning what ought to be the highest priority for the organization.                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                       |
| Pursglove and Dale [21]                  | • Lack of data that may be used for quality cost accounting functions.  
• Unrevised accounting system.  
• Lack of information concerning products that do not meet specifications for production.                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                       |
| Bottorff [22]                            | • Management does not assign adequate time and resources.  
• Because quality cost systems are typically not fully akin to existing product cost accounting systems, these systems usually require separate system administration.  
• Refinement of quality cost data does not directly make use of the data controversial.  
• By only using their own costs, or directly, quality can result in too little management investment in prevention activities.  
• Lack of coaching in quality concepts and group facilitation ways makes it troublesome to guide or participate in cross-functional groups.  
• The conception of quality is usually hampered by financial ideas.  
• When under pressure from the budgeting process, the exchange of dangerous quality costs is difficult to reject without strong commitment from top management.                                                                                                                                                                                                                                                                                                                                                     |
| Dale and Plunkett [23]                   | • Lack of resources and data; and  
• The present report is not in a structure that permits extracting quality cost data.                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                          |
| Roden and Dale [24]                      | • Company culture and employee attitudes towards quality cost systems do not seem to be contributory.  
• Lack of information and accountability makes it tough to gather quality cost data.  
• The complexity in the current method of accounting that cannot sort data by various divisions also makes it troublesome to measure quality cost data.                                                                                                                                                                                                                                                                                                                                                                                                                                                                                      |
| Dale and Wan [25]                        | • The victorious implementation of a cost of quality system is basically addicted to worker attitudes and enterprise culture.  
• There is no need to establish a new or sophisticated cost of quality system based on formal guidelines; simple systems can be very beneficial when integrated into existing enterprise practices.  
• It is also essential for personnel to aware that cost of quality is not an end in itself, but a means to an end.  
• The time to be had for personnel to participate in team conference related to cost of quality.                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                   |
| Rodchua [26]; Bamford and Land [27]; and Elridge et al., [28] | • Lack of data or trouble in gathering data.  
• Lack of commitment from the board of management.  
• Lack of understanding of quality cost principles.                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                     |
Researchers | Research Issues
---|---
Rasamanie and Kanapathy [29] | 1. Lack of coordination with another departments.  
2. Difficulties in gaining access to certain financial data.  
3. Personalize the program (strong interest from only a few sponsors).  
4. Difficulties with standardizing the company's quality cost system.  
5. Lack of comparison opportunities, literature sources and consulting services.  
6. Lack of top management support at the beginning stage.  
7. Difficulties in identifying new quality improvement opportunities.  
8. Identification of activities related to quality.  
9. Difficulties with analyzing data collected.  
10. Identification of quality cost items.

Chopra and Garg [13] | • Knowledge of how to measure this quality cost.  
• Understanding exactly what this information indicates after it is produced.

Trehan, Sachdeva, and Garg [15] | • Lack of management support.  
• The complexity of the manufacturing process.  
• Cannot be used for operational strategies.  
• Quality is part of organizational culture so measurement is not needed.

2.2. Literature related to methodology model of installation and implementation a quality cost system

Based on the problems above, it is not surprising to find so many experts in the field of writing quality costs about the installation process and implementation of quality cost systems. Table 2 summarizes the methodology models from some of the previous researchers. Thus, this research provides a solution through adjusting the methodology model of installation and implementing a quality cost system so that the quality cost system can be widely applied to various industries around the world.

Table 2. Literature summary related to research methodology model of installation and implementation a quality cost system

| Researchers        | Methodology Model of Installation and Implementation |
|--------------------|------------------------------------------------------|
| Morse, et al. [30] | 1. Obtain top management commitment and support    
2. Form an installation team  
3. Choosing an organizational segment as a prototype  
4. Obtain cooperation and support of users and suppliers of information  
5. Determine quality costs and quality cost categories  
6. Identify quality costs in each category  
7. Determine the source of quality cost information  
8. Design cost reports and graphs  
9. Establish procedures for collecting quality cost information  
10. Collect data, prepare and distribute reports  
11. Eliminating errors or bugs from the system  
12. Expand the system  |
| Low and Yeo [31]   | 1. Get support from top management                   
2. Form a quality cost committee  
3. Determine quality costs  
4. Determine the focus area  
5. Get support from top management  
6. Form a quality cost committee  | (continued)
| Researchers                           | Methodology Model of Installation and Implementation                                                                 |
|--------------------------------------|---------------------------------------------------------------------------------------------------------------------|
| Low and Yeo [31]                     | 7. Determine quality costs                                                                                           |
|                                      | 8. Determine the focus area                                                                                         |
|                                      | 9. Establish procedures for collecting quality costs                                                                |
|                                      | 10. Get support from staff in the field                                                                             |
|                                      | 11. Training the personnel involved                                                                               |
|                                      | 12. Carry out, observe, and report regularly                                                                        |
|                                      | 13. Improve system costs                                                                                           |
|                                      | 14. Expand system costs to include more operating areas                                                             |
| Mohanty and Tiwari [32]              | 1. Educate and get support from top management                                                                      |
|                                      | 2. Study of various quality cost approaches                                                                         |
|                                      | 3. Categorization of quality costs for the approach chosen                                                           |
|                                      | 4. Identify quality cost elements according to IS / BIS                                                             |
|                                      | 5. Determine and calculate cost elements                                                                           |
|                                      | 6. Establish methodology for data collection                                                                       |
|                                      | 7. Collecting quality cost data for each element                                                                    |
|                                      | 8. Prepare a summary of quality costs                                                                              |
|                                      | 9. Report and analyze for improvement                                                                             |
|                                      | 10. Presentation before top management                                                                             |
|                                      | 11. Establish a quality cost system and review and monitor                                                          |
| Tye, Halim and Ramayah [33]          | 1. Verify with factual costs                                                                                       |
|                                      | 2. Get management commitment and support                                                                           |
|                                      | 3. Set up an installation team                                                                                      |
|                                      | 4. Select organizational segments as prototypes                                                                    |
|                                      | 5. Conduct management presentations                                                                                 |
|                                      | 6. Conduct a planned pilot program                                                                                  |
|                                      | 7. Conduct education or training in all functions                                                                    |
|                                      | 8. Develop internal quality cost accounting procedures                                                               |
|                                      | 9. Overall quality cost data collection and analysis                                                                |
|                                      | 10. Reporting and use of quality costs                                                                             |
| Chopra and Garg [13]                 | 1. Form a quality cost team                                                                                        |
|                                      | 2. Determine the quality cost base                                                                                 |
|                                      | 3. Data collection related to quality cost elements                                                                  |
|                                      | 4. Placing quality cost elements in four types of categories; prevention costs, valuation costs, internal failure costs, external failure costs |
|                                      | 5. Analysis of the difference in quality costs                                                                     |
|                                      | 6. Deciding how to reduce the level of quality costs                                                                |
|                                      | 7. Presents the level of quality costs in terms of money                                                             |
|                                      | 8. Changes approved by top management must be applied throughout the system                                          |
| Chopra and Garg [1]                  | a) Model for calculating quality costs                                                                            |
|                                      | 1. Form a quality cost team                                                                                        |
|                                      | 2. Determine the scope of work                                                                                      |
|                                      | 3. Establish awareness among employees                                                                             |
|                                      | 4. Identification of quality related activities                                                                    |

(continued)
5. Formulate a methodology for determining the cost of money related to quality activities
6. Determine the cost of money for all these quality activities
7. Placing these activities under categories: prevention costs, valuation costs, internal failure costs, external failure costs

b) Model for implementing quality costs
1. The current level of quality costs is taken as a reference and shown with a chart
2. Analyzing the current level of quality costs
3. The next plan of action is to reduce the current level of quality costs
   The quality cost team sends the report along with the proposed action plan to top management

Aniza [34]
1. Choose a process and determine its limits
2. Determine the resources and data needed
3. Collect the cost of each process using BS 6143
4. Analyze the results and implement improvements

3. Research Methodology and Implementation

3.1. Research Methodology
This research was conducted using qualitative and quantitative methods. Qualitative methods are used in literature studies and pilot studies to look at the problems and conditions of the implementation of the current quality cost system. In addition, literature studies are also used as material in making recommendations related to the theory of the implementation of quality cost systems and the theory of quality cost calculations. Quantitative methods are used in calculating quality costs. In this case, primary data were obtained from a passenger car manufacturing country, namely Indonesia. Data is collected and processed using a variety of methods, including discussion, communication, brainstorming, literature review references, Gantt Charts, spreadsheets, bar or pie charts. Stenecker [35] states that there are two approaches in implementing a cost system; that is, formal approaches and informal approaches. Stenecker [35] discusses more informal approaches because formal approaches have been well covered by other writers. The informal approach requires a minimum of management support. The aim is to conduct a pilot study to collect quality costs and then to present findings to top management. Ashford [36] believes that an informal approach is effective in proving the importance of quality costs.

3.2. Research Implementation

3.2.1. Case Study
The location of the research was conducted at a sole agent factory of a maker and assembler of premium scale passenger car products in Wanaherang Village, Gunung Putri District, Bogor 16965, West Java - Indonesia. The factory is headquartered in Stuttgart, Baden Württemberg, Germany and was established in Indonesia in 1970 which consists of two companies, namely a manufacturer and product assembler and main distributor responsible for marketing products. The company locally (until when this research was made) assembled six types of flagship vehicles in a 42-hectare factory along with the company that assembled commercial vehicles. The country of branch operations that has carried out the installation and implementation of quality costs is India. While the branch operational countries of Indonesia, Malaysia, Thailand, Vietnam, Brazil, Russia, and Egypt are branch operational countries that have not yet installed and implemented quality costs.
3.2.2. Adjustment Methodology Model of Installation and Implementation a Quality Cost System

The eight step model of adjusting the installation methodology and implementing the quality cost system offered in this research, has been adapted and implemented through a case study at the passenger car factory above. The activities for installing and implementing a quality cost system are shown in Table 3.

**Table 3.** Adjustment methodology model of installation and implementation a quality cost system in a passenger cars plant

| Author        | Methodology Model of Installation and Implementation                                                                 |
|---------------|----------------------------------------------------------------------------------------------------------------------|
| Rahardjo (2020) | 1. Determine the area of installation and implementation of the quality cost system and determine its limits               |
|               | 2. Form a quality cost team                                                                                                |
|               | 3. Arranging the activities of the installation and implementation of quality system costs                               |
|               | 4. An initial introduction to the concept of quality costs                                                                  |
|               | 5. Understand together about the concept of quality costs with the quality cost team                                       |
|               | 6. Define and agree on quality cost elements                                                                               |
|               | 7. Collection of data sources and quality data costs                                                                         |
|               | 8. Finalization and reporting of quality cost systems                                                                         |

Step 1 - Based on references from ASQC Q9004-1 [37] regarding the main activities that have an impact on quality in the quality circle element, it is determined that the area to be installed and implemented in the quality cost system is the area of production or provision of services. Because this research in the manufacturing industry (factories that produce passenger cars), then the area is production. Step 2 - The quality cost team in the operational area is shown as in Figure 1. Step 3 - The composition of activities is made in the form of a Gantt chart as in Figure 2.

**Figure 1.** Quality cost team structure

Step 5 - A deeper understanding of the concept of quality costs is carried out by the quality cost team. Step 6 - Definition and collective agreement on quality cost elements results in an adjustment to the quality costing model as shown in Figure 3. Step 7 - The collection of quality cost data for 2019 is carried out through a spreadsheet instrument as in Table 4. Step 8 - Finalization and reporting of the 2019 quality cost system is displayed through pie and bar charts. A bar chart containing the trend of quality costs per month for 2019 is shown in Figure 4. Pie charts incorporated in the form of a dashboard containing the percentage of Preventive costs, Corrective costs, and Rejection costs are shown in Figure 5.
The cost of depreciation tools and equipment is the highest prevention cost, which is 54.78%. These costs include the cost of setting up new equipment and depreciation factor costs when the new equipment is used routinely. While one of the testing costs, Glue + Windshield, is the smallest prevention cost, which is 0.17%. While the cost of repairs, the cost of part rework is 57.84% and the cost of reworking the product in the repair area is 6.84%. Material ordering costs for damaged materials that are not accepted as quality claims to suppliers are the highest rejection costs, which is 84.73%. This cost does not include the cost of the damaged material itself. Because, the material cost is in the Rejected Parts element by 40.22%. Overall, the total quality cost of 2019 at the passenger car factory as a pilot study is shown that the Preventive fee is 58.90%, the Corrective fee is 1.25%, and the Rejection fee is 39.85%. The trend of quality costs per month in 2019 at passenger cars plant is shown that the average quality cost per product unit per month is 0.04% or 3,269,853 rupiah of the total quality cost in all operational areas.
Table 4. Quality cost data for 2019

| No. | Quality Cost Element                                      | Total Quality Cost 2019 |
|-----|---------------------------------------------------------|-------------------------|
|     | Preventive/Proactive Costs (IDR)                        | **4,539,498,921**       |
|     | Preventive/Proactive Costs (IDR/Car)                    | **1,925,965**           |
|     | Destructive Test                                       |                         |
| 1   | Glue + Windshield                                      | 7,823,757               |
| 2   | Teardown Engine                                         | 110,666,727             |
|     | Project Cost                                            |                         |
| 3   | New Tool and Equipment                                  |                         |
| 4   | Calibration Tool and Equipment                          | 10,370,000              |
| 5   | Depreciation Tool and Equipment                         | 454,259,000             |
| 6   | TA/TE                                                  | 2,486,914,920           |
|     | Other Prevention Cost                                   |                         |
| 7   | IATF Training                                           | 25,000,000              |
| 8   | IATF Audit                                             | 69,500,000              |
| 9   | IT for Quality                                          | 919,172,325             |
| 10  | Quality Suggestion System/Best Practice                 | 309,061,960             |
|     | Corrective/Reactive Costs (IDR)                         | **96,550,531**          |
|     | Corrective/Reactive Costs (IDR/Car)                     | **40,963**              |
|     | Rework of Parts                                         |                         |
| 11  | Red Table Rework man-hours Parts                        | 55,848,579              |
|     | Rework of Cars                                          |                         |
| 12  | Station Rework man-hours Parts and or Cars              | 34,101,562              |
| 13  | Rectification Rework man-hours Parts and or Cars        | 6,600,390               |
|     | Rejections (IDR)                                        | **3,070,993,464**       |
|     | Rejections (IDR/Car)                                    | **1,302,925**           |
|     | Un-rework-able Material Costs                           |                         |
| 14  | Scrap                                                   | 32,525,311              |
|     | Claim Costs                                             |                         |
| 15  | Rejected Parts (DIP/LIP)                                | 1,235,013,818           |
| 16  | Order Cost due to Rejected Quality Claims               | 1,803,454,335           |
|     | No. of Cars                                             | **2357**                |
|     | Total Cost of Quality (IDR)                             | 7,707,042,916           |
|     | Total Cost of Quality (IDR/Car)                         | 3,269,853               |

Figure 4. Display trends in quality cost per month in 2019
4. Discussion and Finding

4.1. Discussion

This research established an adjustment of the installation methodology and implementation of a quality cost system at the passenger car factory. Although there is a lot of similar research as shown in the literature review, this methodology adjustment has its own novelty, differences and advantages for the automotive manufacturing industry. For example, the order of the process is different from the order of the results of previous studies. Although there are similarities between the sequence of processes from one author to another, differences still exist. Some authors begin the process of implementing quality costs by obtaining management commitment and support. There are also several writers starting with the establishment of a quality cost installation team. While the authors begin by determining the area of installation and implementation of the quality cost system and determine its limits. Then, a discussion of the methods used to carry out each process sequence. The majority of the literature discusses the definition of each process sequence or the purpose of each process sequence without further discussing how the sequence of processes is carried out. Although the method used is very simple, for example: discussion, or observation, or official meeting - discussion is needed in the literature, as a reference for organizations with an average expertise in this area of quality costs to still be able to implement quality costs.

Meanwhile, adjusting the quality cost category to Preventive-Corrective-Rejection. Preventive / Proactive is intended as a cost of compliance with quality requirements or costs of conformance to quality requirements. These costs are planned costs in most situations and conditions. This cost is also unavoidable. This cost should be optimized. The elements included are destructive tests, project costs, and other prevention costs. Corrective / Reactive is intended as a cost deviation of quality requirements or the cost of non-compliance with quality requirements. These costs are costs that are not planned in most situations and conditions. This cost is mostly avoided. This fee should be minimized. The element that includes it is rework. Rejection is nothing but a cost that should be eliminated. The elements included in this are scrap and part repurchase as well as part purchase costs are all irreparable losses.
The novelty and difference of the results of this research lies in its adjustment. While the advantages of this research result lies in the discussion of how to make adjustments. In essence, each quality cost model has its own limitations due to the complex nature of the difficulties encountered. Thus, there is no one methodology model with the methods in it that are more important or more effective than the other methodologies - they all have their respective contributions to be played in each organization.

4.2. Finding

At the beginning of the construction of a new key performance indicator system, namely regarding quality costs, several things were done and some things were avoided, such as:

- The organization has clear objectives regarding the internal view of quality costs.
- The quality cost system starts from one area.
- The organization is not constrained by the traditional categorization of failure-assessment-failure-quality costs; the organization adjusts the categorization to be closer to standard business practices.
- Quality cost data collection starts with the easiest cost elements, for example internal failure costs.
- Quality data collection officers make friends with accountants from the finance department.
- Report only costs generated or supported by the finance department.
- As the first trial of a cost collection exercise, the quality cost team realized not to expect too much from the results of quality costing.

5. Conclusion

Installation and implementation of a quality cost system is not new for academic researchers. Many quality experts also realize that the purpose and use of quality costs are not always well understood by practitioners in the industry. Disclosing quality cost data is not to preach the sins of others who do not guarantee the victory of cooperation. Apart from that, although most industries realize the benefits of quality costs, only a few use those in organizations because of the difficulties encountered during the implementation process. Therefore, to help these industries, simple models are proposed to implement a quality cost system, which includes determining the quality cost elements and collecting quality cost data.

The methodological model with several methods in it is used by organizations to support the process of implementing quality costs. Each organization is recommended to make adjustments to their own quality cost systems through a pilot study approach - integrating into the organizational structure and accounting systems that exist in each organization. Thus, there is no one methodology model with the methods in it that are more important or more effective than the other methodologies - they all have their respective contributions to be played in each organization.

Products and services deemed quality by customers are products that meet customer expectations. However, that does not mean that manufacturers do not need to produce products and services that far exceed customer expectations. However, optimal production costs are always needed as costs that represent value for customers. Costs related to quality are costs that if managed properly provide a competitive and comparative advantage for the organization. A successful quality cost system, as a daily feature of the organization's management activities, takes a long time to build. It can take up to five years to achieve the credibility and expected benefits from the data displayed in the management information system. A measure of the status of quality cost organizations is if the feature is contained in a quality management system manual - which also complies with the requirements of the IATF management review clause for the automotive industry sector, both manufacturing and components.

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