Design of Supplier Quality Monitoring System Considering Nonconformity Level in Electronics Manufacturing

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Abstract

One of the most important parts of the supply chain is the supplier. Suppliers play a role in supplying raw materials that will be used in the production, it is necessary to make a selection in selecting suppliers to get the criteria that consumers want. Several criteria are considered when selecting suppliers; quality, prices and on-time delivery. To maintain the above criteria, especially quality, it is necessary to evaluate and monitor suppliers. Various manufacturers already have supplier quality monitoring systems but have not considered in detail the critical level of non-conformity that occurs in raw materials and if there is a quality problem, the Quality Control section is often slow in making decisions so there can be a decrease in product quality. Therefore, this research is conducted to obtain a Standard Operating Procedure (SOP) for the design of a supplier quality monitoring system and provide alternative options in handling quality problems in supplier's raw materials that occur with quick and precise decision making. To design a supplier quality control system that considers the level of non-conformity, the method used is Quality Function Deployment (QFD). In this study, Voice of Customers (VOC) were obtained through experts' interviews in the field of quality to find out the manufacturer's wishes regarding the actions taken for handling non-conformity according to the level and level of importance for the customer. Meanwhile, for technical requirements, it is a list of several actions/follow-ups that will be carried out to suppliers.

Keywords
Supplier quality monitoring system, quality management, QFD, electronics manufacturing and Indonesia.

1. Introduction
One of the important components in the supply chain is supplier. Suppliers play a role in supplying raw materials or parts that will be used in the production process in the manufacturing process, therefore making a decision in selecting suppliers is required in order to obtain the criteria that customers desire. When selecting suppliers, several criteria are taken into account, including quality, competitive price, and on-time delivery. The results of supplier's performance evaluation will determine whether the contract is terminated or renewed.

According to ISO 9000:2015, non-conformity is defined as a failure to fulfill specifications or standards. Non-conformity can also be defined as an unexpected and unwelcome event that can lead to divergence (Alatulkkila, 2018). Monitoring of non-conformity is an efficient method for assisting manufacturers in meeting quality objectives and improving product quality (Claver et al., 2003; Majanoja et al., 2017). Based on the conditions observed in the field, non-conformity occurs in the quality of raw materials from suppliers cannot be predicted so it must be handled immediately and take appropriate corrective action to be carried out as soon as possible by the Quality Control Department in manufacturing.

Most of the previous studies solely looked at quality monitoring in terms of defect ratio, they haven't yet considered the critical level of non-conformity that occurs in raw materials. If there is a quality problem, the Quality Control Department is often slow in making decisions which can lead to a decrease in product quality. Based on these two factors, the problem that will be raised in this research is that there is still a limited discussion regarding the supplier quality monitoring system that takes into account the level of non-conformity, particularly on the critical side, which will greatly help control and improve supplier quality for raw materials to be supplied.

1.1 Objectives

The purpose of this research is formulated as follows:

(1) Obtain Standard Operating Procedure (SOP) working procedure for supplier quality monitoring system
(2) Provide alternative options in handling of quality problems in raw materials from suppliers that occur with quick and precise decision making

2. Literature Review

2.1 Definition of Quality

In this age of globalization, rivalry for market share is increasing, causing company owners to compete with one another to attract as many clients as possible. One of the most essential factors in generating customer interest in a product is the quality of the items being promoted, but what is the definition of quality (Dian Kharisma, 2015). The Oxford American Dictionary defines quality as "the degree of excellence." The American National Standards Institute (ANSI) and the American Society for Quality Control (ASQC) define quality as "the sum of a product's or service's features and attributes that are dependent on its ability to fulfill specified standards".

According to Collier and James (2009), quality is a term that can be confusing because different people associate it with different criteria depending on their position the supply chain, such as perfection, being able to please or satisfy customers, reducing waste, doing things right from the start, and consistency. Deming (1986) defines quality as "a known degree of consistency and dependability at a reasonable cost and in conformity with the market," emphasizing operational quality. Meanwhile Juran (1999) outlines two key criteria of quality:

(1) "Quality" refers to product features that can meet customer needs and also provide customer satisfaction. In this view, the concept of quality is profit or revenue oriented. The purpose of the quality improvement is to increase customer satisfaction and increase profits. When a manufacturer wants to provide additional features and/or even higher quality, it generally requires investment and as a result, usually results in increased costs. In this sense, quality is worth the price.
(2) "Quality" is free from errors that require rework or result in failure, customer dissatisfaction, customer claims, and so on. In this view, the definition of quality is cost-oriented, with better quality usually "lower cost".

Based on some of the definitions above, it can be concluded that quality of product or service is able to meet the customer needs and can provide satisfaction to customers, and follow market demand. Quality products or services are also more reliable and have lower prices because there are no failures such as rework, few or no customer claims, and etc.

2.2 Supplier Quality Management (SQM)

Supplier Quality Management (SQM) is a set of processes and practices used by organizations to ensure that the quality of raw materials and equipment produced meets criteria and specifications (Caldas et al., 2012). SQM is widely acknowledged as a critical component for improving internal quality performance (Lee and Li, 2018; Zsidisin et al., 2016). It is defined as a set of management activities that are required to improve the organization's quality performance through the integration of supplier and buyer activities, as well as simultaneous involvement and communication between the two sides (Chakravarty, 2014). Meanwhile, Yeung and Lo (2002) define SQM as an administrative effort needed to create an operating environment in which manufacturers can integrate supplier capabilities into their operational processes. These managerial efforts can be divided into five categories:

(1) Management responsibilities
All activities related to suppliers that can support activities in the company are entirely the responsibility of company management.
(2) Supplier Selection
Supplier selection is described as a set of actions that assist the organization in selecting the best supplier (Yoon et al., 2018). The primary considerations in the supplier selection process are quality performance, price, delivery performance, and the supplier's ability to participate in organizational design and production processes (Araz and Ozkarahan, 2007). Key performance index is one example of measurement that can be used for supplier selection (Ferhan and Demet, 2003).
(3) Supplier Development
Supplier development is defined as a collaboration between buyer and supplier companies to continuously improve supplier performance (Glavee-Geo, 2019). Supplier development can encompass a wide range of operations, from providing suppliers with education and training programs to appraising suppliers and providing

financial investment to suppliers (Arroyo-López et al., 2012; Jin et al., 2019; Lee and Li, 2018). Improving quality performance is identified as a key objective of supplier development initiatives (Modi and Mabert, 2007).

(4) Supplier integration
Supply integration refers to organizations collaborating to capitalize on their strategic position and improve operational efficiency. In fact, cultures that encourage highly cooperative relationships between buyers and suppliers are more likely to result in supplier participation in the product development process (Laura and Stanley, 1994). Many organizations are now adopting supplier integration to obtain a competitive advantage. Suppliers are involved in the design and development process from the beginning (Melissa et al. 2004).

(5) Quality measurement
Measuring the supplier's ability to provide adequate quality raw materials can provide significant information for decision making in organizational planning, control, and decision making. s a result, in order to make the optimal choice, the quality of raw materials must be evaluated on a regular basis (Yeung dan Lo, 2002).

(6) Supplier audits
Conducting supplier audits is another supplier quality action. This activity is very time consuming, yet it is necessary because it adds value to the organization. Many businesses also perform non-conformance audits, where the auditor records all instances where things were not done according to process. It should be noted, however, that this supplier audit should not be viewed as a means of assigning "homework" to suppliers, but rather as a means of improving buyer-supplier relationships (Andrew, 1994).

2.3 Fishbone Diagram

Besterfield et al. (2012) explained that Statistical Process Control (SPC) is one of the most effective technical techniques to improve product and service quality. One of the seven basic methods is the cause-and-effect diagram. A cause-effect diagram is a visual representation of a meaningful link between an effect and a cause using lines and symbols. Dr. Kaoru Ishikawa invented this design in 1943, and it is also known as the Ishikawa diagram or fishbone diagram due to its shape. Fishbone diagrams are used to investigate “bad” effects and take action to correct “positive” causes or effects and understand their causes. Each effect could be caused by a number of factors. An example Fishbone diagram is shown in Figure 1, impacts on the right and causes on the left.

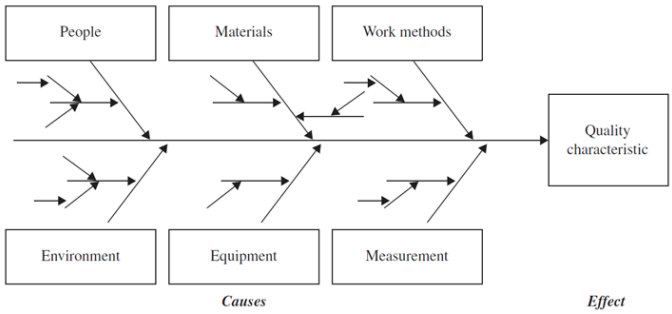


Figure 1. Fishbone Diagram

The first step in creating a fishbone diagram is determining the effect or quality issue. The main causes are then identified and represented on the diagram. Determining all causes requires brainstorming by the relevant team members. After the fishbone diagram has determined the main cause of each criterion, the diagram must be reviewed again to find the minor reasons that are most likely to be the cause of the main cause. Each individual member of the team should express their opinion on this minor cause. Team members can choose more than one reason. The cause with the most votes is then circled, and four or five causes with the greatest likelihood of impact are identified (Besterfield et al., 2012).

2.4 Failure Mode and Effect Analysis (FMEA)

Failure Mode and Effect Analysis (FMEA) is an analytical approach that combines technology and human expertise in detecting and preparing for anticipated failure modes of a product or process. In other words, FMEA is a set of activities designed to identify and analyze the possible failure of a product or process and its consequences, identify steps that can eliminate or reduce the probability of such failure, and document the process. Manufacturing companies have often used it for quality assurance and safety, meeting customer and government standards, quality

control, and safety (Besterfield et al., 2012). FMEA was created in the 1960s by the National Aeronautics and Space Administration (NASA) in the United States to improve the reliability of military equipment. MEA has been utilized in the automotive industry since the early 1970s, and its use has increased during the 1990s to solve the substantial quality and reliability problems posed by Far East automakers (Johnson and Khan, 2003).

The main benefit of the FMEA technique over other risk analysis methods is that it evaluates hazards quantitatively. Potential hazards in the process are identified and analyzed at each stage of the approach. To assess the level of risk of a component or process, FMEA uses a Risk Priority Number (RPN). The RPN index is calculated by adding an index of severity (S), occurrence (O), and detectability (D). The severity level of the failure mode is seen from the magnitude of the influence on the assembly or system as well as the user itself. The probability of an event, which reflects the relative number of failures that must be anticipated, is used to assess the occurrence. Detectability is an assessment of its ability to find possible failures or defects before components are used for production. By multiplying the three values of severity, occurrence, and detectability, we can produce a Risk Priority Number (RPN) index (Kurt and Ozilgen, 2013; Narayanagounder and Gurusami, 2009).

2.5 Quality Function Deployment (QFD)

The idea of QFD is based on the concept of Company-Wide Quality Control (CWQC). Customer orientation, cross-functional management, and focus on process rather than product orientation. This relates to the quality of management and the quality of work performed (Japan Industrial Standard Z8101, 1981). Dr. Mizuno, a professor of technology at the Tokyo Institute of Technology has developed a Quality Function Deployment (QFD) system. In 1972, QFD was employed for the first time at Mitsubishi Heavy Industries after case study research, refining, and training. Toyota has successfully utilized QFD in the manufacture of minivans. Dr. Clausing of the Xerox company was the first to introduce QFD in the United States in 1984. QFD can be used in almost every type of industry or service. Most of the leading companies as well as their suppliers have made QFD the standard of practice (Besterfield et al., 2012).

QFD is defined as a process for establishing targeted design quality to meet customer requirements and then translating customer demands into key design and quality assurance objectives for use throughout all phases of production (Akao, 1990). QFD is also known as "house of quality" (HOQ), this is because the matrix in QFD forms a house-shaped diagram (Bicheno, 1994; Kutucuoglu et al., 2001). QFD is directed to involve individual teams from several functional areas involved in product development, such as marketing, design engineering, quality assurance, manufacturing/manufacturing engineering, testing techniques, finance, product support, and so on (Crow, 1996). According to Shahin (2005), there are four steps of QFD which are achieved by using a matrix that guides the activities of the product team by providing standardized documentation during product and process development (Figure 2). Each phase includes a matrix with vertical "Whats" columns and horizontal "Hows" rows. "Whats" is Customer Requirement (CR); "Hows" refers to the process or method for achieving it. Below are some steps to build QFD matrix:

(1) Customer requirements
Customer needs are also known as "Voice of the Customer (VOC). What is meant by customer needs is "what" they want from the product they produce. Customer needs include the wants, expectations, and product needs of customers.

(2) Customer importance ratings
When the customer's requirements (in this case seen as “Whats”) have been written down, the customer assigns a numerical value to this “Whats” based on its significance to the consumer. A numerical rating of 1 to 5 is generally used for this assessment, with 5 being the most significant and 1 representing the least important or insignificant.

(3) Technical requirements
Technical requirements are technical standards that must be integrated into a product into a product in order to meet customer requirements. Technical requirements act as "Hows" because they are a response to customer needs i.e., how those needs can be achieved.

(4) Relationship matrix
The relationship matrix is created based on technical characteristics or product requirements and customer needs. This relationship matrix is represented by symbols, strong relationship (9 = ◉), moderate relationship (3 = ○) and weak relationship (1 = △).

(5) Correlation matrix

The correlation matrix is the triangular part of the HOQ, often known as the roof. The correlation matrix is used to determine which "Hows" elements support each other and which contradict each other. Positive correlations help in identifying closely related "Hows" elements and avoiding duplication of work. The negative correlation reflects a situation that almost certainly requires a trade-off. Positive and negative evaluations are often measured using the symbol (++) to indicate a very positive correlation, (+) indicates a positive correlation, (-) indicates a negative correlation and to indicate a very negative correlation using the symbol (--).

(6) Technical difficulty assessment
This assessment is carried out by the technical team. This helps in determining the feasibility and realization of each "Hows" component. To define technical complexity, a scale of 1 to 10 is used, with 10 being the most difficult and 1 being the easiest.

(7) Overall importance ratings
Overall importance ratings are the final step in completing the HOQ. The total of all relationship matrix values with the same VOC value in the same row is then summed for all rows in the same column for each column. These results can be used to identify technical features and assist in decision-making

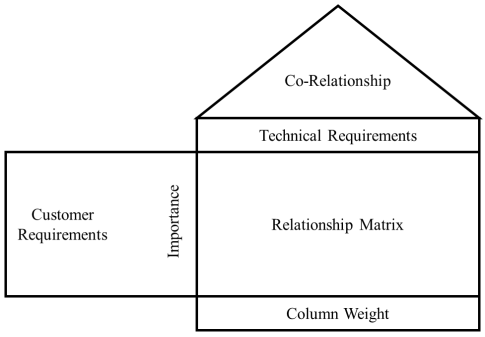


Figure 2. House of Quality (HOQ)

3. Methods

The stages of research methodology will be conducted as follows:

(1) Literature Study
Authors summarized several previous studies that developed supplier evaluation guidelines or tools to control and improve supplier performance in several criteria, namely total cost, quality (defect ratio), and on-time delivery. the other hand, several previous studies have made a development system based on the 3 criteria previously mentioned. A list of previous studies regarding supplier quality monitoring systems is described in Table 1 and table 2 below

Table 1. Summary of Previous Research on Supplier Quality Monitoring System

Author(s)	Year	Industry	Activity	
			Supplier Performance Evaluation System	Supplier Development System
Chavhan et al.	2012	General Company	Evaluation criteria: • On time delivery • Quality (defect per million) • Total cost	- Basic - Moderate - Advance
Patel et al.	2013	Drum Mix Plant Manufacturing	Evaluation criteria: • Quality • Quantity • Delivery	____
Öztop et al.	2013	Automotive	Evaluation criteria: • Quality • Total cost • On time delivery • Management performance • Continuous development • Supplier's relationship	- Class A - Class B - Class C - Class D

			performance	

Table 2. Summary of Previous Research on Supplier Quality Monitoring System (continue)

Author(s)	Year	Industry	Activity	
			Supplier Performance Evaluation System	Supplier Development System
Dey et al.	2014	Carpet Manufacturing	Evaluation criteria: • Quality • Total cost • On time delivery • Organizational capability • Environmental practices • Social practices • Risk management	____
Lima-Junior and Carpinetti	2016	Heavy Vehicle Manufacturing	Evaluation criteria: • Cost • On time delivery	- Group I - Group II - Group II - Group IV
Fırat et al.	2017	Central Services Company	Evaluation criteria: • Quality • Order • Collaboration	- Sufficient - Improvable - Surveillance
Kartal	2019	Defence firm	Evaluation criteria: • Quality • On time delivery • Flexibility • Technology • Manufacturing capability • Firm characteristic	____
Musyahidah and Vanany	2019	Electricity Generation Company	Evaluation criteria: • Supply positioning matrix • Budget • Procurement • Blacklist history	- Grade A - Grade B - Grade C - Grade D
Tseng	2020	Passive Components Company	Evaluation criteria: • On time delivery • Quality (defective rate) • Corrective action response • Correction effectivity • HSF testing compliance • Sample pass rate • Coordination Cost	- Grade A - Grade B - Grade C - Grade D

(2) Data collection
Collection of historical data for a period of 6 months. The data is collected at one of the Electronic Manufacturing Business Units, specifically the AC Business Unit (AC BU).

(3) Non-conformity Classification and Validation of Non-conformity Classification
Classify non-conformity based on the impact of non-conformity on the company's business using fishbone diagram tools. Next step is carried out using FMEA which is carried out with experts in the company in order to ensure that the non-conformity classification results obtained from the fishbone diagram are valid.

(4) Designing of supplier quality monitoring system
Obtain customer needs from the quality expert in AC BU that refer to the business impact caused by non-conformity as well as technical requirements in the form of a list of several handling steps that will be carried

out to suppliers. Next, author create a House of Quality (HOQ) for non-conformity handling in order to see the relationship between the handling steps to a suitable supplier to handle non-conformity at that level. After that, supplier quality monitoring system can be designed in the form of working procedures that is effective to maintain the quality of raw materials supplied by suppliers.

4. Data Collection

Incoming Quality Assurance (IQA) is the section responsible for recording data consistently when non-conformity is found in order to monitor the quality of raw materials sent by suppliers. In this study, the data collected is historical data for the last 6 months which can show quality trends and details of quality or non-conformity problems that occur in raw materials. Table 3 below shows the summary of non-conformity data from July – December 2021.

Table 3. Summary of Non-conformity Data from July - December 2021

Month	Supplier	Material Name	Qty	Non-Conformity Problem
Jul	PT D	Bracket Fan Motor	150	The quantity of material received does not match the order
	PT A	Foamed Polystyrene	17	Appearance defects
	PT E	CC case (indoor)	20	Expiry period of raw materials is too fast
	PT E	Cabinet front plate	37	Material's barcode is not good
	PT A	Top board	200	Incorrect material was supplied
	PT H	Control Board Complete	15	Function problem
Aug	PT O	Brand Badge	175	RoHS test result is NG
	PT B	Screw	250	Material cannot be assembled
	PT C	CC Case (Outdoor)	10	Expiry period of raw materials is too fast
	PT D	Front Grille Complete	14	Appearance defects
	PT D	Discharge Grille Complete	12	Appearance defects
	PT F	Steel Sheet	80	The dimensions do not match specifications
	PT J	Soft Vinyl	136	RoHS test result is NG
	PT P	Rubber	120	RoHS test result is NG
Sept	PT I	Grounding Screw	150	Material cannot be assembled
	PT J	CC case (outdoor)	10	Expiry period of raw materials is too fast
	PT D	Holder Wire	100	Incorrect material was supplied
	PT G	Evaporator complete	200	The quantity of material received does not match the order
	PT C	CC case (indoor)	210	The quantity of material received does not match the order
Oct	PT D	Propeller Fan	128	Material cannot be assembled
	PT C	CC Case (Outdoor)	135	The quantity of material received does not match the order
	PT H	Control Board Complete	10	Function problem
	PT K	Tube Assy	250	Material damage (broken/cracked/dented)
	PT B	Particular pin	180	Incorrect material was supplied
	PT D	Generator Base	100	Appearance defects
Nov	PT L	Base pan	270	The dimensions do not match specifications
	PT D	Front Grille	62	Material damage (broken/cracked/dented)
	PT M	Discharge Grille	30	Material cannot be assembled
	PT D	Generator Base	79	Appearance defects
	PT A	Top Board	120	Incorrect material was supplied
	PT N	Control Assy	124	Function problem
Dec	PT H	Control Board Complete	11	Material damage (broken/cracked/dented)
	PT Q	Remote control	45	Wrong part code on the label
	PT D	Holder Wire	100	Incorrect material was supplied
	PT O	Brand Badge	88	The quantity of material received does not match the order
	PT E	Indication Label	140	RoHS test result is NG

5. Results and Discussion

5.1 Non-conformity Classification

The first step is to conduct interviews with 5 experts from the Quality Assurance and Production departments to determine the definition of each level of non-conformity for Electronic Manufacturing, especially in Air Conditioner (AC) products. According to research by Subramani and Balamurali (2016), Borror (2013) and Kumaresh (2012), non-conformity is classified into three levels (critical, major and minor) which refers to the impact of non-conformity on company processes or business. Non-conformity classification was analyzed using fishbone diagram.

It can be concluded from the results that the non-conformity classification refers to the business impact on the company. Table 4 below is the summary of the non-conformity classification.

Table 4. Classification of Non-conformity Levels based on Business Impact for Companies

NC Level	Business Impact	Type of Non-conformity
Critical	Product marketing discontinued	RoHS test result is NG
	Product will have functional problems	Function problem
	Production will be stopped	Material cannot be assembled
	No material for production	Incorrect material was supplied
Major	Product sales decrease	The dimensions do not match specifications
	Production process isn't running smoothly	Material damage (broken/cracked/dented)
	Target product to be sent to consumers isn't achieved	Expiry period of materials is too fast
	Material shortage	The quantity of material received does not match the order
Minor	Product has appearance problems but does not interfere with its function	Appearance defects
	Traceability process in production is disrupted	Material's barcode is not good
	Disrupted product delivery	Wrong part code on the label
	Number of safety stock materials in the warehouse is reduced	Wrong label

5.2 Validation of Non-conformity Classification

After conducting a non-conformity classification, authors validate the classification using Failure Mode and Effect Analysis (FMEA) method. This method was chosen because FMEA can validate and prioritize the results of the fishbone diagram (Knop, 2017; Mariajayaprakash and Senthilvelan, 2014). Authors refer to research conducted by Ebrahemzadih et al. (2014) which categorizes the critical level of non-conformity based on the RPN value in the FMEA method to validate the three non-conformity classifications discussed in this study. Validation of the non-conformity classification results using the RPN criteria in the FMEA approach as follows:

(1) RPN < 70 are classified as level 1 or minor level.
(2) 70 < RPN < 140 are classified as level 2 or major level.
(3) RPN values > 140 are classified as level 3 or critical level.

Validation begins with the validation of severity, occurrence, and detectability. Before validating, author determined the criteria and rank for the three categories listed above, which were based on the research of Ebrahemzadih et al. (2014) and to validate the occurrence of non-conformity, begin by modifying the FMEA occurrence table with the necessary research to represent the situation in the company. The summary of non-conformity classification validation using the FMEA method is in table 5 below.

Table 5. Summary of Non-Conformity Classification Validation Results

NC Level	Business Impact	Type of Non-conformity	S	O	D	RPN
Critical (RPN > 140)	Product marketing discontinued	RoHS test result is NG	10	4	5	200
	Product will have functional problems	Function problem	10	3	7	210
	Production will be stopped	Material cannot be assembled	10	4	7	280
	No material for production	Incorrect material was supplied	9	4	5	180
Major (70 > RPN > 140)	Product sales decrease	The dimensions do not match specifications	9	3	5	135
	Production process isn't running smoothly	Material damage (broken/cracked/dented)	8	3	5	120
	Target product to be sent to consumers isn't achieved	Expiry period of materials is too fast	7	2	6	84
	Material shortage	The quantity of material received does not match the order	8	5	2	80
Minor (RPN < 70)	Product has appearance problems but does not interfere with its function	Appearance defects	3	5	1	15
	Traceability process in production is disrupted	Material's barcode is not good	4	1	1	4
	Disrupted product delivery	Wrong part code on the label	3	1	2	6

	Number of safety stock materials in the warehouse is reduced	Wrong label	4	0	2	0

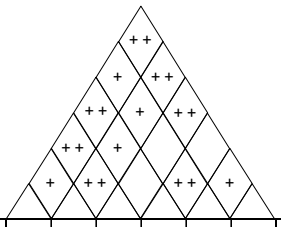
5.3 Supplier Quality Monitoring System Design

There are various flaws in the existing working procedure, including the fact that the non-conformity handling in the form of Corrective Action Request (CAR) is ineffective due to the number of repeated non-conformities, and that if quality problems occur, Incoming Quality Assurance (IQA) is frequently slow in making decisions, which can lead to a decrease in quality. Based on the two points raised above, it is necessary to develop a supplier quality monitoring system in the form of working procedure that can address existing deficiencies, namely by providing alternative options for dealing with non-conformity issues that arise by making quick and precise decisions that can later be used to increase the effectiveness of corrective actions from suppliers. This system was created by the author together with the experts by using one of the quality tools, Quality Function Deployment (QFD). The structure of QFD is based on a set of matrices named the House of Quality (HOQ).

Because the QFD approach was used on non-products in this study, a portion of the HOQ's core structure, specifically the competitive assessment matrix, was ignored (Almannai et al., 2008; Yang et al., 2012). Furthermore, according to Rahim and Baksh (2003), the competitive assessment matrix may not be used if it is deemed irrelevant to the purpose of using the QFD method. Figure 3 below is the House of Quality (HOQ) Non-conformity Handling. From this figure, it can be seen that the collaborative team is an effective action taken to all levels of non-conformity because the highest relative weight value with 29%.

Symbol	Point	Relationship
⊙	9	Strong relationship
○	3	Medium relationship
△	1	Weak relationship
	0	No relationship at all

Symbol	Relationship
+ +	Strong positive
+	Positive
-	Negative
- -	Strong negative



Non-conformity Level	Business Impact	Technical / Follow up Requirements / Customer Needs	Supplier Audit	Supplier Training	Collaborative team	Supplier visit	Regular communication	Corrective Action Request (CAR) form & 5 Why Analysis	Maximum Relationship	Importance to Customer	Relative Weight
			1	2	3	4	5	6			
Critical	Product marketing discontinued	Materials doesn't violate regulations or customer safety	⊙	⊙	○	△		△	9	4	12%
	Product will have functional problems	The materials doesn't experience functional problems so that the product continues to function	⊙	○	⊙	△		△	9	4	12%
	Production will be stopped	Materials support the production process to keep it running	⊙	⊙	○	△		△	9	4	12%
	No material for production	Materials are always available for the production process	△		⊙	⊙	○	△	9	4	12%
Major	Product sales decrease	The material does not cause a decrease in quality so that product sales are stable and even increase		△	⊙	△	○	○	9	3	9%
	Production process isn't running smoothly	Materials support the production process to runs smoothly		△	⊙	△	△	○	9	3	9%
	Target product to be sent to consumers isn't achieved	Materials can support the achievement of product targets to consumers		△	⊙	△	○	○	9	3	9%
	Material shortage	There is always enough material for production			○	⊙	○	△	9	3	9%
Minor	Product has appearance problems but does not interfere with its function	The quality of appearance material must be good			△	△	○	⊙	9	2	6%
	Traceability process in production is disrupted	Traceability process in production isn't disrupted			△	△	○	⊙	9	1	3%
	Disrupted product delivery	Product delivery is running smoothly				△	○	⊙	9	2	6%
	Number of safety stock materials in the warehouse is reduced	Number of safety stock materials in the warehouse is maintained				△	○	⊙	9	1	3%
		Maximum Relationship	9	9	9	9	3	9			
		Technical Importance Rating	329,41	273,53	558,82	264,71	176,47	294,12			
		Relative Weight	17%	14%	29%	14%	9%	16%			

Figure 3. House of Quality (HOQ) of Non-conformity Handling

The author together with the company's experts then classified the handling for each level of non-conformity. This classification is made based on the highest relative weight value from technical / follow-up requirements and also the highest value from each relationship matrix for each level of non-conformity, details can be seen in table 6 below.

Table 6. Classification of Non-conformity Handling Steps for Each Level

Non-conformity Level	Business Impact	Type of Non-conformity	Action
Critical	Product marketing discontinued	RoHS test result is NG	1) Supplier Audit 2) Supplier Training Additional recommendations: - Collaborative Team - Supplier Visit
	Product will have functional problems	Function problem	
	Production will be stopped	Material cannot be assembled	
	No material for production	Incorrect material was supplied	
Major	Product sales decrease	The dimensions do not match specifications	1) Supplier Audit 2) Collaborative Team
	Production process isn't running	Material damage	

	smoothly	(broken/cracked/dented)	Additional recommendations: - Supplier Visit - Corrective Action Request (CAR) form and 5 Why Analysis
	Target product to be sent to consumers isn't achieved	Expiry period of materials is too fast	
	Material shortage	The quantity of material received does not match the order	
Minor	Product has appearance problems but does not interfere with its function	Appearance defects	1) Corrective Action Request (CAR) form and 5 Why Analysis 2) Collaborative Team Additional recommendations: - Regular Communication
	Traceability process in production is disrupted	Material's barcode is not good	
	Disrupted product delivery	Wrong part code on the label	
	Number of safety stock materials in the warehouse is reduced	Wrong label	

The supplier quality monitoring system can be developed from the non-conformity handling classification in the form of an Incoming Quality Inspection working procedure for verifying and monitoring the quality of raw materials with a flowchart, as shown in figure 4 below.

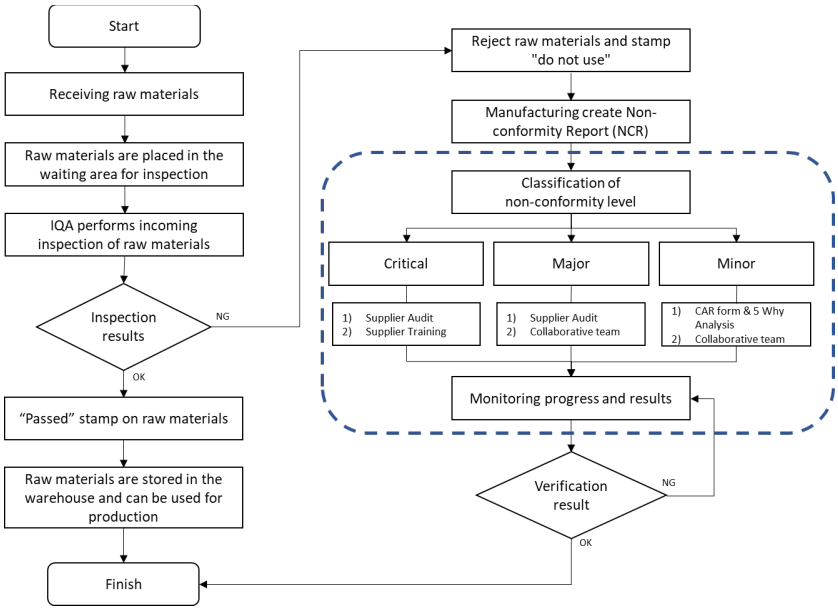


Figure 4. Supplier Quality Monitoring System Flowchart

6. Conclusion

This research aims to obtain working procedures for supplier quality monitoring system design and provide alternative options in handling of quality problems in raw materials from suppliers that occur with quick and precise decision making. This was done by doing literature studies on supplier quality monitoring system, non-conformity classification and validation and also designing a supplier quality monitoring system that considers the level of non-conformity, which is carried out in collaboration with experts from the AC Business Unit. The results of this system design shows that the appropriate handling steps for suppliers for the critical levels of non-conformity are supplier audit and supplier training, for major levels are supplier audit and collaborative teams and for minor levels are Corrective Action Requests (CAR) form and 5 why analysis and collaborative team. This study can provide guidance Quality Department in manufacturing to increase the effectiveness of corrective actions against non-conformity so that corrective actions taken to suppliers can be carried out quickly and there is no decrease in product quality.

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