DEVELOPMENT OF AN INDUSTRIAL INSTRUMENT CALIBRATIONWORK PLANNING PROCESS IN A PINEAPPLE MANUFACTURINGINDUSTRY USING THE QUALITY FUNCTION DEPLOYMENT (QFD)TECHNIQUE

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ABSTRACT: *Calibration systems of measuring instruments have a remarkable impact on organizations' ability to meet their objectives in achieving quality of the output products. The realization of this impact has directed the attention to calibration quality and performance to the entire measuring instrument installed in the process. It also called on the use of total quality management tools for improving calibration quality. The purpose of this paper is to customize the techniques of quality function deployment (QFD) for designing effective calibration job plans and demonstrate its use in the design of a calibration implementation at a pineapple manufacturing industry located in Misamis Oriental. In this study, Quality Control analysts from the operations are used as our external customers and In-house calibration technicians as our internal customers to identify the job technicality and planning requirements. Then with the availability of both customers, the QFD process planning matrices are used for developing several alternative job design concepts. Then based on a simple decision criterion the design concept that closely meets customer requirements is identified. The result of the analysis is a well-planned calibration job that improves the pineapple industry operations.*

Keywords: Quality Function Deployment (QFD), Internal Customer Requirements, External Customer Requirements,Technical Requirements, Electrical and Instrumentation Technician (EIT), Calibration Job Planning

1. INTRODUCTION

Calibration of instruments and processes is absolutely essential for correct operations and for checking their performances against known standards. This provides consistency in readings and reduces errors, thus validating the measurements universally [1]. Different instruments are used to be able to measure different type of controlled variable such as pressure, level, flow and temperature. Calibration establishes a relation between the quantity value provided by a measurement standard and the corresponding indication provided by a measuring instrument or system [2]. And with the need to ensure that these instruments are working according to their set application the importance of calibration then takes an imperative role. There are three main reasons for having instrument calibrated. First, to ensure readings from an instrument are consistent with other measurements. Second is to determine the accuracy of the instrument readings. And lastly, to establish the reliability of the instrument that it can be trusted [3].Considering the importance of the calibration in the business process has brought the quality of measuring instrument calibration at a sharp focus. This focus extends the use of Total Quality management tools (TQM) in calibration operation. These tools include Failure Mode Effect and Analysis, Statistical Process Control and Quality Function Deployment [4]. Quality Function Deployment (QFD) is a specialized method for making customer needs/wants important components of the design and production of the product or services [5] and on this study it will be implemented in calibration area. The development of the practice for the QFD tools work beyond the process of consumer to producer only and extended to the people working within the organization such as maintenance individuals. This results theimprovement of procedures such as maintenance planning which also connected to the development of instrument calibration planning procedures

Pineapple manufacturing industry is made up of different processes that produce can pineapple products that is ready for the consumption of the customers. Each of this process within the pineapple cannery has measuring instruments that gathers all the data needed to be able to continue the needed operation. One example for this is the temperature sensor for the cooking method of the cannery which is responsible in ensuring effective thermal process for the operation. The calibration for the instruments that measure and control manipulated variable such as Temperature, Level, pressure and flow must be ensure. With this scenario, the importance of the planning process for the measuring instrument calibration must be robust and at the same time flexible to be able to achieve maximum confidence level in the efficiency of the measuring instruments installed in the line. Thus, the purpose of this paper is to customize the technique of a Quality Function Deployment as TQM Tools for designing effective calibration job plans and demonstrate its use in the design of measuring instruments at a pineapple manufacturing industry.

2. METHODOLOGY

2.1 Identification of Customer Requirements

The first part in using QFD tools into different applications are gathering and refining the customer needs input [6]. In this study Quality Control analyst from the operations are used as our external customers and In-house calibration technicians as our internal customers to identify the job technicality and planning requirements.

i. External Customer Requirement

The external customers' requirements are obtained from Quality Control analyst in the Pineapple manufacturing

operations department. This type of customer requirements is obtained through carefully designed questionnaires provided to the analyst that enable them to provide the detailed needed necessities to ensure continuous and efficient cannery operation.

ii. Internal Customer Requirement

The Internal Customer's requirements are acquired from experienced Electrical and instrumentation technicians (EIT) in the cannery operation under support group. Different types of questionnaires are premeditated for the technicians in the EI department for them to filled-up and submit to be part of the Customer Requirements parameters.

2.2 Identification of Technical Requirements

The technical requirements for the calibration job are acquired by providing questioners and conducting interview to the Electrical and Instrumentation department technical staff and determined the top six technical requirements that will best fit to addressing all the customer requirements. The technical requirements of the job and their relationships to the customers' requirements are necessary for developing the job planning matrixes for calibration planning.

2.3 Analyzing calibration job planning using QFD process

The QFD process analysis was used to identify the calibration job that meets the customer requirements identified above. The rating of importance has been provided by the Internal and external customer and will be part of the analysis. Quality Control analyst and EID supervisors were asked to rate the importance on a scale 1 to 9 with 9 being "highly important". The average ratings have been used to evaluate the relative importance of the customers' wants and needs. Included in this step is the analysis of the relationship between the customer and technical requirements by providing symbols that are most commonly used in QFD analysis which will be part of the discussion below. The double concentric circle is used to show a strong relationship. A single circle represents a moderate relationship and a triangle is used for weak relationship. For example, if the intersection between the customer requirement and technical requirement is filled with the double concentric circle means that the team agreed that any action to improve the technical requirement of a calibration would have a strong effect on the customers'requirement.

2.4 Designing Job Concepts for Calibration of Instruments

The designing of Job concept for calibration of instruments is basically the classification of the level for each technical requirement identified above. Identification of level for each technical requirement has been gathered using the prioritization form filled up by the EID technical staff. The QFD team collected all the concept design provided by the technical staff and used it as part of the evaluation stage. The selection for the level of each technical requirement to come up with a job design concept that best answer to the need of the operation of the pineapple manufacturing industry was the output during this phase.

2.5 Evaluation of Job Design Concepts for Calibration of Instruments

The evaluation of job design concept helped in decision selection for the best concept that both address the customer requirements and the technical requirements provided above. The output of the design concept generated above will be compared to the existing scenario to be able to evaluate the best concept that best meets the external and internal customers' requirements. In evaluating the different concepts, one concept is chosen as a reference. In this case, the current practice is selected as a reference. For each concept's level of technical requirement, it will be compared to the reference. If the concept is superior to the current design, it will be given a plus sign (+). However, it is given a minus sign (-) when the concept is worse than or minor to the current practice. It will be given same (S) if the design concept and the current practice have the same level for the requirement. After the evaluation is completed, each column is totaled for the number of plusses, minuses, and sames. The QFD process analysis identifies the concept that best meets the external and internal customers' requirements by garnering the most number of plus, marginal number of sames and fewer results for minus.

3. RESULTS AND DISCUSSION

3.1 Customer Requirements

i. External Customer Requirements

Below are the requirements identified by the QA analyst as external customers:

1. Timely calibration implementation (least duration).
2. Reliability of the calibrated instruments for the process.
3. Availability and clarity of calibration tags attach to the instruments.
4. Availability of calibration records.
5. Accuracy of the calibrated instruments.
6. Accessibility to the instruments

ii. Internal Customer Requirements

Below are the identified Internal Customers Requirements by the Electrical and Instrumentation technicians:

1. Availability of standard to be the reference of test instruments.
2. Availability of support equipment in pulling out of instruments.
3. Available of spare instruments in case defective.
4. Assistance from the process owner during pulling out and re-installation of calibrated instruments.

3.2 Technical Requirements

EIT technical staff specified that the following are the necessary technical requirements needed:

1. Priority.
2. Skill Level.
3. Accuracy of standard instruments.
4. Inspection.
5. Support Equipment.
6. Timely calibration Plan

After all the Technical Requirement have been identified the next step was assigning of the level of importance for each technical requirement. Table 1 shows the level summary of the level for each Technical requirement.

Priority The technical requirement for priority has two levels. In the first priority level jobs are done immediately. In the second level jobs can be delayed up to two days.

Skill level for manpower the manpower available at the Electrical and Instrumentation department has three skill levels. The technical requirement for manpower has three levels. These levels are: level 1 (specialist) level 2 (1st class

technician) and level 3 (2nd class technician). The specialist is expected to perform the highest job quality level followed by the 1st class technician and then the 2nd class technician.

Accuracy of standard instruments the accuracy of the standard to be used during calibration has the greatest impact on the result of the calibration job. This includes accuracy and availability of the standard instruments. The technical requirement for standard instruments has three levels. These levels are level 1, level 2 and level 3, level 1 is available with updated calibration certificate, Level 2 available but not updated calibration certificate and the level 3 is no available standard.

Inspection Inspection is performed to ensure the quality of the calibration job. All instruments require a certain degree of inspection before installation and during operation. Requirements for instrument inspection and testing are covered in the organization standard. The level of inspection is determined by who performs the inspection. The manpower that performs the inspection has three types. The types are specialist, 1st class technician and 2nd class technician. Based on the type of manpower, the technical requirement for inspection has three levels. Inspection is considered level 1 (top quality) if a specialist conducts it. Inspection is level 2 (second grade quality) if a 1st class technician performs it and level 3 if a 2nd class technician conducts it.

Support Equipment Support equipment are special tools for pulling out of instruments and transport equipment. The technical requirement for the support equipment has two levels. Level one when all support equipment is available all the time and level two when it's available most of the time.

Timely Calibration Plan A calibration plan is a document containing the entire schedule of calibration for the whole measuring instruments installed and used in the cannery. The technical requirement for timely Calibration Plan has two levels. Level one is when the calibration plan is updated and level two when it's not updated.

3.3 Analysis of calibration job planning

Figure 1 shows the customers' requirements that are presented on the left in the horizontal portion of the matrix. External and internal customers have identified these requirements. Included in the figure is the relationship between customer requirements and technical requirements for each type of customer. The column adjacent to the customer requirements shows the ratings that customers attach to each of their requirements. These were obtained through surveys. The symbols shown directly below the technical requirements indicate the presence and strength of relationship between the customer and technical requirements. These represent team judgments of the goals or ideals targets which EI department team must establish for each technical requirement to satisfy customers

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Table 1. Level of Significance of each Technical Requirement

TECHNICAL REQUIREMENT														
PRIORITY		SKILL LEVEL			ACCURACY OF STANDARD INSTRUMENTS			INSPECTION			SUPPORT EQUIPMENT		TIMELY CALIBRATION	
1ST LEVEL	2ND LEVEL	1ST LEVEL	2ND LEVEL	3RD LEVEL	1ST LEVEL	2ND LEVEL	3RD LEVEL	1ST LEVEL	2ND LEVEL	3RD LEVEL	1ST LEVEL	2ND LEVEL	1ST LEVEL	2ND LEVEL
Jobs are done immediately	Jobs can be delayed up to two days	Specialist	1st class technician	2nd class technician	Available with updated calibration certificate	Available but not updated calibration certificate	NO available Standard	Specialist	1st class technician	2nd class technician	ALL Support Equipment is Available all the time	NOT Available all the time	Updated calibration Plan	NOT Updated calibration Plan

In essence, the QFD matrix captures the information, which will be used to design an effective job plan for instrument calibration. Design concepts or design alternatives for the calibration job will be developed based on the levels of the technical requirements and their impact on the customer requirements.

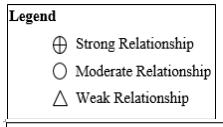
3.4 Job Design Concepts for Calibration of Instruments

Table 2. Summary of the Level for each Concept

Technical Requirement	Design Concept						
	1	2	3	4	5	6	7
Priority	1	1	1	2	1	1	1
Skill Level	1	2	3	1	3	2	2
Accuracy of Standard Instruments	1	1	3	1	2	2	2
Inspection	1	2	3	2	3	2	2
Support Equipment	1	1	2	2	1	1	2
Timely Calibration Plan	1	1	1	1	2	1	2

Table 2 shows different design concepts for the implementation of the technical requirements that will help satisfy the customer requirement of both external and internal customers. The numbers in the cells represents the level of each requirement while numbers in the first row are the design concept number. Concept #7 represents current practice.

Concept 1 assigns level 1 for all technical requirements for the job. In other words the job should have priority 1, assigned



			TECHNICAL REQUIREMENTS							Current Practice		
Customers	Row #	Customer Requirements	Rating	Priority	Skill Level	Accuracy of the Standard	Inspection	Support Equipment	Timely Calibration Plan	Poor	Good	Excellence
QA Analyse (External Customer)	1	Timely calibration implementation (least duration)	9	⊕	⊕	○	⊕	⊕	⊕			
	2	Reliability of the calibrated instruments for the process	9	⊕	⊕	○	○	○	○			
	3	Availability and clarity of calibration tags attach to the instruments	7	△	△	△	○	△	△			
	4	Availability of calibration records	8	○	△	○	○	△	○			
	5	Accuracy of the calibrated instruments	9	⊕	⊕	⊕	△	○	△			
	6	Accessibility to the instruments	7	△	△	△	⊕	○	○			
EI Technician (Internal Customer)	1	Availability of Standards to be the reference of the test instruments	9	⊕	○	○	⊕	△	○			
	2	Availability of support equipment in pulling out of instruments	7	△	○	△	○	⊕	⊕			
	3	Availability of spare instruments in case defective	9	△	△	△	○	△	○			
	4	Assistance from the process owner during pulling out and re-installation of calibrated instruments	7	△	○	△	△	○	○			
		TARGET	9	9	9	8	8	8		STATUS		

Figure 1. Correlation between the Customer Requirement and Technical Requirement

specialized skill level, Accurate Standard instruments for calibration, inspected by a specialist and both support equipment and Timely calibration Plan are available.

Concept 2 assigns level 1 priority, level 2 skill level, level 1, Accurate Standard 2 inspection, level 1 support equipment and level 1 for Timely calibration Plan.

Concept 3 assigns level 1 priority, level 3 skill level, level 3 Accurate Standard, level 3 inspection, level 2 support equipment and level 1 Timely calibration Plan.

Concept 4 assigns level 2 priority, level 1 skill level, level 1 Accurate Standard 2 inspections, level 2 support equipment and level 1 Timely calibration Plan.

Concept 5 assigns level 1 priority, level 3 skill level, level 2 Accurate Standard, level 3 inspection, level 1 support equipment and level 2 Timely calibration Plan

Concept 6 assigns level 1 priority, level 2 skill level, level 2 Accurate Standard, level 2 inspection, level 1 support equipment and level 1 Timely calibration Plan.

Concept 7 (The current practice for this job) assigns level 1 priority, level 2 skill level, level 2 Accurate Standard , level 2 inspection, level 2 support equipment and level Timely calibration Plan.

3.5 Job Design concept evaluation

The job design concepts have been evaluated using the design concept evaluation matrix as shown in Table 3.

Table 3. Design Concept Evaluation Matrix

Technical Requirement		Design Concept						
		1	2	3	4	5	6	7
Priority		**S**	**S**	**S**	**+**	**S**	**S**	1
Skill Level		**+**	**S**	**-**	**+**	**-**	**S**	2
Accuracy of Standard Instruments		**+**	**+**	**-**	**+**	**S**	**S**	2
Inspection		**+**	**S**	**-**	**S**	**-**	**S**	2
Support Equipment		**+**	**+**	**S**	**S**	**+**	**+**	2
Timely Calibration Plan		**+**	**+**	**+**	**+**	**S**	**+**	2
TOTAL	**+**	5	3	1	4	1	2	Reference
	-	0	0	3	0	2	0	
	S	1	3	2	2	3	4	

The design concepts under consideration are listed across the top of this matrix. Concept requirements are shown on the left in the horizontal portion of the matrix. The column that is adjacent to the concept requirements from left shows the source of each requirement. The reference use in this evaluation is the current practice as stated previously. Each column is compared against the current practice for the concept requirements. Concepts 1 and 4 have the greatest number of pluses, five pluses for concept 1 and four pluses for concept 4. Concept 1 has one same and does not have any minuses while concept 4 has two sames and no minuses.

The QFD process analysis identifies the concept that best meets the external and internal customers' requirements. It is clear that without detailed analysis concept 1 is the best design concept that meets customer requirements, since it has the best level for every requirement. But as per result, we can see that incase the organization cannot work on the concept #1 , concept #4 is the next possible option and the option #2 will be the last priority. The results indicate that a room exists for improving the current practice by adopting either concept 1, 4 or 2.

4. CONCLUSION

Quality function deployment has been proven to a powerful prioritization tools in deploying instrument calibration planning. It also provides clear picture of other possible ways to address both the customer and technical requirement attached to the calibration work. The customer driven process for planning reduces the traditional conflict between the team such as the process owner and the technician handling the calibration task. QFD in general can be a very effective tool by improvising and customizing the procedural process to the desired area of application.

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