



## **Structuring of cost of quality**

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## Preface

SDM Research Center for Management Studies (RCMS), since inception, has endeavored to promote research in the field of management education, in various ways. In this direction, in order to promote applied research, the Research Center has taken a unique initiative to encourage the faculty members to carry out various projects in the areas of management.

After completion of the projects, based on the peer review, reports are published with an ISBN number, by the Institute. The projects help the faculty members, and the students, who assist the faculty members for these projects, in various aspects, to gain practical knowledge, in the field of management.

The institute takes into account the time and resources required by the faculty members to carry out such projects, and, fully sponsors them to cover the various costs of the project work (for data collection, travel, etc).

From the academic viewpoint, these projects provide a unique opportunity to the faculty members and the students to get a first-hand experience, in investigating issues and concerns of targeted organizations or sectors, on a face to face basis, thereby, helping in knowledge creation and its transfer.

**Mousumi Sengupta**

Chairperson – SDM RCMS



## Acknowledgement

In the completion of the project there is a feeling of achievement and satisfaction. In this moment of happiness, we feel prompted to express my sincere gratitude to all those who were a source of inspiration, courage and guidance.

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Extending my regards to **Mr. Upendra Kamath, (Head - QA & System Compliance) and Mr. Samarth Raj, Triton Valves Limited, Mysore** for providing an opportunity for this internship.

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## **Executive Summary**

The presence of high competitiveness makes the chase for reduction in manufacturing cost a constant goal in today's market, but it is very important to reduce expenses without compromising the quality of product or service. The purpose of this project is to restructure the cost of quality and better representation of cost of quality using the power of information and technology tools. The cost of quality management acts as one of the important concerns in production oriented companies in measuring, supervising, controlling and decision making activities for better business output. Initially, the cost of quality study gives insights and road map to the management on what cross discipline departments and other improvement tasks should be initiated and integrated. Assessment of cost of quality enables continuous quality improvement in any manufacturing industry like Triton Valves, wherein the present project was carried out. Triton Valves have been always known for their high precision products and have always focused on monitoring the quality cost, using such techniques like scrap reduction, defect prevention, better measurement and inspection, and above all adopting modern techniques of quality control and improvement. Through this project, we have attempted to develop new and improvised representation of quality cost to facilitate better scope in the company's quality improvement process.



## Section 1 : Literature Review

### Cost of Quality

The primary objective of any manufacturing organizations is to satisfy the customer requirements with improved quality products and to meet this objective at low cost. This can only happen if these costs related to quality are measured and reported. Therefore, organization emphasize more measuring and reporting of “Cost of Quality.”

According American Society for Quality, cost of quality is defined as the cost which is associated with delivering poor quality products or services.

Cost of Quality is a methodology that allows any manufacturing organization to find the extent to which its material and resources are used for activities in manufacturing that are used to prevent poor quality, appraise the quality of the product, and those result due to internal and external failure. Cost of Quality helps the organization to look into the potential savings which can be gained by developing and implementing continuous process improvements.

### Categorization of Cost of Quality

#### *Prevention Costs*

These costs are incurred to avoid or prevent quality issues. These costs are related to quality management system with respect to design, implementation and maintenance. The costs are incurred before actual production or operation.

#### *Appraisal Costs*

These costs are related with measuring and monitoring of operations related to quality. Even it is related with suppliers’ and customers’ evaluation of the products to assure the conformance to specification.

#### *Internal Failure Costs*

These costs are incurred when product failed to meet the specification or requirements before delivering it to the external customer.

#### *External Failure Costs*

These costs are incurred when organizations fail to meet the quality requirements and it goes undetected until after transferring it to the customers.

### Examples of Industries implementing CoQ Measurement

In one of the research related to Australian manufacturing firms; it was observed that out of 135 respondents ,25.7% were currently using CoQ in some form. Around 27.2 % were planning to implement CoQ and rest had no plan to implement it. This shows a huge scope of improvement in those manufacturing firm.

The cost of quality was implemented using different quality component in paper and pulp manufacturing mills. They observed and developed a relationship in the quality cost components. The internal failure cost incurs the most cost and prevention cost being the least expensive among the other quality cost components. The combined internal and external failure cost was more compare to prevention and appraisal cost. This resulted in quality reject rate decrease with increase in volume output.

There was effort to introduce and implement CoQ in Indian manufacturing firms i.e. small and medium scale enterprises. The prevention- appraisal – failure model has been applied to most of the industries and quality cost indices were developed and computed.

Many researches have been conducted over the implementation of CoQ Model in the manufacturing sector. In majority of the firms, Prevention - appraisal-failure model has been adopted. The most of the example confirms that quality improvement and cost measurement process bring about a significant reduction in a organizations’ costs of quality towards the quality excellence.

### Benefits of measuring Cost of Quality

The CoQ measurement allows activities pertaining to quality improvement to be expressed monetarily i.e. the language of top management which in turn, allows quality to be dealt like a business parameter alongside line functions like research and development, marketing, and production / operations / services.

We can emphasize the importance of service and product quality to the health of a business by bringing quality costs into business arena and will help influencing attitudes and behavior of individuals at all levels in the organizations towards continual quality improvement and Total Quality Management.

Measurement of Quality costs draws attention towards areas of high expenses and identifies opportunities for potential cost – reduction. Performance measurement and a basis for internal comparison between products, processes, services, and departments is also facilitated by Cost of Quality measurement.

Measurement of cost of quality also divulges accidents and anomalies in standards and cost allocation which may remain unnoticed by the commonly used operation/production and labor associated analyses. It can also remove the embarrassing removal of after sales costs under quality – associated headings.

## Section II : Introduction to the organization

Triton Valves Ltd is one of the largest manufacturing company in auto ancillaries. They are largest manufacturer which designs, manufactures and sells automotive tire tube valves, valves cores and other accessories. They have been meeting the requirements of all the major customers of automotive sector through their high precision products. Triton Valves Limited was founded in 1975 and it is a Bangalore based company with manufacturing plant in Mysore. Triton have wide range of products for all the locomotives ranging from bicycles to “Off Roads” vehicle tires. They offer valves for bicycles, motorcycles, four wheelers, tractors, large transportation vehicles, aircrafts

and OTRs; cores with standard and larges bores and other accessories. Triton Valves exports its products to major tyre and tube producers.

The company is certified for ISO/TS16949, ISO 140001 and BS OHSAS 18001 for quality standard, environment management standard and occupational health and safety standard respectively. Triton have developed reputation and trust among leading original equipment manufacturer through their quality, delivery and customer service. Triton has gained market leadership in every segment that it operates through policies like zero defect, get it right at first time and customer comes first. They are enjoying this market leader position by distinct advantage of superior technology, large installed capacities in different categories of their product, most importantly due to competitive pricing and deals from almost all tyre and vehicle manufacturer in the India.

### MISSION

“We don’t just manufacture tyre valves. Our greater cause is safety in the movement of people and goods in India”.

### VISION

The vision is to set global benchmarks of excellence in every aspect of business.

### VALUES

People, Craftsmanship, Excellence, Passion, Customer Success, Ethics, Joy Of Life.

### Triton valves Product Classification

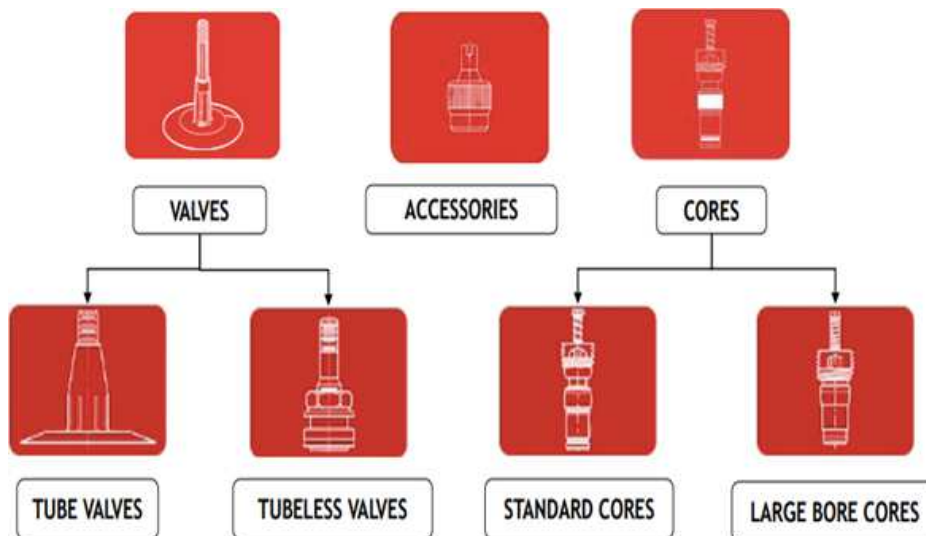


Figure 1: Product Classification

- Valves
- Cores
- Service tools
- Accessories
- Adapters & Plugs
- AC Products

### Major Products



**Figure 2: Major Products**

### Section III : Tyre valve industry

Triton Valves Ltd is major supplier to Original Equipment Manufacturer in both the tyre and automobile industries. Presently, the size of the tyre valve industries in India is estimated to be Rs.300 crores in the organized sector for 2016-2017. The export does not form a major percentage of this turnover. Around 2 manufacturer provides over 80% of the entire production and sales.

The passenger and utility vehicles sales together has increased by 9.23% which touches the mark of three million vehicles. In 2016-17, Indian market also registered highest two wheeler sale and maximum number of passenger vehicle was exported. Although

industry was aiming to achieve double digit growth but some of macro-economic factors had affected and slowed down the three wheeler sales.

The tyre valve market in India is expected to see a steady growth and improvement in coming year. Both the tyre and automobile industries will perform better than the last year with better opportunities. Since Triton imports its primary raw material for manufacturing valves namely brass which is highly volatile commodity. They have faced the fluctuation and volatility in exchange rates and even have to face potential threat from country like China. All of this pose a threat to growth and profitability.

### Major Customers – Domestic and International



Figure 3: Major Customers

## Section IV : Scope of the project

### Goal

To develop and create a proper structured Cost of Quality (CoQ) measurement tool which captures all the cost incurred by the organization during the production process.

### Objectives

- Communicate effectively and work closely with production department.
- Prepare and acquire all the needed resources i.e. cost per unit, no of defects, measurement data, inspection tools, etc.
- Construct a plan or blueprint for the cost of quality project.

### Requirements

- Different segments involved in automotive tube valve production.
- Number of units of goods inward towards finished goods.
- Number of defects found in the constituent elements of the valve like stem, mould, also in the final stage which contribute to internal failure costs at different rejection levels.

- Number of defects which contribute to external failure costs and appraisal costs

### Deliverables

- Proper structure of Cost of Quality with respect to all the cost elements
- Master Excel sheet containing all the quality cost and enabling quality cost computation
- An overall strategic plan for the Triton manufacturing plant to keep track of production line for all the segments with respect to different valves according to item wise details, date wise details and month wise details.
- Dashboard to monitor the poor Cost of Quality.

### Milestones

- First Review after the initial assessment and tracking
- Implementation of the proposed structure of the quality cost model
- Final Review after implementing the overall model.

**Limitations and Exclusions**

- All the values in master sheet have to be entered manually.
- The master sheet covers all the quality costs related to manufacturing only.
- Master sheet maintains quality cost only for daily and monthly basis i.e for each month a separate master sheet has to be maintained.

**Assumptions**

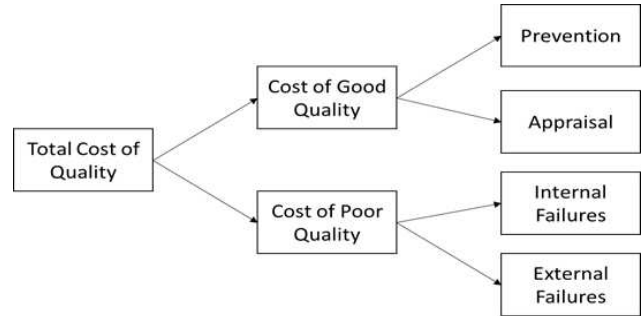
The master sheet will be filled with all the consolidated values from different segments of valve manufacturing by one operator to avoid any kind of ambiguity and other data entry errors enabling better restructuring of the cost of quality.

**Section V : Project methodology**

The project approached towards capturing the Cost of Quality Activity at Triton Valves using the following steps:

- Defining what constitutes cost of quality
- Identifying the processes elements that constitute each costs
- Identifying which process elements are relevant for Triton under each cost component of COQ
- Identifying which of the process elements incur a fixed costs & which constitute variable costs, as units are produced in the production line.
- Identifying the various sub components produced in Triton
- Trying to ascertain the preventive costs to the number of units produced under each sub component on a monthly basis.
- Developing the procedure for the next activity (“What to do?”) based on all these steps and inputs received from the departments.

Here the cost of quality elements is sub divide by the following way



**Figure 4: Cost of Quality Elements**

**Classification of various activities in manufacturing into each component of COQ based on the established and openly available resources.**

**Preventive Costs**

- Design Qualification Testing
- Market Research
- Prototype Testing & Iteration
- Design Review Meetings
- Equipment Fixture Design
- Supplier Evaluation
- Supplier Capability Surveys
- Supplier Scorecard
- New Employee Screening
- Controlled Storage
- Developing a Process Control Plan
- Quality Planning
- Quality Improvement Projects
- Procedure Writing
- Quality System Audits
- Fault Tree Analysis (FTA), Failure Modes and Effects Analysis (FMEA) & Failure Modes, Effects and Criticality Analysis (FMECA)
- Field Evaluation or Testing for New Products
- New Product Design Review & Analysis
- Design Validation & Verification
- Defect Proofing (Poke-Yoke)
- New Supplier Qualification

- Supplier Reviews, Ratings & Quality Planning
- Supplier Quality Agreements
- New Employee Training & Education
- Internal Process Capability Evaluations
- Predictive Equipment Maintenance
- Quality Education & Training
- Process Qualification, Validation & Verification
- Implementation of a Quality Data System
- Development of Quality Control Plans

### **Appraisal Cost**

- Receiving Inspection
- Routine Supplier Audits
- In-Process Testing
- Laboratory Testing
- Measurement Equipment Costs
- Product Audits
- Control Charts & Statistical Process Control
- Review of Inspection Data
- Source Inspection
- Routine Supplier Surveys
- Finished Goods Inspection
- Equipment Setup Inspection & Testing
- Destructive Testing Material Costs
- Periodic Review of Documentation
- Maintenance & Calibration of Test Equipment
- Process Monitoring & Control

### **Internal Failure Costs**

- Scrap or Sorting
- Re-work or re-processing
- Re-inspection or re-testing
- Extra Material Handling
- Excess Inventory Costs

- Excess Capacity Needs
- Supplier Corrective Actions
- Material Review Board
- Rebuilding or replacing Equipment tooling
- Scrap or Rework due to Design Change
- Root Cause Investigation Support Costs
- Lost Equipment capacity due to downtime
- Labour losses due to equipment downtime
- Rejected or Downgraded Raw Material
- Internal Corrective Actions
- Employee Turnover
- Rebuilding or replacing Equipment tooling
- Scrap or Rework due to Design Change
- Root Cause Investigation Support Costs
- Lost Equipment capacity due to downtime

### **External Failure Costs**

- Warranty Costs
- Repair Costs
- Customer Returns or Rejects
- Lost Sales & Customers
- Product Service Calls
- Customer Complaints & Investigation
- Product Liability & Legal Fees
- Overhead Cost of Field Service Team
- Product Recalls & Market Actions
- Loss of Reputation or Goodwill

### **Project action plan**

#### **Identifying which process elements are relevant for Triton Valves under each cost component of COQ**

- This is an important step because we need to define “What data or parameter or metric to capture” which we could define if we know what activities are relevant to Triton’s manufacturing processes.



- We also need to know which among those processes were implemented during the time of designing & set up of Triton’s production line since its inception. For example, Failure Modes, Effects and Criticality Analysis (FMECA) & market research for a product is done during its design stage at the very beginning before the start of production.
- It is also important to know which costs are implemented in current financial year especially in the preventive costs segment. For example, Quality costs audit expenditure or New Supplier Evaluation and Capability Surveys may be done at the onset of the year.
- This section is necessary to ascertain preventive costs to the production of units so as to systematically **map out preventive costs** in the final output dashboard.

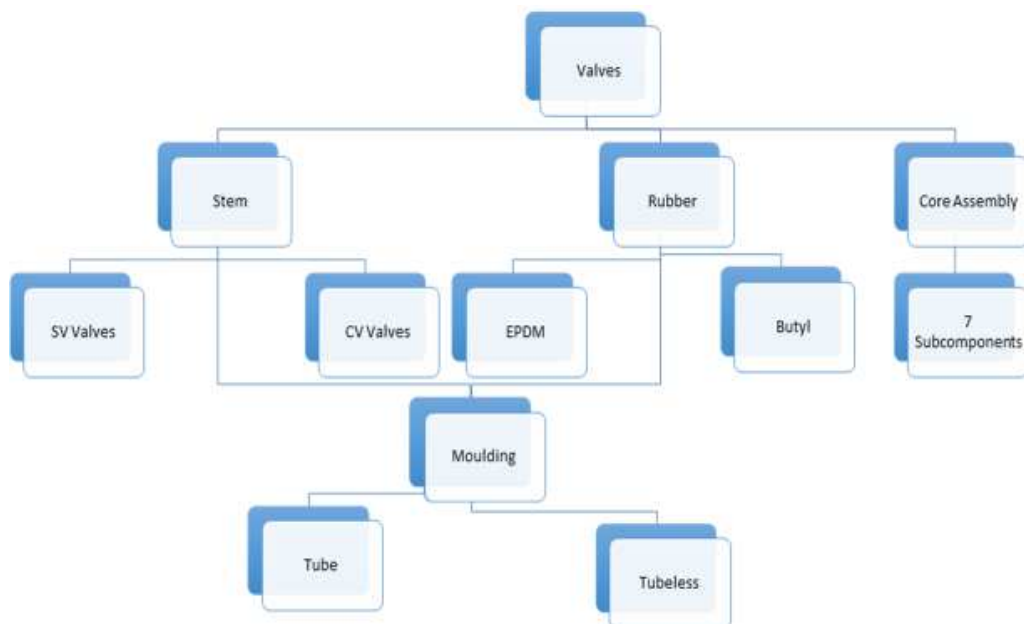
**Identifying which of the process elements incur fixed costs and which constitute variable costs as units are produced**

- Basically most of the activities coming under preventive costs & some under appraisal costs incur fixed costs for example, quality system audits, supplier audits, etc. are generally considered as overheads as in Poka Yoke, and maintenance costs.
- But some of the appraisal costs like inspection & testing and many internal failure costs like rework, scrap, sorting, etc. incur costs per batch of units produced

- This information will help us classify & ascertain systematically all the relevant activities under each COQ component.

**Collecting the information about the various sub components which are produced in Triton Valves:**

- This step is based on our information collected and our observation of the production line.
- This step is critical to identify COQ measurements of which sub components are very critical in terms of higher number of defects/reworks wherever occurring.
- Based on our observation, we have classified the various sub components of valve assembly produced for both types of valves, shown in Figure 1.
- The areas where COQ measurements are most critical are tube and tubeless moulding processes, SV & CV valves stem manufacturing are next most critical, and the 7 subcomponents of the core assembly are the least critical. COQ measurement for other processes are of not much concern.
- The aim here is to classify COQ even for each subcomponent level which can be aggregated together to get total COQ for the whole assembly manufacturing.
- So all the important sub components become the cost drivers for allocating the overheads (even preventive costs).



**Figure 5: Process Diagram**

To ascertain the preventive costs to the number of units produced under each sub components per month, the information collected is:

- Based on the inputs provided by the company, this is the most crucial step to map preventive costs systematically to every sub component level
- Triton Valves devised a new quality control plan for the tube valves molding process. New Quality Control Plan comes under preventive costs. If they had incurred a total cost of Rs 10,00,000.00 planned for the whole year and if it is forecast to produce 14.25 crores tube valves this year, then the calculation are as follows:

- For the month of August, if Triton Valves actual production is 95 lakhs tube valves. So the allocated quality control plan cost monthly for tube valve is:

Rs 10 Lakh\*(95 Lakh/14.25 Crore) = Rs 66666.67 for August this year.

- This cost has mapped in the preventive costs for tube valves (for new quality control plan) in the monthly COQ dashboard
- Similar we can repeat this exercise for every such fixed preventive costs for every sub component per month which can be aggregated together to give total assembly's COQ per month.

## Section VI : The COQ software

### Inputs to the Software

#### Values & Cost (Master Sheet)

Segment	Item Name	Value	INTERNAL FAILURE COSTS			EXTERNAL FAILURE COSTS		APPRAISAL COSTS
			Internal Product Scrap/Rejections			Warranty	Replacement	Testing
			Stem Rejection	Mould Rejection	Final Rejection			
CORE	TRC1	1.85	0.48	1.67	1.67			
	TRC 1(INS)	1.85	0.48	1.67	1.67			

Figure 6: Values & Cost Sheet

This sheet has to be filled with the all the basic costs which has been and it has to be updated once in a month. This sheet carries the information for the cost like purchasing cost, rejection cost, warranty cost, rejection cost and testing cost. Since this sheet has to be updated once in a month, it has been kept hidden in order to avoid any tempering of data due to any confusion.

#### Database

This sheet has the value of each item for every day. It tells us about the cost incurred by an item from start to finish. Since this sheet has to be updated once in a month, it has been kept hidden in order to avoid any tempering of data due to any confusion.

#### Prevention Cost

Method	Costs in Rs
Quality Audits	
Training Costs	
Calibration Costs	
Kaizen Costs	
Total	0.00

Figure 7: Prevention Cost Sheet

Prevention costs are incurred to prevent or avoid quality problems. These costs are associated with the design, implementation, and maintenance of the quality management system. Here we have included four factors in Prevention cost. It includes cost occurred due to quality audits, training costs, calibration costs and Kaizen costs has to be filled manually. This sheet has to be filled monthly once.

**Daily Sheets**

Segment	Item Name	Value of Goods Inwarded to FG		INTERNAL FAILURE COSTS								EXTERNAL FAILURE COSTS															
				Internal / Product Scrap / Rejections						Total Internal Failure Cost	Total Internal COPQ as % of COGS	Replacement		Warranty		Complaint Visit Time	Material Return	Analysis	Total External Failure Cost	Total External COPQ as % of COGS							
		Scrap Rejection		Model Rejection		Final Rejection		No of Defects	Cost			No of Defects	Cost	No of Defects	Cost						No of Defects	Cost	No of Defects	Cost			
		No of Units	Value	No of Defects	Cost	No of Defects	Cost			No of Defects	Cost					No of Defects	Cost	No of Defects	Cost	No of Defects					Cost		
COE	FR1		20.00		20.00		20.00		20.00																		
	FR2		20.00		20.00		20.00		20.00																		
	FR3		20.00		20.00		20.00		20.00																		
	FR4		20.00		20.00		20.00		20.00																		
	FR5		20.00		20.00		20.00		20.00																		
	FR6		20.00		20.00		20.00		20.00																		
	FR7		20.00		20.00		20.00		20.00																		
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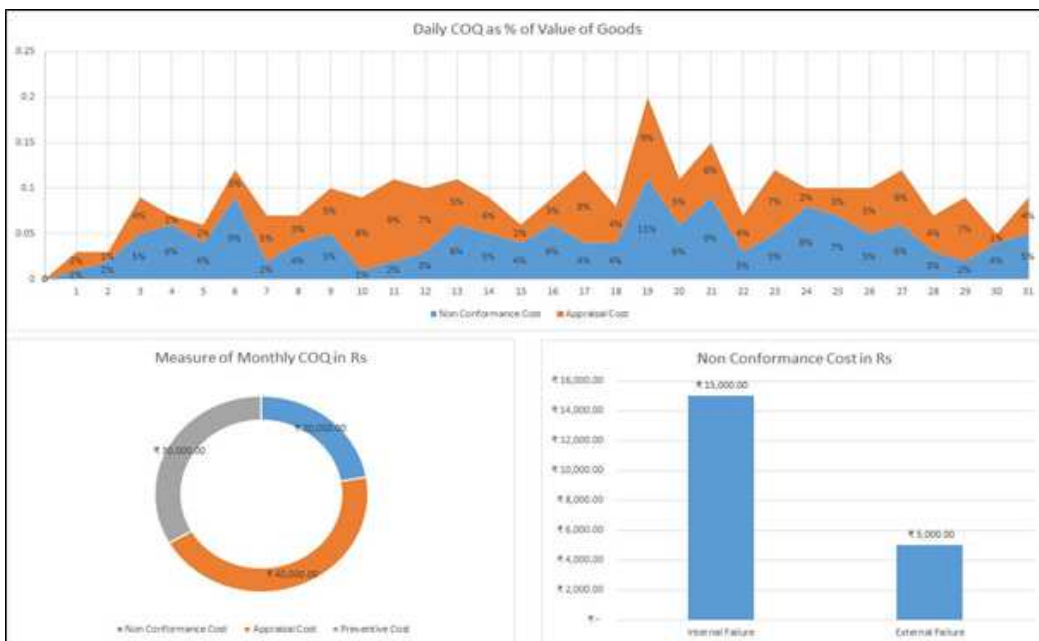
**Figure 8: Daily Sheet**

There are 31 daily sheets which have to be updated on the daily basis. This sheets includes segments under which item or components are mentioned. After that first column is for Value for Goods inwarded. It is further divided into two columns, first is number of units and second column is for value of the that good. Number of units has to be filled on the daily basis and the value of per unit will be directly retrieved from the master file and then it will be multiplied by the number of units and the total value will be shown here. Similarly, in every field, number of defects has to be filled.

This sheet also shows the graphical representation of non-conformance cost vs internal and external failure cost. Also graphical representation of daily COQ vs non-conformance cost and appraisal cost is displayed. This will help the user to analyses the daily performance in regards to COQ.

**Outputs from the customized Excel Software**

**Monthly Dashboard**



**Figure 9: Monthly Dashboard**

This is the main sheet where user can view the monthly performance of the company. This sheet mainly consists of three graphs. First is daily COQ as % of value of goods vs non-conformance cost and appraisal cost. Costs incurred from failure to meet product quality requirements. Nonconformance costs results from production imperfections and encompasses both internal and failure costs. Appraisal costs are associated with measuring and monitoring activities related to quality. These costs are associated with the suppliers and customers' evaluation of purchased materials, processes, products, and services to ensure that they conform to specifications. This graph will give an idea of appraisal cost and non-conformance cost in comparison to daily COQ.

Second graph is for measure of monthly COQ vs non-conformance cost, appraisal cost and prevention cost. Prevention costs are incurred to prevent or avoid quality problems. These costs are associated with the design, implementation, and maintenance of the quality management system.

Third graph is for non-conformance cost vs internal and external failure cost. Through this

graph user can track monthly internal and external failure costs. They can compare internal and external cost and take decisions to improve the process which is contributing more.

**Report**

This sheet will show the final outcome or result of complete one month. It will show the total cost incurred in the COQ process. There is one benefit of this sheet is that one can also view

the result. Suppose someone wants to see the results for one week, he/she can select the date in duration box then select the item from the drop-down menu and at last value can be selected. Here value refers to the factor based on the which the user wants to see the result. One can get the sum as well as the average of a particular value for a particular SKU, or a segment or the whole total.

<b>Item</b>	TRC1	<b>Duration</b>			<b>Value</b>	
<b>Sum</b>	-					
<b>Average</b>	-					
<b>Percentage</b>	-					

**Figure 10: Report Sheet**

### Instructions

- 1) 31 Sheets correspond to the respective number of days in a month from Day 1 to Day 31
- 2) So use this template monthly. Save a master copy of this excel workbook & keep aside.
- 3) In daily sheets, enter data corresponding to number of units in cells highlighted
- 4) In daily sheets, do not enter in the other cells
- 5) In daily sheets, cells corresponding to total costs for each sub unit for individual COQ component is highlighted
- 6) In daily sheets, cells corresponding to total costs for each individual COQ component is highlighted
- 7) The rows & columns are in fixed pane so as to provide convenience in tracking and entering a particular number of units
- 8) In daily sheets, there is a dashboard keeping daily track of non-conformance costs & appraisal costs as percentage of value of goods
- 9) Since prevention costs are to be tracked monthly, please enter the respective costs in cells in Prevention Costs sheet highlighted
- 10) The Monthly Report Sheet shows a dashboard tracking daily COQ as percentage of COGS (appraisal & non-conformance costs only) & also measure of monthly COQ. Please don't temper this sheet
- 11) In the sheet named report, we get the sum as well as the average of a particular value for a particular SKU, or a segment or the whole total.
- 12) After selecting a particular SKU, choose the duration for analysing a particular value e.g. warranty. All selections to be made on cells highlighted
- 13) For obtaining a data for a particular day only type the start & end with the same date value in the duration cells
- 14) The sheet named database can be used for further data extraction and linking as an actual database of the unique cost elements

## Section VII : Benefits of using the COQ workbook

The CoQ workbook forms a means of providing a first step towards controlling costs and quality improvement activities. This is so because it provides a visual means of tracing at which day the non-conformance costs or the testing costs have shot up. The workbook provides means of even tracing back which item segment production was responsible for this increase of non-conformance costs and we can also pinpoint exactly as which sub-component or SKU of that particular segment caused the glitch. Thus there is a deeper scope of cause and effect analysis to find the root cause of problem and help us in quality improvement.

Theoretically it is said that if the preventive costs are more than the appraisal costs and much more than the failure costs, then the quality control program is going in the right direction. Thus we can check this with the help of our dashboards if the preventive costs keep in check the non-conformance costs both monthly as well as in daily basis, so as to see if the quality control methods employed by Triton valves is in right direction. Also it shall help solve the company's dilemma whether they do excess appraisal and testing than required.

The daily entry sheet is user friendly and helps us enter the respective values of internal rejections, the produced units, etc. for each SKU effectively with the help of its "slide and track referencing" means. Also these daily entry sheet forms the basis for this whole COQ workbook as well as for the tracking of quality costs. The values are automatically calculated and fed to the database, once appropriate values are entered.

The report helps find the cumulative COQ for any required duration and for any SKU, or product line and also for any parameters, like stem internal rejection, internal rejection, or the total non-conformance, and delivers the output in terms of value, the average value for that duration and also as percentage of the costs to the total value of that goods produced (COQ percentage). This is the most efficient and effective result tab of the whole software and is better than several graphs and charts in a dashboard.

The values and cost master sheet is very user friendly tab. This is so because, suppose in future there will be changes in the process for which there will be changes in the cost of every process. So a single number change in the master sheet shall populate it in all the sheets throughout the workbook. Suppose in future, Triton Valves were to add more SKU item for some components say core or CV, etc, we can type them in the vacant spaces in the "Item Name" column of the master sheet, typing its subsequent costs that shall be populated throughout the workbook. Had the individual costs been written in all sheets instead of a master sheet, the whole book would be obsolete due to its inability to carry out the tasks explained in the above steps.

The critical sheets of this software like Values and costs master sheet and the database are hidden and password protected. This is done so as to maintain the confidentiality of the critical values and costs data with the data entry employees, and that such things should be subject to change even by accidental entry.

The database tab that pertains to each and every costs measurement is an important tab as it can be further used for data mining activities for the whole year when all the databases are combined together in a data warehouse so as to get a bigger picture and help with the decision making context for the top level management.

Lastly, this COQ software primarily being an excel workbook is reusable and can be used for several months, keeping a copy unedited as a master sheet. Thus, a basis for internal comparison between products, processes, and departments is facilitated by this COQ measuring excel workbook.

## **Section VIII : Limitations of the COQ workbook**

This COQ software primarily being an excel workbook is prone to similar limitations as another excel workbook in terms of calculations and data entry. One must be careful while entering the values in the Values and Costs Master sheet as it is the backbone of this software. It is very case sensitive and if we enter a non-numeric value in the cells where we are supposed to enter numbers, then we shall get errors throughout the workbook and finally the dashboard will not function. Also if the data entrant does

accidental entry in the daily sheet, then we can get errors for the analysis of that day. But one relief is that this error is easily traceable, and one needs to trace backwards as where the error was first committed. This is easy to do so because of the interlinking of those required cells and sheets in the software.

## **Section IX : Extensions of the Scope of the COQ Workbook**

We have used this software in automotive spares sector applications. This was so because the cells, columns, rows and the sheets were specifically designed as per the information that we obtained from our client who deals with valves, with respect to their product lines, different SKUs for every segment, their manufacturing process, their testing and quality processes, and information on various critical points where inspections are done and failures take place.

But the concept of the COQ, the basic skeleton of the software like the database, and values and costs master sheet, daily sheets and the dashboards shall remain the same for applications in any sectors and industries as referenced through the literature review from several papers. Thus the scope of this software can be extended to any industries say even pharmaceutical companies. Only necessity is the know-how of product, process, and the departments.

## **Section X : Suggestions for improvement**

We can do further thorough study on concepts of Microsoft excel so as to find means of editing only the required cells and protecting the other critical cells of a sheet, so as to avoid accidental entry into critical cells containing formulas or an entry of non-numeric value into a number input cell.

Instead of excel, we can further extend the scope of this COQ software using other third party software to get better pictorial representation of data and analytical processing abilities.

We can make this COQ excel workbook available online in the company network which can be accessed by authorized personnel for a particular functions say data entry or view only. One such option possible is the Google Sheets format for this COQ software.

As a suggestion to the Triton Valves Mysore, we propose that they implement this COQ software as soon as possible so as to allow quality improvement processes to be measured monetarily and that the top management can foresee where their quality improvement programs are heading and make the right decisions.

**Annexure**

Sr. No	Segment	Item Name	Vau e of Goods Inwarded to FG	
			No of Units	Value
1	CORE	TRC1		₹ 0.00
2		TRC 1(IN S)		₹ 0.00
3		0		₹ 0.00
4		0		₹ 0.00
5		0		₹ 0.00
6		0		₹ 0.00
7		0		₹ 0.00
8		0		₹ 0.00
9		0		₹ 0.00
<b>Total</b>			0	₹ 0.00

*Figure 11: Daily Sheet with item Name*

EXTERNAL FAILURE COSTS									
Replacement		Warranty		Complaint Visit Travel	Material Return	Analysis	Total External Failure Cost	Total External COPQ as % of COGS	
No of Defects	Cost	No of Defects	Cost	Cost	Cost	Cost			
	₹ 0.00		₹ 0.00						
	₹ 0.00		₹ 0.00						
	₹ 0.00		₹ 0.00						
	₹ 0.00		₹ 0.00						
	₹ 0.00		₹ 0.00						
	₹ 0.00		₹ 0.00						
	₹ 0.00		₹ 0.00						
	₹ 0.00		₹ 0.00						
	₹ 0.00		₹ 0.00						
0	₹ 0.00	0	₹ 0.00	-	-	-	₹ 0.00	#DIV/0!	

*Figure 12: Daily Sheet View for External Failure Costs*

INTERNAL FAILURE COSTS							
Internal Product Scrap/Rejections						Total Internal Failure Cost	Total Internal COPQ as % of COGS
Stem Rejection		Mould Rejection		Final Rejection			
No of Defects	Cost	No of Defects	Cost	No of Defects	Cost		
	0.00		0.00		0.00		
	0.00		0.00		0.00		
	0.00		0.00		0.00		
	0.00		0.00		0.00		
	0.00		0.00		0.00		
	0.00		0.00		0.00		
	0.00		0.00		0.00		
	0.00		0.00		0.00		
	0.00		0.00		0.00		
	0.00		0.00		0.00		
0	0.00	0	0.00	0	0.00	0.00	#DIV/0!

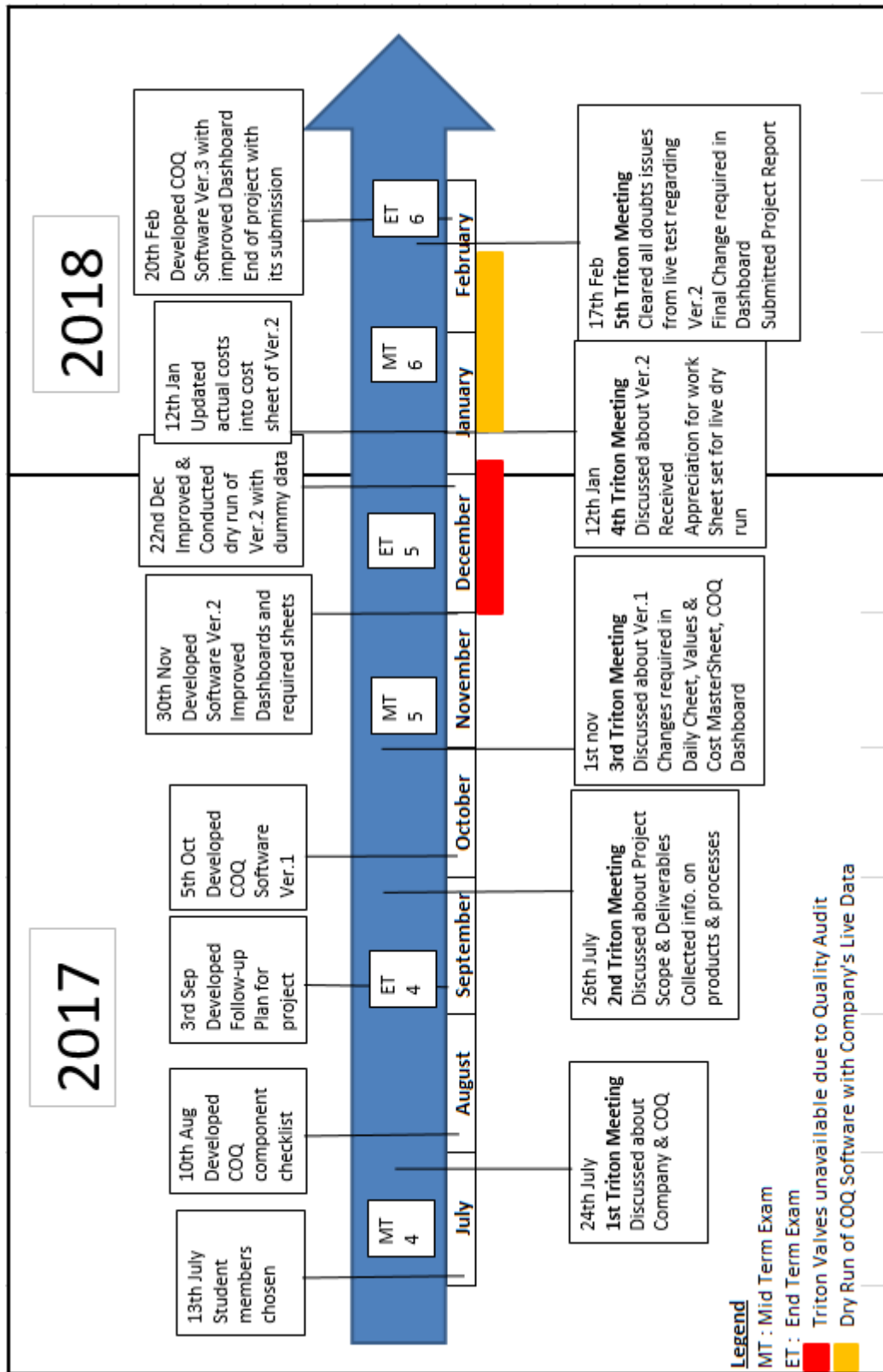
Figure 12: Daily Sheet view for Internal Failure Cost

APPRAISAL COSTS			
Testing		Total Appraisal Cost	Total Appraisal Cost as % of COGS
No of Defects	Cost		
	0.00		
	0.00		
	0.00		
	0.00		
	0.00		
	0.00		
	0.00		
	0.00		
	0.00		
0	0.00	0.00	#DIV/0!

Figure 14: Daily Sheet view for Appraisal Costs



Project Time Line



## References

- Cost of Quality (COQ). (n.d.). Retrieved February 01, 2018, from <http://asq.org/learn-about-quality/cost-of-quality/overview/overview.html>
- (n.d.). Retrieved January 14, 2018, from [http://www.tritonvalves.com/about\\_us.html](http://www.tritonvalves.com/about_us.html)
- Batley, T. (1993). Comparative Perceptions of Product Quality Management. *International Journal of Quality & Reliability Management*, 10(4). doi:10.1108/02656719310038630
- Campanella, J. (2000). *Principles of quality costs: principles, implementation, and use*. Milwaukee, WI: ASQ Quality.
- Albright, TL. And Roth, H.P. (1992), "The Measurement of Quality Costs: An alternative Paradigm", *Accounting Horizons*, p.15
- Allen, N. and Oakland, J.S. (1988), "Quality assurance in the textile industry: part 1," *International Journal of Quality and Reliability Management*, Vol.5 No.5, p.25
- ASQC (1970), "Quality Costs – What and How", *American Society for Quality Control*, pp.54
- Atkinson, J.H., jr., Hohner, G., Mundt, B., Troxel, R.B. and Winchell, W. (1991), *Current trends in Cost of Quality: Linking the Cost of Quality and Continuous Improvement*, NAA Publication, Montvale
- Baatz, E.B. (1992), "What is return on quality, and why you should care", *Electronic News*, October, p.60
- Bohan, G.P. and horney, F.N. (1991), "Pinpointing the real cost of quality in a service company", *National Productivity Review*, Vol.10, No.3, p.309
- Bottorff, D.L. (1997), "CoQ Systems: The right stuff", *Quality Progress*, March, p.33
- Breeze, J.D. (1981), "Quality cost can be sold: part 1", *ASQC Technical Conference Transactions*, p795