

# Pareto Analysis of the Engineering Related Quality Issues of Rural Electrification Projects

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**Abstract**—This case study aims to identify the Causes and Reasons behind different Quality Issues and determine Potential Risks related to the Engineering Department of the Rural Electrification Projects Division of Vijai Electricals Limited. Data has been gathered from the different documents maintained in the Engineering Department, Emails and Minutes of Meetings and via face to face interview of the employees of the Engineering Department, of the Projects Division, of Vijai Electricals Limited. Pareto Analysis was done to identify the most significant Causes and Reasons of Quality Issues. The Pareto Analysis helped us to identify the most significant Causes and Reasons behind different Quality Issues and determine Potential Risks related to the Engineering Department of the Rural Electrification Projects. Implementation of the Preventive Actions mentioned against the most significant Causes and Reasons behind Quality Issues can help avoid approximately Eighty Percent of Identified Risks or Future Quality Issues.

**Key words**—Pareto Analysis, Potential Risk Identification, Quality Management, Rural Electrification Projects.

## I. INTRODUCTION

Quality management ensures that an organization, product or service is consistent. It has four main components: quality planning, quality assurance, quality control and quality improvement. Quality management is focused not only on product and service quality, but also on the means to achieve it. Quality management, therefore, uses quality assurance and control of processes as well as products to achieve more consistent quality. [3]

**Modern quality management complements project management. Both disciplines recognize the importance of:**

- ✓ Customer satisfaction - Understanding, evaluating, defining and managing expectations so that customer requirements are met. This requires a combination of conformance to requirements (to ensure the project produces what it was created to produce) and fitness for use (the product or service must satisfy real needs). [3]
- ✓ Prevention over inspection - One of the fundamental tenets of modern quality management states that quality is planned, designed, and built in—not inspected in. The cost of preventing mistakes is generally much less than the cost of correcting them when they are found by inspection. [3]
- ✓ Continuous improvement - The plan-do-check-act cycle is the basis for quality improvement as defined by Shewhart and modified by Deming. In addition, quality improvement initiatives undertaken by the performing organization, such as TQM (Total Quality Management) and Six Sigma, should improve the quality of the project's management as well as the quality of the project's product. Process improvement models include Malcolm Baldrige, Organizational Project Management Maturity Model and Capability Maturity Model Integrated. [3]
- ✓ Management Responsibility - Success requires the participation of all members of the project team, but remains the responsibility of management to provide the resources needed to succeed. [3]

In Quality Management, ISO 9000 is considered to be the most important and most recognised International standards. The aim of the ISO 9000 family of standards is to help different companies to effectively document and maintain an efficient quality system. The ISO 9000 standards are not specific to any one industry and can be applied to organizations of any size. ISO 9000 can help a company satisfy its customers, meet regulatory requirements, and achieve continual improvement.

In the early days, the ISO 9001 (9002 and 9003) requirements were intended to be used by procuring organizations, as the basis of contractual arrangements with their suppliers. But the present ISO 9001 standard is generic in nature. Different parts of the standard must be carefully interpreted to make sense within a particular organization. Diverse organizations including — Manufacturing plants (manufacturing units of Vijai Electricals Limited), Software companies (Tata Consultancy Services, Wipro Limited, Infosys Limited), Banks (Canara Bank, India), Hospitals (Manipal Hospital, Bangalore), Police departments (United

States), Professional Soccer Teams (Mexico), and City Councils (UK), — have successfully implemented ISO 9001 systems. [5][6][7]

## II. RISK BASED THINKING AS PER ISO 9001:2015

One of the key changes in the 2015 revision of ISO 9001 is to establish a systematic approach to considering risk, rather than treating "Preventive Actions" as a separate component of the quality management systems.

Risk based thinking ensures the risks are identified, considered and controlled with the help of the quality management Systems.

The organization shall determine external and internal quality issues, relevant to each process and identify the effects of these issues and determine control measures. [9][10][11]

This case study aims to identify the Causes and Reasons behind different Quality Issues and determine Potential Risks related to the Engineering Department of the Projects Division of Vijai Electricals Limited (Hyderabad), which is an ISO certified organization.

## III. VIJAI ELECTRICALS LIMITED COMPANY PROFILE

Vijai Electricals Limited was established in the year 1975 in Balanagar, Hyderabad and expanded its Manufacturing operations to different units located in India and abroad. Vijai Electricals Ltd. one of the largest and leading manufacturer-exporters of Power and Distribution Transformers up to 15 MVA, 66 kV class in India with a turnover (2008-2009) of around US \$ 302 Million. It was a benchmark for the organization when it plunged in to the manufacturing of Extra High Voltage Power Transformers with technical Collaboration from M/s Daihen Corporation, Japan, to meet the Generation and Transmission needs of the country. The organization has also diversified into the manufacture of Switchgear products, Conductors and AB Cables.

Vijai Electricals Limited has made an impact in the industry and its products have been inspected and accepted by several internationally reputed third-party Inspection Agencies like Lloyds-UK, Crown Agents- UK, BSI Inspectorate Griffith -UK, Bureau Veritas, OMIC Japan, CAPE- Thailand, Societe Generale de Surveillance (S.G.S), Tuboscope Vecto GmbH - Germany, Robert W. Hunt Organization, RITES and AT Survey & Inspection Company – Bangladesh.

Corporate Head Office of the Organization is located in Somajiguda, Hyderabad.

The Projects Wing, of Vijai Electricals Limited, started operation from year 2003 and now it is carrying out major projects in Transmission and Distribution of Power, in different States, all over India.

As this case study aims to identify the Causes & Reasons behind Quality Issues and determine the Potential Risks related to the Engineering Department of the Projects Division of Vijai Electricals Limited, it is important for us to discuss the Scope of Work of Projects Division and then describe various activities of Engineering Department of VEL (Vijai Electricals Limited) Projects Division. [8]

### *Detailed Scope of Work of Projects Wing of Vijai Electricals Ltd.:*

The Turnkey Projects done by Vijai Electricals Limited are under different schemes of Govt. Of India like Accelerated Power Development Reforms Programme (APDRP), Integrated Power Development Scheme (IPDS), Deendayal Upadhyaya Gram Jyoti Yojana (DDUGJY), Pradhan Mantri Sahaj Bijli Har Ghar Yojana—"Saubhagya" and direct work of different State Electricity Boards.

#### A) Rural Electrification Line Work -

Rural Electrification Line Work comprise of Installation, Testing and Commissioning of 33 KV, 11 KV & LT Overhead Lines, Aerial Bunched Cables, Underground Cables, Consumer connections and Distribution Transformers.

#### B) Substation Works -

Substation work comprise of Construction of New Substations, Augmentation of the existing one, for transformation capacity, construction of new bays, and extension of the existing bays.

#### C) High Voltage Distribution System (HVDS) -

Execution and consultancy services for upgrading the existing Distribution System to Higher Voltage.

#### D) Extra High Voltage Systems -

Installation, Testing and Commissioning of EHV (Extra High Voltage) Lines and Substations.

### *The various activities of Engineering Department of VEL Projects Division, are listed below:*

1. To review the technical & safety specification and relevant schedules of tenders for RE (Rural Electrification) works and Substations.
2. Preparation of Bill of Quantities for both supply and erection portion of RE works and substations during pre tendering stage, L1 stage and Post award stage.
3. Preparation of survey guidelines for Site and Execution team.

4. Verification of GTP (Guaranteed Technical Particulars), Drawings and Type Test Reports (received from different suppliers) of equipments and obtaining approvals of Equipment drawings from customer.
5. Submitting BOQ (Bill of Quantities), Survey diagrams to customer and obtaining approvals from customer.
6. To review and update the survey progress.
7. To arrange soil investigation at sites and preparation of designs, calculations and civil drawings (Foundations, structures and foundation layouts) for approval and obtaining approval from customer.
8. Preparing, Reviewing and obtaining approvals of Erection drawings of Lines and Substations from customer.
9. To issue BOQ for supply and erection portion of Lines and Substations to concerned.
10. Preparation of As built drawings and obtaining approval from customer.
11. Circulating the final approved technical documents to all concerned.

#### **Quality Policy of Vijai Electricals Ltd.:**

The Company has well-established Quality systems to ensure quality at all stages and Total Quality Work Culture, where participation by everyone reigns supreme. Quality is a watchword across the entire Organisation and has proved to be a corner stone for the Company's sustained growth and success. The Company today has the latest certification for compliance to ISO 9001:2008. The ISO 9001:2008 certification is presently being updated to ISO 9001:2015. Enhancing Customer satisfaction is the prime objective of the Quality Policy of the company. [8]

#### **IV. BACKGROUND STUDY**

##### **Pareto Principle:**

The pattern underlying the 80/20 Principle was discovered in 1897, by Italian economist Vilfredo Pareto (1848–1923). His discovery has since been called many names, including the Pareto Principle, the Pareto Law, the 80/20 Rule, the Principle of Least Effort and the Principle of Imbalance. [1]

The 80/20 Principle states that there is an inbuilt imbalance between causes and results, inputs and outputs, and effort and reward. Typically, causes, inputs or effort divide into two categories:

- ✓ The majority, that have little impact.
- ✓ A small minority, that have a major, dominant impact.

Typically all, results, outputs, problems or rewards are derived from a small proportion of the causes, inputs or effort responsible for producing the results, outputs, problems or rewards.

The relationship between causes, inputs or efforts on the one hand, and results, outputs, problems or rewards on the other, is therefore typically unbalanced. When this imbalance can be measured arithmetically, a good bench mark for the imbalance is the 80/20 relationship—80 per cent of results, outputs, problems or rewards are derived from only 20 per cent of the causes, inputs or effort. [1]

##### **Pareto Chart:**

A Pareto chart is a graphic representation of the frequency with which certain events occur. It is a rank-order chart that displays the relative importance of variables in a dataset and may be used to set priorities regarding opportunities for improvement. [2]

A Pareto Chart is a tool that helps in prioritizing quality issues. It is often used to analyse the data collected using check sheets. This chart consists of bars and line graphs. Bars are used to represent individual values in descending order, whereas line graphs are used to show the cumulative frequencies. Thus, bars are arranged in a descending order in the chart from left to right. This implies that values represented on the left are more significant as compared to those on the right.

A Pareto Chart is based on the Pareto principle (80/20) according to which 80% problems come from 20% of causes. In simpler words, Pareto principle suggests that 80% of quality issues arise because of 20% reasons.

Basically, this chart breaks a big problem into smaller parts, recognizes the most significant factors, and highlights the areas to be focused more, based on the quality issues. In addition, the chart helps in utilizing the limited resources of organisations in the most efficient manner. For example, without the help of Pareto Chart, organisations would require to investigate each and every reason of quality issues with equal efforts. This would involve a high cost and effort. However, a Pareto Chart helps in identifying the most significant reasons for quality issues. Therefore, organisations can put more effort in resolving the most significant reasons first.

Therefore, we can see that a Pareto Chart can be used to analyse different types of quality issues, starting from product defects to glitches in the systems ranging from production to quality. In addition, service quality profitability of services, such as banking, telecommunications, and travel, is done on the basis of Pareto analysis. [2][4]

##### **Pareto Analysis :**

The following steps are followed to find out the most significant seasons for quality issues through Pareto analysis:

- ✓ First we will make a table, list the causes of quality issues, and write down their percentage frequencies in a descending order.
- ✓ Next we will add new column named “Cumulative percentage” to the table and calculate the Cumulative percentages.
- ✓ We will plot the causes of quality issues on the x Axis and cumulative frequencies on the y Axis.
- ✓ Now we will join the points of the graph to make a curve.
- ✓ We will plot a bar graph with the causes/reasons of quality issues on the x Axis and percentage frequencies on the y Axis on the same graph.
- ✓ We will draw line on the y Axis parallel the x-Axis at 80%.
- ✓ Now we will drop the line (AB) on the x Axis from the point the 80% cut off line intersects the Cumulative percentages curve.
- ✓ This line separates the most significant reasons on the left from the less significant reasons. Thus the Pareto Chart helps in prioritizing quality issues and improves quality. [2][4]

## V. RESEARCH METHODOLOGY

- ✓ Data has been gathered from the following documents maintained in the Engineering Department:

1. VELP/ENGG/REC/04 - Continual Improvement (Retention Period - 3 Years).
2. VELP/ENGG/REC/07 - Corrective and preventive Action Report (Retention Period - 2 Years).

All quality issues related to Engineering Department are not documented, and the data is not readily available. Therefore data has also been collected from other resources, as mentioned.

- ✓ Data has been gathered via face to face interview of the employees of the Engineering Department of the Projects Division of Vijai Electricals Limited (Hyderabad).
- ✓ Emails and Minutes of Meetings, for the month of March, April and May 2018, were referred in order to collect data related to Causes of Quality Issues in the Engineering Department of Rural Electrification Projects Division.

Data or Information from Confidential Documents or Controlled Copy documents were not used for the purpose of this study.

## VI. OBJECTIVE OF THE CASE STUDY

- ✓ To identify different Causes and Reasons behind Quality Issues, related to Engineering Department of Rural Electrification Projects for the months of March, April and May 2018.
- ✓ To calculate Percentage of Occurrence and Cumulative Percentage of the different Causes and Reasons behind Quality Issues identified.
- ✓ To identify the most significant Causes and Reasons behind Quality Issues, related to Engineering Department of Rural Electrification Projects in the months of March, April and May 2018, with the help of Pareto Analysis.
- ✓ To determine the prominent Effects, of the identified Quality Issues.
- ✓ To find the Corrective Actions / Solutions to the Quality Issues identified by Pareto Analysis. Approximately 80% of Quality Issues related to Engineering Department of Rural Electrification Projects (identified for the month of March, April and May 2018) can be resolved with the help of these Corrective Actions.
- ✓ To find the Preventive Actions to the Quality Issues identified by Pareto Analysis. If these Preventive Actions are implemented, approximately 80 % of Quality Issues (identified for the month of March, April and May 2018) can be avoided in future.
- ✓ To offer suitable suggestions for improvement of Quality Management practices in the Engineering Department.

## VII. LIMITATIONS OF THE STUDY

- ✓ The Engineering Department only prepares the Survey Guidelines and monitor the survey done by Site and Execution team. Thus the Quality Issues related to Survey is not included under Engineering Department.
- ✓ Issues related to ERP (enterprise resource planning) software, update of data in ERP software and other IT related Issues were not considered in this study.
- ✓ Data or Information from Confidential Documents or Controlled Copy documents were not used for this case study.

## VIII. FINDINGS AND INTERPRETATIONS

### *Pareto Analysis 1:*

The Pareto Analysis 1, will help us determine the most significant “Causes of Quality Issues” related to Engineering Department of Rural Electrification Projects.

All Causes of Quality Issues were identified and noted. With the help of this data, Percentage of Occurrence and Cumulative Percentage of the different Causes of Quality Issues were calculated. (Table 1.)

Table 1. List of the Causes of Quality Issues Related to Engineering Department of Rural Electrification Projects along with Percentage of Occurrence and Cumulative Percentage



SI No.	Cause of Quality Issues	No. of Times of Occurrence	Percentage of Occurrence	Cumulative Percentage
1	Line Equipment	81	39.1	39.1
2	Substation Equipment	31	15.0	54.1
3	Line Drawings	25	12.1	66.2
4	Cables / Conductors	23	11.1	77.3
5	Civil Works	14	6.8	84.1
6	Substation Drawings	12	5.8	89.9
7	Poles	11	5.3	95.2
8	Meters	8	3.9	99.0
9	Nuts and Bolts	1	0.5	99.5
10	Other / Site	1	0.5	100.0

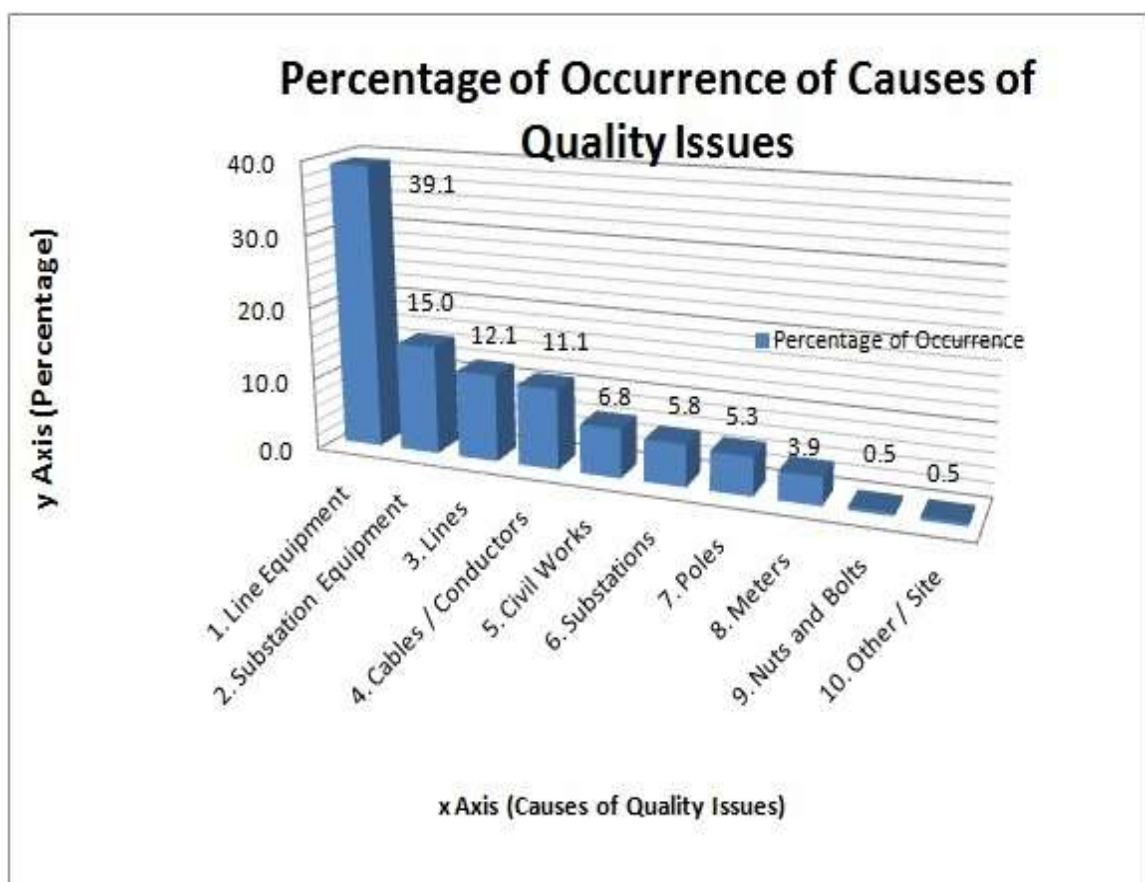


Figure 1. Percentage of Occurrence of Different Causes of Quality Issues Related to Engineering Department of Rural Electrification Projects.

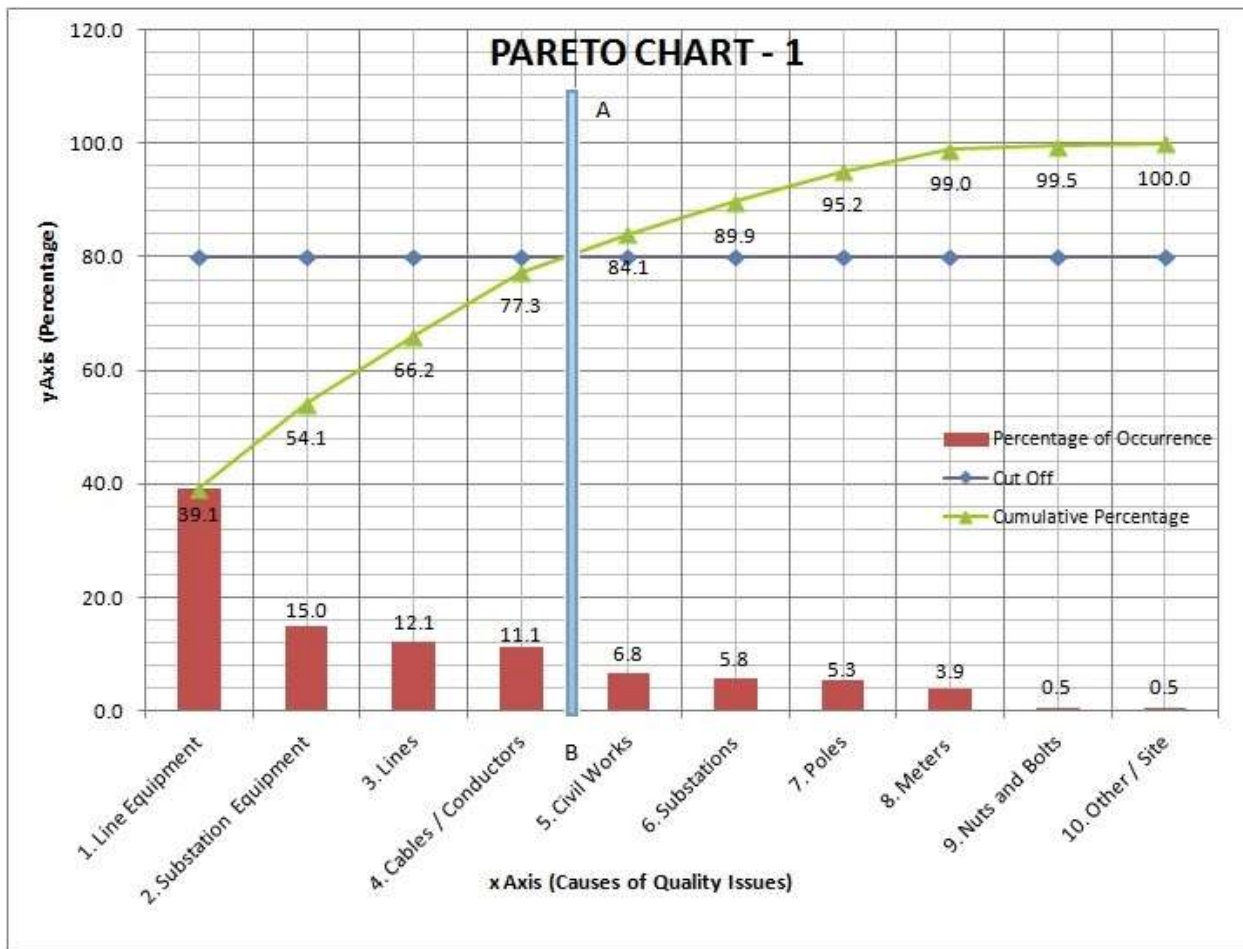


Figure 2. Pareto Analysis of the Causes of Quality Issues Related to Engineering Department of Rural Electrification Projects.

**Conclusion reached on the basis of Pareto Analysis 1:**

A line AB (Fig. 2.), parallel to the y Axis is drawn through the point where the Cumulative Percentage Curve, crosses the 80 % Cut Off Line. This line separates the most significant Causes of Quality Issues, on the left from the less significant Causes.

The Pareto Analysis of the “Causes of Quality Issues” identifies the following as the most significant :-

1. Quality Issues caused by Line Equipment.
2. Quality Issues caused by Substation Equipment
3. Quality Issues caused by Line Drawings
4. Quality Issues caused by Cables / Conductors

Maximum importance must be given to 4 mentioned Causes of Quality Issues to avoid approximately 80 % of Quality problems.

**Pareto Analysis 2:**

Now we will separately study the Reasons behind Engineering related Quality Issues.

Table 2. List of the Reasons behind Quality Issues Related to Engineering Department of Rural Electrification Projects along with Percentage of Occurrence and Cumulative Percentage

SI No.	Reasons behind Engineering Related Quality Issues	No. of Times of Occurrence	Percentage of Occurrence	Cumulative Percentage
1	Documents directly approved by customer without being initially scrutinized by VEL Engineering	55	25.5	25.5
2	Technical requirements not accurately / completely identified at tender stage	36	16.7	42.1
3	Clarifications given by Engineering Department not followed by supplier	21	9.7	51.9

4	Lack of clarity in technical specification / customer requirement	19	8.8	60.6
5	Wrong comments by customer during approval of documents	18	8.3	69.0
6	Approval pending with customer	16	7.4	76.4
7	Problem with first / L1 supplier	12	5.6	81.9
8	Customer asking for changes	11	5.1	87.0
9	Responsibility of / deviation by Supplier	6	2.8	89.8
10	Responsibility of / deviation by Execution	4	1.9	91.7
11	Improper Site selection by customer	4	1.9	93.5
12	Standards not available	4	1.9	95.4
13	Project specific special requirements	3	1.4	96.8
14	Technical requirements not accurately / completely identified at engineering stage	2	0.9	97.7
15	Total quantity is less	2	0.9	98.6
16	Type Test Report not available with supplier	2	0.9	99.5
17	Technical requirements not fulfilled by supplier	1	0.5	100.0

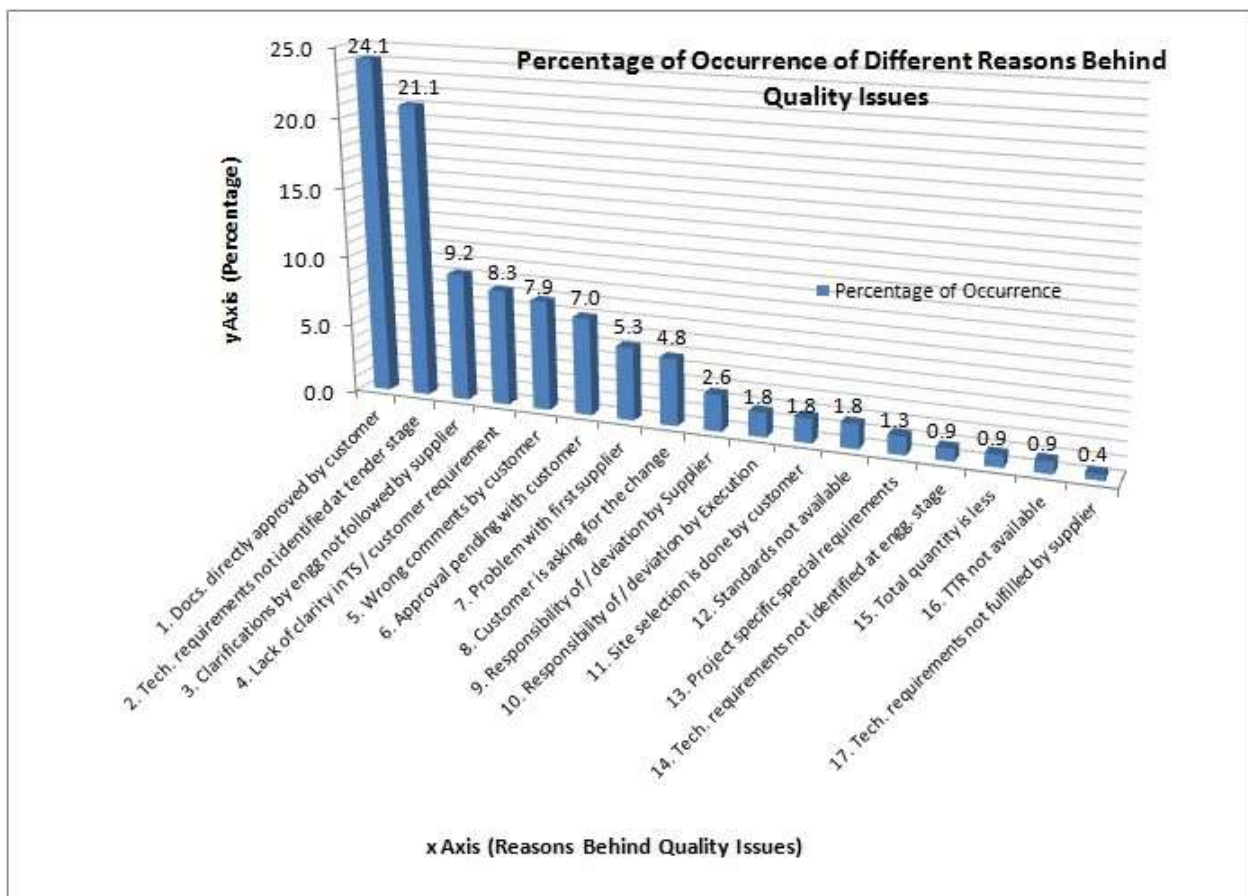


Figure 3. Percentage of Occurrence of Different Reasons behind Quality Issues Related to Engineering Department of Rural Electrification Projects.

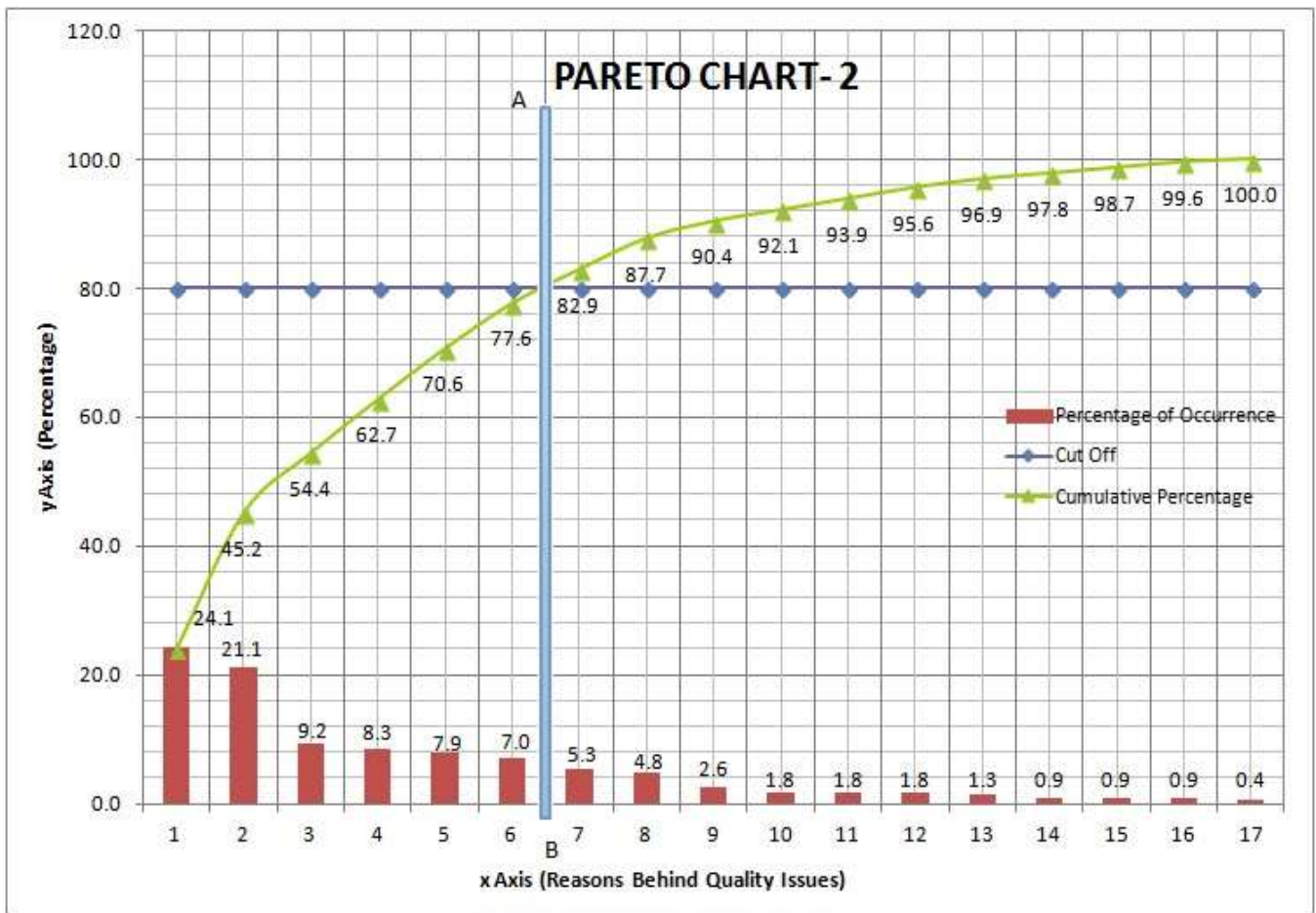


Figure 4. Pareto Analysis of the Reasons behind Quality Issues Related to Engineering Department of Rural Electrification Projects.

According to Pareto Principal 80 % problems come from 20 % of Reasons (approximately).

A line AB (Fig. 4.), parallel to the y Axis is drawn through the point where the Cumulative Percentage Curve crosses the 80 % Cut Off Line. This line separates the most significant Reasons behind Quality Issues, on the left from the less significant reasons.

The Pareto Chart (Fig. 4.) shows that the following Six Reasons behind Quality Issues related to Engineering Department of Rural Electrification Projects, to be most significant.

The reasons of quality issues are explained in detail along with Effects, Corrective and Preventive Actions in Table 3.

Table 3. Detailed Explanation of Significant Reasons behind Quality Issues along with Effects, Corrective and Preventive Actions.

Si. No.	Reasons behind Quality Issues	Effects of the Quality Issues	Corrective Actions	Preventive Actions
1	Sometimes customer gives generalized approval of documents. These documents related to Equipments, Lines and Substations are not initially scrutinized by VEL Engineering Department. In the last few months this has resulted in many Quality issues in different projects.	Deviation from Standards / TS / Requirements	Communication with Customer	All technical docs. must be scrutinized by VEL Engineering before approval by customer  All technical docs. must be scrutinized by VEL Engineering after approval by customer
		Redesign	Communication with supplier	
		Resupply	Redesign	
		Time Delay	Resupply	
2	Sometimes because of lack of time Technical requirements are not accurately identified during tender stage. This results in major quality issues in later stages of the projects.	Financial Loss	Maximum possible cost reduction	Technical requirements must be accurately identified at tender stage
		Time Delay	Communication with Customer Communication with supplier	
3	Sometimes clarifications given by engineering department, related to different equipment, are not followed by suppliers. This can cause quality issues	Deviation from Standards / TS / Requirements	Communication with supplier	Technical requirements must be accurately followed during supply



	during inspection of the equipment, after supply and during execution of the projects.			
4	Lack of clarity in Customer Requirements and Technical Specification provided by customer, results in many quality issues.	Time Delay	Communication with Customer	Technical requirements must be accurately identified at tender stage
5	Wrong comments are given by customer during approval of documents related to Equipments, Lines and Substations. These also results in many quality issues.	Time Delay	Communication with Customer	All technical docs. must be scrutinized by VEL Engineering after approval by customer
6	Customer delay in giving approval of documents. This is a significant quality issue and results in loss of valuable project time.	Time Delay	Communication with Customer	Communication with Customer

#### **Conclusion reached on the basis of Pareto Analysis 2:**

If the Corrective measures are taken for the above six seasons, 80% of Quality Issues, (identified for the months of March, April and May 2018) related to Engineering Department of Rural Electrification Projects, can be resolved.

The most significant Reasons behind Quality Issues, identified with help of Pareto analysis, can also be considered as significant Potential Risks. Thus the few Preventive actions mentioned (Table 3) can mitigate 80 % of the identified Potential Risks.

Implementation of the Preventive Actions mentioned (Table 3) against the six most significant Reasons behind Quality Issues can help avoid 80 % of Identified Risks / Future Quality Issues.

#### **IX. FUTURE RESEARCH POSSIBILITIES**

Separate Pareto analysis can be done on the Quality Issues of other departments of the Rural Electrification Projects division and the total data collected from all other departments can be used do a Pareto analysis of the entire Rural Electrification Projects division. This can help determine external and internal quality issues, relevant to each process and identify the effects of these issues and determine control measures i.e. Quality control throughout the organization.

Similar Pareto analysis can be done for any field of work and/or organization to establish Quality control and Risk management system throughout the organization.

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