Abstract: - The goal of reliability engineering is to ensure and to improve product reliability and safety, under the abnormal conditions. As part of safety related issues and mission accomplishment issues, the reliability tools (FMEA, MTBF etc.,) are helpful to avoid the irregular situations in Medium Voltage panel. Reliability engineering is involved in product design, test and maintenance actions, unit the whole process of end of life. The main thesis of this project is to analyze manufacturing procedure to estimate reliability of Medium Voltage (MV) Panel. The MV panel can provide an additional protection from the efforts of internal arcing faults. The major faults such as earth faults, over Voltage (OV), under Voltage (UV), Over Loads and the transformer faults will leads to reduce the performance of MV panel. MV panel reliability analysis process is mainly intended to bring out the process issues and failure modes on by using reliability tools like Reliability Prediction, FMEA concepts and MTBF calculations. The result of this test is going to be analyses using the reliability software adhering the military standards-217 F. The application of accelerated test will be used to improve the component or process for improvement of the system reliability.

Keywords: - Reliability, MTBF, FMEA, System reliability Prediction, military standards-217 F.

I. INTRODUCTION

According to international rules, there are only two voltage levels:

1. Low voltage: Within and including 1kV AC (1500V DC).
2. High voltage: More than 1kV AC (1500V DC).

The electrical appliances in which we are using in commercial purpose perform with low voltage. High voltage is used for transmitting electrical energy to very large distances, but also for regional distribution to load centres through fine branches and also high voltage levels are used for regional distribution and transmission purpose, because the task and purpose of switchgear and substations are very different, the term ‘medium voltage’ has come to be used for generating necessary voltage for regional power distribution which is the part of high voltage which ranges from 1kV AC to 52kV AC. The operating system of medium voltage panel ranges from 3kV AC to 40kV AC. The systems such as electrical transmission and distribution may not only connect power stations and also with their interconnected systems form a super regional backbone with reserve for reliable supply and also for the comparison of differences in load.

Low currents are preferred for power transmission such that it controls losses. Maximum 10 kV to 30kV range voltage is used in medium voltage systems in public power supplies. The values vary differently from different countries depending upon the usage of technology and local conditions.

II. RELIABILITY

The Reliability, R (t) is determined as the probability of different components or systems or devices obtain no failures within the time interval 0 to t1 such that the components or system was repaired in the sense of new condition or was functioning at t0. The unreliability, F (t) of the device or system for a specified time is the number of components failed to time t divided by the total number to samples tested. The following relation says that the device or system experience its first failure in the time interval zero to t or remain operating over this period.

\[ R (t) + F (t) = 1 \]

2.1 RELIABILITY PREDICTION

Reliability prediction is the main form of reliability analysis. Reliability prediction predicts failure rate of the component and total system reliability. From this prediction we can evaluate the design analysis and also we can able to compare design alternatives, potential failure areas can also be identified and tracking of reliability improvement can be done.

2.2 The ROLE OF RELIABILITY PREDICTION

Reliability Prediction has many roles in the reliability engineering process. The impact of proposed design changes on reliability is determined by comparing the reliability predictions of the existing and proposed
designs. The ability of the design to withstand the reliability level in specified environmental condition and can also be evaluated in different environmental conditions as per the requirement. Predictions can be used to evaluate the need for environmental control systems. The analysis of strength and withstand of the component can be evaluated by using reliability prediction analysis. From these results we can do analysis for the need of any subsystems, components or any backup systems. MIL-HDBK-217F, Bellcore (Electronic Reliability prediction) Provide failure rate and MTBF data for electrical, electronic parts and equipments. From this reliability prediction we can also analyse the importance of reported failures. By this result we can analyse further analysis such as a FMEA (Failure Modes and Effect Analysis), RBD (Reliability Block Diagram) or a Fault Tree analysis.

2.3 MEAN TIME BETWEEN FAILURE (MTBF)

In repairable items MTBF is the crucial measure of reliability. MTBF is the analysis of failures of a system or component or devices before the system fails, under specified conditions of a constant failure rate. MTBF can also be defined as the expected value of the time between two consecutive failures, for repairable systems. MTBF can be calculation of inverse of the failure rate, \( \lambda \). For example, a component consisting of failure rate of two failures per million hours the MTBF would be the inverse of that failure rate, \( \lambda \),

\[
\text{MTBF} = \frac{1}{\lambda}
\]

III. FAILURE MODE AND EFFECT ANALYSIS (FMEA)

- Failure modes and analysis (FMEA) is a step wise process to determine all failures in design and manufacturing process
- “Failure Modes” means the ways in which things inside the system might fail.
- “Effects Analysis” refers to studying the consequences of those failures and provides a basis for identifying root failure causes and for developing correct actions.
- Identifies reliability or safety critical components.
- By this we can able to investigate the design process in all stages.
- Provides a basis for different analysis like maintainability and logistics analysis.

3.1 History/Standards

- Reliability program or Equipment Development – Task 204, tells the procedures for performing FMECA.
- MIL-STD-1629 established for requirements and procedures to perform FMECA.
- Automotive suppliers may use SAE J 1739 FMEAs.
- QS-9000 standard.
- IEC 60812- It analyses techniques for system reliability procedure for FMEA.

IV. COMPONENTS

ROTATORY SWITCH:
A rotary switch is a switch in which the contacts are changed when the spindle is rotated in either a clockwise on an anticlockwise direction.

CURRENT TRANSFORMER:
Current Transformer is one of the devices which are used for stepping down current and voltage of the electrical power system for metering and protection purpose.

ELECTRIC LAMP:
By use of an Electric Lamp, we can able to create artificial light and it is an electric device.

ALPHANUMERICAL DISPLAY:
A Display that gives the information in the form of characters (numbers or letters).

AC AMMETER:
Designed to measure A.C. current, these meters indicate true Root Mean Square (r.m.s) values and are substantially independent of system waveform.

VACUUM CIRCUIT BREAKER:
It is a circuit breaker in which arc takes in vacuum. This is mainly medium voltage application. The functioning of device such as opening and close of current carrying contacts and arc interruption take place in a vacuum chamber inside the breaker which is called vacuum interrupter.

4.1 PROCESS FLOW CHART
This flow chart explains the step by step process of the manufacturing process of Medium Voltage (MV) Panel from work allotment to dispatch to the customer.
V. RISK PRIORITY NUMBER (RPN):

RPN is the product of the severity, occurrence and detection scores.

\[ \text{SEVERITY} \times \text{OCCURRENCE} \times \text{DETECTION} = \text{RPN} \]

**TABLE 1: RPN values for different failure modes**

<table>
<thead>
<tr>
<th>Process</th>
<th>Failure Mode</th>
<th>Effect</th>
<th>Severity</th>
<th>Occurance</th>
<th>Detection</th>
<th>RPN</th>
</tr>
</thead>
<tbody>
<tr>
<td>Component fixing</td>
<td>Wrong placement</td>
<td>Functional failure</td>
<td>8</td>
<td>6</td>
<td>5</td>
<td>210</td>
</tr>
<tr>
<td>Bus bar preparation</td>
<td>Size mismatch and Improper bending of bus bar</td>
<td>Fitment problem, Not using of HT hardware</td>
<td>7</td>
<td>5</td>
<td>4</td>
<td>140</td>
</tr>
<tr>
<td>Cable Preparation</td>
<td>Excess Length/Short length, Using of damaged cables</td>
<td>Moderate distributions at assembly stage</td>
<td>6</td>
<td>5</td>
<td>6</td>
<td>180</td>
</tr>
<tr>
<td>Crimping</td>
<td>Wrong crimping</td>
<td>Functional failure</td>
<td>5</td>
<td>4</td>
<td>6</td>
<td>120</td>
</tr>
<tr>
<td>Visual Inspection</td>
<td>Bus bar alignment as per Engine ringing Document</td>
<td>Customer complaints may arise</td>
<td>7</td>
<td>6</td>
<td>4</td>
<td>168</td>
</tr>
</tbody>
</table>

**5.2 Comparison of RPN and Failure Modes:**

The Risk Priority Number or RPN, is a numerical analysis of risk assigned to a process or steps in a process (either in manufacturing or design), as a part of FMEA, in each failure mode numeric values that qualify occurrence, detection and severity of impact.

Fig 2: Graphical representation of RPN
VI. RELIABILITY PREDICTION OF MV PANEL

In this chapter, Failure Rate and MTBF prediction is determined by using online Reliability Analytics Toolkit MIL-HDBK-217F software.

The Prediction results are tabulated as follows

<table>
<thead>
<tr>
<th>S no</th>
<th>Part type</th>
<th>environment</th>
<th>qty</th>
<th>Base failure rate (FPMH)</th>
<th>Pi-q description</th>
<th>Pi-q</th>
<th>Part failure rate</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Rotator switch</td>
<td>GF</td>
<td>1</td>
<td>0.33</td>
<td>MIL-SPEC</td>
<td>1</td>
<td>0.33</td>
</tr>
<tr>
<td>2</td>
<td>Circuit breaker</td>
<td>GF</td>
<td>1</td>
<td>1.4</td>
<td>MIL-SPEF</td>
<td>1</td>
<td>1.4</td>
</tr>
<tr>
<td>3</td>
<td>Current transformer</td>
<td>GF</td>
<td>1</td>
<td>8.70</td>
<td>MIL-SPEC, PI-Q=3</td>
<td>3</td>
<td>0.000261</td>
</tr>
<tr>
<td>4</td>
<td>Relays</td>
<td>GF</td>
<td>1</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>5</td>
<td>VCB</td>
<td>GF</td>
<td>1</td>
<td>0.05</td>
<td>MIL-SPEC, PI-Q=3</td>
<td>3</td>
<td>0.15</td>
</tr>
<tr>
<td>6</td>
<td>AC ammeter or voltmeter</td>
<td>GF</td>
<td>1</td>
<td>0.61</td>
<td>MIL-SPEF</td>
<td>1</td>
<td>0.61</td>
</tr>
</tbody>
</table>

6.1 GRAPHICAL REPRESENTATION OF DIFFERENT FAILURE RATES

Base and Part failure rate is calculated and shown in above table and the comparison for two failure rate are shown below

COMPARISION BETWEEN BASE FAILURE RATE AND PART FAILURE RATE COMPONENTS:
CONCLUSION:

Process FMEA of MV panel had done successfully and failure modes are detected and necessary actions are taken to reduce the risk level of the failure modes of the components. Failure rates and MTBF are evaluated and comparison of Base failure rate and Part failure rate had done successfully. The performance is assessed by using MIL-HDBK-217F.

REFERENCES:


