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Asset Management Strategy to Improve Substation Performance

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Due to the economic burden imposed by deregulation, utilities are looking at new ways of operating and maintaining their assets. The utilities are concentrating at managing their substation assets. Financial managers try to maximize return-on-investment for each asset; substation maintenance managers try to maximize the value of each task. By minimizing unexpected breakdowns, we maximize return on capital investment. Asset criticality, reliability, and condition assessment plan key roles in helping to manage risk. By conducting reliability cantered maintenance as an overall strategy for critical asset management, a powerful enterprise system, like Meridium, bring together the information from across the enterprise to make effective decisions.

Keywords: RCM (Reliability Centered Maintenance), Deregulation, FMEA (Failure Mode and Effect Analysis), PM (Preventive Maintenance) and MTBF (Mean Time between Failure).

1. INTRODUCTION

Due to the economic burden imposed by deregulation, utilities are looking at new ways of operating and maintaining their assets. The utilities are concentrating at managing their substation assets. Financial managers try to maximize return-on-investment for each asset; substation maintenance managers try to maximize the value of each task. This is done by careful consideration of the condition of each asset and its ability to produce revenue [1]. This requires a deep understanding of both the criticality and the reliability of each asset.

The asset management strategy [2] needs a deep understanding of the impact of failures on the overall business. Currently, utility mainly depends on predictive maintenance assessments conducted periodically on the equipment. This approach improves the maintenance work that is actually conducted on each asset by ensuring that the asset actually needs the service. This approach has the effect of limiting the overall work scope carried out on each asset and ensures that only necessary work is carried out.

The utilities in competitive market have employed the concept of asset management for many years. One characteristic that separates the top performers in these competitive industries is the use of data and analysis to drive decisions.

2. TYPES OF RCM

There are two major thought exist for RCM Analyses. One thought (and probably the

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most popular) is given by John Moubray in his book: 'Reliability Centered Maintenance II'. John Moubray [3] takes the 'component-based' position where all decisions about the maintenance strategy for a equipment are based on the component taken 'within its operating context'.

The other thought suggests that the production unit is broken down into systems and then only RCM tasks that mitigate system failures be considered. This approach has several advantages over the component-based approach, but has some disadvantages as well.

3. RCM PROCEDURES

RCM has the reputation of being tedious, complex and time consuming. This depends upon the level of sub-component upon which the failure mode analysis is done. A complete analysis would look at actual and potential failures for each sub-component. Below is the general four step procedure used to carry out RCM Analysis.

3.1. Step 1 System Definition: Critical Asset Identification

3.1.1. System Based Approach

The system-based approach to RCM requires practitioners to identify critical units. A critical system is one where a failure of that system causes a failure of the production unit or process. To conduct a system analysis, the analyst needs to identify system boundaries that prescribe which components belong to which system.

In order to determine criticality of the system, the analyst must understand what happens when system failure occurs:

- Does unit fail if the system fails?
- Define system function: What function does the system perform?
- Define system criticality: Is the system critical for operation, or can we operate the plant or circuit without this system? Does the system contain redundancies or backups?
- Define each functional failure: For each functional failure, describe ways in which it affects the overall system or other components.
- Does system fail if a component in the system fails?

3.1.2. Component Based Approach

Anthony M. Smith [4] gives the component-based approach, which looks at each asset within its operating context and attempts to answer the following questions:

- Is failure hidden or evident?
- Does failure cause safety problem or potential loss of life?
- Does failure cause loss of production?
- Determine component criticality.
- Does production unit fail if the component fails?

3.2. Step 2: Failure Modes and Effects Analysis

The next step in Reliability-Centred Maintenance is to conduct a Failure Modes and Effects Analysis (FMEA). The Failure Modes and Effects Analysis is a powerful tool that helps to understand what causes failure and what happens when certain types of failures occur.

To conduct the FMEA For each component contained within the system, the analyst needs to answer the following questions:

- What are the functions and associated performance standards of the asset within its present operating context?
- In what ways does it fail to fulfil its functions?
- What causes the functional failure?
- What happens when each functional failure occurs?
- What can be done to prevent each failure?
- What if a suitable preventive task cannot be found?

3.3. Step 3: RCM Task Development

Once the FMEA has been completed, the analyst has two analysis options for selecting RCM Failure Mitigating Tasks: System-Based Analysis or Component-Based Analysis. For system based analysis, the analyst needs to develop tasks that only preserve system function. For component based analysis, the analyst needs to develop tasks that will mitigate or diminish the effect of the failure mode identified with FMEA. Both approaches result in the specification of a task type. The task types for this analysis are as follows:

- Scheduled On-Condition Task.
- Scheduled Restoration Task.
- Scheduled Discard Task.

3.1. RCM Task Definition

For each failure mode identified, a task needs to be developed that conforms to the following criteria:

- Will the task effectively mitigate the failure?
- How often does it need to be performed?
- What is the cost?
- What is the benefit?

Each RCM task is subjected to the above reasoning to ensure that improved reliability goals and reduced costs are met.

3.4. Step 4: Task Comparison

At this point, the analyst needs to compare existing tasks with PM Tasks that already exist for the equipment under study. In some cases, existing tasks may be part of the maintenance of the equipment. The RCM analysts recommend adding new tasks or modifying existing tasks. Analysts may delete existing tasks, provided that they have proven to be ineffective. To know if a particular task has been effective, an analyst need only review past work order data.

4. ANALYSIS METHODS

4.1. Linear Estimations

Measurements of mean time between failures (MTBF) and other reliability measures can be calculated directly from the failure records. A number of calculations are used, but the most common is simply to specify a particular period of time (typically one year) and divide by the number of failures in the period. This approach suffers from a lack of consistency in the data and methods used, therefore, comparisons to standard values, as a basis for decision-making is difficult.

4.2. Statistical Estimations

Distribution and Growth Analysis are generally considered more advanced and behave more consistently than linear estimations. Distribution Analyses include Weibull, Exponential, and many others. The most flexible and most frequently used is the Weibull analysis. Weibull analysis not only gives the failure rate but also the failure pattern, either infant mortality, random failures, wear-out failures or rapid wear out. Another popular approach to reliability analysis is Reliability Growth Analysis. Growth is used to detect changes in the failure rate. This is particularly useful for RCM.

4.3. Corrective actions

Reliability Analysis [5] can be a guide to most common problems experienced with substation equipment. Among these types of problems are:

4.3.1. Equipment design problems: It can be identified with queries of failure modes by equipment type. This process can identify commonly failed components among a population of similar equipment.

4.3.2. Equipment material problems: In some cases, the reliability analysis can point to a deficiency in materials or in material selection. These problems often behave as 'early wear-out' failure mode, which is easily identified with a Weibull analysis.

4.3.3. System design problems are identified using reliability analysis where the wrong piece of equipment was used in the design of substation and frequent failure of this equipment occurs as a result. Failures of similar systems can be subjected to the same analysis procedures that are conducted at the asset level.

4.3.4. Identification of unsatisfactory maintenance procedures: Unsatisfactory maintenance procedures can be identified and separated by comparing similar components between systems maintained by different crews. The levels of training, adherence to standard procedure play a role in the quality of repairs provided by the operating and maintenance crew.

4.3.5. Identification of improper operating procedures: Wide temperature swings and inadequate level control can lead to poor product quality and reduced equipment life. Failures caused by inadequate operating procedures evident themselves as premature 'wear-out' modes and are easily identified through Weibull Analysis.

5. KEY PERFORMANCE INDICATORS

Software programs offer users an opportunity to develop and track key performance indicators. Key performance indicators [6] allow companies to compare performance with other companies or internal departments within the same company. This kind of analysis can point to specific reliability problems with certain areas. Some of the key performance indicators available in Meridium are:

- Mean Time Between Failures (MTBF) by Equipment type and Manufacturer.
- Average Repair Cost by Equipment Type and Manufacturer.
- Average Number of Failures and Repairs by Equipment type and Manufacturer.
- Average Downtime by Equipment Type and Manufacturer.
- Cost of Unreliability by Unit, Equipment Type and Manufacturer.
- Monthly Total Number of Failures Equipment Type and Manufacturer.
- Monthly Average Total Cost Equipment Type and Manufacturer.

6. CASE HISTORIES

The following examples are based on real data extracted from work order information. Heinz P. Bloch and Fred K. Geitner [7] gives the Weibull parameters for comparison to industry data. This kind of analysis can be conducted on different kinds of equipment, groups of equipment or even systems or circuits. Growth also gives a good estimate of the current MTBF (failure rate) and can tell the user if reliability is improving or declining. Unlike Weibull, Growth models can include data from various failure modes and is a good alternative when the failure causes are unknown. Growth models parameters can be used in forecasting failures.

7. PREDICTIVE MAINTENANCE ASSESSMENTS

Another powerful method that is used as an overall asset management strategy is to periodically inspect substation equipment for signs of deterioration[7]. Many have employed the application of predictive maintenance methods for substation equipment. Among the Inspection methods used are:

7.1. Infrared imaging requires the use of an infrared camera to detect areas of abnormally high temperatures. This technology is effective for substation equipment because a key failure mode for high voltage equipment is the corrosion of contacts and deterioration of high voltage connections. Prior to failure, elevated temperatures are experienced at or near the connections.

7.2. Portable Hydran units measure the hydrogen concentration in a sample of a transformer or circuit breakers insulating oil. The Hydran unit detects the presence of gaseous hydrogen in the sample that is indicative of partial discharge arcing.

7.3. Acoustics and Vibration detection equipment can be used to detect transformer core looseness and core misalignment. High levels of acoustical energy at 2 times line frequency (120 Hz) and harmonics is indicative of transformer core misalignment.

7.4. Dissolved Gas Analysis is usually conducted on samples taken from oil filled transformers and breakers. Laboratory analysis of insulating oil samples is accomplished using a gas chromatograph (GC), which can measure the chemical composition of the sample.

8. COST BENEFITS METHOD

Matusheski, Robert, Holman and Mike [8] provides a guide for calculating the benefit associated with a work order that prevented a failure, similar to the one shown below. The example below shows the estimated benefit from an Infrared thermography scan of a transformer.

9. CALCULATIONS

The calculation is based on assumptions about what could have happened if the fault goes undetected. Worst case, probable and possible scenarios are estimated and assigned appropriate probabilities.

10. CONCLUSIONS

We maximize return on capital investment by minimizing unexpected breakdowns. Asset criticality, reliability, and condition assessment play key roles in helping to manage risk. By conducting reliability centered maintenance as an overall strategy for critical asset management, a powerful enterprise system, like Meridium, is necessary to bring together the information from across the enterprise to make effective decisions. Effective informed decisions are the key to minimizing risk of failure and effectively managing the reliability of substation equipment.

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