Produced by: Engineering 360 Media Solutions
November 2017

How to Create An Effective and Safe Compliant Electrical Maintenance Program

Sponsored by: IRISS, Inc.

An electrical maintenance program is a schedule of planned maintenance testing and corrective actions with the intent of preventing failures of critical assets. An effective electrical maintenance program will find faulty components before they can actually fail, as well as assess the useful life of existing assets. It ensures optimal working conditions and extends the life span of the equipment.

The failure modes and effective analysis (FMEA) method is a well-documented evaluation process that leads to calculating the risk priority numbers (RPNs) of critical assets, followed by taking preventive steps to mitigate risk on the highest priorities and then recalculating the RPN. One effective method of mitigating risk is through critical asset surveillance technologies (CAST). Condition-based monitoring through CAST allows for safe, efficient and cost-effective inspection of electrical distribution assets.

Condition-based monitoring through CAST allows for safe, efficient and cost-effective inspection of electrical distribution assets.

What is FMEA?

FMEA is a systematic, proactive method to identify where and how a process or asset might fail and to assess the impact of different failure types. FMEA uses RPNs to quantify risks to a system and also measure risk reduction achieved by proactive measures. RPN is calculated by finding the product of severity, likelihood and detection measurements.

Severity is a numerical estimate of how severe a failure will be perceived by those affected. Likelihood, sometimes called occurrence, is a numerical estimate of the probability that the cause of a failure mode will occur during the design life. Detection, sometimes also called effectiveness, is an estimate of the ability of the controls to prevent or detect the cause or failure mode before it affects systems or users that are dependent on the equipment. It is important to remember to consider RPNs within the context of their component severity, likelihood and detections. High-severity

Figure 1: The FMEA process. Source: IRISS

Sponsored by:

Produced by:

modes should be prioritized even if the overall corresponding RPN is low as compared to other modes. Medium severity with high likelihood should be prioritized as well.

RPNs are most effective when used to assess risk reductions after the implementation of proactive measures. FMEA provides a framework for doing this for electrical system failure. The first step in the process is to identify electrical equipment failure modes. Next, thoroughly consider the effects of electrical equipment failure at each mode and rank their severity. Review the potential causes of these failures and rank them by likelihood. Finally, list the existing condition-based monitoring that can be implemented and rank their ability to detect potential failures.

At this point calculate the RPNs for the assets. Once the highest risk priorities have been identified, take preventive steps to mitigate the risk for those failure modes. For critical electrical assets and their failure modes, create an electrical maintenance program of regular testing and corrective actions. An effective electrical maintenance program will find faulty components before they can fail as well as assess the useful life of existing assets. Identify and install inspection equipment and implement or modify existing inspection processes, as needed. Finally, recalculate RPNs to quantitatively measure the effectiveness of these changes. Repeat the FMEA process until acceptable risk levels (low RPNs) have been achieved for all failure modes. In this manner, FMEA becomes a continuous improvement process.

Industry standards can be used to determine how to implement or modify inspection processes for critical electrical assets. The SAE JA1012_201108 is a guide to the reliability-centered maintenance (RCM) standard (SAE JA1011) and provides an outline for how to calculate the technical feasibility of an inspection technique. Potential failure conditions are identified and stable degradation intervals are defined based upon degradation data for the critical asset. Tasks are performed at intervals less than the degradation intervals with enough time provided so that reaction intervals are long enough to implement

Figure 2: An inspector using an EMSD to collect Ultrasound Data. Source: IRISS

predetermined corrective actions. This means that an inspection occurs frequently enough to identify issues based on past data, and that when an issue is identified there is enough time to implement a planned solution before critical failure occurs. All of this occurs within a framework that ensures safety, environmental and economic criteria are met. An excellent way to implement the above is through CAST.

Implementing CAST and RCM

CAST refers to condition-based monitoring technology and equipment in use every day to inspect electrical distribution assets. These surveillance methods determine the condition of the individual asset or system being inspected and can include technologies such as infrared thermography, airborne ultrasound, motor current analysis, partial discharge testing (Transient Earth Voltage), corona cameras, visual inspections, online monitoring and others.

Many hidden electrical equipment problems can be detected with CAST inspection technologies. For instance, airborne ultrasound can detect arcing and tracking, infrared thermography can find hot spots and UV cameras can spot corona on high voltage equipment. Motor current analysis can identify issues with rotors, windings and stator faults. Safe, efficient visual inspection is important for checking audible noises, vibration, dust, water and small animal ingress. Electrical maintenance safety devices (EMSD) allow for critical, real-time inspection and maintenance data logging while the equipment remains in a closed, safe condition and can be used to perform multiple types of inspections. The latest edition of the NFPA70E standard specifically calls out the use of EMSD such as Infrared Windows as a safer alternative as part of the substitution aspect of the hierarchy of control. NFPA70 allows closed panel inspection using and EMSD without the need for personnel to wear any incremental Personal Protective Equipment (PPE).

To better estimate how CAST can improve RPNs, particularly in determining the likelihood of failure modes for critical electrical assets and how they can be detected, it is important to understand their equipment

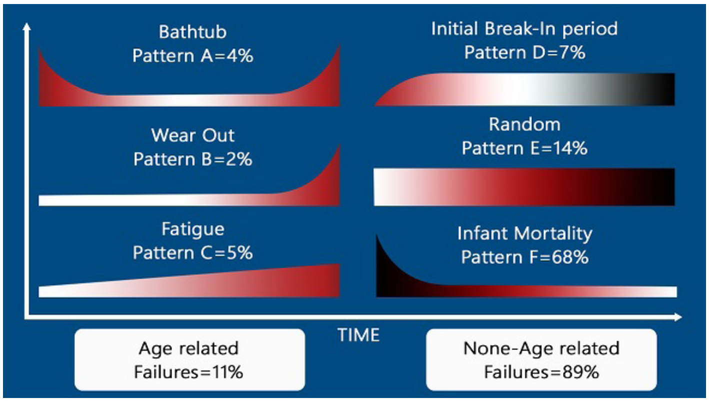

Figure 3: The RCM curves. Source: IRISS

failure patterns. Reliability Centered Maintenance (RCM) is an effective approach for determining the appropriate strategy based on understanding equipment failures. RCM curves are the age reliability behavior curves that graph the conditional probability of failure against age. The curve shapes are referred to as bathtub, wear out, fatigue, initial break-in period, random and infant mortality. They can be broadly categorized into age-related failures and random failures.

These three curves fall under the age-related failure category.

- Bathtub curves have a high probability of failure when the equipment is new, followed by a low-level of random failures, followed by a rapid increase in failures late in life.
- Wear out curves have low-level random failures followed by a sharp increase in failures at the end-of-life.
- Fatigue curves show a gradually-increasing level of failures over the course of the equipment's life.

These last three fall under non-age related failures. It's interesting to note that non-age related failures account for 89 percent of equipment failures to just 11 percent for age related failures. Furthermore, infant mortality failure curves account for 68 percent of all RCM curves.

- Initial break-in period curves start with a significantly-low level of failure followed by a sharp rise to a constant level.
- Random curves have a consistent level of random failures over the life of the equipment.
- Infant mortality curve shows a high initial failure rate followed by a constant random level of failures.

The failure patterns reinforce that failure can happen at any time and that regular inspection of assets is necessary throughout equipment life to detect and correct problems.

Benefits of Electrical Maintenance Programs

The electrical inspection PF curve can be used to understand the failure of electrical assets over time. Point P on the curve is the time at which something has physically changed in the equipment that, if left unaddressed, will eventually lead to full function failure — point F on the curve. It could be days, months or even years that pass before that functional failure happens, depending on the nature of the defect. Along the curve, different inspection techniques can detect the early warning signs and help determine the severity of the issue so that corrective action can be taken.

Typically, the longer the reaction interval, or the longer the problem goes unaddressed, the more expensive it is to repair the equipment back to working order. The real value of CAST is the detection of potentially expensive problems early, which greatly reduces the cost of corrective action but extends asset life. This also lowers the number of

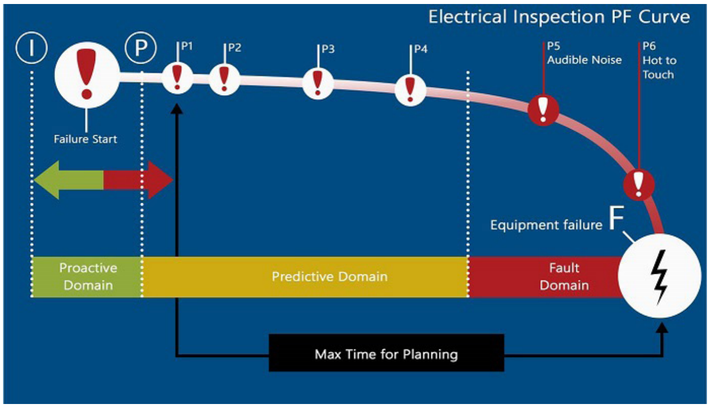

Figure 4: The PF curve. Source: IRISS

unexpected electrical system failures, thus greatly reducing the severity in the RPN calculation, resulting in added efficiency in avoiding critical asset failures.

Any assessment of CAST should involve understanding both the cost of implementation and the savings in avoiding critical failure. In addition, it is important to include the reduction in overall risk of downtime and safety hazards by early identification of potential issues. Other factors to consider are improved worker morale and company reliability and reputation. IEEE recently published a study summarizing that the use of programs like CAST could reduce the cost of repairs on different types of electrical infrastructure by an average of 66 percent. That provides a basis for understanding how early problem identification in critical electrical assets can significantly decrease overall cost.

So which critical electrical assets should be considered first for EMSD and CAST implementation — whether in new equipment or in retrofit situations? The assets where failure would have the greatest impact in terms of downtime and cost to repair would become the priorities. In most facilities, this means the assets that would cause the broadest interruption in electrical service to the plant such as MV switchgear, main transformers (whether dry or oil-filled) and the primary LV switchgear. These are the usual first points of deployment for EMSDs. The next deployment tier includes the process equipment that is critical to the plant's operation. This might include LV secondary switchgear and switchboards, variable speed drives and large motor wiring termination chambers. Often these are devices that, if they failed, would starve the production process of some key element causing a broader process interruption. The lowest EMSD priority is typically the third tier of LV distribution, including small power distribution panels, load centers, lighting panels, disconnect switches and low-HP MCC buckets.

Implementing EMSDs in these situations increases energy utilization and efficiency, on-time delivery to customers, environmental and regulatory compliance, waste reduction, operation uptime and employee safety. In addition, due to the reduced need to take apart equipment to identify the source of failures and the user-friendly, noncontact inspection procedures used with EMSDs, they serve to bridge the skills gap. Early identification of potential problems doesn't require a deep electrical engineering background and can become the duty of easily-trained technicians with little or no experience.

When problems are identified, they can be handed over to the more experienced engineers for implementing a solution. This frees up the engineers from inspection work, reduces cost and improves safety. This is a critical aspect of implementing EMSDs as many electrical engineers are approaching retirement age, thus reducing the availability of that skill set. Furthermore, the regular collection of data will help better identify potential issues in the future. Identification of failure patterns over time feeds back into the system and helps identify critical failure modes and informs the inspection method best suited to address them.

Conclusion

Effectively inspecting critical electrical assets through CAST in conjunction with EMSDs provides cost savings, reduced downtime and increased safety. Identifying critical failure modes and understanding their failure patterns allows you to implement a process that identifies potential problems early. Quickly implementing a solution based on failure patterns increases the life of equipment and improves the experience of those who depend upon the electrical assets. Calculating RPNs for those critical failure modes, both before and after CAST have been implemented, help quantify the reduction in risk and make the business case for EMSDs. EMSDs improve reputation and safety while lowering costs of repairs and downtime of critical electrical assets.

IRISS, INC.

10306 Technology Terrace
Bradenton, Florida 34211
941-907-9128
www.iriss.com

ENGINEERING 360 MEDIA SOLUTIONS

201 Fuller Road, Suite 202
Albany, NY 12203-3621
Tel: +1 518 880 0200

ABOUT IRISS, INC.

IRISS is the global leader in Electrical Maintenance Safety Devices & Solutions. We help our customer's reduce downtime related costs & maximize efficiency by reducing inspection times. EMSD's warn you of potential equipment failures before they occur, maintain the energized compartment's closed, safe and guarded condition ensuring workers are never exposed to the dangers of Arc Flash or electrocution, & automate asset inspection data collection process driving more efficiency improvements. Our EMSD solutions reduce risk, minimize cost and maximize efficiency.