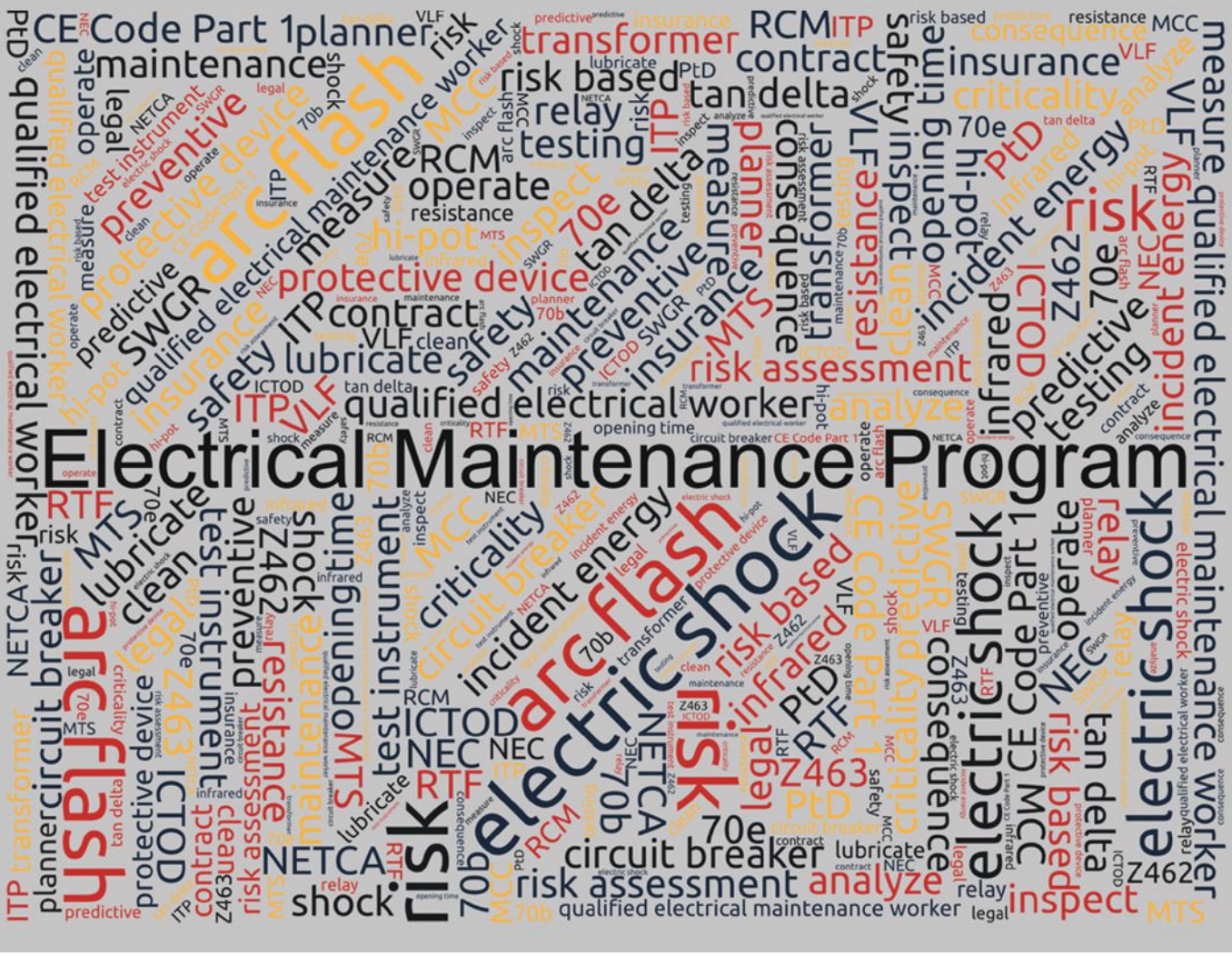


Safety Measures ELECTRICAL

"Elimination is the first priority! Ensure a risk assessment is completed before energized work tasks are completed."

Electrical Maintenance Program Requirements & Best Practices

By Terry Becker, P.Eng., CESCP, IEEE Senior Member

There are three core requirements that an Electrical Maintenance Program (EMP) needs to address: determine specific maintenance strategies for specific electrical equipment assets, define electrical equipment asset specific inspection and test procedures (ITPs) and determine the specific maintenance intervals for each electrical equipment asset for the ITPs to be applied to achieve the desired outcome of a specific electrical equipment condition (e.g., Condition 1, 2 or 3 as identified in CSA Z463, NFPA 70B or ANSI/NETA MTS).

All three of these items can be determined based on the completion of a documented electrical equipment asset qualitative risk assessment procedure with a supporting electrical equipment maintenance prioritization risk matrix. The risk assessment procedure as noted in previous articles would consider the consequences (e.g., reference Table 1 below) related to the electrical equipment asset and the desired electrical equipment condition to effectively manage the likelihood of failure due to the lack of electrical equipment maintenance. An example of an Electrical Equipment Maintenance Priority Risk Assessment Matrix that can be used when completing an electrical equipment asset qualitative risk assessment is provided in Figure 1.

Maintenance Strategies

A key requirement of the EMP and specific to each electrical equipment asset is what maintenance strategy applies. The following list is provided. The maintenance strategy is selected based on the potential consequence(s) related to the electrical equipment asset which relates to the potential negative impact on operations or the process and a documented risk assessment.

Preventive Maintenance (PM)

Preservation of the asset. Time based, routine servicing, part replacements, complete overhaul. Reduce probability and cost of failure, age related. Asset inventory, PM schedule (maintenance intervals) and CMMS software typical requirements of this strategy.

Predictive/Proactive Maintenance (PdM)

Preservation of the asset. Attempt to evaluate the condition of an asset by performing periodic or continuous electrical equipment monitoring (e.g., temperature, partial discharge). The maintenance interval is determined by actual condition-based decision rather than a predetermined schedule. Data collection and analysis, early fault detection, time-to-failure prediction, maintenance scheduling and resource optimization.

Reliability Centred Maintenance/ Risk Based Maintenance

A formal structured process, originally developed in the airline industry, but now commonly used in all industries, to determine the equipment maintenance strategies required to ensure that any physical asset will continue to fulfill its intended functions in its present operating context.

Run to Fail (RTF)

Reactive, corrective, breakdown. Cost and impact of failure are less than the cost of preventive actions. Critical and other spare parts and equipment considerations.

Inspection & Test Procedures

Defining appropriate inspection and test procedures (ITPs) for electrical equipment assets is dependent on the electrical equipment asset itself. Electrical equipment manufacturers will provide guidance in the operating and maintenance manuals related to inspection and specific maintenance requirements.

The CSA Z463 Maintenance of electrical systems Standard and NFPA 70B Standard for Electrical Equipment Maintenance provide very detailed prescriptive inspection and test procedures that in most cases will exceed manufacturer's requirements.

The independent ANSI/NETA Standard for Maintenance Testing Specifications (MTS) also provides electrical equipment asset specific inspection and test procedures that will be used by NETA Accredited Corporations. Within the ANSI/NETA MTS it uniquely provides test results tables for pass/fail or level of health.

A more detailed list of what an electrical equipment asset's ITP will encompass is: inspection (e.g. visual, infrared), cleaning/lubrication, testing (e.g., both electrical and mechanical), operate and document (e.g., test data, test results, interpretation of results, report, equipment failure investigation,

Table 1 – Electrical Equipment Asset Maintenance Prioritization Consequence Criteria

Item #	Conseqence/Prioritization Criteria Description	Comments / Notes
1	OH&S Regulatory, Injury/Fatality	e.g. liability.
2	Other Regulatory Compliance	e.g., airports Canada TP 312, hospitals, etc..
3	Maintenance for Safety (e.g., abnormal arcing fault likelihood, electrical protective device opening times for incident energy calculations, etc.)	e.g., likelihood unknown non-interaction, calculated incident energy levels may be higher.
4	Criticality of Service (e.g., Uptime, Loss of Revenue)	e.g., profitability.
5	Equipment Damage, Replacement Cost	e.g., unplanned expense budget, critical spares identified and cost.
6	Legal, Contractual Obligations, Confidentiality	e.g., data centres financial penalties/confidential data, production commitments (e.g., miss deliverable and penalty), production targets, etc..
7	Insurance Requirements (may dictate specific maintenance intervals)	e.g., production loss penalties, reduced insurance premiums/ credit, premium increases, warranty void, equipment replacement costs.
8	Company Reputation, Valuation	e.g., license to operate, stock price.

Figure 1 – Electrical Equipment Priority Risk Assessment

Electrical Equipment Maintenance Risk Assessment Matrix

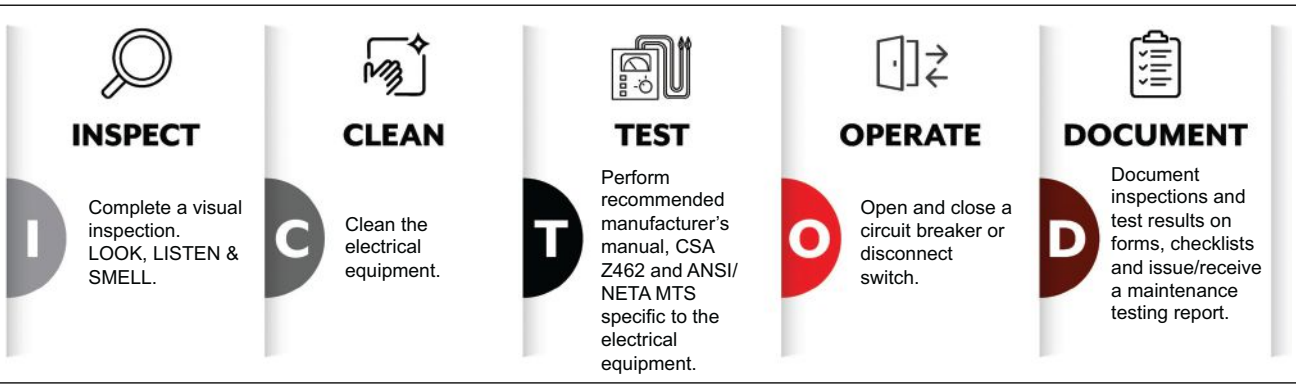
Arc Flash	Electric Shock		Consequence				Likelihood of Occurrence of Failure		
Exists when energized work task is performed and voltage is 208VAC three phase, >150VDC & interaction or abnormal electrical equipment condition.	Exists when there are exposed energized electrical conductors and circuit parts and interaction or abnormal electrical equipment condition.	Severity	OH&S Regulaotory Safety to Personnel. Maint. For Safety.	Other Regulatory Compliance	Reputation / Company Valuation / Insurance	Criticality of Service / Loss of Revenue or Equipment Replacement Cost	Improbable L1 Condition 1	Likely L2 Condition 2	Possible L3 Condition 3
≥ 1.2 Cal/cm²	> 30 Volts ac or > 60 V dc (Severity is higher as voltage increases as may have higher potential current flow thru Body)	S3	Permanent Injury or Fatality	Shutdown Operations	Major Impact	Major Damage > $1MM			
		S2	Lost Time Incident	Restricted Operations	Minor Impact	Minor Damage < $100k			
< 1.2 Cal/cm²	≤ 30 Volts ac or ≤ 60 V dc	S1	No Injuyr or First Aid	No Impact	No Impact	No Damage/Minor Impact on $			

L1	Improbable	Normal Equipment Condition. Not Likely To Occur. Low Frequency Expected.
L2	Likely	More Frequent Breakdowns/Reactive Could Happen. Trending Increasing.
L3	Possible	Very Likely To Happen or High Frequency Expected. Unpredictable Breakdowns/Reactives.

etc.). From Webster's Dictionary:

- **Inspect:** *to view closely in critical appraisal: look over*
- **Clean (Lubrication):** *free from dirt or pollution*
- **Test:** *a critical examination, observation or evaluation; a result or value determined by testing*
- **Operate:** *to perform a function*
- **Document:** *conveying information*

Figure 2 – Inspect, Clean, Test, Operate, Document (ICTOD)



Maintenance Intervals

With respect to electrical equipment assets and the determined maintenance strategy and related ITPs the ITPs will be completed at a defined maintenance interval.

As identified in previous articles electrical equipment asset maintenance intervals shall be determined using a risk assessment procedure. It is recommended that a simple qualitative risk assessment procedures (RAP) be completed. The RAP needs to consider both the consequences (e.g., severity) and likelihood of occurrence of electrical equipment failure desired (e.g., Condition 1, 2 or 3 as defined by CSA Z463, NFPA 70B and ANSI/NETA MTS)

Table 2 summarizes the three determined conditions and potential maintenance interval ranges in months. The detailed maintenance intervals are documented specific to each electrical equipment asset in CSA Z462 Annex M and NFPA 70B Table 9.2.2.

It is recommended the three requirements listed above are more formally defined in a detailed compliant Electrical Maintenance Program. I encourage you to review the previous articles in this series: Importance of Building a Compliant Electrical Maintenance Program (EMP) – May/June; Electrical Maintenance Program Project Execution Plan (PEP) – July/August; and Electrical Maintenance Program Risk Assessment Consequences, – September/October.

If you are interested in discussing the information presented in this article or would like a specific topic presented do not hesitate to contact me.

Table 2 – Electrical Equipment Asset Condition of Maintenance, Maintenance Intervals

Standard	Determined Maintenance Interval, Months		
	Condition 1	Condition 2	Condition 3
CSA Z463 Annex M	Optimized Program for Critical or Severe Duty Application. Minimal Frequency	Good Electrical Practice	Maximum Frequency
Maintenance Interval Examples	1, 2, 3, 6, 12	24, 36, 48	60, 72
NFPA 70B Chapter 9 Table 9.2.2	Equipment Appears New. Clean. Maint. Up to Date. No Cont. Montit. Issues. No Acti. Recomm from PdM.	Deviation of Maint. Test Results from Norm. Prev. Maint. Required Repairs. Cont. Monit. Notifications Have Occurred. Active Recomm. From PdM.	Two Maint. Cycles Missed. Cont. Monit. Notification. Urgent Issues from PdM.
Maintenance Interval Examples	3, 12, 24, 60	3, 6, 12, 24, 36, 60	1, 3, 6, 12 Before Use

HAPPY NEW YEAR! Looking Forward To 2026!

I will continue my efforts to communicate information in Electrical Safety Measures and share the knowledge and experience I have in an effort to "Get it Right!!" My electrical safety journey and mission will continue!! Knowledge is power! TAKE CONTROL of ARC FLASH! PLACE MORE FOCUS on ELECTRIC SHOCK!

Terry Becker, P.Eng., CESCP, IEEE Senior Member is a founding member and the First Past Vice-Chair of the CSA Z462 Workplace electrical safety Standard Technical Committee and currently a Voting Member and Clause 4.1 and Annexes Working Group Leader. Terry is also a Founding Member and a Voting Member on the CSA Z463 Maintenance of electrical systems Standard and a Voting Member of the IEEE 1584 Guide for Performing for Arc-Flash Hazard Calculations. Terry is also a voting member of the CAN/ULC S801 Workplace Electrical Safety Standard for Utility Generation, Transmission and Distribution. Terry has presented at over 95 Conferences and Workshops on electrical safety in Canada, USA, India, Australia and New Zealand. Terry is a Professional Engineer in the Provinces of BC, AB and ON. Terry is an Electrical Safety Specialist, Management Consultant, and can be reached at 587.433.3777 or by email **terry.becker@twbesc.ca**.