North American Transmission FORUM

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NATF Equipment Problem Coding Process Reference Document

Version 1.0

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Versioning

Version History

Date	Version	Notes
12/04/2019	1.0	Initial version

Contents

1. Purpose

Equipment engineers and asset managers need to understand what equipment problems and failures are occurring to make decisions about asset maintenance and replacement. When classified by asset type, make, model, and the nature of the problem, such data is useful for analysis, trending, reporting, and decision-making. However, the exact nature of equipment problems can be difficult to determine using narratives entered by field personnel into work management systems and other databases. Furthermore, without a standard method of coding equipment problems, it can be difficult for utilities to share detailed data about the types of problems observed.

The objective of this effort is to provide a standard framework for coding the nature of field-observed equipment failures and problems of in-service equipment. Standardized recording of equipment issues enables better analysis and data sharing, and maximizes the usefulness of historical data.

2. Scope

The specific purposes of the effort are:

- To develop and implement problem codes that are easily applied in the field by those who are performing corrective maintenance.
- To develop and implement problem codes that apply to both end-of-life and in-service functional failures.
- To provide a standardized coding structure that enables utilities to exchange observed failure/problem data and to better understand the types of problems experienced throughout the industry.
- To provide a problem coding structure that can be applied easily to processes, Computerized Maintenance Management Systems (CMMS), and/or failure databases of any utility
- To provide a data structure hierarchy that can be applied to all equipment types
- To provide enough detail to reveal failure precursors while remaining user friendly
- To establish a data structure for equipment demographic and failure/problem data sharing with industry groups such as the Electric Power Research Institute (EPRI), the North American Transmission Forum (NATF), etc.

3. Definitions

Component

A portion of a piece of equipment that is a potential point of failure or problem.

Corrective Maintenance (CM)

The maintenance carried out, after a failure has occurred and/or deficiency identified, that is intended to restore an item to a state in which it can perform its required function and/or exhibit a desired condition.

Corrective Maintenance Driver

The way the deficiency or failure was found (e.g., during preventative maintenance, during inspection, or through an alarm condition).

Computerized Maintenance Management Systems (CMMS)

A software package that maintains a database of information about an organization's maintenance operations. This information is intended to help maintenance workers do their jobs more effectively.

Deficiency Code

A description of an observed condition tied to the function of the equipment that is outside of operating requirements and easily recognized in the field. For the purposes of this process, deficiencies include functional failures. Generally, these codes identify how the equipment failed or is deficient, but do not explain why. The codes are high-level and indicate the equipment's inability to perform the intended function. The following are some codes used to define deficiencies:

- Degraded condition – An observed condition where equipment performs its required functions but its operating condition is less than optimal.
- Fails to open – Equipment fails to open or break electrical connection (e.g., circuit breakers, switches, etc.).
- Fails to close – Equipment fails to close or make electrical connection to complete electrical conducting path (e.g., circuit breakers, switches, etc.).
- Fails to carry load – Equipment fails to complete electrical conducting path and disrupts electrical power flow (e.g., circuit breakers, transformers, switches, etc.).
- Fails to insulate – Equipment is unable to maintain dielectric boundary integrity.
- Fails to operate – Programmable device does not function as intended (e.g., monitoring equipment, etc.).
- Fails to provide proper DC output – DC charger/rectifier unable to provide the required / designed DC output voltage.
- Fails to provide capacity – Equipment unable to provide the design loading, power, voltage, etc. (e.g., battery, transformer, etc.).
- Fails to provide communication path – Equipment unable to provide complete communication circuit between designated communicating devices/locations.

End-of-Life (EOL)

Loss of an asset's ability to provide the intended function, wherein the loss of functionality would cause unacceptable consequences or risk resulting in that asset NOT being re-energized. End-of-life can have one of three drivers:

- Technical EOL – Asset removed from service at end-of-life because of a condition assessment that indicates it is likely to fail or cannot be expected to perform reliably.
- Economic EOL – Asset that has required unacceptable maintenance costs to achieve required performance or function.
- Strategic EOL – Asset that does not have the necessary spare parts or skill sets available, the forecast loading has exceeded the rating of the asset, or an assessment has determined it should not be retained for any other business driver.

Equipment

An asset that performs a required function within a system. There is a parent-child relationship between equipment and components.

Failure

The termination of the asset's ability to perform its specified functions or operational requirements without major repair and without acceptable risk. There are two types of asset failures:

- Functional Failure
- Failed in Service

Functional Failure

The inability of a system or equipment to perform a previously defined function where the equipment has not been removed from service.

Failed in Service

An equipment failure caused an automatic operation that removed the equipment from service.

Function

The purpose or output of equipment in general terms of performance. Functions can be active or passive. Active functions include, but are not limited to, transforming voltage and switching load. Passive functions include, but are not limited to, preservation of a pressure boundary or structural integrity.

Problem Code

Classification of an observed or confirmed deficiency and/or failure deemed to be unacceptable to utility standards.

Preventative Maintenance (PM)

Tasks intended to prevent equipment failure that are performed on a fixed time schedule.

Retired before failure (RBF)

Asset was removed from service at EOL (see above) but before failure in service.

4. Benefits of Equipment Problem Coding

Equipment problem coding provides additional information to utilities to better understand the performance of maintenance programs. The problem coding structure described in this document is a way to classify equipment findings into field usable codes that can be analyzed by engineering. By implementing such a structure, utilities may realize the following benefits:

- Identification and trending of equipment-specific issues
- Development of targeted equipment bulletins to address issues found through problem coding analysis
- Improved insight into extent-of-condition of equipment issues
- Improved understanding of failure modes for use in failure mode effects analysis (FMEA)
- Industry-coordinated solutions based on shared problem code results
- Justification for investment strategy through improved understanding of failures
- Improved understanding of preventative maintenance effectiveness
- Analysis of workforce efficiency (e.g., through study of deficiency type versus hours spent)
- Understanding of equipment deficiencies to implement single point of failure studies and address issues at critical locations
- Improved equipment specifications through use of lessons learned from problem code trends
- Enhanced analytics through use of problem coding data as source for utility and EPRI life extension and failure prediction analytics tools

5. Problem Coding Process

The equipment problem coding process is a consistent, hierarchal approach. Codes for new equipment types can be implemented easily and, once initial field training is provided, little additional training is needed when new codes are added.

The NATF Problem Coding Structure Master spreadsheet is the roadmap for building the data hierarchy. The master spreadsheet is organized by equipment type and contains deficiencies and components specific to each equipment type. In some cases, additional "sub-components" are added as hyphenated extensions to components, providing additional detail for field personnel to select from.

The NATF Problem Code Applicability Matrix is a companion to the master spreadsheet. While the master spreadsheet defines the coding structure, the Applicability Matrix helps refine the data collection effort by suggesting how Problem Codes can be associated with specific Component Codes. Implementation of the Problem Code Applicability Matrix in the CMMS is optional.

Before closing out corrective maintenance work, field personnel select the required codes in the CMMS. The typical workflow for this process is shown in Figure 1.

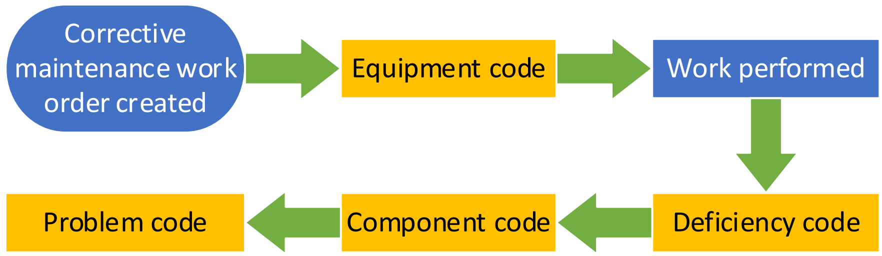

Figure 1: Problem Coding Process

Corrective maintenance work order created: The problem coding process begins with the recognition of a corrective maintenance driver and the creation of a CM work order in the CMMS.

Equipment code: The first element of the coding structure is the equipment code. The CMMS is configured to automatically apply the appropriate equipment code based on the equipment that is the target of the CM work order or to allow the originator of the work order to assign the equipment code. The equipment code controls the selections available for the subsequent elements of the coding structure via logic implemented in the CMMS.

Work performed: Field personnel are assigned to the CM work order, respond to the equipment location, investigate, determine the condition of the equipment, make repairs, and document the work performed. The documentation includes the second, third, and fourth elements of the coding structure

Deficiency code: The second element of the coding structure is deficiency code. This is a field observed condition that might be a functional failure (e.g., fail to close, fail to open, or fail to interrupt) or a non-functional failure condition (e.g., degraded condition or hot spot.) The key is that the deficiency code is based on field observations, not an after-the-fact assessment by a reliability engineer.

Component code: Once the deficiency code is assigned, field personnel apply the component code. At the highest level, components include such things as mechanical, electrical/controls, and physical/structural. Sub-components are specified for some components as hyphenated extensions (e.g., hydraulic system, air system, and cabinets). Field personnel assign the most appropriate component and sub-component codes available.

Problem code: Lastly, field personnel apply a problem code that best suits the observed condition. Problem codes are a listing of words and phrases with definitions that are used to describe the field finding. Examples of problem codes include damaged, corrosion, leak, and improper position. The problem codes are the same for all equipment types and will therefore become familiar to field personnel.

6. Implementing Equipment Problem Coding

Figure 2 suggests the major steps a utility can use to implement this process.

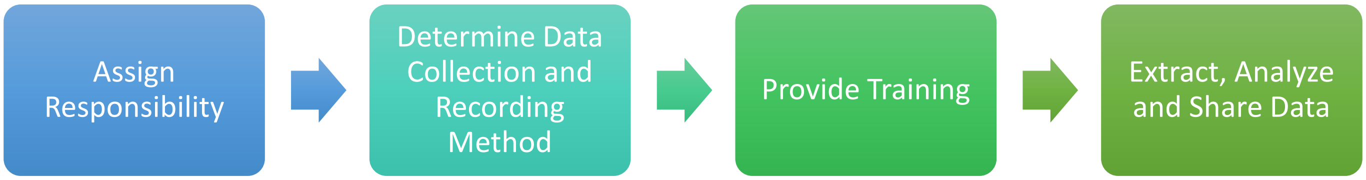

Figure 2: Steps for implementing equipment problem coding

Assign Responsibility

The first step in implementing the problem coding process described in Figure 1 is to determine which personnel will be responsible for data collection and recording and for data extraction and analysis.

Data Collection and Recording

This effort to capture problem coding data – the deficiency code, component code and problem code – focuses on what is happening in the field, and as such, the field personnel who respond to the equipment failure or perform the corrective maintenance are the best source for this information. If field personnel are not involved with selecting and/or recording the specific deficiency, component and problem codes, the person who does this has to rely on information in the work order (e.g., a free-text description) or on communication with field personnel after the work is performed to determine the appropriate codes.

Data Extraction and Analysis

The main goal of this effort is to analyze the problem coding data – deficiencies, components and problems – and use the results to inform maintenance practices, equipment replacement plans, etc. This involves extracting the data on a regular basis, looking at information and trends, and reporting to appropriate stakeholders. This task should be assigned to engineering staff who support maintenance, operations, reliability and/or asset management.

Determine Data Collection and Recording Method

After deciding who will collect and record the problem coding data, the next step is to determine how to collect and record the data. There are two factors to consider when making this decision:

1) data collection and recording should be as simple as possible, and

2) the way the data is recorded should enable efficient data extraction.

The recommended approach is to use a CMMS that is already in place to log work order information. An alternative approach, which may require less start-up effort, is to use spreadsheets.

As mentioned earlier, it is ideal to have the field personnel who worked on the equipment collect of the deficiency, component and problem coding data. If field personnel are already involved in a work order completion/documentation process, then incorporating the task of recording problem codes in the CM work order is the most efficient and accurate way to capture this data. If they are not involved with this process, establish a mechanism by which they communicate and document the deficiency, component, and problem codes to those who will enter the codes.

The administrative burden added by this effort depends on the method chosen for problem coding data collection and entry. A properly designed data entry process that leverages an existing work order management system may add just a handful of mouse clicks to an existing task. Alternatively, doing after-the-fact entry or post-event review using spreadsheets may be more labor-intensive.

No matter who does the data collection and recording and no matter how the data is collected, the deficiency, component, and problem code selections have to be reviewed for relevance and accuracy by a maintenance engineer or similarly qualified individual. This is especially important in the early stages of the effort, as there is a learning curve while personnel become accustomed to the coding structure and the data collection process.

Provide Training

Once responsibilities have been assigned and the data collection process has been established, affected personnel should be trained. Training needs to cover the coding structure as well as how to collect and record the data. Training should include a description of how the code hierarchy was determined as well as the information it contains. This will help the users navigate the structure to select the codes that best describe the nature of observed conditions. Sample training materials are provided in Appendix A.

Utilities should expect a learning curve when this effort is initially introduced, both in navigating the problem coding structure as well as the collection and recording process. Allow time for answering questions and providing assistance during the early stages. Provide frequent refresher training until the process is established in the normal workflow.

Extract, Analyze and Share Data

This last step is the reason for all the effort – to analyze the data and use the results to better understand equipment condition. While the primary reason for the effort is to use the data to inform maintenance and equipment decisions, an important secondary effect is to demonstrate that the work expended to collect and record the data is worthwhile.

The problem coding structure is designed to provide standard descriptions for problems likely to be encountered. These descriptions make data extraction from a CMMS far easier than sifting through keywords contained in work order descriptions and other text-based narratives. When problem code data is extracted, it should be associated with the following equipment and work order information (if available):

- Equipment type, such as gas breaker, power transformer, arrester, etc.
- Location of equipment

- Voltage class
- Manufacturer and model number
- Age
- Health index or similar risk/condition assessment
- Hours and dollars spent on the task

Once the data has been extracted, it can be analyzed for trends and correlations between problem codes and equipment information and population. Each utility can perform their own analysis and use the results in ways that benefit their specific maintenance program and practices.

The design of the problem coding structure also yields a standard set of data collected by utilities who undertake this effort. The problem coding data gathered by utilities from across industry can populate a database that produces results based on a much larger population of equipment than exists at any one utility.

7. Strategies for Success

Utilities that have implemented this data collection process have learned that employing change management principles during roll-out and implementation is key to success. Specific strategies are listed below:

- Get support from company leadership. Several departments may be involved in the effort and having senior leadership buy-in and a champion eases implementation.
- Understand who is affected and how they are affected.
- While collecting, recording, and analyzing this data is important, it adds administrative workload to employees who are already busy. It is crucial that these groups are informed of their new responsibilities prior to any implementation.
- Clearly defined roles and responsibilities for data collection, recording, extraction and analysis.
- Clearly communicate the "why."
- Communicating "what is in it for me?" can help ease any initial resistance to doing extra work.
- Consider providing sample analysis results to show the kind of information that can be generated from this effort.
- Get buy-in on the problem coding structure and implementation. Ensure there is time set aside to explain, discuss, and review the problem coding structure before the roll-out. The importance of this step cannot be overstated. The employees who do the data collection, recording, and analysis will have ideas for how to do this in the easiest and most efficient manner.
- Consider a test group/pilot or small-scale implementation. This provides an opportunity to identify issues and develop solutions prior to affecting all users.
- Consider an optional reporting period to get users accustomed to the changes. Gather feedback during the optional reporting time. Define an end date for optional reporting. Notify users when the optional reporting time has ended and mandatory reporting has begun.

- Find a champion at the implementer/user level to help with messaging. Messaging from a peer can have a more substantial effect than a directive from above.
- Provide training on how to enter the information into the work management system. Training aids such as instruction sheets and/or reference materials are very helpful.
- Budget time to support the effort and monitor coding selection/entry during early stages.
- Plan on a learning curve and be ready to spend time answering questions on how to apply and interpret the coding structure. Monitor entries for accuracy until users become accustomed to the coding structure. Provide guidance, feedback, and corrections during initial stages.
- Field personnel may experience frustration with matching the field event/condition with the choices available in the coding structure. Some investigation may be needed to determine if the frustration can be addressed with additional training or with encouragement to think through the issue to determine the appropriate choice.
- The effort to support problem coding will diminish as familiarity grows and the effort matures.
- Report on results and demonstrate how they will be used.
- Gather feedback after initial implementation (usually within 2-3 months).
- Provide refresher training 6-12 months after initial roll-out.

8. Limitations

There are limitations to be considered when using this reference document and implementing these equipment problem codes.

- To obtain consistent and sharable results across the industry, utilities should adhere to the specified coding structure.
- This process does not initiate an NATF data collection effort.
- This document is not intended to duplicate or replace outage coding and tracking. The proposed problem coding system captures the conditions observed during equipment corrective maintenance or inspection activities that may or may not have resulted in an outage.
- This document provides the problem codes framework, but the implementation strategy, selection of software and tools, creation of utility processes, and training is at the discretion and the responsibility of the utility.

9. Related Documents

NATF Problem Code Structure Master

NATF Problem Code Applicability Matrix