

## Preventive Maintenance Feedback Status and Methodology Review

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### 1. Introduction

Power plant maintenance can be roughly divided into corrective and preventive. Preventive maintenance (PM) is more controllable tool for plant reliability than corrective. Korea Hydro & Nuclear Power (KHNP) has been implemented PM programs based on components importance. A half components are classified as critical and minor class which are managed by PM programs, the other half are run-to-failure which are managed by corrective maintenance only. At early stage of plant operation and PM implementation, it is not possible to apply component specific PM program effectively, because it is not known the performance of component and not predictable result of PM activities. It will be adjusted by monitoring the status of PMs and corrective maintenance trend. KHNP has been focused on PM development until recent years, but it would be diverted to effective adjustment of implemented PM. This paper suggests how we can improve PM feedback practice and its application to PM change.

### 2. PM feedback Status and Methods

In this section status of the PM feedback and process to utilize it into PM improvement are described. The method of improving current PM feedback practice and contributing to living PM process are suggested.

#### 2.1 As-Found Condition Code

Most common PM feedback process is to evaluate as-is status of subject component and input As-Found Condition Code (AFCC) before PM work begin. Each utility has its own code system. Electric Power Research Institute (EPRI) document 1022578 mentioned that Institute of Nuclear Power Operators (INPO) guideline AP-913 suggest using nine codes, but utilities have been more successful using fewer than nine or using codes which has slightly different meanings. [1, 2]

Though INPO AP-913 recommended nine categories of AFCC, complicated code system make maintenance workers ambiguous to select the code without providing specific criteria. KHNP adopted simplified AFCC system which is similar with EPRI guideline as shown in table I.

Having a consistency is more important than detailed code system for trending PM effectiveness. Finding issues and solving the problems are main purpose of continuous PM improvement. Simple code system is

more useful for finding problems requires additional focus. The codes of superior and worse are focal point. In such purpose, the percentage of superior and worse should be limited to manageable level of percentage.

Table I: As Found Condition Code

Basic Meaning	EPRI PM Guideline	KHNP	INPO AP-913
Superior	Superior (A)	Superior (A)	Superior(8)
As-Expected	Sat(B) Improve(C)	As-Expected (C)	Satisfactory(7) Within-Tolerance(6)
Worse	Abnormal (D)	Worse than Expected (D)	Degraded(5) Out-of-Tolerance(4) Normal-repair(3)
Failure	Extreme (E)	Extreme (F)	Abnormal-repair(2) Unanticipated-failure(1)
Other			Not-applicable

#### 2.2 Descriptive Maintenance Feedback

PM work orders have a section of text feedback which is intended to describe what was found and performed during maintenance or what is recommended after work. In case of “Superior”, “Worse” or “Failure” of AFCC, the reason of why he/she selected this code should be described in this section. Without this information reviewer couldn’t decide whether PM should be changed or not. AFCC “As-Expected” wouldn’t require additional description for this assessment. KHNP’s PM work process does not require any descriptive explanation of AFCC selection. Table II shows that PM workers are tend to select “Superior” than the others.

Table II: KHNP’s PM AFCC distribution (2017)

Superior (A)	As-Expected (C)	Worse than Expected (D)	Extreme (F)	N/A
70%	28.4%	1.1%	0.1%	0.3%

It is considered that they are tend to show that no issues are exist by selecting “Superior” because any additional comment which recommend extending PM frequency or skipping PM activity are not found. EPRI document TR-1022578 recommended that as-found data should not rely solely on a code but should be supplemented with meaningful and relevant written comment. If PM process require to write the reason of selecting “Superior”, this distribution will be different.

### 2.3 As-found Feedback Process

The Maintenance workers who performed PM work activity is the preferred As-found data provider. Capturing equipment condition requires considering several factors; consistency, retrievability, simplicity, relativity, applicability and resolution. [4] As-found checklist provides component specific information, such as failure mechanism and industry operating experience, to help maintenance worker select appropriate AFCC. [1, 3]

After work orders are completed, as-found data should be evaluated by initial evaluator who has responsibility to confirm AFCC and written feedback appropriately entered having consistency with actual work result. The procedure of PM and work management process should clearly define who has this responsibility.

PM feedback reviewer is a responsible person who evaluate AFCC trend and decide whether PM should be changed or maintained. Industry practice shows the most effective reviewers are reliability engineers, component engineers, maintenance engineers and system engineers. [1]

EPRI proposes As-found data processing milestone as Figure 1. Initial evaluator should provide feedback and inform maintenance workers within 7-14 days. Reviewers should complete PM effectiveness evaluation and prepare PM change request if necessary within 30 days from work completion. PM program change is recommended to be activated before next PM execution.

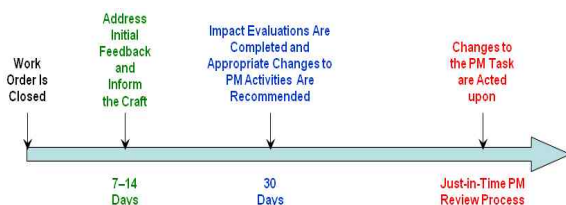


Fig. 1. Key Milestone for addressing As-found condition

### 2.4 Other tools for effective PM feedback

Some utility developed automated tool to assess PM effectiveness. This tool calculate points by AFCC and deduct corrective/elective maintenance penalty points which is applied differently by functional importance.

This system analyze three different periods of 18, 36, and 54 months.

Some utility evaluate quality of feedback comment which gives points if the comment includes equipment condition or qualitative evaluation, or agrees with AFCC. Comment quality tracks monthly for individual worker and overall plant.

Most utilities has performance indicators to evaluate maintenance feedback performance which consist of percentage of feedback input, feedback quality, feedback ability(process), feedback response time, and PM review process, PM template development and integration of industry data into PM template.

## 3. Conclusions

For the continuous improvement of equipment reliability and maintaining living PM process, maintenance feedback is one of the most important elements. Accurate and descriptive as-found data input, timely and technically sound evaluation, and effective implementation of as-found evaluation are key success factors.

KHNP has been implemented PM program and collected As-found condition data. To be successful in living PM program, clear definition of as-found data processing process and quality improvement of as-found data should be prepared.

EPRI recommended to use as-found checklist at an as-found data entry for the consistency and feedback comments should be supplemented. Plant procedure for as-found data processing should clearly define the process, responsibilities and milestones. Another important element of effective as-found program is keeping workers engaged and motivated to provide quality as-found data by notifying and emphasizing that maintenance feedback is valuable and contributing to PM and equipment reliability improvement.

## REFERENCES

- [1] EPRI, Developing an Effective As-Found Program, 1025578, 2012.
- [2] INPO, Equipment Reliability Process Description, AP-913 Rev-5 2016.
- [3] EPRI, Preventive Maintenance (PM) Program Guideline, 1022951, 2011.
- [4] EPRI, Guideline for As-Found Reporting – A Process for a Living Preventive Maintenance Program, 1002935, 2003.