Procedure Based Maintenance

Taking Your Maintenance to the Next Level

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Imagine an operation in which there are no lost time accidents, OEE is increasing, and there is a plan to address the skills shortage. These sites do exist and chances are they using procedure based maintenance. Procedure Based Maintenance is simply having all maintenance activities documented in a procedure. The procedures are followed step by step when conducting breakdown, corrective and preventative maintenance.

This level of operational excellence comes with discipline. Not just discipline that deals with people doing what they should be doing (or not doing), but discipline to the process and eliminating variation. That is the goal of the procedure based maintenance, to eliminate variation in all aspects of maintenance, including data collection, repairs, calibration, and commissioning. Another goal of Procedure Based Maintenance is to eliminate and reduce the odds of mistakes by maintenance staff. By ensuring that all activities are performed the same way, organizations can accomplish three key deliverables; build a knowledge library to survive the skills gap; identifying key areas of variability and reducing that variability to ensure consistent outcomes from activities, and minimize the odds of a mistake during maintenance activities.

However, the use of procedures must be thought out well in advance. Without this thought out approach, the adoption of the organization to use the procedures will fail. The procedures need to be organized in a way that they can be quickly located. They must be written in a way that there is no interpretation of the meaning of the task and that non-native English speakers can understand. Lastly, they must be used by the staff, feedback captured and used to improve them.

History of Procedures in Maintenance

The use of procedures can be traced back many decades, and the results speak for themselves. Consider the USS Thresher, which was lost along with 129 lives, on April 10, 1963. During the investigation into the loss of the USS Thresher, it was concluded that the loss of the ship occurred as a result of flooding caused, most likely, by the failure of a seawater system component that may have been reinstalled improperly during shipyard overhaul. There were additional factors, but the primary finding was that the component was reinstalled incorrectly.

At the outcome of the investigation, the US Navy implemented a new program to address submarine safety. This program was known as “SubSafe.” The SubSafe program required detailed written procedures and checklists to be developed and followed to the letter by all personnel engaged in maintenance of specified components of all systems affecting submarine safety. To date, the US Navy has not lost a submarine due to a maintenance mistake, under which the system is covered by the

SubSafe program. This shows the impact that a robust Procedure Based Maintenance program can have on reliability and safety (Orzalli, 2018).

Later in the 1960's, there was a focus on improving the reliability of commercial aircraft. This study, which was published by Nowlan & Heap, brought to light that most failures were not induced by time or wear, but were either random or were trigger by improper maintenance or installation. Looking at the six failure patterns, it can be observed that failure pattern six which experiences a high level of infant mortality followed by a random by consistent failure rate was more prevalent at 68%. This indicates that the highest probability of failure is when the equipment is new, or just overhauled. So what caused the spike in the probability of failure? The causes could be related to;

- Design
- Manufacturing Defects
- Installation Defects
- Improper Commissioning
- Improper Routine Maintenance
- Maintenance Workmanship

Seeing the causes of the high probability of failure for new or recently overhauled equipment, more maintenance was not the answer. The solutions were related to controlling the variation in activities. These activities included such activities as design reviews, supplier quality & certification programs, and development of procedures for operation and maintenance of the equipment. There was a conscious move from relying on On-The-Job training, intuition, etc. to the use of detailed, technical procedures. As a result of these changes (along with the move to condition-based maintenance from time-based maintenance), worldwide aircraft incident rates have fallen from around 40 incidents per million takeoffs in the early 1960s to around 1-2 incidents per million takeoffs in 2016 (Aviation Safety Boeing Commercial Airplanes, 2018).

Importance of Procedures

Procedure Based Maintenance serves to address two key issues when performing maintenance activities. First, it reduces the variation that occurs where many craftspeople are conducting the same work. Consider how many different ways there are to rebuild a pump;

- How does the disassembly happen?
- Does the disassembly occur with PTH (Precision Torch and Hammer), or does it occur with the proper tools?
- Does the rebuild occur in a clean room or in a dirty shop that can contribute to contamination?
- Are the parts inspected according to a standard or left to the experience of the rebuilder?
- Is there a standard list of parts that are replaced or is it left to the inspection?
- Is thread locking component used during reassemble or not?
- Are the clearances checked based on experience or based on technical specifications?

- Are fasteners tightened using a torque wrench or the strength of the rebuilder?
- How is the pump tested before being put back into stock or service?

If you ask a group of craftspeople the questions above, you will likely get a wide range of different answers and not two people will have the same process for rebuilding and commissioning a pump. This variation virtually makes it impossible to establish a root cause of a premature failure or poor performance of a rebuilt pump. A procedure based on the experience of the staff, can capture the collective knowledge and put it into a repeatable and consistent procedure, eliminating this variation.

Secondly, Procedure Based Maintenance minimize the odds of an individual from performing a mistake. There are various types of factors can contribute to a mistake, and it is important to understand the different factors that impact of human performance to ensure that the procedures are written to address them;

- Anthropometric Factors are those related to the size or strength of the person performing the activity. These are primarily addressed with redesign or tools, and not procedures.
- Human Sensory Factors are those concerned with the ease of which people can see, hear, feel and even smell what is going around them. These are also primarily addressed with redesign, or tools, and not procedures.
- Physiological Factors refer to environmental stresses, such as high or low temperatures, excess noise, humidity, etc. Once again, these cannot be addressed through procedures.
- Psychological Factors are related to the causes of which mistakes are made. Psychological errors are divided into two types, unintended errors which occur when someone does a task incorrectly. An intended error occurs when someone deliberately sets out to do something, but what they do is inappropriate. The intended error can be either be a mistake or violation. A mistake is a misapplication of a good rule, or application of a bad rule, or an inappropriate response to an abnormal situation. A violation is when someone knowingly and deliberately commits an error. Procedures will help to address unintended errors and mistakes, but not violations (Moubrary, 1997).

By accounting for the different ways activities are performed, types of mistakes, and utilizing a feedback cycle, Procedure Based Maintenance takes the learnings from all the craftspeople and incorporates them into the procedure. The result is the safest, most efficient and reliable way to complete the task.

How Procedures Impact Reliability

Once Procedure Based Maintenance is in place, the operation will see noticeable improvements in 5 key areas.

- Safety will improve as tasks are well planned out, with the risks identified. This allows the development of effective risk reduction activities. Also, the procedures can be used in the event of a failure, which can reduce the risks associated with unplanned work.

- Improved Reliability as tasks is completed consistently with proper technical specifications. This reduces premature failures, and in the event of one, it can be analyzed to determine the root cause as the procedure and activities are defined and consistent.
- Reduction in start-up failures as the procedure will ensure all bolts are tightened properly, the area is inspected, all foreign objects removed and proper commissioning activities are performed.
- Reduction in Mean Time To Repair as a procedure is available which will reduce the time to repair as all the required information is readily available.
- Knowledge Management is a major benefit of Procedure Based Maintenance as the experience and knowledge of the experienced craftsman can be captured in the procedure and transferred to the junior craftsman.

As previously observed in the reduction of incident rates in aircraft, Procedure Based Maintenance should become a cornerstone of all maintenance activities.

Getting Started in Procedure Based Maintenance

As seen, Procedure Based Maintenance is used by many industries that require high uptime. Nuclear Power, Nuclear Navy, and Aviation to name a few. But just because these industries use it, doesn't mean you can't. Here is what you need to get started in Procedure Base Maintenance;

1. Start by documenting the steps to complete the PM tasks. Walk through each task and document each step of the procedure, including any specific technical specifications. Once the procedure has been developed, be sure to review it and make sure it represents the best practice in completing the task. This may take many revisions or reviews. This procedure may be developed by a senior craftsperson, a planner, or by having recent, high skilled retirees come back on contract to write the procedures.
2. Using the procedure above, create a checklist that can be used when completing the procedure. Checklists are used in all major industries as a way to ensure nothing is missed. There may be pushback around using a checklist, as the craft may say they are skilled, but doctors and pilots use them to ensure nothing is missed, so why shouldn't craftspeople?
3. Define a training and certification program for the new procedures. This will ensure that the craftspeople are trained in the task and Procedure based maintenance before being allowed to perform these critical tasks. Training on the procedure should be performed by the individual(s) responsible for developing the procedure.
4. Once the craftspeople have been trained, be sure to reinforce the use of the procedures. Conduct audits to ensure they are followed, and that only trained personnel is using them. Try to reward those that embrace Procedure Based Maintenance as well.
5. Utilize the feedback provided on the procedures. This does not mean taking all feedback as absolute truth; it means reviewing, evaluating and either using the feedback or provide explanations to why the feedback will be used. This type of approach will ensure that feedback is provided.

6. As more maintenance tasks are converted to procedures, develop and use a single template. This will ensure consistency across the organization, making Procedure Based Maintenance easier to put in place and sustain

One caution with using a craftsperson to write the procedures. Be sure to train them first on how to write procedures. The procedures need to be specific and actionable without any unnecessary information. I have seen this and the approach where the craftspeople write the procedure and then it is edited by a technical writer. Both approaches have their pros and cons, so be sure to choose the right approach for your organization.

Writing Procedures to Make Them Usable

Writing procedures is not an easy task. Many people have different opinions on the sequence, specifications, etc. But once that is sorted out, the procedure itself needs to be written in a way that it can be followed by all craftspeople, included in non-native English speakers. Thankfully, with English being the universal language of aviation, we can continue to learn from the aviation industry. The aviation industry has developed Simplified Technical English.

Simplified Technical English is a controlled version of English, that is designed to help the users of English-language maintenance documentation understand what they read. Technical writing can be complex and difficult to understand even for native English speakers. Complex writing can be misunderstood, which may lead to accidents or premature failures (think about the Psychological Factors discussed above). Simplified Technical English makes procedures easy to understand and follow, eliminating language issues and reducing premature and maintenance induced failures.

Simplified Technical English provides a set of Writing Rules and a Dictionary of controlled vocabulary. The Writing Rules cover grammar and style. The Dictionary specifies the words that can be used and those that can't be used. For the words selected, there is only one word for one meaning and one part of speech for one word. Some of the benefits of Simplified Technical English may include;

- Reduce ambiguity
- Improve the clarity of technical writing, especially procedural writing
- Improve comprehension for people whose first language is not English
- Improve Reliability concerns of maintenance and assembly by reducing their probability to introduce defects

The Simplified Technical English specification is not easy to learn, but there are training and software available (if you are interested in this standard, please visit the ASD Simplified Technical English website). The detailed contents of the Simplified Technical English specification will not be covered, but instead, the rest of this section will cover what you can immediately do to make your procedures more readable and drive reliability.

So without becoming an expert in Simplified Technical English, how can you begin to write better procedures? You can begin with some basic writing practices and by reviewing the procedures before it issued. Some of the basic practices to use when writing procedures include;

- Use short sentences. (The recommended maximum is 20 words in a procedural sentence and 25 words in a descriptive sentence.)
- Restrict noun clusters to less than three nouns
- Restrict paragraphs to less than six sentences
- Avoid slang or jargon
- Avoid the passive voice
- Be as specific as possible
- Use articles such as “a/an” and “the” wherever possible
- Use simple verb tenses (past, present, and future)
- Write sequential steps as separate sentences
- Put commands first in warnings and cautions, with the exception of conditions.
    - For example, write Make sure that the valve is open. Do not write Make sure the valve is open.
- Use the conjunction that after subordinate clauses that use verbs such as make sure and show.
- Introduce a list item with a dash (hyphen).
- Use graphics where needed to clarify meanings. A picture is worth a thousand words
- Use the word "Warning" to protect against personnel harm and the word "Caution" to protect against equipment harm

Once the procedure is written, be sure to review and delete any information which is not relevant (i.e., Instead of synthetic lubricating oil, use only oil). Well-written procedures should help in eliminating any interpretation and driving clarity to the craftsperson performing the activity. Here is an example of how the wording of a procedural step could be open to interpretation. The task “Replace the filter” could mean either of the following:

- Put back the filter that you took out.
- Install a new filter.

Now you can see how one person may perform a task and how another would perform it differently. Once the task is clear, a technical specification should be added to ensure the task is performed to a standard such as “Tighten to 15 ft-lbs”. The result of ensuring the task is clear, and a specification is present is “Install a new filter and tighten to 15 ft-lbs”. This task is simple, clear, easy to understand and can be performed in a consistent and repeatable manner.

If the organization decides not to purchase and follow Simplified Technical English, that is perfectly ok, but make sure there is a standard in place for writing procedures to ensure everyone is doing it the

same way. It may sound crazy to have a procedure to write a procedure, but it is vital for consistency and repeatability.

Having the Staff Actually Use the Procedures

One of the hardest parts of implementing Procedure Based Maintenance, is the change that it brings to the organization. There is a change in the way maintenance is performed for all levels of the maintenance department. For example, the craftspeople must know follow procedures, specifications, and rely less on personal experience and intuition after doing so for the past 20 years. Maintenance supervisors are now focused on ensuring procedures are used and update. Planners now become more focused on updating procedures, making sure they are readily available for use.

Helping the organization through this change is not easy, and requires a well thought out approach. I personally like to use the ADKAR framework (Prosci, 2018). The ADKAR framework enables organizations to plan out and manage the change being implemented and how to bring the people along with the change. ADKAR stands for Awareness, Desire, Knowledge, Ability, Reinforcement. Each step in the framework provides specific actions that should be taken;

- Awareness of the need for change
- Desire to participate and support the change
- Knowledge on how to change
- Ability to implement required skills and behaviors
- Reinforcement to sustain the change

The whole purpose of using a framework like ADKAR is to identify any concerns associated with the change, address those concerns, demonstrate how the change will benefit the staff, provide the knowledge and training and finally demonstrate that the change is not a flavor of the month. The more time spent on planning and managing the change, the more likely that the change will be adopted and sustained.

Conclusion

Procedure based Maintenance has the opportunity to drive significant improvements in safety, reliability, and operational improvements. But before an organization can jump into Procedure based Maintenance, there needs to be a well thought out plan on how to implement Procedure based Maintenance, who will write the procedures, to what standard will the procedures be written, and how will staff be trained on the new procedures.

With Procedure Based Maintenance being adopted by the US Navy, Aviation and Nuclear Power, the results have been proven. So if those types of organizations are using Procedure Based Maintenance, what is preventing your organization from using Procedure Based Maintenance.

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