From the Reliability Professionals
at Allied Reliability Group

# Lean Manufacturing & Reliability Concepts

**Inside:**

Key Principles of Lean Manufacturing

3 Types of Inspections for Mistake-Proofing

## A Must-Read Guide for Maintenance and Reliability Leaders

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# Lean Manufacturing and Reliability Concepts

**The concepts contained within Lean Manufacturing are not limited merely to production systems. These concepts translate directly into the world of Maintenance and Reliability.**

At the core of Lean Manufacturing philosophy is the concept of elimination of waste. It is about getting precisely the right resources to the right place at the right time to make only the right products (the requested quantities at the required quality level) in the most efficient manner possible.

The concept of the elimination of waste can be easily traced to Benjamin Franklin. Poor Richard encouraged the elimination of waste in numerous ways. Adages like “Waste not, want not”, “A penny saved is two pence clear…Save and have”, and “He that idly loses 5s. [shillings] worth of time, loses 5s., and might as prudently throw 5s. into the river”. Yes, it was Benjamin Franklin that educated us about the possibility that avoiding unnecessary costs could return more profit than simply increasing total sales.

It was Henry Ford who furthered this idea by integrating the concept of waste elimination into daily operations at his manufacturing facilities. Mr. Ford’s attitude can be seen in his books, My Life and Work (1922) and Today and Tomorrow (1926), where he describes the folly of waste and introduces the world to Just-In-Time (JIT) manufacturing. Mr. Ford cites inspiration from Benjamin Franklin as part of the foundation of these methods.

However, it was not until Toyota’s Chief Engineer, Taiichi Ohno, systematized these concepts and the idea of a visual “pull” (Kanban) into the Toyota Production System and created a cohesive production philosophy that was focused on the elimination of waste that the world was able to see the real power of Lean Manufacturing. Interestingly enough, when Mr. Ohno was asked about the inspiration of his system, he merely laughed and said he read most of it in Henry Ford’s book.

Part 1 of this guide will focus on one very specific Lean Manufacturing method known as 5S. This section will detail how a 5S initiative that focuses on a plant's Preventive Maintenance (PM) program can immediately unlock resources within the maintenance department and make the PM process significantly more effective and efficient. Part 2 will look at the Deadly Wastes (Muda) of manufacturing and how elimination of these wastes is also a focus of the reliability process. Part 3 will discuss the overall objectives of Lean Manufacturing and parallel them with the overall objectives of the reliability process. The focus of Part 4 will be on Poka-Yoke (mistake proofing) and showing how several standard maintenance techniques are, in fact, Poka-Yoke techniques. A brief discussion of Kaizen and how both Lean Manufacturing and Maintenance and Reliability initiatives share these very same goals and objectives summarizes the entire report.

# Part 1: 5S

5S is the name given to the Lean Manufacturing method for the clearing out of all unnecessary items to allow room for the acquisition of tools and parts in the fastest and easiest manner. A comparison of 5S methodology with an evaluation and optimization of a PM program at a plant quickly shows how similar these processes are.

### Seiri – Sort (tidiness and/or organization)

**Lean Concept:**

The workplace is rid of anything that is unnecessary. Tools and parts are sorted through, and only the essential items are kept; everything else is stored or thrown away. This makes the workplace uncluttered, safer, and more organized for productive work.

**PM Application:**

Studies agree that somewhere between 30% and 50% of the tasks in most PM programs are non-value added and should be removed. These tasks actually cost more to perform than the benefit they yield. The labor associated with the completion of these tasks can be reassigned to other maintenance functions like working down the ready backlog.

### Seiton – Straighten (orderliness)

**Lean Application:**

The workplace must be arranged in a systematic manner that will encourage efficiency and will reduce unnecessary travel and/or motion. Specifically, 5S requires the tools and parts that are used in the work or storage area to be organized in such a way that they are easily accessible and visually obvious when not present. Things should be placed where they best meet their functional purpose. (A Second Look at 5S, James Van Patten, Quality Progress, October 2006)

**PM Application:**

Another 30% of the tasks contained within most PM programs should be reassigned either to operations or to a lubrication route. Some of these tasks are generally classified as “Asset Care” tasks and should be performed by an operator. Other general inspection tasks should be reassigned to operators once they have completed task qualification training. Lubrication tasks should be reassigned to a lubrication route where a trained lubrication technician can ensure that the task is performed to industry Best Practice standards.

Another way to look at this concept with regard to order is the concept of load leveling the PM tasks, operator care and inspection tasks, and lubrication tasks. The tasks are grouped by functional area within the plant and then arranged to ensure that each person has approximately the same load or amount of tasks to complete and that the tasks are grouped and arranged to be completed in the most efficient manner possible.

### Seiso – Shine, also Scrub (cleanliness)

**Lean Application:**

The workplace must always be as clean as possible. Waste and trash must be dealt with immediately. Machines must be kept clean, making leaks and other defects more easily recognized.

**PM Application:**

When cleaning out a PM program, it should be scrubbed of all tasks that do not specifically address a failure mode or do not pass a simple cost/benefit analysis. More specifically, it should address a failure mode that is appropriate for PM tasks. Weibull analysis of failure data should show a strong wear-out curve. This means that it truly is a wear-out mechanism and a traditional interval-based activity or PM should be applied to properly combat it. Failure modes that exhibit a Weibull shape indicating random failure patterns are not good candidates for interval-based PM activities. For these failure modes, a comprehensive inspection program is more appropriate. Condition Monitoring (CM) technologies, like Infrared Thermography, Vibration Analysis, and Oil Analysis, are very powerful tools for such failure modes and easily pass a cost/benefit analysis.

### Seiketsu – Standardize (standardized cleanup)

**Lean Application:**

Everyone in the workplace must maintain the same basic standards for cleanliness.

**PM Application:**

All of the tasks that remain in the PM program should follow the same standard for format and content. All of the tasks should include a clear definition of the task, specific steps, necessary safety warnings, appropriate tools, and required parts. Additionally, the tasks should have been through a technical review and approval process and should contain a revision tracking mechanism. Also, the procedure should always provide for a feedback mechanism for the crafts personnel to make suggestions and corrections about the procedure. This mechanism creates a continuous improvement loop for the task procedure.

### Shitsuke – Systematize, Sustain (discipline)

**Lean Application:**

The workplace must maintain a culture of discipline. Workplace standards must be maintained day after day. Once attained, the workplace is kept safe and efficient.

**PM Application:**

Creating a culture of discipline in the PM program requires systematizing the program so the tasks are of a nature that not only encourages crafts personnel to respond, but requires it. PM programs where the comments and recommendations of the crafts personnel are not acted on quickly become ineffective. In creating a systematic and sustainable PM program, all of the tasks should be quantitative in nature, with specific, measurable activities that detail nominal measurements with minimum and/or maximum allowable limits. PM inspections should require the use of measurement tools such as calipers, micrometers, and torque wrenches. "As Found" and "As Left" comments should be required fields and their responses cataloged in the Computerized Maintenance Management System (CMMS).

### Summary

Performing a Preventive Maintenance Evaluation (PME) identifies the amount of waste in a PM program and also helps sort out which PM tasks can be reassigned to other teams within the maintenance and operations departments. It is a very quick and powerful assessment that can free up some manpower within the maintenance organization to be used for other tasks.

Additionally, the PME process will identify how many tasks need to be optimized. Preventive Maintenance Optimization (PMO) is the process of revisiting those tasks that will remain in the PM program and making sure all task procedures are systematic and standardized and contain all of the necessary information for the task to be completed in the most orderly and efficient manner possible.

The following table summarizes the 5S concepts and shows their interconnectedness with each other and relationship to Maintenance and Reliability.

| Lean Manufacturing Definition[1] | Japanese "English Translation" | Allied Reliability Group PME Definition |
|---|---|---|
| **Organized:** Distinguish between the less essential and the necessary. | Seiri "Separate" | **Step 1:** Eliminate all non-value added tasks from the PM. |
| **Neat:** Put things where they best meet their functional purpose. | Seiton "Straighten" | **Step 2:** Reassign appropriate tasks to operations or to lubrication routes. |
| **Clean:** Inspect for and eliminate waste, dirt, and damage. | Seiso "Scrub" | **Step 3:** Eliminate all tasks that do not directly address a specific failure mode. |
| **Standardized:** Maintain known, agreed upon conditions. | Seiketsu "Standardize" | **Step 4:** Ensure all remaining tasks follow a standardized format including clear definition, specifc steps, necessary safety warnings, appropriate tools and required parts. |
| **Disciplined:** Practice the habit of doing what is required even if it is difficult. | Shisuke "Systematize" | **Step 5:** Make sure all tasks are quantitative in nature with specific measurable activities detailing nominal measurements with minimum and maximum allowable limits. |

[1] A Second Look At 5S, *James Van Patten, Quality Progress, October 2006*

The PME and PMO are a very powerful combination of techniques that can be performed on a PM Program. Once completed, the PM Program will be rid of unnecessary tasks, tasks that don't address a specific failure mode and tasks that are more appropriately assigned to other teams within the maintenance department or to other departments. Remaining tasks will be optimized for efficient completion.

The table below details the analysis of a PM program and the number of craft personnel that can be freed up, reassigned, or used for other tasks, like CM.

Many maintenance organizations complain about having insufficient manpower to be able to reduce their maintenance backlog. These same organizations also complain about not having enough manpower to staff an internal PdM effort. Additionally, they complain about having a PM program that is too big, is too difficult to manage, and does not produce any results (i.e. does not reduce unplanned downtime). The biggest reason that this situation exists is that they have not applied the 5S concept to their PM program, thereby creating a PM program that is actually worth keeping.

| PM Task Action Recommendation | # of Tasks | % of Tasks | Man-Hours Represented |
|---|---|---|---|
| Reassign to Operator Care | 1,380 | 7.5% | 5,605 |
| Reassign to Lube Route | 2,856 | 15.6% | 11,600 |
| Replace with PdM | 6,437 | 35.1% | 28,222 |
| Reengineer | 5,200 | 28.3% | 26,221 |
| No Modifications Required | 2,487 | 13.5% | 8,987 |
| Totals | 18,360 | 100% | 80,635 |

# Part 2: Muda

A key to effective (profitable) manufacturing is to use only the resources (capital, human, and time) needed to produce a product that meets every customer expectation at the price the market will bear. Any manufacturing process or maintenance system that consumes more than precisely the resources that are needed is wasteful. These wastes reduce effectiveness and, ultimately, profit.

Muda is the Japanese word for “waste” and in the context of Lean Manufacturing is the elimination of waste and the core of the Toyota Production System. In Lean terms, Muda refers specifically to waste created by the manufacturing process. In Maintenance and Reliability terms, Muda refers generally to the concept of wasted resources spent on inappropriate maintenance strategies and poor execution of daily maintenance activities.

Before wastes can be eliminated, they must be identified. Mr. Ohno originally named seven “deadly wastes”, but two more have since been added. For each type of waste, there is a specific strategy surrounding its elimination.

### Overproduction

**Lean Definition:**

Making more than what is needed, or making it earlier than needed.

**Maintenance and Reliability Application:**

An analysis of a typical maintenance department finds a tremendous amount of “over maintenance”. Traditionally, time-based rebuilds or component replacements have been used in an effort to combat premature equipment failures. Not realizing the random nature of the failures, a sense of frustration is felt with each emergency repair, so the frequency of the time-based replacement is increased. Maintenance costs continue to rise, and failure rates are unaffected.

**Elimination Strategy:**

The best way to eradicate this deadly waste is to get a better understanding of the true nature of the equipment’s failure pattern and adjust the maintenance strategy to match.

### Unnecessary Transportation

**Lean Definition:**

Moving products farther than is minimally required.

**Maintenance and Reliability Application:**

The concept of transportation as a waste in a maintenance context goes directly to the amount of time that crafts personnel spend traveling back and forth between the job site and the storeroom to retrieve parts that were damaged, not kitted, or not the correct part for the task. Excessive transportation is most often a direct reflection of inadequate job planning or incomplete Bills of Materials (BOM).

**Elimination Strategy:**

Improve maintenance job planning and job plan procedures. Create an accurate BOM for each asset. Ensure that parts are stored, maintained, and transported in a manner that does not reduce their life cycle.

### Waiting

**Lean Definition:**

Products that are waiting on the next production step, or people that are waiting for work assignments.

**Maintenance and Reliability Application:**

Waiting in a maintenance context is very similar. Instead of people waiting for work to do, it is people waiting to do work. This slight variation in statements reflects a very common problem for maintenance crafts people. Where the amount of time spent doing value-added work (a.k.a. wrench time) is low, it is very typical to see a lot of maintenance crafts personnel standing around and waiting for the opportunity to work. The job is planned (and may in fact be planned well), but the timing with operations was poorly coordinated. The inter-functional coordination was non-existent, or at best disconnected.

**Elimination Strategy:**

Inter-departmental communication and coordination must rise to the top of the list of priorities. Utilizing a cross-functional work scheduling process is one effective method for reducing the waste of waiting.

### Inventory

**Lean Definition:**

Having more inventory than is minimally required – excess inventory. This is the deadliest type of waste in Lean considerations.

**Maintenance and Reliability Application:**

Organizations who continue to operate in a reactive manner never know what is going to break next. As such, a large amount of spare parts need to be warehoused either on-site or nearby to be available for the next emergency.

**Elimination Strategy:**
The closer an organization moves to a proactive strategy, the fewer parts that are kept on hand. As defects are discovered early and job plans are completed early, the parts can be ordered and delivered “on time” and “as needed”, instead of kept in the warehouse.

### Motion

**Lean Definition:**
People moving or walking more than minimally required.

**Maintenance and Reliability Application:**
Once again, we find ourselves focused on crafts personnel wrench time. Low wrench time is a major area where improvements can be seen quickly. Most North American maintenance organizations are surprised to learn that their wrench time is 20-35% (or even less). They are even more shocked to learn that Word Class is 55-60%. Many people guess that their maintenance crafts personnel average a wrench time of 70% and that 95% is possible.

**Elimination Strategy:**
Improvements such as lower overtime and lower contract labor costs are easily possible with improved wrench time. Wrench time studies should be scheduled every year to see how the situation has changed/improved and what adjustments need to be made to make even more improvements. Items like improved planning, scheduling, and parts kitting can make huge improvements in a facility’s wrench time.

### Processing Itself

**Lean Definition:**
Stand-alone processes that are not linked to upstream or downstream processes. Using complex machines and processes to do simple tasks. Not combining tasks to simplify the process; essentially “processing itself” = process simplification.

**Maintenance and Reliability Application:**
An excellent place to see the connection between Lean and Maintenance and Reliability for the concept of “process simplification” is the

fact that there is no standardization of parts across like machines. Design engineers love to use the latest and greatest parts and designs. If there is truly a competitive advantage to be had with the new part, then like parts in the facility should be upgraded as well. If not, then the more standardized solution should be chosen at the time of design. Using a different seal or impeller just because it is new can lead to unnecessary confusion and downtime when a repair is needed. An example would be using two different seals for the same model pump in the same application, when standardizing with one seal would save time, money, and confusion, especially if one of the seals has proven to be a better performer.

**Elimination Strategy:**
Maintainability and parts standardization must become a major focus of design/redesign efforts.

## Defects

**Lean Definition:**
The effort involved in inspecting for and eliminating defects.

**Maintenance and Reliability Application:**
From a maintenance and reliability standpoint, defects are the deadliest type of waste. It is not the presence of defects that plague an organization; it is how that organization deals with those defects. While the number of defects can be minimized through methods like precision maintenance techniques, they cannot be completely eliminated. Processes such as eliminating intrusive inspections or implementing a CM Program can make very large impacts on the number of defects present in the asset base.

**Elimination Strategy:**
The most important point to make about defects is that an organization has to be ready, willing, and able to detect these defects at their earliest stages, immediately begin the planning process to deal with the defect, and then identify and eliminate the root cause of the problem. This is the only way sustainable improvements in productivity and unit cost of production can be realized.

## Safety

**Lean Definition:**

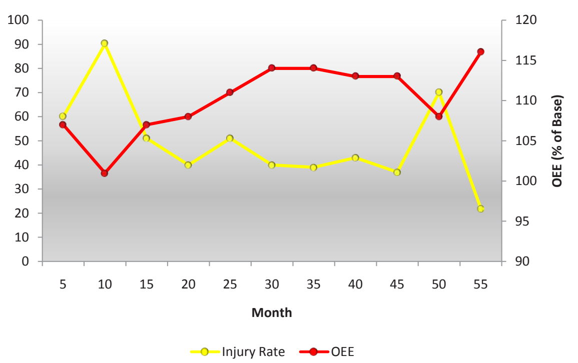
Unsafe work areas create lost work hours and expenses.

**Maintenance and Reliability Application:**

A decrease in emergency repairs always results in a decrease in safety incidents.

**Elimination Strategy:**

An increase in reliability has proven time and time again to produce a decrease in injury rates.




## Information

**Lean Definition:**

The age of electronic information and Enterprise Resource Planning (ERP) Systems requires current and correct master data details.

**Maintenance and Reliability Application:**

Maintenance and reliability people and information are part of the resources that need to be planned. Good planning and scheduling and effective maintenance engineering rely on complete and correct machinery design and performance information. The more incorrect or incomplete the information is for a given asset, the longer it will take to find the solution to a particular problem, and the more uncertain that solution will be upon delivery. Some of the information that needs to be current and correct is the machinery failure data, BOM, and machinery nameplate data.

**Elimination Strategy:**

A culture of information discipline must be fostered.

# Part 3: Key Principles of Lean Manufacturing

**A summary of Lean Manufacturing contains 6 Key Principles. It doesn't take a very detailed analysis to find that all of these key principles are common to both Lean Manufacturing and Maintenance and Reliability.**

### Lean Manufacturing Key Principle #1

**Pull Processing:** products are pulled from the consumer end (demand), not pushed from the production end (supply). This is Kanban.

**Maintenance and Reliability:**
In the maintenance realm, the concept of pull is used in the design of the maintenance strategy. The potential failure modes of the equipment and the effects of those failure modes on that asset's ability to perform its function and on the system at large determine the maintenance strategy. Failure modes and their effects pull the maintenance strategy into existence. The OEM recommendations are not pushed as the maintenance strategy of choice. Some people may become confused at statements like these and infer that the maintenance strategy is reactive. Nothing could be further from the truth. Just like Kanban is not a reaction to customer demand, neither is an Equipment Maintenance Plan (EMP) based on failure modes.

Failure modes are how a piece of equipment might fail or is expected to fail. The differentiating factor becomes when this analysis of failure modes and effects takes place. It should always be done before the failures occur – proactively, not reactively. While there is an ever so slight difference in these two concepts, the implications of this slight difference are enormous.

### Lean Manufacturing Key Principle #2

**Perfect First-Time Quality:** the quest for zero defects; revealing and solving problems at the source.

**Maintenance and Reliability:**
This is the identification and elimination of the root cause of machinery defects that drive the continuous improvement of the maintenance strategy. Procedure-based organizations use quantitative, documented procedures for both regular maintenance jobs and the PM tasks to drive consistency and quality in the

maintenance process. Additionally, these same organizations employ precision maintenance techniques to deliver “Right-the-First-Time results”. The combination of these three powerful forces has a large impact on the quest for zero defects.

### Lean Manufacturing Key Principle #3

**Waste Minimization:** eliminating all activities that do not add value and safety nets; maximize the use of scarce resources (capital, people and land).

**Maintenance and Reliability:**
Industry data indicate that 30% - 50% of the PM tasks in a typical North American maintenance organization are non-value added tasks. Additionally, most maintenance organizations operate in a very reactive mode and, in doing, waste a lot of valuable resources. Most studies agree that, on average, 30% of the labor and 50% of the parts and materials used in unplanned jobs are wasted, not to mention the amount of unplanned downtime associated with such jobs. Those same productivity studies agree that the combination of these three items (labor, parts and downtime), along with other benefits like increased safety, decreased spares inventory, etc., can account for as much as a 30:1 Return on Investment (ROI) that most North American facilities have previously been unwilling to reach for.

### Lean Manufacturing Key Principle #4

**Continuous Improvement:** reducing costs, improving quality, and increasing productivity and information sharing.

**Maintenance and Reliability:**
At the core of every good maintenance and reliability person exists the concept of continuous improvement – it is an attitude and a way of life. They are always striving for a better technique, a part of better design, an improved methodology, or an easier way to get it done. Every maintenance person looks for a solution that makes assets easier to maintain and more reliable. Every reliability person looks for a solution that makes asset availability and plant productivity rise and life cycle cost and unit cost of production go lower.

### Lean Manufacturing Key Principle #5

**Flexibility:** producing different mixes or greater diversity of products quickly, without sacrificing efficiency at lower volumes of production.

**Maintenance and Reliability:**
Flexibility is the key to keeping up with the changing business environment. It is no different for maintenance and reliability. As the market changes, so does the mix of products and volume. While the core function of a manufacturing facility rarely changes, the requirements for its operation do change, and consequently the reliability and criticality of different machines can change, almost on a daily basis. The onus then is on the maintenance and reliability function of a facility to create systems and processes that are less affected by changes in the market place. Otherwise, drastic changes in the daily execution of the maintenance process will cause the process itself to become dysfunctional.

### Lean Manufacturing Key Principle #6

**Establish High-Quality Supplier Partnerships:** building and maintaining a long-term relationship with suppliers through collaborative risk sharing, cost sharing, and information sharing arrangements.

**Maintenance and Reliability:**
In the sentence above, simply replace the word “suppliers” with the word “operations”. Now it reads: building and maintaining a long-term relationship with operations through collaborative risk sharing, cost sharing, and information sharing arrangements. A partnership must be established between maintenance and operations. As with any true partnership, it must be born of mutual respect and the attainment of common goals. A partnership that is based on winning and losing, or an attitude of “This is my plant and you work for me!”, is destined for failure or, at best, mediocrity.

# Part 4: Poka-Yoke

As previously mentioned, continuous improvement is integral to any effective Lean Manufacturing system. At the heart of a strong continuous improvement methodology is Poka-Yoke. Poka-Yoke is the process of fervently reducing the potential of defect occurrence.

Poka-Yoke was first introduced at the Toyota Motor Corporation in 1961 by Dr. Shigeo Shingo, an industrial engineer. Originally named Baka-Yoke, meaning “fool-proofing” or “idiot-proofing”, the name was changed to Poka-Yoke (“mistake-proofing”) in 1963 for want of a more honorable and less offensive name.

Poka-Yoke can take the form of a mechanism designed to ensure that proper conditions exist before a process step occurs, thereby preventing a defect from occurring. It can also be a procedure designed to identify and/or eliminate defects as early as possible in the process. Essentially, Poka-Yoke is the concept of easily and quickly detecting and removing defects.

There are many parallels between Lean Manufacturing and Maintenance and Reliability with respect to Poka-Yoke. The concept of detecting and removing defects is the very heart of maintenance and reliability efforts, and any technique that helps accomplish this easier, quicker, or earlier in the process is a Poka-Yoke technique.

In explaining the origin of defects, Dr. Shingo said, “The causes of defects lie in worker errors, and defects are the results of neglecting those errors. It follows that mistakes will not turn into defects if worker errors are discovered and eliminated beforehand”. Additionally, he stated, “Defects arise because errors are made; the two have a cause-and-effect relationship”.

Statistical analysis of machinery failures essentially reflects the same scenario. RCM studies from the ‘60s and ‘70s show that as much as 68% of failure modes detected in machinery were the result of poor maintenance and/or operating procedures and another 14% were the result of random events caused by people’s carelessness. Add to this an additional 7% for wear-in failures and a total of 89% of the failures are the result of people's lack of attention to detail or an incomplete understanding of their operations. This means only 11% of the failure modes were the result of age, wear, and fatigue. Studies from the '80s and '90s reflect that proper attention to procedures dropped the previously reported 68% to as low as 6%, but the 14% from random events climbed to as high as 25%. So, while improving maintenance and operating procedures did lower the instances of infant mortality, carelessness in other areas related to operations did not improve.

Dr. Shingo explained three different types of inspections in the concept of Poka-Yoke.

### Judgment Inspection

Judgment inspection means identifying defective products or material after the completion of the process, essentially finding the defect when it is too late. Dr. Shingo warned that relying on this method is not effective quality management and, therefore, judgment inspections should be avoided when possible. Maintenance and reliability personnel sometimes have no choice but to utilize this method of defect detection as it is not manufacturing defects but machinery defects that are being sought.

Best Practice organizations use CM technologies like Vibration Analysis, Infrared Thermography, and Oil Analysis to identify machinery defects. While there are some benefits to identifying these defects and handling them in a proactive manner, the real benefit lies in using these Condition Monitoring technologies to help identify and eliminate the root cause of these defects. Not using these technologies to help eliminate the root cause of defects is the type of inspection that Dr. Shingo and the rest of the quality culture were warning against. Do not be satisfied with the fact that defects occur in your systems and that you are able to successfully identify and eliminate them. You must move further back in the process to identify them and eliminate them at their source.

Another way that CM is considered a judgment inspection is in its use as a troubleshooting tool. Organizations that do not use CM technologies have to rely on traditional troubleshooting techniques, such as trial and error, disassembly, and parts replacement. Utilizing CM technologies can give the crafts person a tremendous amount of information before the job is even started. Things like gear problems, electrical problems in motors, and contaminant ingression can be highlighted and detailed before the machine itself is ever shut down.

Using CM to help with troubleshooting and identifying the root cause of machinery defects makes CM itself a very powerful judgment inspection Poka-Yoke technique.

### Informative Inspection

The second type of inspection in the Poka-Yoke system is the informative inspection. This type of inspection is used to prevent defects through utilizing data gathered from the inspection process. The most common example of an informative inspection is the use of statistical process control.

Dr. Shingo offered two different types of informative inspection. The first method was for the very next station in the manufacturing line to perform a quality check or defect inspection on the material that just came from the previous station. While this method is reliable and cost effective, the second method of informative inspection reduces the time and cost of the additional inspection to almost zero. This method requires each station to perform a pre and post process inspection, thereby simultaneously checking the quality from the previous station and checking the quality of their work before sending it to the next station.

From a Maintenance and Reliability perspective, an example of using this type of informative inspection would be performing Weibull analysis to constantly adjust the maintenance strategy for a piece of equipment or a system within the plant. In doing so, the defect that the inspection process is detecting is an inadequate maintenance strategy. Many organizations believe that using the Mean Time Between Failure (MTBF) as the proper interval for time-based replacements and/or overhauls is the best method to cost-effectively prevent unplanned downtime. This is not correct and results in higher costs than are necessary.

Weibull analysis shows that by the time the MTBF is reached for a group of machines, 63.21% of the machines have already failed.

The better type of informative inspection would be to use failure data to populate a Weibull analysis model for the machine or system and let the analysis show the most cost effective time to perform the maintenance action. In the absence of a comprehensive failure history, a single failure point and some local knowledge about the frequency and types of failures can lead to some excellent approximations of the actual Weibull shape. This method is known as Weibayes and is a very powerful technique.

In using the failure data that comes into the CMMS system on a daily basis to keep the failure modes library and Weibull analyses up-to-date, the maintenance strategies can be adjusted as more detailed information becomes available. Using statistical analysis in this way makes Weibull analysis an extremely effective informative inspection Poka-Yoke technique.

### Source Inspection

The third and final type of Poka-Yoke inspection is the source inspection. Source inspection is the inspection of an operating environment or materials before the production process begins to ensure that the proper conditions exist. Source inspections in the Maintenance and Reliability arena are very common. They take at least three forms when considered in the context of machinery repairs: precision maintenance, procedure utilization, and CM.

Precision maintenance techniques are a type of source inspection. A precision maintenance technique is defined as any technique that makes the likelihood of extended defect-free operation more possible. Some examples of precision maintenance and reliability techniques might include:

- All rotating equipment will be balanced in-place to a minimum standard of 0.05 inches per second. This is significantly lower than most balance standards but not impossible. This tighter balance standard would lead to measurably longer bearing component life, in the absence of other issues.

- All rotating equipment will be aligned to < 0.5 mils per inch. As with the balance standard, this is tighter than most alignment standards and will lead to much lower radial and axial loading on the bearing and, therefore, longer bearing life.
- Milling the bottom of all cast frame motor feet so that they are flat and co-planar. This technique makes the alignment process quicker and easier. It also helps prevent a condition called soft-foot, which leads to warped motor frames, high frequency vibration in the motor bearings, and reduced bearing life.
- All electrical connections will be installed using torque wrenches and will be torqued to manufacturer's specifications. Contrary to popular belief, tighter is not necessarily better; some types of electrical connections can be too tight. This spreads the individual strand of wire out more and creates the very problem that needed to be avoided, a high resistance connection.
- All lubricant will be removed from the bulk container and placed into lubricant reservoirs via filter carts with a 3-micron filter. This prevents solid contaminants that would be detrimental to asset health from being introduced into the machinery reservoir.

By no means a comprehensive listing, these are just a few examples of precision maintenance techniques. Using these techniques extends the amount of time between machine commissioning and the point of defect ingression. As such, they are techniques that ensure the proper conditions are present for defect-free operation and are therefore a type of source inspection Poka-Yoke technique.

The most comprehensive source inspection Poka-Yoke technique is the use of procedures when performing machine repairs and inspections. Even with the most skilled crafts personnel, mistakes are made, steps are skipped, and conditions are overlooked. A technically accurate, well-constructed procedure decreases the conditional probability of a mistake being made. A feedback loop from the crafts person to the planner ensures the continuous refinement of the procedure. A technical review and approval process ensures that all procedures are correct and up-to-date. As these procedures are designed to help eliminate the possibility of a workmanship defect during a repair or inspection, they are a source inspection Poka-Yoke technique.

Another type of Poka-Yoke source inspection technique is the use of CM as a post repair commissioning inspection. Technologies like Vibration Analysis, Structure-Borne Ultrasound, Infrared Thermography, and Motor Circuit Analysis are excellent tools to certify repairs and new installations. Should workmanship defects like inadequate alignment or the presence of a bearing fault due to improper installation be identified, the defect can be corrected before the machine is returned to service. Using CM technologies can help easily identify defects or conditions that will cause defects early in the process and is, therefore, a source inspection Poka-Yoke technique.

# Kaizen

"Continuous improvement" is the translation most often used for the Japanese word Kaizen. Contrary to the popular use of the term, Kaizen is not an event. Kaizen is a frame of mind or the attitude with which you address items. It means always looking at a situation with what martial arts instructors refer to as Shoshin, which means "first mind" or "a beginner's mind". Beginners are always learning. With each moment of learning, improvements are made. With each improvement, more learning is desired so that more improvements can be made. This becomes a continuous cycle. The moment learning ceases is the moment improvement ceases. The moment improvement ceases is the moment your competitors start to gain ground. The term "expert" bears the connotation of "nothing left to learn". In an environment that embraces Kaizen, there is no such thing as an expert.

Just like Kaizen, concepts like 5S, Kanban, Poka-Yoke, and Muda are not single events; they are concepts that are practiced on a daily basis. Kaizen is an attitude; it is a way of life. It is the style with which Lean Manufacturing is managed on a daily basis. Kaizen is also the attitude with which maintenance and reliability people operate on a daily basis. A few examples include:

- Improving maintenance job plans so that the number of side trips a crafts person has to make to acquire parts, materials, and permits approaches zero;
- Improving written maintenance procedures so that everyone, regardless of specific experience with that plant or machine, knows the proper steps to affect the repair;
- Improving the inspection process to identify defects closer to their point of inception, thereby giving the planning function more time to adequately deal with the problem; and
- Improving the operations of the plant to produce fewer variations in the process.

Numerous other examples could be cited, but these clearly demonstrate that the concepts of Lean Manufacturing and the concepts of improved Maintenance and Reliability go hand-in-hand. It is not just difficult to separate these concepts, quite frankly, it is impossible.

# About Allied Reliability Group

Allied Reliability Group offers best-in-industry maintenance, reliability, and operational consulting and services, training, staffing, and integrated software solutions servicing the industrial and manufacturing sector.

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