

# The Strategic Importance of Plant Reliability



# The Strategic Importance of Plant Reliability

## Introduction

It is often misunderstood that effective reliability management of a manufacturing plant is merely a process of performing maintenance better. It is much more than that. In a manufacturing enterprise two important Key Performance Indices are used – one for the production side, called Overall Equipment Effectiveness (OEE), and the other on the enterprise side, called Overall Management Effectiveness (OME). Both of these key indices have a direct dependency on an attribute called Plant Reliability.

For purposes of clarity, by Plant Reliability we mean the overall reliability of the production assets in the shop floor. In a shop floor production flow line, Plant Reliability is determined by the measures of reliability of the individual assets. The asset that has the maximum failure rate becomes the weakest link. As a result of a single asset or a group of assets not being very reliable, it is quite possible that the overall Plant Reliability can be adversely impacted – and more importantly, the return on the investment and profitability as well get impacted along with it.

Plant Reliability, therefore, is not merely a buzzword but has emerged as a competitive advantage for manufacturers in today's global environment. As a result many companies are now developing reliability strategies at their corporate levels rather than just dealing with plant maintenance activities at the shop floor level.

The purpose of this paper is to establish and uncover the significant importance of Plant Reliability to a manufacturing organization as a whole – not just to the plant maintenance department. Even though there is an intuitive understanding of the benefits of Plant Reliability, there is still lack of clarity on the direct contribution of Plant Reliability to profitability at an operational level and competitive advantage at a strategic level.

The paper also discusses the need for an agile, real time infrastructure between the shop floor and the enterprise levels to achieve and sustain improvements in Plant Reliability. While reliability as a concept can be adopted by the manufacturing enterprise, the success will lie in the implementation of appropriate resources, methods, tools and technologies to monitor, track, evaluate and continuously improve reliability.

## Plant Reliability and Overall Equipment Effectiveness (OEE)

It is well known in the industry that OEE is calculated as a product of three factors: availability, quality and production speed.

Availability is normally calculated as the difference between the total time available for production and the scheduled downtimes of the plant for maintenance activities. Or, in other words, we can define the term "Planned Availability" as:

$$\text{Planned Availability} = \{\text{Total hours available in a year} \\ \text{minus number of hours scheduled for Maintenance}\}$$

Whenever there is a definition for a planned item, there is a need for tracking the actual value of the item and how the actual deviates from the plan. The Actual Availability therefore can be defined as:

$$\text{Actual Availability} = \text{Total hours available in a year} \\ \text{minus} \\ \{\text{number of hours scheduled for maintenance plus} \\ \text{number of hours spent on unplanned machine repair}\}$$

Similarly, we can define the term Quality as:

$$\text{Planned Quality} = \text{number of good products that were} \\ \text{planned to be produced under the Planned Availability,}$$

The Actual Quality as:

$$\text{Actual Quality} = \text{Planned Quality} \\ \text{minus} \\ \{\text{number of rejects plus number of parts reworked} \\ \text{plus number of parts lost due to start-ups}\}$$

And finally, the Production Speed as,

$$\text{Planned Production Speed} = \text{planned throughput of} \\ \text{the plant}$$

$$\text{Actual Production Speed} = \text{planned throughput} \\ \text{minus} \\ \{\text{idling losses plus speed losses}\}$$

The product of the individual ratios of the Actual to the Planned in each of the above (viz., availability, quality and speed) is one way of calculating OEE.

Now let us look at how plant reliability impacts each term of OEE.

The relationship between availability and plant reliability is intuitive, since, any lack of availability is a form of downtime and the greater the reliability, the lesser the downtime. Specifically, two forms of downtimes are provided in the definition of Actual Availability above – planned and unplanned.

Reduction of both is necessary. Reduction of the unplanned downtimes results in the Actual Availability tending towards the Planned Availability. Reduction in the planned (or scheduled) downtimes (by a proper proactive maintenance strategy) can even move the Planned Availability towards the theoretically available total number of hours in a year, which is 8760 hours!

Now let us look at the impact plant reliability has on quality. It is well known that during equipment's useful life, some of the major failures are due to process related problems. It is very important that the right asset is selected for a process, which is normally the case. Upon commissioning, the degradation in the said asset's performance leading to its inability to produce products according to the desired process capability standards will impact directly on the number of parts that will be rejected or reworked. In other words, poor management of asset reliability will cause poor Quality.

Also, after every breakdown (either scheduled or unscheduled), there is going to be a "run-in" period which will involve the trial run of the production on the asset that is coming out of the breakdown. These trial runs involve a very high degree of rejects. Thus, the more frequent the breakdowns, the poorer the quality.

Finally, production speed; once again, idling reduces the throughput, especially, if the idling assets are critically constrained resources (CCR). Also due to a poor reliability program, the asset's performance may be sub-optimal – resulting in lower speeds of production, thereby affecting the throughput.

Thus, poor reliability affects all the three factors that comprise OEE – availability, quality and production speed.

## Plant Reliability and OME

There are two important factors that decide overall management effectiveness of an organization – Return on Net Assets (RONA) and Return on Equity. For the purposes of this paper, let us concentrate on Return on Net Assets.

Return on Net Assets is an indicator of the return that an organization has achieved from its investment on assets. In the case of a manufacturing organization, the major component of investment is on plant, machinery and spare parts. (Let us bundle these three items and call them as "Production Assets" for the purposes of this paper.) While all levels of the manufacturing organization impact RONA, this metric has been used thus far only by the C-Level executives as a benchmark of the financial operation of their organizations. However, in general, the C-Level executives thus far have not tracked this metric to the performance of the plant

floor – especially to the improvement of reliability across the plant, which is where a manufacturing organization has the maximum potential to improve this metric.

In order to focus on the return on production assets, let us define the term ROPA as:

$$\text{ROPA} = \frac{\text{net operating profit after tax}}{\text{Total value of Production Assets}}$$

which is a variant of the RONA (RONA also includes cash, working capital requirements, and non-production related assets as well).

From the metric as defined above, it is clear that ROPA and net profit are directly proportional. Similarly, the total value of production assets (which is the investment) is inversely proportional to ROPA. Therefore, for achieving improvements in ROPA (which means the company is providing better return to its shareholders), we need more net operating profits for the same value of production assets. This is what Plant Reliability can directly achieve!

Let us look at a case study of a manufacturing organization whose revenues are around \$14 billion, net income of \$1.26 billion and a total investment in production assets of \$26 billion. Their ROPA is therefore 4.8%. The industry standard is 5.5%. Concerned by the "lower than the industry return" on production assets, the manufacturer planned a reliability program that was appropriate for their company. Their estimates indicated that by adopting this program they will realize an improvement in their net operating profits to \$1.96 billion with no significant addition in their production assets. Their estimates also suggested that their ROPA would have increased to 6.9 % from a modest 4.8% by the end of one year from the time of inception of the reliability program and to 8.4% by the end of the second year. The management looked at these impressive figures and gave a go ahead to a pilot program which was quite successful. Some elements of the pilot program are discussed in this paper as a reference.

## Strategic Plant Reliability

The first step the said manufacturer had to take towards achieving better reliability is to get rid of the mind set of considering asset maintenance as an operational activity. Improvement of reliability became a mandate for the corporate executives rather than a plant floor mandate. This was a shift in the thinking of the corporate executives since, until then, all of the maintenance and plant shut downs were only viewed as "costs" of a different (production) department. The impact of such costs on the organization's growth in general was never analyzed. When they started to analyze, the need for a strategy for plant reliability emerged.

# The Strategic Importance of Plant Reliability

More specifically, when the organization started its reliability program, it uncovered the following symptoms/conditions in general, and their production facilities in particular (and this is more or less typical of most manufacturing companies):

- Information flow between the Procurement, Operations and Management were still following an archaic, “silo based” methodology. These departments were not integrated from a business (information) process flow perspective. The inherent latency in the information flow was increasing costs and thereby eroding profitability. In other words, there was no infrastructure to monitor across several departments – for example, capture the dynamics of a business flow in one department (a faulty component of a machine) and act proactively in another department before the said dynamic can impact the flow in the second department (spare parts inventory procurement), and so on. In other words, not only were they losing profitability, they did not know how much they were losing as well until very much later (at the end of the month).
- No clear idea of the “hidden production capacity” of the plant – this is sort of related to the first point, but is concerned with the demand side. Requests for capacity increases were historically tackled by capital purchases or outsourcing, even though, in many cases some of the capacity demands could have been fulfilled by better planning and reduction of production downtimes;
- Recurring failures in the assets for which the same resolution has been provided every time, without analyzing the root causes which will prevent them. The principle of ‘Prevention is Better than Cure’ was not widespread with respect to asset health maintenance and therefore there was incidence of repetitive maintenance costs that could have been avoided;
- There was not a clear strategy defined for maintenance based on the criticality of the assets, and more specifically, their usage and/or types of failure rates of such assets. Maintenance was more based on calendar duration and some assets were maintained more than the others even though the usage of the over-maintained assets did not justify the maintenance activity.

The company defined a three pronged approach to improve reliability, and through reliability, the profitability of the plant.

- Build Reliability Centered asset health maintenance across all production facilities;
- Implement the said strategies using a dynamic, agile infrastructure that can integrate procurement, operations and management;
- Ensure that the infrastructure can provide continuous improvement rather than a onetime burst of reliability centered activities.

The management accepted the proposal and started the implementation of the changes. Let us discuss each of the above-mentioned more in detail to understand what specific changes were made to the organization.

## Plant Reliability Program – Implementation Approach Building Reliability Centered Asset Health Maintenance

Reliability Centered Maintenance (RCM) is a process used to determine systematically and scientifically what a company must do to continuously improve the availability, safety and general health of their physical assets. This process involves several factors, ranging from use of safety devices, identification of critical versus noncritical failures by studying failure modes, understanding the root causes of failures, elimination or reduction of random functional failures of equipment via predictive maintenance, optimization of preventative maintenance, elimination of non-value adding maintenance tasks, etc.

The RCM process in general is quite comprehensive. The manufacturing organization discussed in the previous section did not implement the overall gamut of reliability-centered maintenance processes but restricted that to those that are suitable to their organization. This is very important since many manufacturing organizations do not study carefully which processes are suitable and which are not. As a result, some processes that are not suitable are force fitted and they not only result in unnecessary costs, but also may result in a conflict with the normal business processes of the company. This may induce inefficiency in the organization which is counterproductive to the goal of RCM.

The said organization was very careful in identifying the goals. The selected goals of the reliability centered maintenance were:

- To optimize Preventative Maintenance
- To eliminate unplanned downtimes by predicting imminent failures in advance;
- To remove non-value added labor
- To reduce the time to restore.

Let us briefly analyze the choice of the above-mentioned goals by looking at the current status of their plant.

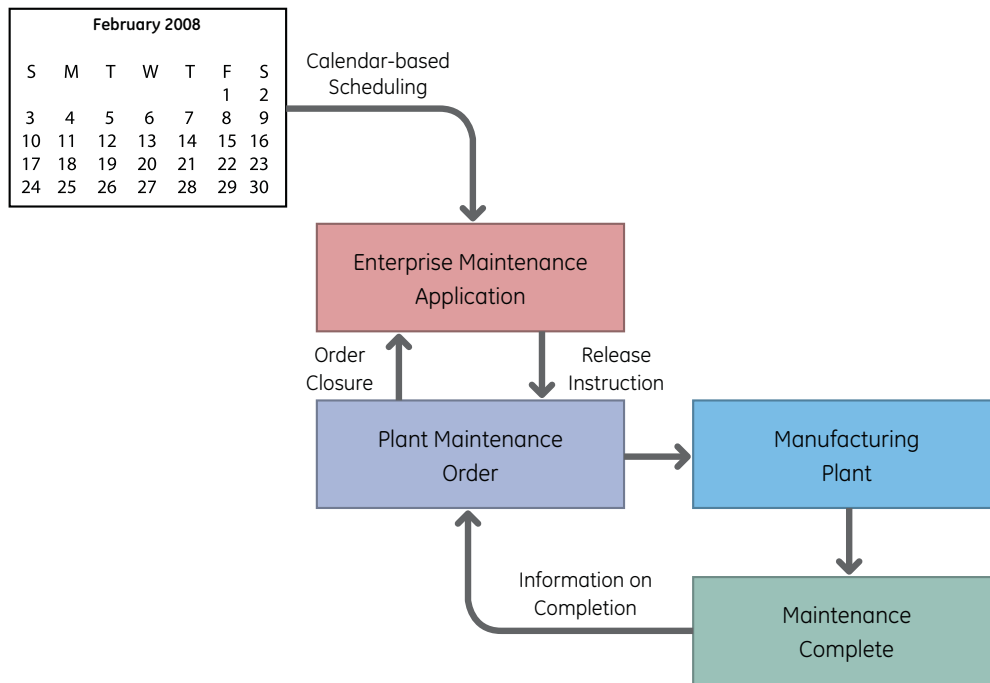


Figure 1. Calendar-based Scheduling of Preventative Maintenance

### Preventative Maintenance

Even though Preventative Maintenance was already in place in the said organization, the methodology of implementation was based on calendar time – which was not the most optimal way. In other words, the following calendar based scheduling process was used.

- Based on an approximate estimate of the production volume and therefore asset utilization, a date from the calendar or a day of the week in a month (for example, first Monday of every month), was chosen for scheduling a Preventative Maintenance Order (PMO) for an asset or a group of assets. This is done by manual entry into a maintenance application running on an enterprise system.
  - On the day of the scheduled maintenance, the PMO is released to the maintenance department.
  - The maintenance personnel perform maintenance activities on the asset as per a maintenance plan that is also provided by the maintenance application running on the enterprise system.
  - After the maintenance activities are completed, the maintenance personnel “close” the PMO by entering the details of the maintenance activities performed in the maintenance application.

This created the following problems:

- The use of time or calendar-based maintenance schedules resulted in either “under maintenance” or “over maintenance” – both of which were costly options.
- There was no warning of a breakdown or failure in this process – and diagnostic action occurred as part of “unplanned maintenance” only after a breakdown occurred, resulting in downtimes and much higher costs of diagnosis and rectification. Therefore, even though there was a PM in place, most of the time the maintenance was “reactive”.
- There was no “learning” from previous experiences – the same types of failures recurred and same “corrective” measures were used.
- There was a need for manual entries of failures when they occurred unexpectedly to trigger a PMO. This was a non-value adding activity of production labor.
- The shop floor personnel did not get up-to-date status information on a maintenance activity that should have taken place on a broken down asset until the order was closed. The events that occurred, and the time spent between the maintenance order generation and order closure were not tracked.

# The Strategic Importance of Plant Reliability

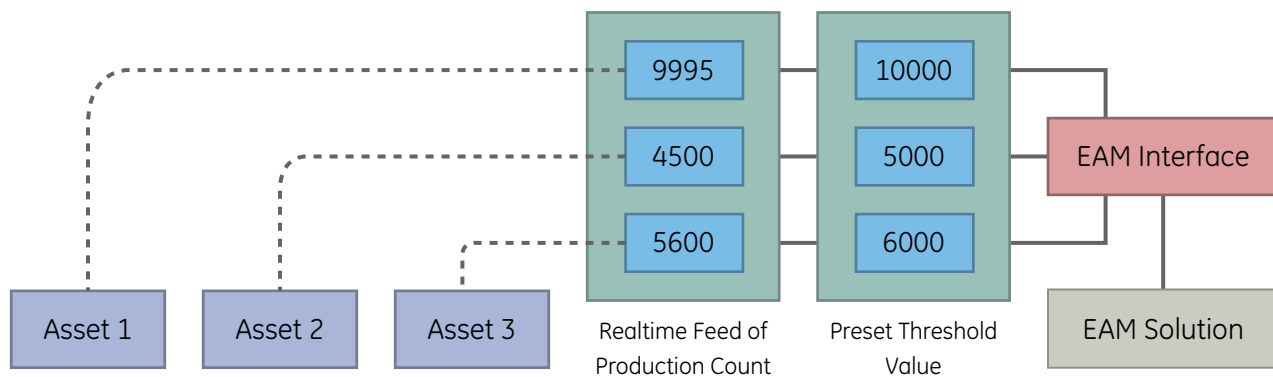


Figure 2. Usage-based Preventative Maintenance

The above-mentioned drawbacks justified the selection of the four goals of their RCM strategy. In order to address the above-mentioned drawbacks, the following improvements were made:

- To plan Preventative Maintenance based on usage of equipment as opposed to scheduling based on calendar time – this is now termed in the industry as Usage Based Preventative Maintenance;

Usage based maintenance allowed the company to order a maintenance activity when a particular asset had crossed a certain threshold of usage. The respective usage of the critical assets was tracked by the said organization individually and each type of asset was provided a certain threshold before maintenance activity could be initiated. This optimized their cost of maintenance by eliminating unnecessary planned shutdowns due to over-maintenance and unplanned breakdowns due to under-maintenance.

While this solves part of the problem of under-maintenance or over-maintenance, the remaining part is to optimize the shut down for maintenance. The key component in such optimization is the identification of the “key constraints” in the manufacturing plant. Key constraints include process, equipment, man-power and materials (spare parts). Also, when Preventative Maintenance is based on usage, the company is forced to follow a strategy of periodic, shorter shutdowns as opposed to long, “across the board” plant shut downs for a couple of weeks or a month which is typical of a calendar based Preventative Maintenance approach.

The said company replaced a two week calendar-based Preventative Maintenance shut down conducted every six months (approximately 5300 hours of planned maintenance activity annually comprising 24 maintenance personnel) to a three day shut down occurring six times a year (approximately 3500 hours of planned maintenance activity) based on the new usage based Preventative Maintenance approach.

This strategy alone impacted their bottom-line significantly and positively!

## Predictive Maintenance

Predictive Maintenance is the process of monitoring the condition of the critical assets continuously and effecting maintenance actions based on symptoms of failure before the machines break down.

While Preventative Maintenance can be optimized to the maximum extent possible, machines can still fail due to certain environmental conditions – driving the machines beyond their normal operational limits, stress, fatigue, etc. Therefore, apart from Preventative Maintenance, there is a need for monitoring the health condition of the assets continuously.

The company implemented Predictive Maintenance on all of its critical assets in addition to the usage based maintenance approach. This means critical process variables, events that relate to the health condition of the machines were never allowed to cross limits – and any tendency towards crossing such limits were detected early and a proactive rectification action was initiated. To be able to do this, the maintenance personnel studied the failure histories of the equipment and identified the root causes of the critical failures. Also, the symptoms that relate to these root causes were recorded and an automated system was used for monitoring those symptoms or patterns. When they occurred, immediate maintenance action was taken as mentioned earlier. The “agility” in the dispatch of maintenance resources– such as man power, tools, spare parts, etc., was identified as a key success factor in the “proactive approach” since the objective has changed to ensuring that breakdown does not occur. Let us discuss this more in detail in the section below.

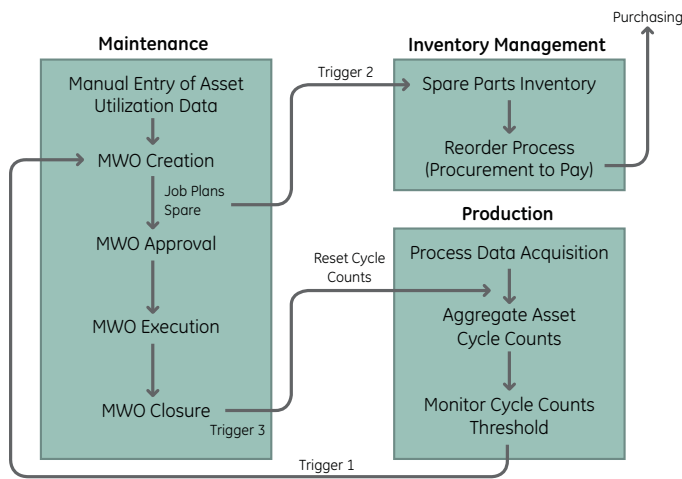


Fig 3: Triggering Multiple Work flows Using an Agile Infrastructure

### Agile Infrastructure

By agile infrastructure, we mean the elimination of unwanted latency between operations across departments, especially, disparate applications used to manage the functions of the departments. In this specific context, the said manufacturing organization investigated the three departments – production, maintenance and inventory management (refer to Figure 3).

The figure shows a work flow in the production department wherein production and asset related data are collected automatically by a MES system. One such datum is the number of production cycle counts of an asset. This is needed for comparison with a pre-set threshold and to order preventive maintenance (usage-based maintenance discussed in Figure 2) upon crossing of such a threshold. This activity happens in the production department.

When the threshold crossing occurs, the figure shows a maintenance work order work flow for the asset being triggered instantaneously in an enterprise asset management system as opposed to waiting for an operator to enter the details in the enterprise application after a delay. The same example could be used for a Predictive Maintenance situation wherein the threshold could be a process variable crossing a pre-set limit. In this case, the agility in the generation of the maintenance work order becomes even more important because the aim is to attend to the problem before a breakdown can occur. The lack of such agility relating to the elapsed time between the collection of data from the machine to the actual generation of a work order in the enterprise system is called the Forward Loop Latency.

Figure 3 also shows an automatic trigger from the maintenance work flow to the spare parts inventory “procurement to pay” work flow if the spare parts inventory falls below a threshold limit. Finally, from the same maintenance work order work flow, when the maintenance work order is executed completely, the counter in the MES application that is counting the cycles is reset for accumulating the counts for the next maintenance cycle. This time delay between the moments a maintenance work order is generated in an enterprise asset management application to the actual closure of the work order is called “Reverse Loop Latency”. Decrease in this delay would also increase agility.

In other words, agility is the minimization of both the forward and reverse loop latencies. The company set up an agile infrastructure which integrated an already existing MES system to an Enterprise Asset Management System to be able to monitor and trigger work flows as mentioned in the Figure 3 above. This real time infrastructure enabled the company, even in the early stages of its implementation, to eliminate a significant percentage of unplanned downtimes, non-value added labor in data entry, to analyze better the root causes of failures, and finally, track and monitor delays in the repair cycle. All of this meant more availability and therefore increase in the profits as planned.

### Continuous, Sustained Improvement

Approach to Plant Reliability cannot be one time. It has to be a continuous activity that is aimed at sustained improvement of reliability. This is because the plant conditions are always dynamic in that the critical constraints and the production demand are constantly changing.

As the reliability program evolves, it is the expectation of the company that the level of understanding of asset health will also improve, leading to more opportunities to optimize and this will in turn drive changes in the maintenance strategies and so on. It was realized that more and more with every passing day, Predictive Maintenance strategies will provide a wealth of knowledge to schedule better Preventative Maintenance shut downs and achieve better optimization. Also, new causes for failures will be identified, throwing more light on how to minimize unplanned downtimes.

This rightly formed the third item in the said company’s three pronged approach to the implementation of their Plant Reliability Program. The realization of the corporate management that reliability is an attribute that requires continuous and sustained improvement and their motivation to tirelessly drive that message to their managers and shop floor personnel was a key success factor of the overall implementation of the reliability program.

# The Strategic Importance of Plant Reliability

## Conclusion

Reliability begins when the attitude towards asset management is shifted from “fix when it is broken” to a proactive “identify early and eliminate failure”. It was demonstrated that such improvement in reliability increased OEE, profits and return on production assets. Therefore, it was argued that Plant Reliability should be dealt with strategic importance by C-level executives in an organization as opposed to an operational function.

For large manufacturing companies the infrastructure will exist to implement reliability programs across their production facilities. Most leaders in manufacturing verticals already have sound programs that are working very well towards increasing their bottom-line. It is the small to mid level manufacturing organizations that need to embark more and more on such programs with a goal of using reliability as a tool to improve their competitive advantage. In order to illustrate the importance of this, a real case study of a mid size manufacturing organization was discussed in this paper.

The case study demonstrated a logical three pronged approach of the mid size company to achieving improved reliability. It also provided an idea of what benefits can be realized in the financial operation of such companies because of such improvement. More specifically, it was shown that the organization had the potential to increase its Return on Production Assets significantly by a well thought out, organized process of implementing reliability in their production facilities.

The case study also implicitly demonstrated that reliability is like quality. It is not a one time goal. It is a continuous practice towards improvement of the organization’s profits, market share, and competitive advantage.

### GE Fanuc Intelligent Platforms Information Centers

Americas:  
1-800-GE FANUC or (434) 978-5100

Asia Pacific:  
86-21-3222-4555

Europe, Middle East and Africa:  
+800 1 GE FANUC or +800 1 4332682  
or +1 780 401 7717

Europe, Middle East and Africa (CNC):  
+(352) 727979-1

### Additional Resources

For more information, please visit the GE Fanuc web site at:

[www.gefanuc.com](http://www.gefanuc.com)

