The Japanese Path To Maintenance and Reliability Excellence.

The e-book that tells you how the Japanese destroy maintenance!

Compiled after a visit by Mike Sondalini to a World Class Japanese Chemical Manufacturer’s process manufacturing plant in August 2002.

This e-book is about the Japanese way of doing asset management and maintenance. If you think you already have a good system then you will enjoy reading it as you compare yours and theirs. If you have a poor system then you will get a totally different view of how great maintenance is done.
In August 2002 I spent a week in Japan at the chemical plant of the internationally renowned chemical manufacturer Sumitomo Chemicals. While there I asked them about how they do their maintenance. They told me about their maintenance philosophy. I want to pass on to you what I learnt on that trip about the Japanese way of doing maintenance.

You will learn about a number of diverse topics in the next few pages. You will read about how this particular Japanese company determined its equipment and component criticality. You will learn about a new, truly effective way, of making next year’s maintenance plan. You will learn about condition monitoring the Japanese way. The Japanese are great maintenance investigators and you will be impressed when you learn how they do their failure analyses. We will also cover their psychology of maintenance – the way they think about maintenance and how they look at it. You will be astounded at their mind-set.

The report is divided into three broad sections. Planning Maintenance shows the methods used by this Japanese chemical company to arrive at its daily work activities. Implementing Maintenance explains the methods used to arrive at which activities are required. The Maintenance WAR explains the mindset of the Japanese involved in operating and maintaining plant and equipment.
A systematic method of equipment reliability improvement is adopted. It is based on the well-proven quality management ‘Plan - Do – Check – Action’ self-improvement approach.

Consultation between Production and Maintenance Departments produces the PM-10 (Preventing Maintenance over 10 years) plan of production equipment to be investigated for improvement. The operating problems are scrutinised and analysed and then corrective plans are put into place.

The improvement work is designed, organised and scheduled. The improvement may be a design-out, a process change or a simple procedural change. Continuous improvement was the normal way of thinking and living in this Japanese company.

Once the change is in place it is again evaluated against the originally intended aims. If the original problem has not been solved satisfactorily the issue is again reviewed. The plan for future improvement work is adjusted if further progress is needed on the problem.

The continuous improvement method is followed until the equipment problems are considered to be unimportant enough to be left off the PM-10 plan.
Condition Monitoring the Japanese Way

The Japanese use their plant operator’s five physical senses along with modern non-destructive testing methods and technology to condition monitor their equipment. They maximise the use of non-intrusive maintenance.

The table shows the types of technology based condition monitoring used, where they were used and what they were used to detect. The focus was on detecting abnormalities before failure occurred. This was the theme the Japanese constantly enforced – the prevention of failure! They did not want unexpected stoppages. They were focused on detecting variation from normal and removing it so that they could maximise equipment performance and production results.

Interestingly, process pumps were not vibration-monitored. The Japanese engineers were asked why no vibration analysis was done on the pumps. They said that precision alignment was done using the twin reverse dial indicator method and as long as the alignment was to specification and tolerance they did not see any advantage in also vibration monitoring the pumps as they would be running as perfectly as was possible.

When a precision alignment was done and the operators performed their sensory checks and inspections there was confidence in being able to detect equipment problems before failure. Vibration analysis was used only on critical equipment and on expensive equipment. All other operational monitoring was by the operators.
The Japanese make great use of their operators in doing their plant's maintenance. The operators do as much minor maintenance as possible and they use their five senses to condition monitor their plant. Technological tools are also used for condition monitor, but the operator is seen as the 'front line' of defence against failure.

Many visual inspections of wearing parts are done to establish the working life of an item. The working life is then known and the PM-10 plan is updated to include change-out before the item life is up.
The long-term maintenance plan was a compilation from several sources. These included the PM-10 improvement activities, the computerised maintenance management system (CMMS) preventative maintenance work orders and decisions from equipment failure analyses conducted after equipment failures.

The long-term plan cascaded down into the annual plan, which in turn was separated into the monthly plan. The monthly planned work was performed and the self-improvement ‘Plan-Do-Check-Action’ process was applied to feed improved methods and ideas back into the long-term plan.
This slide is an example of the ‘ten year plan’. Remember that I visited in August of 2002 yet the ten year plan starts from 1994. The ten-year plan is not ten years into the future! It is only two years into the future but includes the previous eight years. It was a ten-year plan the like that I had never seen before! Why?

The maintenance plan my Japanese hosts showed me in August 2002 listed all the equipment in a plant by tag number covering the period 1994 through to 2003. The maintenance histories of problems on a piece of equipment for the past eight years were also listed. A short note detailing the month of occurrence and the failure was made in the column of the year in which it happened. For this year, 2002, and the next, 2003, the spreadsheet listed what maintenance and modifications were going to be done on the equipment.

The ten and five-year plans I had seen were always ten and five years into the future and never covered the past. So why did they do it that way – 1994 to 2003? They never told me their reasons. But now, as I write, it has become clear why it’s worthwhile doing it like that. What I saw was not a plan! What I saw was a strategy! It was a strategy to reduce the known production stoppages and to focus the maintenance effort.

Can you see how something like that would work? You know what has gone wrong with the equipment over the last eight years, it’s listed right there in front of you. You can see how effective the past practices, methods and solutions have been. From that you can wisely decide what to do over the next two years to prevent reoccurrence of problems.
Instead of writing the usual ‘blue sky’ 5 or 10 year maintenance plan that no one believes anyway, you only plan for the believable two years ahead. You write down exactly what can really be done in the foreseeable future to reduce or prevent the real problems.

The plan for the next two years would include proposed modifications, equipment replacements, new condition monitoring plans, etc.

Now that is a great way to make next year’s maintenance plan! It would be one that is totally defendable and fully justifiable to upper management because it is well thought out, rooted in getting the best return for your money and based on the important business requirements to continue in operation.

My suggestion to cover the period beyond the next two or three years (and only if it is necessary in your company), is to use the spreadsheet to make forecasts. Project ahead based on what you plan to do in the coming two to three years to fix the current problems. If you aren’t going to fix the problems then don’t assume less maintenance in the future. Remember that a forecast is not a plan! A forecast is a best-guess suggestion, often known as ‘blue sky dreaming’. A plan is a set of action steps that over time will produce a desired result. They are totally different to each other.
The 'ten year' plan actually covers eight years in the past and two years into the future. By doing it that way it allows the effect of historical equipment problems to be put in perspective. If the faults have continued to occur their impact on the operation can be seen and a decision can be made to address the problem in some suitable fashion.

If modifications and changes done in the past were successful then the problem can be seen to have disappeared. By reviewing past history and its impact on the operation it would be easy to justify which issues to transfer into the PM-10 process.
A Japanese way to decide equipment criticality.

How do you decide what level and type of maintenance to use on an individual item of plant and its sub-assemblies? Not all equipment is equally important to your business. Some are critical to production and without them the process stops. Others are important and will eventually affect production if they cannot be returned to service in time. While other items of plant are not important at all and can fail and not affect production for a very long time.

As a maintainer you want to know which equipment in your plant falls into each of those categories so you can determine your response. Furthermore you want to know which sub-assemblies in each item of equipment are critical to the operation of the machine.

From this information you can decide which spares to hold on-site and which to leave as outside purchases. The equipment criticality also determines what level of preventative maintenance to use, what type and amount of condition monitoring to use and what type and amount of observation is required from the operators. You can also use it to justify on-line monitoring systems to protect against catastrophic failure.

The western approach to determine criticality is often to use either Reliability Centred Maintenance or Risk Based Maintenance to determine consequences of failure and then address the appropriate response to prevent the failure. The Japanese chemical manufacturing company I visited had a novel way of determining their equipment criticality. They based the equipment and component criticality on the knock-on effect of a failure and the severity of the consequences. It is the same intention as the previously mentioned
methods but they arrive at the rating and the response to it in a unique, quick four-step process.

They used a simple flow chart that production and maintenance worked through together, equipment by equipment. Those failures that caused safety and environmental risks were not allowed to happen and either the parts were carried as spares and changed out before failure or the plant item was put on a condition monitoring program. Those failures that caused production loss or affected quality also were either not allowed to happen or put into a condition-monitoring program. And those failures that didn't matter were treated as a breakdown.

The flow chart let one arrive at a rating and a corrective action for each piece of equipment and component fast. No need to spend hours and days looking at failure modes and deciding what to do about them. If an equipment or component loss produced dangerous situations, or if the failure stopped production or affected quality, it was either changed out before the end of its working life or it was put on a monitoring program.

The maintenance philosophy for every bit of plant could be arrived at in a four-step decision process. It was very easy to use and to decide what action to take.

The SABC is the criticality rating scale. On the chart you notice that equipment gets an ‘S’ rating when it is never permitted to fail because of serious danger to life or the environment and the operation from a failure. Under the ‘S’ rating, parts are replaced before they reach the end of their working life. This then makes the decision to replace parts a time-based decision. You change the parts well before they can fail because failure is such a catastrophe. It means that you sacrifice what life the parts could have had, but you protect the operation from the far greater cost of an operational disaster. Beware that ‘time-based maintenance’ also means ‘usage-based maintenance’ where the ‘time’ (i.e. usage) is the total throughput (or activity) seen by the item. An item can be replaced depending on how much ‘clock-time’ goes by and/or how much activity (i.e. usage) the item suffers.

You cannot use a condition based approach for ‘S’ parts because condition based maintenance allows failure. Though, if you had full-time, second-by-second, condition monitoring of a part that could detect impending failure well before it happened and gave you time to plan and do a corrective repair or replacement, you could in that situation argue a strong case to replace time-based maintenance with continuous condition based maintenance. Then you could use the full life of a part until you have to repair it before it fails.

An ‘A’ rating also requires parts to be changed before the end of their working life but that is only because of the production problems a failure would cause. A ‘B’ rating required condition monitoring. And a ‘C’ rating meant breakdown maintenance was acceptable. The RABC chart is both a criticality scale and a maintenance strategy decision tree.
The SABC criticality-rating chart was also used to determine the critical parts within the machine. The same decision logic was applied to the equipment's components. From that review process the critical spares were determined and a decision made to either stock them or to monitor their condition and look for deterioration.

Parts that must never fail were changed out in a time-based cycle, parts that wore out unpredictable were monitored and parts that did not matter if they failed were brought in when they broke.
Once the criticality ratings are determined for each machine, and its components, a spreadsheet is developed listing the applicable maintenance strategy and the maintenance tasks to be used on the equipment.

The complete maintenance philosophy, spare parts requirements, condition monitoring requirements and preventative maintenance frequency for every item of plant are all there on one sheet for all to see.

With this spreadsheet done first, it is an easy matter to transfer all of the required inspections and checks into a CMMS and generate preventative maintenance work orders to care for the equipment.
This is my favourite part. It is why this e-book is titled ‘The Maintenance WAR’. The Japanese mind-set is that maintenance is an enemy to be defeated! It must not be tolerated! It must be destroyed!

I have kept the words exactly as my Japanese hosts translated them for me. The Japanese-English lends a certain authenticity. It reflects exactly how they see things!

**JAPAN AT WAR.**

It’s true! The Japanese are at war with maintenance. They will accept no equipment defects. And I believe that they are right in thinking about it that way.

Near the end of my week’s stay in Japan my kind hosts passed me this flow chart and the next that overviewed their defect elimination process. Without much thought I took them and added them to the other information that they had given me during my stay.

Upon my return to Australia I made a short presentation to the managers in my company. After showing them the charts of the Japanese defect elimination process, one of them made an interesting comment. He said that they had selected very war-like words to use on the charts.

And then it hit me! YES … THE JAPANESE WERE AT WAR WITH MAINTENANCE!
The charts used words like ERADICATE, PREVENT, REDUCE, ELIMINATE, CONQUER, DESTROY. It was a declaration of war on maintenance. They wanted to slay all equipment failure.

That is the beauty of the Japanese maintenance mindset. They want to get rid of all failure! They will not accept any defect! They want to get rid of all causes of unnecessary maintenance.

Both you and I need to think the same way.

**The Failure Reduction Cycle**

There is a simple management cycle that this Japanese chemical manufacturer used to trap problems and fix them.

It began with recognising a problem as a failure from discussions at production and maintenance daily morning meetings. Those that were deemed in need of eradication were registered on a control sheet. Investigations were conducted and reported back. Where simple changes to the operating procedure or maintenance program would solve the problem they were implemented using the PM-10 planning process.

Changed maintenance practices were recorded in the PM-10 process so that they would automatically occur when required in the form decided by the results of the investigation. This may have meant more preventative maintenance, more condition monitoring or end-of-life part replacement.

Failures requiring design changes were closely reviewed to insure that the changes would actually remove the root cause problem and not introduce new failure modes.

Once the failures were eliminated they were removed from the control sheet.
Failure Management Cycle

Failures are classified as either grave or slight failures. The grave failures are treated separately to the slight failures with greater effort being put into eliminating grave failures from equipment while slight failures were preferably solved by procedural changes.

Can a change in the maintenance program prevent the failure? For example can it be prevented by using condition monitoring, or by applying more preventative maintenance? Or does the root cause need to be re-engineered and designed out?

A grave defect is passed into a separate defect elimination process outside of the day to day maintenance requirements. In this separate process engineers are devoted to solving the root cause of the problem. Their focus is the removal of failure and not simply the repairing of equipment.

The success rate by which they remove failures is measured and trended. They use a Failure Measure Implementation Rate as described below.

\[ \text{FMIR} = A \times B \times C \times D \]

\[ A = \text{Rate of Causes Determined} = \frac{\text{Number of Cases where Causes were Determined}}{\text{Total Number of Failures}} \]
B = Rate of Failure Prevention Determined =
\[
\frac{\text{No of Cases Failure Prevention Measures Determined}}{\text{No of Cases where Causes Determined}}
\]

C = Rate of Failure Prevention Implementation =
\[
\frac{\text{No of Failure Prevention Measures Implemented}}{\text{No of Cases Failure Prevention Measures Determined}}
\]

D = Rate of Prevention =
\[
\frac{\text{No of Cases where Prevention was Successful}}{\text{No of Failure Prevention Measures Implemented}}
\]

**How the Japanese do Equipment Failure Investigations.**

When a piece of equipment fails, the engineers I spoke to Japan told me, they conduct the most thorough of investigations until the root cause is discovered and eradicated. Any changes done to the equipment resulting from a root cause defect discovery are also made to other similar machines to prevent the failure happening to them. This is known at the ‘lateral development’ of the root cause.

They showed me the information on a shaft failure that had been investigated some year’s back. The failure was at a shoulder where the diameter changed, the corner radius was too sharp and had acted as a stress raiser and the shaft had failed from fatigue. I had never seen such detailed records from a failure investigation as I saw in that report.

In the report were design drawings marked up showing the location of the failure. There were numerous photographs of the failure, from all directions. There was a metallurgical report on the shaft material and on the failure mode from a laboratory. There were design check calculations and a shaft stress analysis. There were redesign drawings showing the changes to make. There were several written reports from the investigating engineers detailing their findings and recommendations. All this was stored in a lever arch record file easily retrieved from their library.

The thoroughness of the investigation provided great confidence in the analysis results. The change made to the shaft was to use a generous corner radius. It was done several years ago and no failures have occurred since.

You too must get rid of the problems that cause maintenance in the first place. If you want to cut maintenance in the long term it is your only option. You do that by making it someone’s job to tackle and get rid of maintenance problems forever. One by one, from the most expensive through to the least expensive, you take them on, devote resources, time, money and effort to beat them and then they never return.
The Japanese examine each grave defect they find and decide what to do about it. They apply the ‘5 Whys’ method to trace the root cause. Their whole focus is to remove the problem forever from their plants.

Their belief is that grave failures must be exterminated! They must never reoccur, neither in the plant suffering the original failure nor in any other plants using the same equipment. When a failure occurs in one item of plant it is highly likely that it will happen to other equipment of the same design. The Japanese are proactive maintainers and will remove the known failure modes before a problem occurs.

Once the detailed failure analysis is completed a decision is made to implement a trial of the proposed changes in the plant with the problem. From experiences with the trial changes a new compliance standard for the equipment is drawn-up and used to investigate likely problems in other similar equipment throughout the company.

A decision is also made to extend the corrective changes to all other plants. The results of the implemented changes are reviewed. Any required changes to future maintenance are incorporated into the PM-10 Maintenance Plan.

**Destroy Maintenance Forever**

If we can come to see equipment failure as the enemy, as the destroyer of our personal happiness, as the creator of anger, mistrust, loss of face, hate and stress, as the greatest evil
our business has to fight against, then we are thinking the right way. We are thinking the Japanese way and world class performance is in our grasp.

But if we accept that maintenance is a necessary evil ... we are beaten from the start. We then are just holding down a job, just wasting our lives, allowing the destruction of our business and we will never find the happiness of true success in our careers.

Equipment failure must be destroyed! It must never be allowed into your company, nor be allowed to stay in your company. It must never be accepted as normal by your management or your employees, even in the smallest degree. It is not normal, it is not right! It is not what was intended to happen when the machine was designed and purchased.

You must never accept equipment failure as natural – it can be stopped. It must be conquered, eliminated, eradicated, destroyed and removed from our lives and our businesses!

You must marshal your forces, and, battle by battle, destroy the enemy. You must obliterate any refuge or acceptance it may find in your company. Only by devoting resources to the war you will reduce your maintenance.

That is what the Japanese do and they are the best in the world! You should do no less.

My best regards to you,

Mike Sondalini