

Introduction

World Class Maintenance Management Explained

The challenge in any equipment's reliability initiative is starting to improve in a reactive world of maintenance with the same amount of resources and time. Remember that all world class companies were not born that way. They started from being reactive themselves.

1.1 Why Most Industries are Reactive?

Have you ever figured it out why your equipment keeps on failing despite the very best efforts on Preventive Maintenance? Below are lists of questions and try to answer them as honestly as possible on your own. If you answer yes to most of these questions, then you definitely need to read this book.

- You are always press for time and do not have the luxury to attend to training because your boss or schedule will simply not allow you to do so.
- Are you instructed to turn on your cell or mobile phone at night when you are at home to receive late calls from other shifts wanting you to go to the plant in the middle of the night or early morning for a problem that they cannot seem to fix?
- Does maintenance complain that they are always outnumbered by their everyday failures and maintenance is always complaining about the lack of labor and manpower resources to fix their day-to-day failures?
- Do you have to sacrifice some family time in order to keep working overtime and when you return home everyone is asleep? Your cold food is waiting for you at the table.
- When equipment is newly overhauled or had just been into a major Preventive Maintenance shutdown, do you ever wonder why operators tell you that this equipment is better off if you had not performed your regular scheduled Preventive Maintenance because they have difficulties running the equipment smoothly during start up?

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- Do you need to cannibalize some parts from other stationary equipments since there is no stock or spare around the stockroom? Do you do this all the time?
- Now this is the worst part, do you have nightmares of your work or your boss yelling at you to do this and that, which wake you up in the middle of the night?

If you answer yes to almost all of these questions then do not be surprise since you are not alone in this planet. Let me explain to you, when I was still studying all these things about reliability and maintenance, I used to have an old friend and mentor, I called him Mang Tibo, (in our country, Mang represents someone who is an old person) who have worked for a very long time in an industry. They retired him because he was old. I guess that would be the trend. Anyway, I remember asking him about what was the best maintenance strategy that an industry can adapt and he told me that if I wanted to know the answer to my question he said to come and follow him. I took his advice and we walk and sat down on a park near his place. The park had a basketball court and he asked me to sit down and watch the game because their team was playing and there was an ongoing league at that time. We sat and watch the game and not a single word from him was ever spoken about the question raised, instead, as we were sitting on a bench and you can feel his enthusiasm about the game shouting words of support to his team. We just watched the game from start to finish, it was a close game and their team won. It was getting a little bit dark and he told me to go home since my place was a couple of hours away. I told him, why we watched this game and asked him that I though that you were going to answer my question about the best maintenance strategy to adopt. Calmly, he looked at me, smiled and said, if you watched the game carefully, then you have already answered your own question. I was shocked, since I have no idea what he meant or if he was making any sense after all. I usually give this story to people whom I teach and wonder for a while if they can figure it out themselves. I guess, just like me they find a hard time what that old man was talking about or if he was making some sense after all.

As I was about to leave, he explained to me that maintenance is no different from playing a game of basketball. A team mainly composes of two guards, two forwards and one center. He asked me, what if I place five centers in a team and no forward or guards in it. Is it a balance team? I said no of course. It is like assuming that all parts will eventually wear out which is unlikely to happen since only around a small percentage of most equipment parts and components will have a wear out pattern. Imagine putting a basketball team of 5 people which are all guards, again is it a balance team, then it is like assuming that all parts will randomly fail, again there are still the case of infant mortality and wear out failures. So you see, just like basketball, maintenance is a game of balance. Therefore, the best maintenance strategy to adopt is not about preventing or applying the best predictive maintenance strategy but it is about creating a balance and understanding when to use the different strategies simultaneously when you need it since every failure have their own unique pattern and consequences. Therefore, just like in basketball, the best maintenance strategy to adopt should be based upon the consequences of every single failure itself and not just confining to a single strategy.

Putting too much effort on your current Preventive Maintenance activities will only lead you to more failures since PM can only accommodate failures that have a wear out or age

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related pattern. This is like putting five centers in one basketball team. Your team will not work and the players will not blend. This is what I believe is one of the main reasons why most industries are reactive, since they place all their center players in one team. They assume that their current Preventive Maintenance structure will capture all kinds of failures. Eventually, they are wrong in every way. Therefore instead of preventing the failure, most industries today perform their maintenance on a firefighting or reactive mode, fix it when it fails syndrome, others called this the “Band-Aid or Firefighting Therapy.” This generation of maintenance evolved during the 1940’s way before the Japanese bombed Pearl Harbor. Equipment’s at that time were simple hence; this type of maintenance does not seem to make any effect on production after all. However, as time passed by, more and more developments had been made, equipment’s are now highly automated, complex and modernize to perform the task required, but sad to say when we speak about the way we maintain, I think nothing or little had changed so far. Most companies hire and look for maintenance people with extreme experience on the repairing the equipment and not on the system of maintenance, which is why there are only few people with such knowledge and understanding on the maintenance strategy itself.

Maybe your industry had been religiously adapting the concept of Preventive Maintenance and standards are in place. Your group had every piece of detail from overhauling and replacement of parts to be performed on a specific set of time indicated in the equipment. In addition, since we find it hard to satisfy everyone most specially our customers, time to time something had always been added with our never ending growing list of PM checklists since they thought that it is the right thing to do. I call this the “Add on PM Checklists Syndrome”. Before the maintenance, checklists only compose of around 15 activities when the equipment was newly commissioned in the plant but today the checklists of things to do rounds up to more than 150 items. My question is, does increasing the amount of activities on Preventive Maintenance guarantee a higher reliability on the part of the equipment or it is just the other way around? Perhaps doing more maintenance on our equipment will do us more harm than good in the end. Through the years, I have research and studied on possibly the best strategies on maintenance to adopt such as Total Productive Maintenance, Reliability-Centred Maintenance, Lubrication Strategies, and Root Cause Failure Analysis, Tribology and Contamination Control and other related maintenance management courses. It seems that as I dwell more with the subject on maintenance and reliability, the more it becomes clearer on what maintenance can do and cannot do with our equipment. There are things that we simply need to understand before we can provide a holistic approach on our maintenance strategy and maintenance needs to walk into this thin line if they are dead serious about improving their equipment. But the problem with most people is that they abuse the use of this strategy which is Preventive Maintenance.

1.2 Can Equipment Failures be eliminated?

Failures are grandeur and diversified by nature. When I ask people their thoughts if all their equipment failures can be eliminated? Some say yes and others simply say that we can only eliminate a fraction of them. Hence, I tried to be a little bit more specific and rephrase my question by asking which of these following statements would they think would be more appropriate, relevant, meaningful and much more realistic:

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- First, we can eliminate failures by analyzing them through Root Cause Failure Analysis.
- Second, we cannot eliminate the likelihood of failure but rather, we can only prevent or predict the timing of failure from occurring on its own.
- Third, we can eliminate failures and our goal is to zero out the breakdown.
- Fourth, failures cannot be eliminated, the best that maintenance can do is to anticipate, delay or prolong the process of failure from occurring on its own.

First, all failures are not created equal; every single failure will have their own unique set of consequences. People have different points of view or interpretation as to what failure is all about or when to call it a failure. A failure can differ from the operations, maintenance safety point of view. Sometimes confusion arise as when do we call it a failure. Hence, I would like to explain failure in the way I understand it. Technically, when operators call maintenance to fix their equipment, it is not the equipment that failed after all; it is a part, component or system that failed in their equipment. Failure is when an item, spare, part or system in the equipment fail to perform its desired function at all. Therefore, to answer these questions;

First: We can definitely eliminate failures by analyzing them through RCFA

Wrong! Failures cannot be eliminated by analyzing them through RCFA or RCA. We must consider that there are a variety of possible causes that caused the failure to occur and every single failure have their own unique causes and when we treat a single cause then there is a likelihood of that same part to fail again in the future due to a different cause. Remember, when we speak about Root Cause Failure Analysis, we are dealing with evidences as to what really have caused the part to fail and not all the probable causes or failure modes that might have cause the part to fail.

A bearing can fail for a multiple or variety of reasons and taking care only on one single cause (perhaps the analysis indicates that the bearing's inner raceway shows failure is attributed to lubrication) will not eliminate its recurrence since it can fail in the future due to some other reasons such as false brinelling, pitting, fatigue, spalling, misalignment, contamination, careless handling or lack of lubrication and much more.

Second: We cannot eliminate the likelihood of failure, but rather we can only prevent or predict the failure from occurring.

Yes, for some failures, it is possible to prevent them and this is true for age-related failures or parts and components which inhibits some sort of wear out mode. For airline industry, these parts constitute to around 15 to 20% of overall equipment failures. Perhaps, this is slightly higher for land industries. Likewise, there are failures that can be predicted for those which show signs of potential failures or they are on the verge of failing out. But this is not the goal of maintenance, if a bearing fails prematurely, we can predict that it is on the verge of failing, but the life of the bearing had not been reached and maximized at all. We might have some success on advising operations about it but we should not stop from

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there. Data from Predictive Maintenance can be most useful in analyzing why component fails. Predictive Maintenance is one-step forward towards being proactive. Likewise, not to mention that not all failures can be predicted nor prevented.

Third: Failures can be eliminated and our goal to zero out breakdowns.

Wrong! Some think that when we have experience zero breakdown or have reduced failure tremendously as seen on our breakdown indices for the past couple of years, we think that we have eliminated the failure completely, but technically, come to think of it, have we really eliminated the likelihood of failure or rather we have just delayed the failure process from occurring, because of our good system of maintenance? Just try to think of buying a second hand car, driving it and giving it your best maintenance ever, eventually there are many parts that are subject to wearing out and when parts wear out then they have actually and eventually failed isn't it?

4th: Failures cannot be eliminated and that the best that maintenance can do is to anticipate, prolong or delay the process of failure itself from occurring.

Correct! I think that we must not be misled that maintenance can eliminate failures. Failures cannot be eliminated, they will happen and they will occur, the best that maintenance can do is to anticipate failure, delay its process, control the timing of failure or eventually prolong the occurrence of failure from happening, yet in the end failure and breakdowns will still likely to occur eventually in our equipments and we must be ready for it. Maintenance must focus on something that is more realistic and not idealistic in nature.

Let me provide a clearer example, a small plant have around 100 equipments or more, each equipment compose of around 20,000 parts. This plant has ten people working in the maintenance department in order to address the issue of equipment failure. Some people are deployed to perform maintenance work, they have some form of Preventive Maintenance that sort of schedule their equipment's from time to time for some form of replacements and overhauls. Others perform some inspections on their equipment from time to time. They even deploy a group called a sustaining or other names to perform repairs and troubleshooting. There are modifications and redesign they do in their equipments as well. However, despite the very best efforts machine still fails? Right! The truth is all equipments are vulnerable to failure. Therefore, the aim of maintenance is to control the timing of failure so that we can select or perform a more suitable task before a failure happens. The best that we can do to our equipment will be to extend the length of time between failures, prevent the failures by replacing the most worrisome component before they fail, monitor failures by providing signs and symptoms that they are on the verge of failing which is possible by determining the condition of the equipment. Making equipment more reliable is about extending the useful life and Mean Time between Failure (MTBF) as well as preventing failures by replacing the part and components that are most likely on the verge of failing.

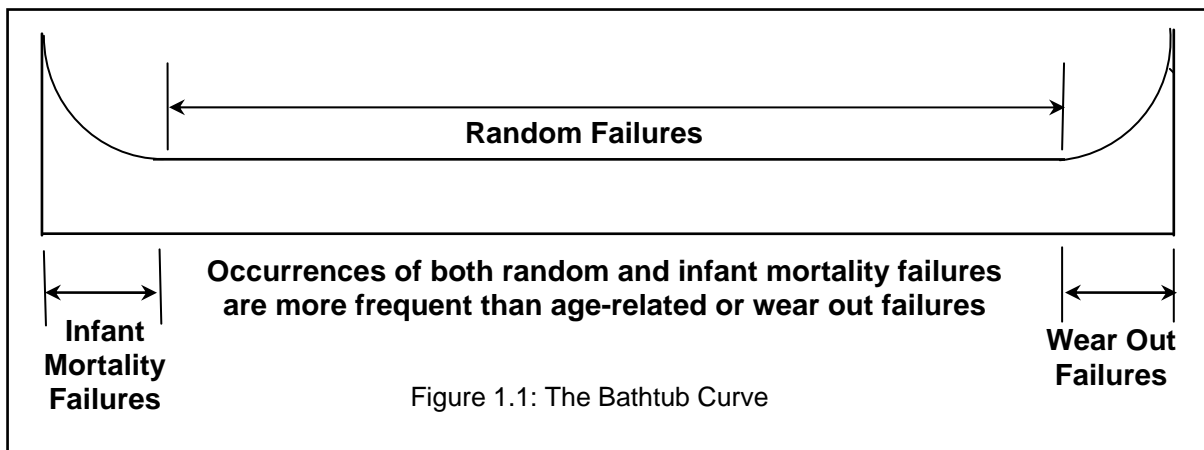
Failures cannot be eliminated and failures vary in consequences, the best that we maintenance and reliability people can do is to delay the process and control the timing of failure but eventually and inevitably expect failure to occur in the equipment. If you are

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experiencing a no failure situation in your equipment, this is just temporary again because of your good system of maintenance. The truth is you are just delaying the process of failures. I have been in the field of TPM for so many years and its goal of zeroing out unplanned breakdowns is somewhat idealistic and in its technical sense, next to impossible if we really understand how part behaves. When a part wears out, in its technical sense it had failed. Hence, we are not really eliminating failure itself but just doing the best we can to prolong the life of the part or component or extending its natural lifespan. Hence, by understanding these things we maintenance know what we can do and cannot do with our equipment. But before going further, let us learn the diversity of failures itself by understanding its patterns, classifications, types and occurrence before adopting a more structured and robust maintenance strategy in our equipment.

1.3 Patterns of Failure (How Parts Behave)

Failure of parts can be categorized into the following patterns; either it can be infant mortality, random or age-related failures. These failures can be illustrated in figure 1, which is known as the bathtub curve. The bathtub curve starts with a high incidence of infant mortality failure followed by a constant or gradual increase in the conditional probability of failure and ending up in a wear out or age related zone.



Infant Mortality Failures are failures, which occur at the beginning of life, others refer them as commissioning failures, start-up failures or debugging failures. Many factors affect Infant Mortality Failures, which includes poor equipment design, poor quality manufactured, incorrect installation, incorrect commissioning, incorrect operation, poor set-up and conversion practices, unnecessary maintenance, slip and lapses, human errors, bad workmanship and excessive Preventive Maintenance. The case of Infant Mortality Failure, which is Pattern F of the Six Failure Pattern, starts with a high incidence of early failures, which eventually drops to a constant or very slow increase in the conditional probability of failure ending in a no wear out zone. Operators often say kiddingly, that if you have not performed your regular overhauling and replacement on this piece of equipment, I bet it will be running without any problems. Most operators complain about having a hard time starting up their equipment after a major overhaul is performed. But isn't it true, that the main purpose of scheduled maintenance is to ensure that the equipment performs as it is intended, but the opposite seems to happen whenever maintenance do something on the equipment. Is it

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profound ? NO! You are just a victim of what you called Infant Mortality Failures. From a maintenance point of view, their pride hurts, but it is a fact of life that we must live with and with all humbleness and humility must understand and admit. In almost all cases, Infant Mortality Failures are caused by human errors and intrusive or forced maintenance which are carried on with the equipment. In fact many things can go wrong when we try to dismantle an equipment for overhauling purposes because our belief is that we can put it back together in one piece just the way it used to be. Human errors such as slip and lapses can occur on the part of the maintenance performing the overhauls. The message of infant mortality failures is simple, if you are equipped with the right knowledge, skill and have the right tools to perform the job of replacement and overhauls then go ahead and proceed but if you have the slightest doubt of bringing it back altogether in one piece, then, think again before dismantling it. It might be a better idea not to disturb the equipment after all.

¹Studies done by the pioneers of RCM, Stanley Nowlan and Howard Heap for civil aircraft industry revealed results that 68% of items that failed in airline industries conformed to pattern F, which is the case of Infant Mortality Failures. An example of some of the benefits achieved from this learning on infant mortality failures by the civil aircraft industry was the dramatic reduction in their scheduled overhauls in their DC-8 aircraft in which 339 items were previously scheduled for overhaul and trimming it down to only seven items for their DC-10, which is a more complex and modern aircraft. One of the items that were no longer subject for overhaul was their turbine engines. Another milestone in their research was a reduction in inspection for the United Airlines Boeing 747, where they spend around four million man-hours of inspection compared to around sixty-six thousand man-hours on structural inspections for their DC-8 aircrafts. Airplanes today are bigger, complex, automated and most of all safer to travel compared to fifty years ago. Truly, it had been a remarkable achievement and feat for the airline industries, which saved them millions of dollars on maintenance without compromising safety and improving reliability. However, perhaps the greatest benefit on learning from Infant Mortality Failures by the airline industry is that it saved them future lives.

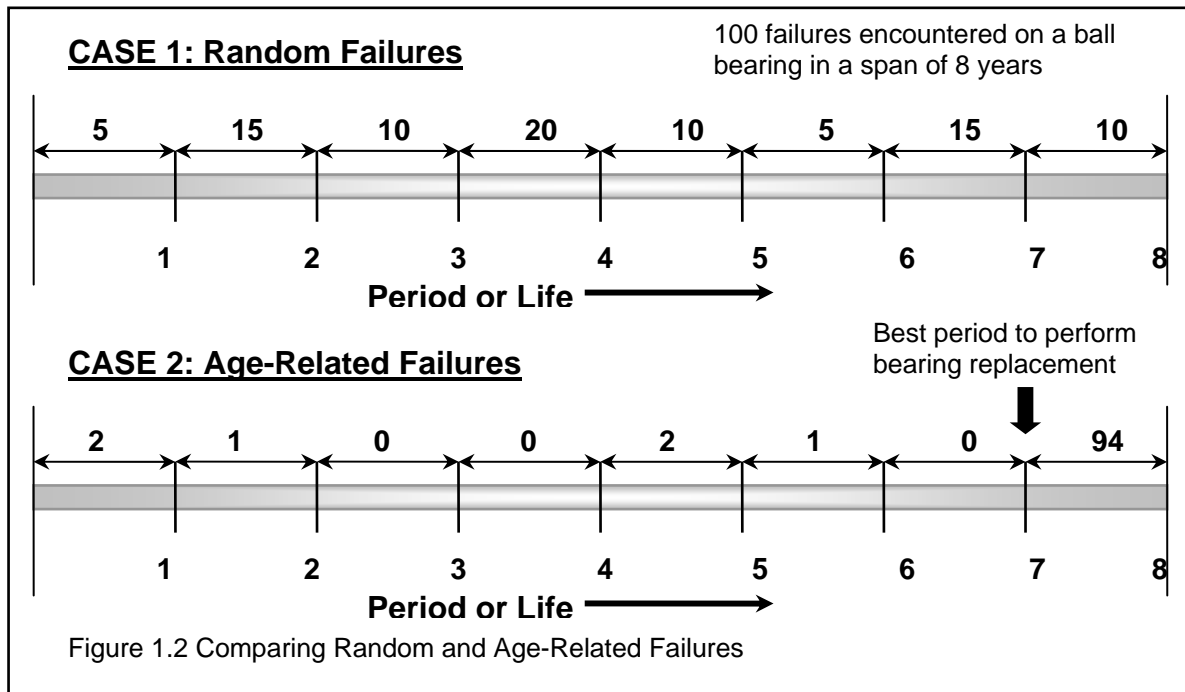
The Lesser the Maintenance, the Better

Performing too much overhaul on the equipment to comply with PM specs and activities is not a guarantee that the equipment will be reliable in the future. It is similar to the logic that a fat child is not exactly a healthy child; healthy and fat are not synonymous. In fact, there are cases when a child is more prone to disease and sickness when he or she is fat. On the other hand, eating plenty of food each meal is not an indication of a healthy person, eating the right balance food each meal can make us a healthy person. Similar things holds true with maintenance, the more activities we perform on our equipment the more likely it will fail and induce what we call infant mortality failures. I have seen a lot of cases that when an equipment is subject for an overhaul and returned back to operations, operators complain and have a hard time of running the equipment, as well as a lot of cases where maintenance tend to forgot some small pieces that should be in the equipment most specially if the part is just a small item. Most people are shocked when I say that the more PM you perform on your equipment, the more problems you will encounter, while the less PM you perform, then

¹ Reliability-Centred Maintenance by Stanley Nowlan and Howard Heap

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the less problems you will encounter. In hindsight, this is where I stopped, I never said no PM means no problem. PM will always have a place in the maintenance function. If Infant Mortality Failure exists, the question to raised, is can we eliminate them? Many factors contribute to infant mortality failure and it is impossible to eliminate them, the best we can do is to reduce its likelihood. Let us look at the following perspective on the most common causes of infant mortality failures:



Design Stage

No equipment is perfect by design, there is always a design weakness flaw attributed within it. There are parts that tend to fail prematurely during commissioning and even in actual operation. We need to identify these parts and conduct a physical investigation and Root Cause Analysis as to why these parts keep on failing prematurely. Only when we understand fully the cause of failure can we recommend a redesign or modification in the part such as changing the parts shape, size or strength of materials.

Commissioning Stage

Problems occur during commissioning of equipment in our plant. Either some human error was involved during set-up or start up. Infant Mortality Failures are the reason why vendors and manufacturers provide some form of warranty period on their equipment most specially during commissioning and start up activities of the equipment in their plant. There are likewise a lot of debugging during the commissioning stages of the equipment before it can be finally be endorsed to operations.