

9 Types of maintenance: How to choose the right maintenance strategy



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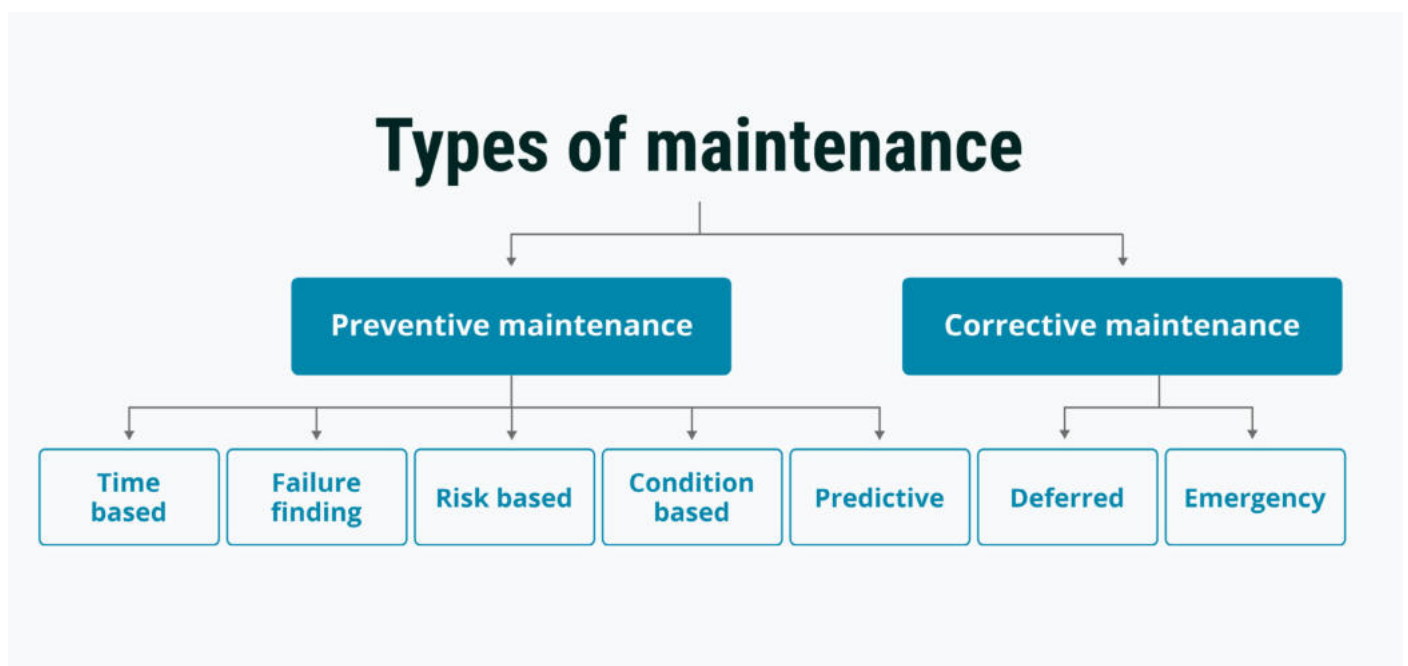
Overview

Across industry, many definitions are used when it comes to the different types of maintenance. It can quickly get confusing when people talk about [preventive maintenance](#), condition-based maintenance, or predictive maintenance but actually have something else in mind than you do. Some people get very excited about these definitions and can spend a lot of time on for example disagreeing with what is and what isn't preventive maintenance. Let's not do that, instead, I'll offer you my view of the different maintenance types and more importantly, when to use them.

What are the different maintenance types?

As far as I am concerned terminology is not important. Other than making sure we are talking about the same thing. If what I consider to be condition-based maintenance you call predictive maintenance that doesn't really matter. As long as we sensibly talk about the underlying principles. Like, when to use condition-based maintenance. And how to use it.

However, as I'm often asked questions about the different a specific type of maintenance I decided to put a quick overview together. At least, the way I see it:





There are **9 maintenance types** split between Preventive Maintenance and Corrective Maintenance.

Preventive Maintenance is done before a failure occurs and consists of maintenance types like: Time-Based Maintenance, Failure Finding Maintenance, Risk-Based Maintenance, Condition Based Maintenance and Predictive Maintenance.

Corrective maintenance is done after a failure has occurred either as Deferred Corrective Maintenance or as **Emergency Maintenance**. In the rest of this article, I will discuss each of these different maintenance types in detail:

Preventive Maintenance (PM)

- Time-Based Maintenance (TBM)
- Failure Finding Maintenance (FFM)
- Risk-Based Maintenance (RBM)
- Condition-Based Maintenance (CBM)
- Predictive Maintenance (PDM)

Corrective Maintenance (CM)

- Deferred Corrective Maintenance
- Emergency Maintenance (EM)





Preventive Maintenance vs Corrective Maintenance

At the top level, I see maintenance being either preventive or corrective:

- When we do **preventive maintenance** we are doing a task **before a failure has occurred**. That task can be aimed at preventing a failure, minimising the consequence of the failure, or assessing the risk of the failure occurring.
- When we are conducting **corrective maintenance** the **failure has now occurred** and we are basically reinstating equipment functionality. To be clear, corrective maintenance can be the result of a deliberate run-to-failure strategy.

**Preventive
maintenance**

vs

**Corrective
maintenance**

before a failure
has occurred

after a failure
has occurred

Preventive Maintenance (PM)

Preventive maintenance, sometimes referred to as routine maintenance, can be defined as “an equipment maintenance strategy based on replacing, or restoring, an asset at a fixed interval regardless of its condition. Scheduled restoration tasks and replacement tasks are examples of preventive maintenance tasks.” (source: [Reliabilityweb](#))

Time-Based Maintenance (TBM)

When people talk about preventive maintenance (or preventative maintenance) they usually refer to what is better described as Time Based Maintenance (TBM). Time-Based Maintenance is basically a type of maintenance that is done at a regular interval while the equipment is still



functioning with the objective of preventing failure or reducing the likelihood of failure.

Preventive maintenance can be time-based i.e. every week, every month, or every three months. But preventive maintenance can also be based on usage e.g. every 150 cycles, every 10,000hrs, or like your car: service every 10,000km.

Apart from the regular interval approach (time-based maintenance) there are also other maintenance types that fall within the category of preventive maintenance:

- **Time-Based Maintenance (TBM)**
- **Failure Finding Maintenance (FFM)**
- **Risk-Based Maintenance (RBM)**
- **Condition Based Maintenance (CBM)**
- **Predictive Maintenance (PDM)**

In the following paragraphs, I will explore each of these maintenance types in more detail including when you should consider using them.

Risk-Based Maintenance (RBM)

Risk-Based Maintenance (RBM) is when you use a risk assessment methodology to assign your scarce maintenance resources to those assets that carry the most risk in case of a failure (remembering that risk = likelihood x consequence).

As a result, equipment that has a higher risk and a very high consequence of failure would be subject to more frequent maintenance and inspection. Low-risk equipment may be maintained at a much lower frequency and possibly with a much smaller scope of work.

When you implement a Risk-Based Maintenance process effectively you should have reduced the total risk of failure across your plant in the most economical way.

Risk-Based Maintenance is essentially preventive maintenance where the frequency and scope of the maintenance activities are continuously optimised based on the findings from testing or inspection and a thorough risk assessment. Examples of Risk-Based Maintenance would be Risk-Based Inspection as applied to static equipment like vessels and piping or even pressure relief valves.

Failure Finding Maintenance (FFM)

Failure Finding Maintenance tasks are aimed at detecting hidden failures typically associated with protective functions. Think pressure safety valves, trips transmitters, and the like. This type of equipment won't be required to function until something else has failed.

That means that under normal operating conditions you will not know whether this equipment is still functional i.e. the failure modes are hidden. And since these failures are hidden, you'll need to find them before you are relying on that equipment to protect you.



Simple really.

It's important to realise that failure-finding maintenance tasks do not prevent failure but simply detect it. And once detected you'll have to repair the failure you found. Failure Finding Maintenance is conducted at fixed time intervals typically derived from legislation or risk-based approaches.

Condition Based Maintenance (CBM)

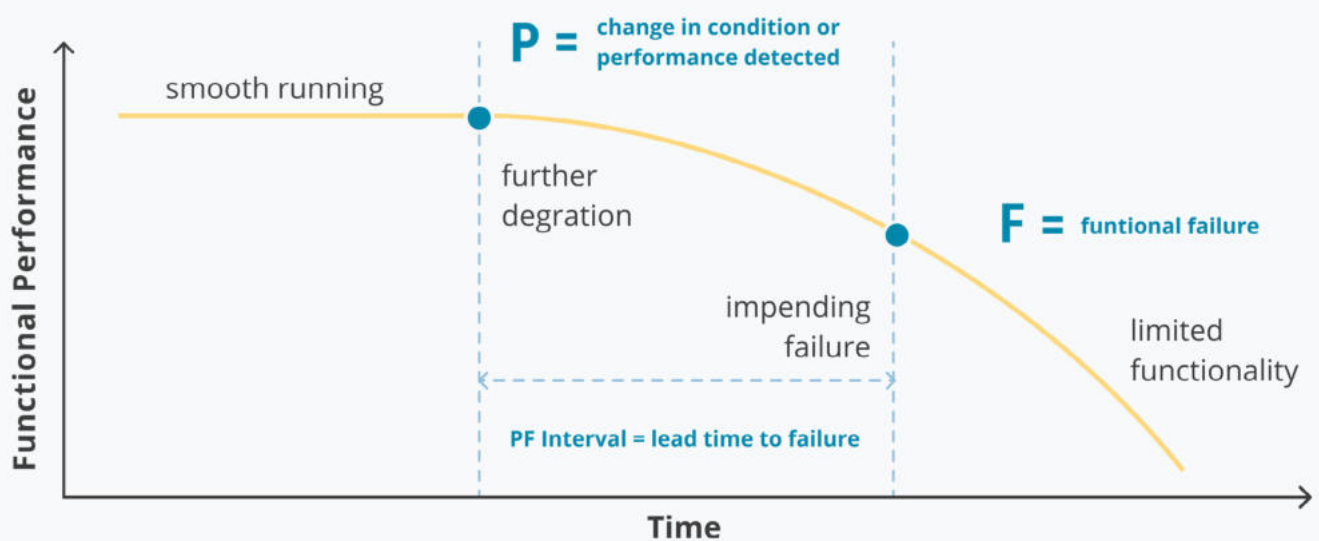
Most failure modes are not age-related. However, most failure modes do give some sort of warning that they are in the process of occurring or are about to occur. If evidence can be found that something is in the early stages of failure, it may be possible to take action to prevent it from failing completely and/or to avoid the consequences of failure.

Condition Based Maintenance as a strategy, therefore, looks for physical evidence that a failure is occurring or is about to occur. Thinking of CBM in this way shows its broader applications outside condition monitoring techniques often only associated with rotating equipment.

An important concept within Condition Based Maintenance is the P-F curve shown in the figure below.

The curve shows that as a failure starts manifesting, the equipment deteriorates to the point at which it can possibly be detected (point "P"). If the failure is not detected and mitigated, it continues until a [functional failure](#) occurs (point "F"). The time range between P and F, commonly called the P-F interval, is the window of opportunity during which an inspection can possibly detect the imminent failure and give you time to address it.

The P-F Curve





It is important to realise that CBM as a maintenance strategy does not reduce the likelihood of a failure occurring through life-renewal, but instead is aimed at intervening before the failure occurs, on the premise that this is more economical and should have less of an impact on availability.

In other words: condition monitoring does not fix machines and condition monitoring does not stop failures. Condition monitoring only lets you find problems before they become a failure.

A common rule of thumb is that the interval between CBM tasks should be one-half or one-third of the P-F interval.

How much more effective condition-based maintenance is compared to breakdown maintenance depends on how long the P-F interval is. With plenty of warning the rectification can be planned, materials and resources can be mobilised and breakdown prevented (though production is still stopped for the maintenance duration). When the P-F interval is only a few days the resulting organisational and workplace actions are much like a breakdown and the value of CBM is largely lost.

For CBM to be effective as one of your maintenance strategies, early intervention is essential. This requires an efficient and effective process for data gathering, data analysis, decision making, and finally intervention.

For failure modes where the P-F interval shows a large variability, condition monitoring is not an effective strategy.

If you're interested to find out more about how to best manage failure modes don't forget to check out my article [Reliability Centered Maintenance – 9 Principles of Modern Maintenance](#).

Predictive Maintenance (PDM)

Up until recently when people spoke about Predictive Maintenance (PDM) this was essentially as a synonym for Condition Based Maintenance. But with the advent of Artificial Intelligence, much lower costs of equipment sensors (IIoT), and machine learning there is clearly a difference appearing between Predictive Maintenance (PDM) and Condition Based Maintenance (CBM), at least in my view.

I see Predictive Maintenance as an extension, a more advanced approach to CBM where we use potentially many process parameters gained from online sensors to determine if our equipment is moving away from stable operating conditions and is heading towards failure. The central idea here is to predict when the failure is going to occur and then determine the appropriate time for maintenance intervention.

There are a lot of (very large) companies actively moving into this space and it is certainly a fast-moving and exciting part of our discipline as Maintenance & Reliability professionals. However, I do still believe that even the most advanced Predictive Maintenance approaches need to be underpinned by sound reliability principles and understanding. And I also believe that the use of Predictive Maintenance has been hyped up too much



across the industry. In most cases it is little more than Condition Based Maintenance, just marketed with a new buzzword.

Corrective Maintenance (CM)

A Run to Failure or Corrective Maintenance strategy only restores the function of an item after it has been allowed to fail. It is based on the assumption that the failure is acceptable (i.e. no significant impact on safety or the environment) and that preventing failure is either not economical or not possible.

Apart from being the outcome of a deliberate Run to Failure strategy, Corrective Maintenance is also the result of unplanned failures which were not avoided through preventive maintenance.

A run to failure strategy can effectively be used for general area lighting, smart process instrumentation (without trip functionality) etc. where the consequence of failure is limited and would not necessitate a need for an urgent repair.

When opting for corrective maintenance as a strategy it is essential to ensure that the failure modes under consideration do not have the potential to become Emergency Maintenance. You see if you adopt run-to-failure for equipment that once it has failed must be restored immediately to have doomed your organisation to a reactive maintenance environment. A reactive maintenance environment is not where you want to be. It is more expensive, less efficient, and less safe.

So although a run-to-failure strategy can be a good option, make sure you decide wisely.

Deferred Corrective Maintenance

In the chart of maintenance types I broke 'corrective maintenance' into two sub-types:

- **Deferred Corrective Maintenance**
- **Emergency Maintenance**

And that was very deliberate because it is so essential that we absolutely minimise the amount of Emergency Maintenance we allow into our organisations. As I already pointed out above Emergency Maintenance is expensive, various sources have suggested that Emergency Maintenance is 3 to 5 times as expensive as 'normal' preventive maintenance.

Emergency Maintenance typically leads to longer equipment outages and more production impact. And it is less safe. So when a corrective maintenance work request is raised it is essential that you prioritise it properly to make sure that where possible you defer the work request and give your team the time to properly plan and schedule the work.

If you want to read more about prioritisation of corrective maintenance have a look at the article [You Will Fail Without Planning & Scheduling](#).



Comparison of maintenance types

Maintenance type	Preventive Maintenance					Corrective Maintenance	
	Time based	Failure finding	Risk based	Condition based	Predictive	Deferred	Emergency
Task type	Scheduled Overhaul / Replacement	Functional Test	Measurement of condition	Calculation and extrapolation of parameters	Inspection or Test	Repair/ Replace	Repair/ Replace
Objective	Restore or replace regardless of condition	Determine if hidden failure has occurred	Restore or replace based on a measured condition compared to a defined standard	Determine if failure is imminent and intervention is required	Determine condition and conduct risk assessment to determine when next inspection, test or intervention is required.	Restore or replace following failure. Result of a Run to Failure Strategy or an unplanned failure.	Restore or replace following unplanned failure.
Interval	Fixed time or usage interval e.g. 1 month, 1,000hrs or 10,000 km	Fixed time interval (can be set based on risk assessment e.g. SIL)	Fixed time interval for condition measurements/ inspections	Continuous online monitoring of parameters, intervention as required	Time based interval between tasks and scope of task is based on risk assessment	Not applicable, but intervention is deferred to allow for proper planning & scheduling.	Immediate intervention required.

Emergency Maintenance (EM)

Emergency Maintenance is corrective maintenance that is so urgent that it breaks into your Frozen Weekly Schedule (you do have one don't you?).

It upsets your plans and schedules and typically throws everything into disarray. Some people thrive in this type of environment and often get heralded as heroes when they've worked 16hrs non-stop to get production back online. But when it comes to the Road to Reliability it is a dead end.

So Emergency Maintenance is the one and only maintenance type that we really want to avoid as much as possible. In fact, World Class organisations ensure that less than 2% of their total maintenance is Emergency Maintenance. How much Emergency Maintenance do you have?

Maintenance types: A comparison

The table below shows a brief summary of:

- **The different maintenance types;**
- **What type of tasks are involved;**
- **The objective of the task;**
- **How the interval between the tasks is determined.**

An efficient and effective Preventive Maintenance Program will have a mix of all these different maintenance strategies.



Maintenance type FAQ

In the rest of the article, I want to answer some of the most Frequently Asked Questions (FAQ) I get from readers or email subscribers.

Let's start with a classic:

What type of maintenance is the most expensive?

This is an interesting question and generally speaking unplanned corrective maintenance i.e. Emergency Maintenance is the most expensive to conduct.

This is because this type of maintenance does not go through the full maintenance planning & scheduling process because it's so urgent and it's simply planned on the fly. That means when you execute Emergency Maintenance you typically have very low efficiency with additional time wasted looking for materials,

organising access to the equipment, waiting on other trades etc.

Another common issue with Emergency Maintenance is that often parts and services are expedited to arrive faster and increased costs are incurred to make that happen.

Emergency Maintenance is typically at least 3 – 5 times as expensive as well-planned preventive maintenance.

What is breakdown maintenance?

A frequently asked question is 'what is breakdown maintenance' and as it's not in my explanation I thought I'd just cover it here briefly. As far as I am concerned, breakdown maintenance is simply corrective maintenance and not another type of maintenance in itself. In the case of breakdown maintenance, you've had a failure and so now it needs to be fixed.



And depending on the risk associated with that breakdown it could be urgent or less urgent. But, in many people's minds, breakdown maintenance is urgent maintenance, maintenance that needs to be done right now i.e. Emergency Maintenance. And if that's the case for you, you know what to do: get rid of it!

What is the difference between preventive maintenance and predictive maintenance?

I think I have covered this in the article, but as it's such a frequently asked question I'll just summarise the key differences here:

Preventive maintenance covers multiple maintenance types that are used before a failure has occurred. Predictive maintenance is a form of preventive maintenance.

When most people talk about preventive maintenance they really mean Time Based Maintenance which is a repair or replacement on a fixed interval irrespective of the condition of the equipment. The interval can be time-based (days, weeks, or months) or usage-based (operating hours, cycles, or km).

Are planned maintenance and preventive maintenance the same?

In my view, they are not the same. Planning refers back to the [maintenance planning & scheduling](#) process so planning maintenance is about preparing the maintenance work so that is ready to execute. Whereas preventive maintenance is maintenance that has been identified to prevent or mitigate a failure mode.

So in my view, Planned Maintenance is

maintenance that has been through the planning process and is properly prepared with all job steps, labour, parts, and tools identified and organised.

All Preventive Maintenance should be Planned Maintenance as it has been identified upfront and there is no reason why it would not go through the normal maintenance planning & scheduling process.

The opposite of Planned Maintenance is Unplanned Maintenance which has not properly been prepared and is planned on the plan as the job is done. This is highly inefficient and something you should avoid at all cost. The only time you should be conducting unplanned maintenance is when you have a high-priority work request that comes in and is so urgent that you break into the Frozen Weekly Schedule to complete the work without going through the normal planning & scheduling process. I refer to this as Emergency Maintenance.

Why is preventive maintenance better than breakdown maintenance?

In general, prevention of a failure is simply a lot cheaper and safer than letting equipment fail. Plus, preventive maintenance would have much less impact on production than breakdown maintenance (i.e. running to failure).

However, there are instances when a deliberate run-to-failure maintenance strategy is the right thing to do. A good example would be something like general area lighting in an industrial plant where you will simply wait till you have a number of lights that have ailed



and then you replace them. Trying to replace these lights before they fail would be a waste of money because we cannot accurately predict when lightbulbs will fail. And because the consequence is low we can simply accept that general lighting is run to failure.

Which is better: preventive maintenance or predictive maintenance?

Predictive Maintenance really is a type of Preventive Maintenance as they both see you conducting maintenance before the failure has occurred. The issue is though that most people think of the traditional Time-Based Maintenance when they talk about Preventive Maintenance. So from that perspective which is better? Neither. You need to select the right maintenance type based on the failure mode you're trying to manage and its characteristics.

If you have a failure mode that is random in nature you would want to opt for a condition-based or predictive maintenance task so that you can see the potential failure coming closer and take action before the failure

occurs.

But, if you have a failure mode that is very clearly age-related or where a condition-based task is simply not economical then you would use a time-based maintenance task.

Lube oil change out on a turbine with thousands of liters of oil is often best done on condition to ensure you get the maximum life out of the oil. But, if you are only dealing with 50 liters of oil the time and effort it takes to sample the oil and analyse it probably means it's not worth going condition-based and you simply change that oil out based on a fixed time or fixed number of running hours.

Is reliability-centered maintenance a maintenance type?

No, reliability-centered maintenance is not a type of maintenance it is a decision-making process, a methodology to develop or improve a preventive maintenance program that is both effective and efficient.



