MA CMMS

Advanced CMMS Metrics

The key performance indicators (KPIs) for maintenance excellence, and how you can measure them with your CMMS.

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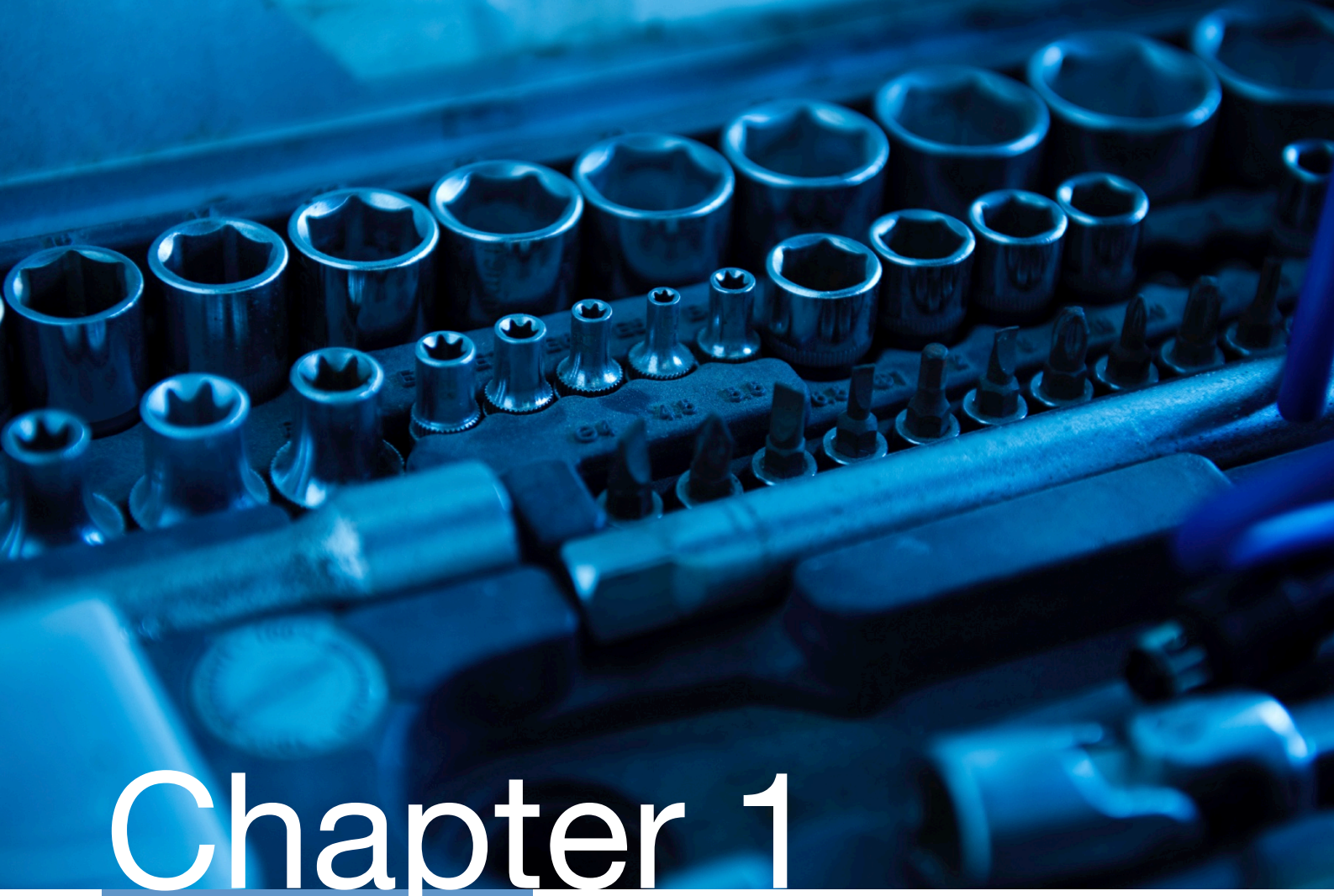
Introduction

You can't improve what you can't measure. That's why the first step on the road to reliability excellence is to calculate your maintenance key performance indicators (KPIs) to help you achieve your goals. KPI's are used to track performance in a number of areas over time and indicate when the organization is operating inside or outside of acceptable levels.

Tracking your maintenance KPIs will also help you benchmark your organization against others in the industry. KPIs can also give insights into the behaviors of personnel maintaining the system. For example, a bad maintenance technician will spend the day running around putting our fires. They'll fix the problem but they won't prevent it from happening again. On the other hand, a good maintenance technician will regularly perform inspections to spot failures before they occur and put in measures to prevent further failure reoccurrence. This results in less machine-related downtime.

Each plant will have its own specific set of KPIs that can be used to make informed decisions that impact employee safety and productivity, plant efficiency and budget planning and forecasting.

There are 5 main maintenance KPI's that will satisfy 90% of organizations and they will be discussed in this short e-book. They are: Mean Time to Repair, Mean Time Between Failure, Overall Equipment Effectiveness, PM Compliance and Planned Maintenance Percentage.



Chapter 1

Mean Time to Repair (MTTR)

Mean time to repair (MTTR) is the average time required to troubleshoot and repair failed equipment and return it to normal operating conditions. It is a basic technical measure of the maintainability of equipment and repairable parts. Maintenance time is defined as the time between the start of the incident and the moment the system is returned to production (i.e. how long the equipment is out of production). This includes notification time, diagnostic time, fix time, wait time or cool down time, reassembly, alignment, calibration, test time, back to production and so on. It's also important to remember that MTTR generally does not take into account lead-time for parts. Overall however, MTTR reflects how well an organization can respond to a problem and repair it.

How is MTTR Calculated?

Expressed mathematically, MTTR is the total maintenance time divided by the total number of maintenance actions over a specific period.

$$MTTR = \frac{\text{Total maintenance time}}{\text{Number of repairs}}$$

Over the lifetime of an asset each failure will vary depending on the severity of the issue. Some issues will require a simple parts swap while others could take days to diagnose and repair. The frequency versus repair time plot follows the lognormal distribution. We will have a large number of repairs that are quick to repair, and a small number that take much longer.

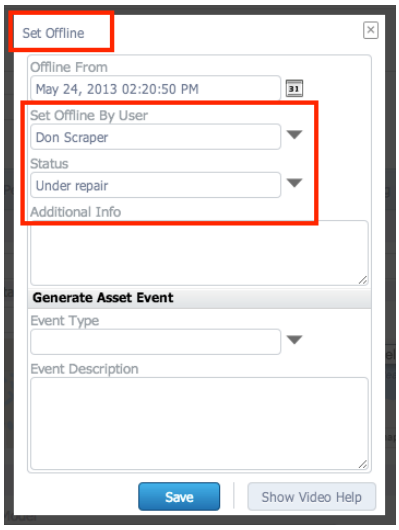
What does MTTR mean for my organization?

For mission critical equipment, MTTR can have a dramatic effect on the organization's bottom line. Taking too long to repair equipment can mean product scrap, missed orders and soured business relationships. To limit the impact of MTTR, organizations employ their own onsite maintenance teams, hold spare parts onsite, or run parallel production lines.

How can I measure MTTR in my CMMS?

Every time a system is logged down for repair in your CMMS, the timestamp is logged in the database. The CMMS tracks the repair time until the system is returned online back to production. It is then possible to run the MTTR reports to see how it trends over time. If you break up the downtime further into sub components such as waiting technician, waiting part, under repair etc., you can extract a more accurate calculation of MTTR.

(*See the diagram on the right for an example*.)

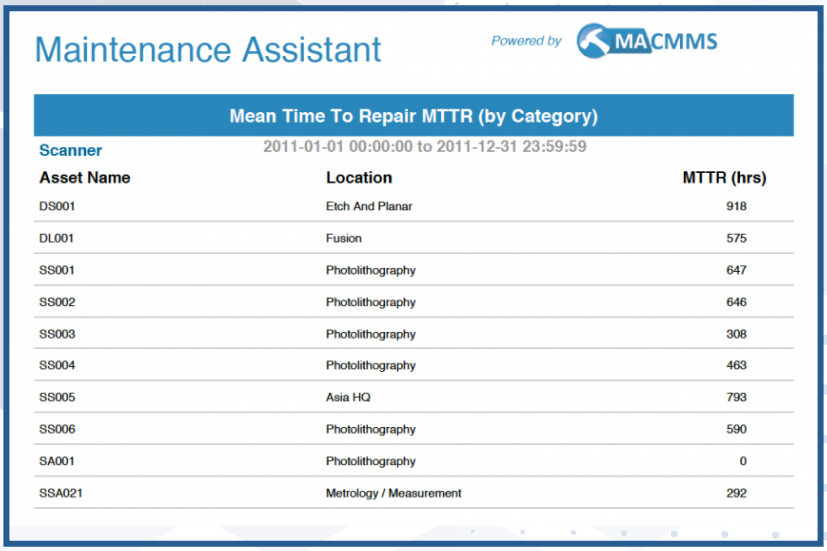


What can Mean Time To Repair tell me?

Predicting the number of hours that a system or component will be unavailable while undergoing maintenance is very important in reliability and availability studies. MTTR yields a lot of information that can help reliability engineers make informed decisions such as whether to repair or replace, hire, optimize maintenance schedules, store parts onsite or switch their parts strategy. For example, as a system ages it may take longer and longer to repair. Over time it may be more economical to replace than repair. In this situation MTTR will trend upwards, prompting the repair versus replace decision.

For an accurate calculation of MTTR, we must make the following assumptions:

1. One technician performs all tasks sequentially.
2. Appropriately trained personnel perform the maintenance.



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Mean Time To Repair MTTR (by Category)

Scanner

2011-01-01 00:00:00 to 2011-12-31 23:59:59

Asset Name	Location	MTTR (hrs)
DS001	Etch And Planar	918
DL001	Fusion	575
SS001	Photolithography	647
SS002	Photolithography	646
SS003	Photolithography	308
SS004	Photolithography	463
SS005	Asia HQ	793
SS006	Photolithography	590
SA001	Photolithography	0
SSA021	Metrology / Measurement	292

Screenshot of MTTR calculation reports in Maintenance Assistant CMMS

What are some other uses of MTTR?

You can also use MTTR to predict performance or the life cycle cost of new systems. Equipment manufacturers are now using a modular design philosophy so parts or sub assemblies can be swapped out quickly and easily. Consider being faced with a purchasing decision that involves 2 similar systems – the first has a lower MTTR as it is modular, the other has a higher MTTR because repairable items are difficult to remove due to their location. The additional time and costs to maintain the system should be factored into the life of the system to simplify the purchasing decision. Manufacturers also use MTTR to justify redesigning or improving systems.

Chapter 2

Mean Time Between Fail (MTBF)

Mean Time Between Failures (MTBF) is an important metric where the failure rate of assets needs to be managed. MTBF is the average time between breakdowns of a system. In other words, MTBF is the average time the system or component functions normally between breakdowns. For mission critical or complex repairable assets such as generators, tankers or airplanes, MTBF becomes an important indicator of expected performance. It has also become a fundamental component in the design of safe systems and equipment. MTBF does not take into account any scheduled maintenance such as inspections, recalibrations, lubrications or preventive parts replacements. Whereas MTTR affects availability, MTBF affects both availability and reliability.

How is MTBF Calculated?

There are a number of factors that can influence MTBF and they are mainly human. For example, was the product applied in the correct way? Was it designed and built correctly? Did the actions of the technician during a previous repair contribute to the failure? The MTBF formula is as follows:

$$MBTF = \frac{\Sigma\ (\text{Start of Downtime} - \text{Start of Uptime})}{\text{Number of repairs}}$$

MTBF is usually measured in terms of hours. For accuracy, this measurement includes only operational time between failures and does not include repair times, assuming the item is repaired and begins functioning again.

Why is MTBF a useful thing to measure?

MTBF figures are often used to anticipate how likely a single unit is to fail within a certain period of time. Therefore, MTBF is a great way to quantify the reliability of a system or component. It refers to the average time the asset functions normally before it fails so it can be used to predict future performance. Organizations that provide automobile break down assistance, for example, factor in MTBF when determining their pricing. The more likely the average automobile is to break down, the more they have to charge.

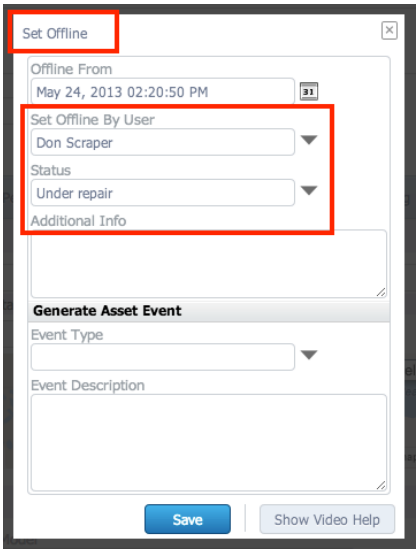
Manufacturers may provide the minimum MTBF for system or component to indicate its expected reliability based on intensive testing. However, in many cases the manufacturers' predicted MTBF metric might be inaccurate. The calculation could be based on laboratory testing, analytical modeling or data from newer generations and technologies. For a more accurate representation of MTBF for your facility, you need an estimation based on actual field data from your own equiptment.

> ***"Mean time between fail is a great way to quantify the reliability of a system or component"***
>
> *- Jeff O'Brien, Customer Success*

How do I measure MTBF in my CMMS?

Most CMMS applications come complete with MTBF reports built in, so it's easy to pull MTBF data for any particular assets directly from your CMMS.

When an asset goes down for repair, simply select the reason that accurately describes the situation. Reasons to set an asset offline can be configured in the lookup tables in the settings section of your CMMS. When the repair is complete, log the system back up to production. This online/offline data is then used to calculate MTBF. Shown below are some screenshots of what these reports look like in Maintenance Assistant CMMS.



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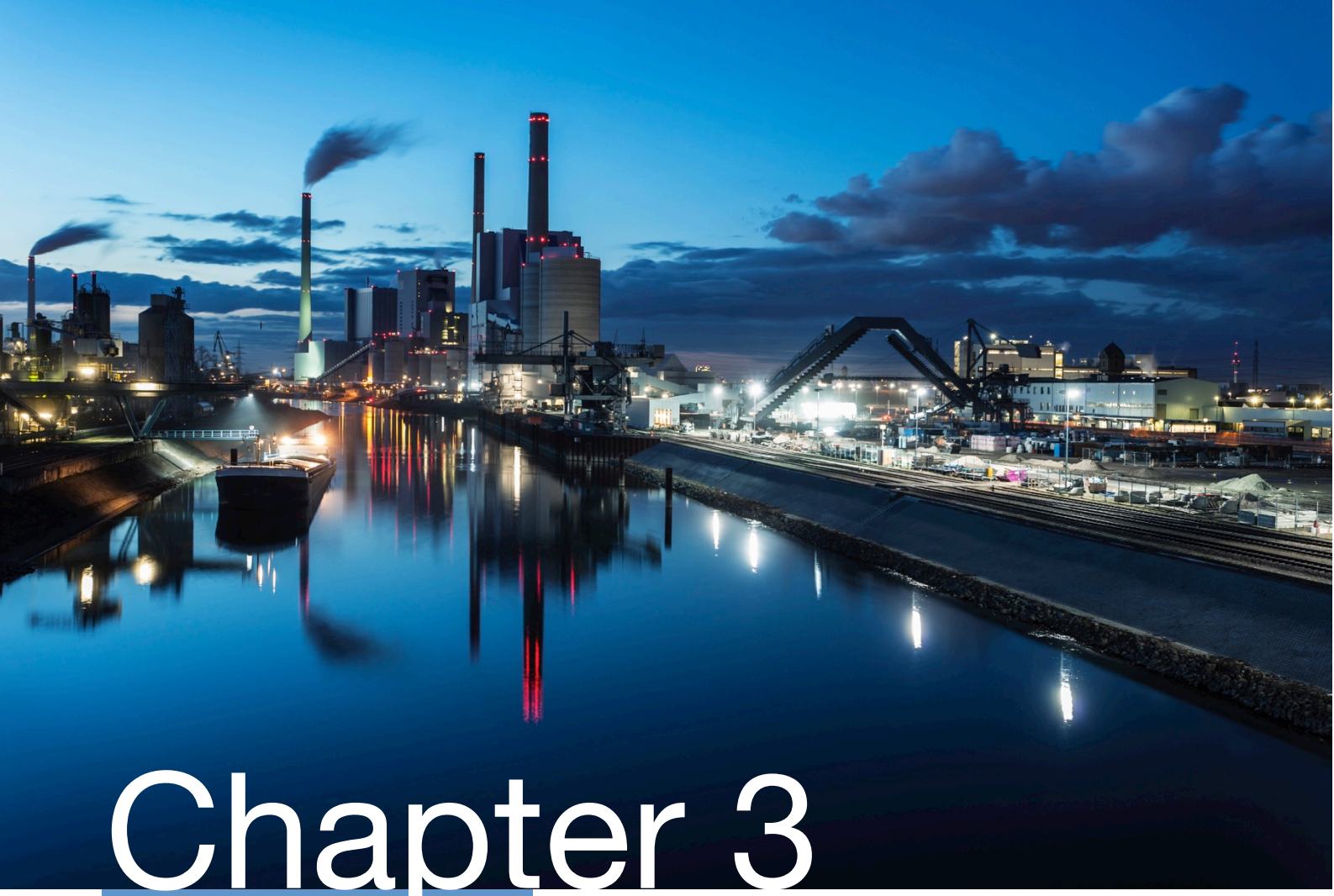
Mean Time Between Interrupt MBTI (all)

2011-01-01 00:00:00 to 2011-12-31 23:59:59

Asset Name	Location	MTBI (hrs)
A99	Healthy Heart Hospital	8590
Company Vehicle	Staff Carpark 1	8695
DL001	Fusion	4346
DS001	Etch And Planar	1353
DS003	Photolithography	2172
Delivery Truck	Staff Carpark 3	8735
MM001	Photolithography	4285
Manufacturing Plant 1	US HQ	8328
Mill 1	Manufacturing Plant 2	4368
Office Building 1	US HQ	2911
Office Building 2	US HQ	8735
Robot Interlock Override Tool	Tool Storage Room 1	8735

Screenshot of MTBF calculation reports in Maintenance Assistant CMMS



Chapter 3

Overall Equipment Effectiveness (OEE)

Overall Equipment Effectiveness is made up of three components: how available your equipment is, how it performs versus its specifications, and what kind of quality it produces. OEE can be used to monitor the efficiency of your manufacturing processes and to help identify areas of improvement. In practice, OEE is calculated as the product of its three contributing factors:

OEE = Availability x Performance x Quality

Availability = The system is functioning when it is needed.
Performance = A measure of system throughput divided by its maximum throughput.
Quality = The number of good units divided by total units started.

How is OEE Calculated?

OEE excludes planned shutdowns such as preventive maintenance, holiday shutdowns and periods when there are no orders to produce. When you subtract this planned downtime from total plant operating time, you are left with planned production time. OEE is calculated on planned production time. The ideal manufacturing facility is one that produces the best product, as quickly as possible, with no unscheduled down time. This is an OEE of 100%, which is difficult, if not impossible to achieve. For discrete manufacturing plants, world class OEE is generally considered being 85% or better, however, the average OEE score in North America is ~60%.

What is OEE used to measure?

OEE is a good indicator of machine or system productivity. It can also give insights into the behaviors of personnel maintaining the system. A bad maintenance technician spends the day running around putting out fires, fixing problems as they come up but not preventing them from happening again. A good maintenance technician performs regular inspections to spot failures before they occur, performs recurring scheduled maintenance and puts measures in place to prevent further failure reoccurrence, resulting in less machine-related downtime. OEE also provides a way of measuring the success of manufacturing, productivity or lean initiatives such as TPM.

When you calculate the 3 different elements that make up OEE, it is easier to identify where improvements are possible and where to put your focus. If availability is the focus, then you can run downtime or issue reports in your CMMS and identify which issues are causing the majority of the system stoppages. In reality, OEE measures the losses that affect your equipment. The 6 big losses are:

	IDEAL	AVERAGE
Availability	90%	79%
Performance	95%	80%
Quality	99%	95%
OEE	85%	60%

1. Equipment failures
2. Setup and adjustment time due to product changeover
3. Idling or minor stoppages - jams, misfeeds, sensor errors etc.
4. Reduced speed due to rough running or equipment wear
5. Defects in operation or process
6. Startup or reduced yield

Dependency	What Kills It?	How can I improve it?
Availability	• Breakdowns • Machine Idle Time • Adjustment Time • Stoppages	• Improve PM Scheduling • Reduce reactive maintenance • Retrain Personnel • Effective Parts Strategy • Knowledge Transfers
Performance	• Poorly operating equipment • Inefficient work processes • Material variations • Lack of Lubrication • Older Systems	• Equipment overhaul • Regular equipment PMs • Replacements
Quality	• Poorly maintained equipment • System misalignment • Inconsistent raw materials • Guesswork	• Improve the quality of raw materials used

Chapter 4

How is it PMC Measured?

You should work to the **10% rule of preventive maintenance**. The 10% rule states that a preventive maintenance action should be completed within 10% of the scheduled maintenance interval. For example, a quarterly PM every 90 days should be completed within 9 days of the due date or it is out of compliance. The 10% rule helps keep your PM intervals constant, reducing the time variable variation, thus improving reliability.

If you're still using a white board or excel based tracking system it is next to impossible to get an accurate indicator of PM compliance. In fact, it is next to impossible to adequately track any maintenance metrics or costs without a proper CMMS.

Preventative Maintenance Compliance

Preventative Maintenance (PM) is taking precautionary and proactive steps against unscheduled equipment downtime and other avoidable failures. The purpose of preventative maintenance is to institute scheduled inspections so defects can be spotted before they evolve into something more severe. If you let too much time go by between PM's, there is a greater chance the asset will suffer a major failure. Therefore, it is important to complete these PM's, and complete them on time. Your preventive maintenance compliance (PMC) score is the percentage of scheduled PM work orders that get done in a defined time interval.

If done correctly, measuring PM compliance and charting it against unscheduled breakdowns and costs is an excellent way to determine if your PM program is working for you or not. We'll go over an example of how to measure this on the following page.

Steps to Calculate PMC:

1. Define the preventive maintenance schedule and tasks for each asset

2. Conduct the preventive maintenance at the defined interval

3. Measure the percentage of the PM work-orders completed in the defined interval

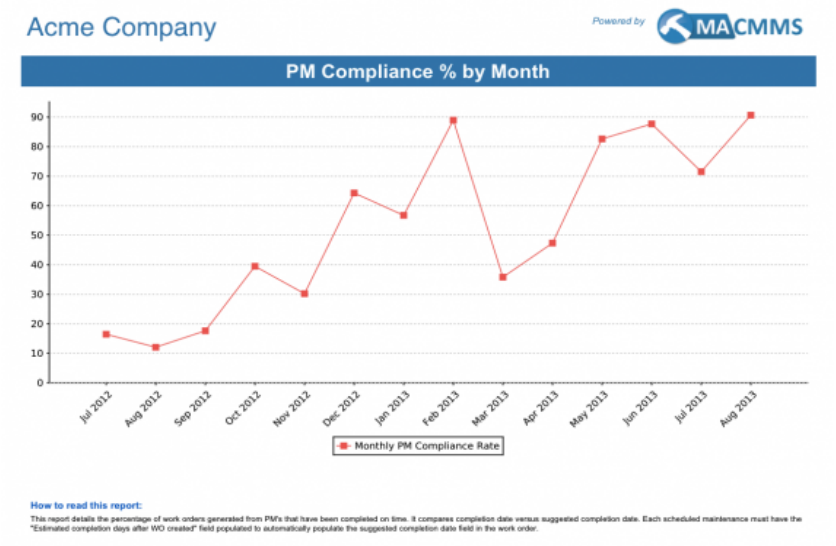
That is your PMC score

Example:

- Week 1 - 5 PM work orders scheduled, 4 completed
- Week 2 - 5 PM work orders scheduled, 1 completed
- Week 3 - 5 PM work orders scheduled, 5 completed
- Week 4 - 5 PM work orders scheduled, 4 completed

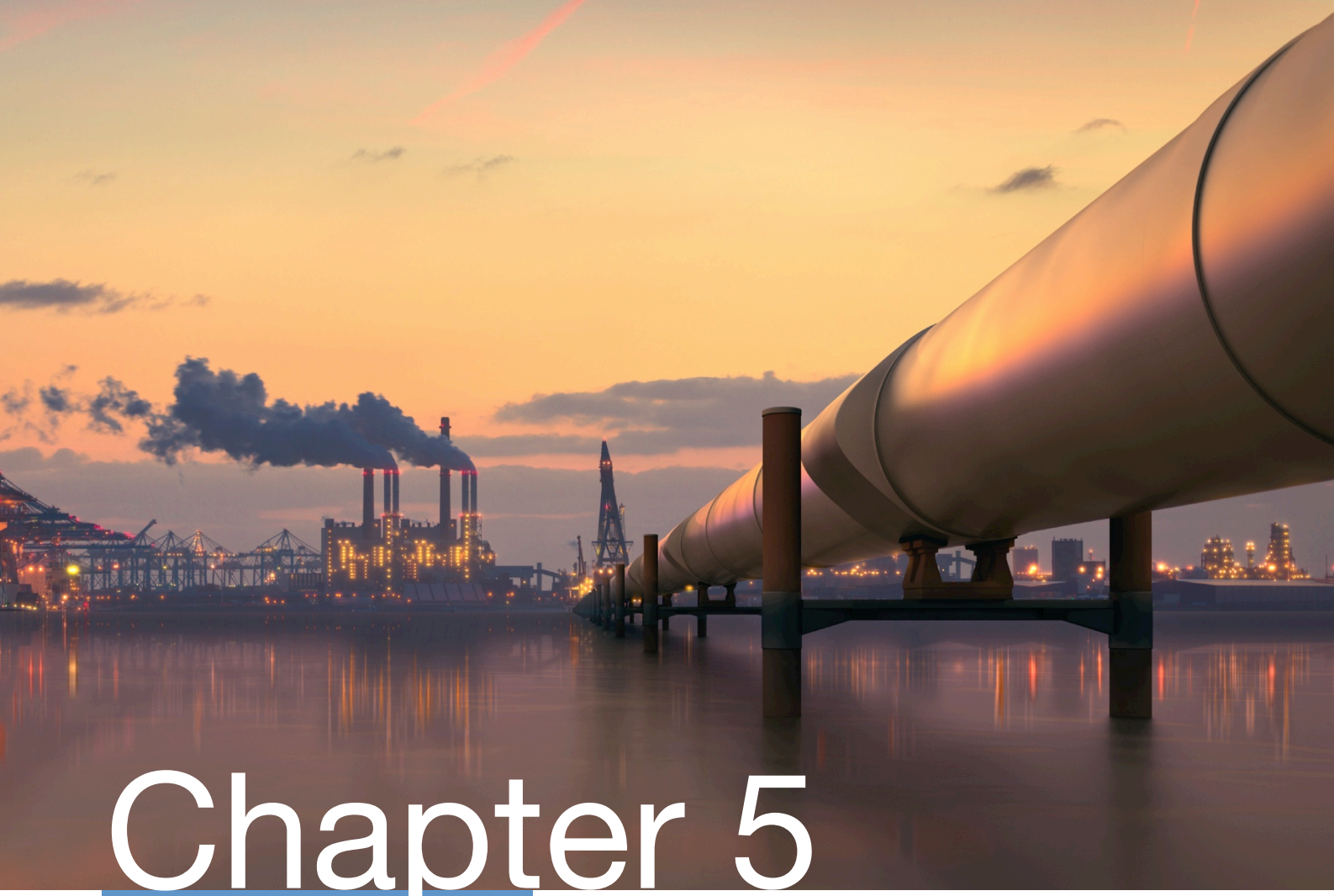
Your PMC score = (4+1+5+4)/(5+5+5+5)= 0.7 or 70% for the month

It is quite common for organizations to use the PMC metrics to measure maintenance performance although PM compliance gets a mixed reception from operations managers. PM compliance could be 100% yet system downtime could still be a major issue. This is because the formula only measures whether the PM was complete or not, regardless if it was weeks late.



Screenshot of PM compliance reports in Maintenance Assistant CMMS

When faced with a number of PM's in the backlog, use the scheduled maintenance critical % to determine which PM to complete first. Scheduled maintenance critical percent shows how late your scheduled maintenance work orders are in relation to the maintenance schedule.



Chapter 5

Definition of Planned Maintenance Percentage

Planned, predictive and preventive maintenance are organized, documented and scheduled repairs that are addressed before the breakdown occurs.

The process of planning the maintenance makes the tasks more efficient and eliminates the effect of maintenance on the operations of the facility.

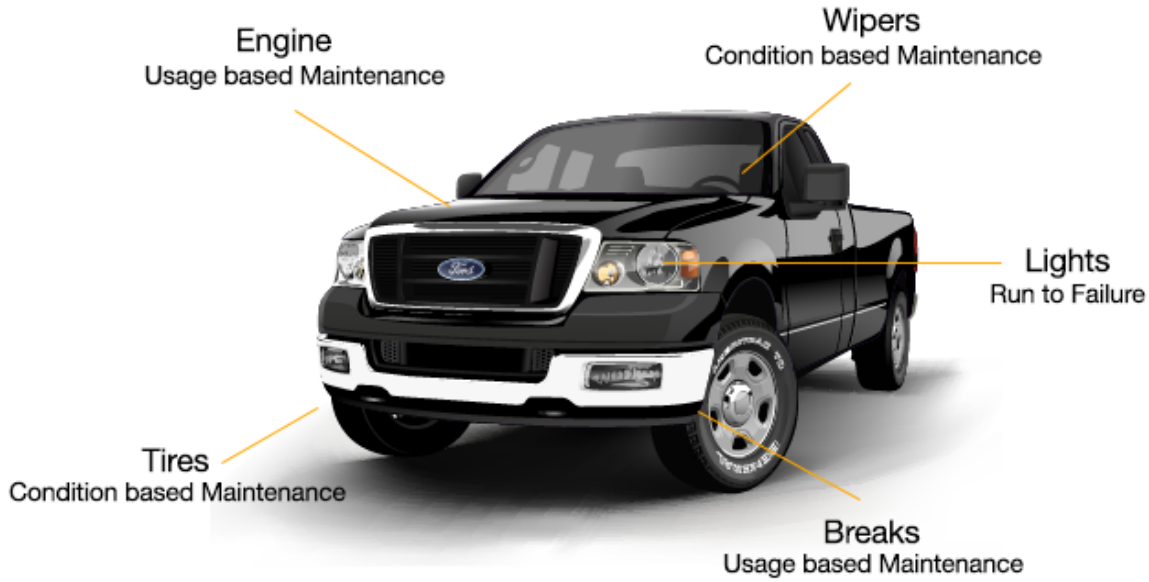
Planned maintenance percentage is the total amount of planned maintenance hours, documented and scheduled in advance, divided by the total maintenance hours in the same period.

Planned Maintenance Percentage

There are two types of maintenance – planned maintenance and unplanned maintenance. You can plan to service a system, plan to inspect for wear, or plan to let a light bulb go out before you replace it. Either way, you consciously planned the maintenance. On the other hand, unplanned maintenance occurs when you least expect it. This is commonly called breakdown or emergency maintenance. Unplanned, breakdown maintenance costs 3-9 times more than planned maintenance due to overtime, rushed parts, service call outs, scrapped production etc. So, in general, we want to plan all non-emergency work where possible.

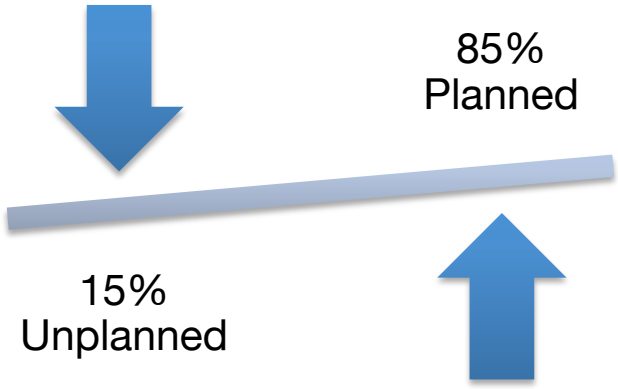
Planned	Unplanned
Condition Based	Fix it when it breaks
Usage Based	
Run to Failure	

The easiest way to see the difference is to use your car as an example. You plan to change the oil at regular use-based intervals be that time or meter based; you plan to let the light bulbs run to fail; you inspect the condition of the tires and replace when they have warn down below safe levels; you respond to the warning lights on the dashboard and take the car to the dealer. It's all planned maintenance. On the other hand, when you smell smoke coming from your engine and pull over to the side of the road, you'll need some unplanned breakdown maintenance to get the vehicle running again.



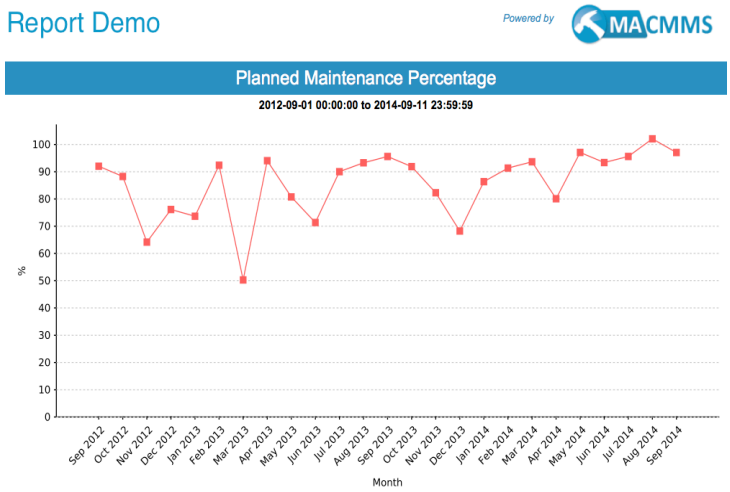
Best in Class Maintenance

Organizations with best in class maintenance will spend 85% or more of their time performing planned maintenance. We can get more granular and break the 85% figure up further into planned maintenance types. The top performing organizations will do about 30% usage based, 50% condition based and the remaining planned run to failure. That leaves <15% of available time to perform that unplanned breakdown maintenance. Where does your organization stand on the scale? How do the costs of doing that planned maintenance relate to overall maintenance costs?



Measuring Planned Maintenance Percentage

Without a CMMS, you'll need to extract your work orders and PM data and calculate manually. However, most CMMS programs come with a planned maintenance percentage report, saving you the time and hassle of manual calculations. We've included a sample report here.



Screenshot of Planned Maintenance reports in Maintenance Assistant CMMS

Benefits of performing planned maintenance

Whatever your organization's type or size, planning and scheduling maintenance should be the base of any effective maintenance program. The benefits of planned maintenance include:

1. **Reduction in costs** – Unplanned breakdown maintenance costs 3-9 times more than planned maintenance, so it makes sense to plan maintenance where possible.
2. **Easy to control maintenance budgets** – You can predict the costs in advance and level them out throughout the year.
3. **Efficient use of resources** – Work schedules can be planned and optimized in advance
4. **Lower Energy costs** – Properly maintained equipment uses less energy.
5. **Reduced production scrap** – Planned maintenance can be written into the production schedule and performed when the equipment is dry.
6. **High staff morale** – Constantly dealing with emergency repairs increases stress levels and lowers morale. Planned maintenance gives technicians time to properly prepare their work in advance, lowering stress levels and improving morale.

Conclusion

A CMMS helps you apply the best maintenance and reliability strategies at your facility by giving you the ability to measure and track your maintenance KPIs. Used correctly your organization can maximize the value of your CMMS investment through better planning, improved efficiency, increased safety awareness and reduced costs. Consider it a critical cog in your maintenance and reliability machine.

The data in your CMMS is static, but it contains valuable information that can be used for informed decision making if you use the calculations in this e-book. Business intelligence reports built into the CMMS can also be used to pull your maintenance KPIs and summarize or categorize your activities. By analyzing asset failures, downtime, resource utilization and spending patterns in the CMMS, the reliability engineer can implement changes that will add value or reduce risk. Starting out, the focus should be on the critical assets that can have the biggest impact on costs and availability.

When used to its full potential a CMMS pays huge dividends. According to David Berger of Plant Services, a CMMS can deliver a 10% increase in availability, a 5% increase in throughput and a 5% increase in quality of output. With a fully functioning CMMS, coupled with a preventive maintenance philosophy you will see significant improvement in OEE and hence the company financials.

Remember, asset management is a process of continuous improvement so its important to monitor your KPIs over time for trends. Continually tracking your KPIs can help determine whether any changes you've made added value or reduced cost. Publishing those KPIs at regular intervals will keep everyone motivated and committed to achieving the corporate goals.

"You can't improve what you can't measure."

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