Advanced CMMS metrics
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What’s a KPI?

Key performance indicators (KPIs) are metrics used to track performance in a number of areas over time.

Why are KPIs important?

At the most basic level, KPIs are important because you can't improve what you can't measure. They indicate whether the organization is operating inside or outside acceptable levels, and help you benchmark against other businesses in your industry.

They also give you insights into the behaviour of the personnel maintaining the system. For example, a bad maintenance technician will spend the day running around putting out fires. They'll fix the problem but they won't prevent it from happening again. On the other hand, a good technician will regularly perform inspections to spot failures before they occur and work to prevent further failures.

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

There are 5 main maintenance KPIs that will satisfy 90% of organizations

- Mean time to repair
- Mean time between failure
- Overall equipment effectiveness
- PM compliance
- Planned maintenance percentage

In this guide we explain each of these maintenance KPIs, why they're useful, and how to calculate them.
Mean time to repair

Mean time to repair (MTTR) is the average time required to troubleshoot and repair failed equipment.

An important part of this is maintenance time—the time between the start of the incident and the moment the system returns to production (i.e. how long the equipment is down for). This includes the time it takes to notify technicians of the failure, diagnose the issue, and fix the problem, as well as wait time or cool down time, reassembly, alignment, calibration, test time, the time it takes to return to production and so on. MTTR generally does not take into account lead-time for parts, but overall it reflects how quickly an organization can respond to a problem and repair it.

Why is MTTR useful?

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.

Predicting how many hours a system will be unavailable during maintenance is very important for reliability and availability. MTTR can help reliability engineers make informed decisions on whether to repair or replace a machine, hire more technicians, 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 the system, rather than fight to repair it every time.

MTTR can also be factored into purchasing decisions, since you can use this info to predict the life cycle cost of new systems. Consider being faced with a purchasing decision that involves two similar systems—the first is a modular system with parts that can be swapped out easily, so it has a lower MTTR. The other isn’t modular, and has a higher MTTR because repairable items are more difficult to remove. The additional time and costs to maintain the system should be factored into the life of the system to simplify the purchasing decision. The same thought process can be used to justify redesigning or improving systems.
How do you calculate MTTR?

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

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

To accurately calculate MTTR, you need to assume two things:

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

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.
Measuring MTTR in your CMMS

Every time a system is logged as down for repair in your CMMS, the timestamp is captured in the database. The CMMS tracks how long it takes for the system to come back online. It is then possible to run 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.

<table>
<thead>
<tr>
<th>Scanner</th>
<th>Asset Name</th>
<th>Location</th>
<th>MTTR (hrs)</th>
</tr>
</thead>
<tbody>
<tr>
<td>DS001</td>
<td>Etch And Planar</td>
<td></td>
<td>918</td>
</tr>
<tr>
<td>DL001</td>
<td>Fusion</td>
<td></td>
<td>575</td>
</tr>
<tr>
<td>SS001</td>
<td>Photolithography</td>
<td></td>
<td>647</td>
</tr>
<tr>
<td>SS002</td>
<td>Photolithography</td>
<td></td>
<td>640</td>
</tr>
<tr>
<td>SS003</td>
<td>Photolithography</td>
<td></td>
<td>368</td>
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<tr>
<td>SS004</td>
<td>Photolithography</td>
<td></td>
<td>460</td>
</tr>
<tr>
<td>SS005</td>
<td>Asia HQ</td>
<td></td>
<td>718</td>
</tr>
<tr>
<td>SS006</td>
<td>Photolithography</td>
<td></td>
<td>590</td>
</tr>
<tr>
<td>SA001</td>
<td>Photolithography</td>
<td></td>
<td>0</td>
</tr>
<tr>
<td>SSA021</td>
<td>Metrology / Measurement</td>
<td></td>
<td>282</td>
</tr>
</tbody>
</table>
Mean time between failures (MTBF) is the average time between system breakdowns.

For mission critical or complex assets like generators, tankers, or airplanes, MTBF is an important performance metric, and a fundamental component in safe systems and equipment design. MTBF does not take into account scheduled maintenance like inspections, recalibrations, lubrications, or preventive parts replacements.

Why is MTBF useful?

MTBF is used to anticipate how likely a single unit is to fail within a certain time period, making it a great way to quantify the reliability of a system or component.

For example, organizations that provide automobile breakdown assistance factor in MTBF when determining their pricing. The more likely the average automobile is to break down, the more they have to charge.
How do you calculate MTBF?

Even though a system or component manufacturer might provide a minimum MBTF for their product, this prediction might be based on laboratory testing, analytical modeling or data from newer generations, and could be inaccurate. For a more accurate representation of MTBF for your facility, you need an estimation based on actual field data from your own equipment.

Additionally, a lot of factors that can influence MTBF are human. Was the product applied the right 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:

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

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

Most CMMS applications come complete with MTBF (also called) reports built in, so it’s easy to pull data for any assets directly from your CMMS.

When an asset is down for repair, simply select the reason for the repair (reasons to set an asset offline can be configured in the lookup tables in the settings section of your CMMS). When the repair is done, log the system as backup for production. This online/offline data is then used to calculate MTBF.

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

Overall equipment effectiveness (OEE) is based on three factors:

- The **availability** of equipment
- How equipment **performs** versus its specifications
- What kind of **quality** the equipment produces

You can use OEE 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:

\[
\text{OEE} = \text{Availability} \times \text{Performance} \times \text{Quality}
\]

**Availability:** The system is functioning when it is needed.

**Performance:** A measure of system throughput divided by its maximum possible throughout.

**Quality:** The number of good/useable units divided by total units started.

<table>
<thead>
<tr>
<th>Dependancy</th>
<th>What kills it?</th>
<th>How can I improve it?</th>
</tr>
</thead>
</table>
| **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  
• Systems misalignment  
• Inconsistent raw materials  
• Guesswork | • Improve the quality of raw materials |
Why is OEE useful?

OEE is a good indicator of machine or system productivity. It provides a way of measuring the success of manufacturing, productivity or lean initiatives such as TPM.

Another way to look at it is that OEE measures the losses that affect your equipment. The six big losses are:

1. Equipment failures
2. Setup and adjustment time due to product changeover
3. Idling or minor stoppage 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

By understanding where these losses are coming from, you can identify what to focus on to improve your business.

How do you calculate OEE?

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 about 85% or better. However, the average OEE score in North America is ~60%.
Preventive maintenance compliance

Preventive maintenance (PM) is about taking precautionary and proactive steps against unscheduled equipment downtime and other avoidable failures. The purpose of preventive maintenance is to institute scheduled inspections so defects are spotted before they evolve into something more severe.

But a preventive maintenance strategy is no good if no one adheres to it. This is where preventive maintenance compliance (PMC) comes in. Measuring PMC and charting it against unscheduled breakdowns and costs is an excellent way to determine if your PM program is working for you or not.

How do you calculate PMC?

Your PMC score is the percentage of scheduled PM work orders that actually get done within a defined time period.

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.
Planned maintenance percentage

There are two types of maintenance—planned and unplanned.

Let’s use a car as an example. You usually plan to change your oil at regular intervals, be they time or meter based; you plan to let the light bulbs run to fail; you inspect your tires and replace them when they have worn down below safe levels; you respond to the warning lights on the dashboard and take the car in to be serviced. All of these things count as planned maintenance.

On the other hand, if 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.

Unplanned or breakdown maintenance can cost three to nine times more than planned maintenance because of overtime, rushed parts, service call outs, scrapped production etc.
How do you calculate planned maintenance percentage?

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

Planned maintenance percentage is the total planned maintenance hours—hours that are documented and scheduled in advance—divided by the total maintenance hours in the same period.

<table>
<thead>
<tr>
<th>Planned</th>
<th>Unplanned</th>
</tr>
</thead>
<tbody>
<tr>
<td>Condition-based</td>
<td>Fix it when it breaks</td>
</tr>
<tr>
<td>Usage-based</td>
<td></td>
</tr>
<tr>
<td>Run-to-failure</td>
<td></td>
</tr>
</tbody>
</table>
Measuring PMP in your CMMS

Without a CMMS, you’ll have to extract your work orders and PM data and calculate your planned maintenance percentage manually. However, most CMMS programs come with a planned maintenance percentage report, saving you the time and hassle of manual calculations.

Report Demo

How to read this report:
This report numerically the sum of the hours completed on scheduled work orders as a % of hours completed on all work orders. Scheduled work orders have come from scheduled maintenance items. You must log hours completed on each work order for this report to give accurate data.
Maintenance best practices

Organizations should aim to spend 85% or more of their time on planned maintenance.

This 85% can be broken down into planned maintenance types—30% usage-based, 50% condition-based, and the remaining planned run-to-failure. That leaves about 15% of available time to perform any unplanned breakdown 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 three to nine times more than planned maintenance.

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, which lowers stress levels, and improves morale.
A CMMS lets you make educated decisions about maintenance, rather than always taking shots in the dark. This e-book focused on analyzing asset failures, downtime, resource use, and spending patterns to implement changes that add value or reduce risk. Tracking KPIs can help determine whether the tweaks you’ve made in your facility actually worked, and what the outcome was.

For more information on CMMS features, check out our other resources:

Other resources:

> 22 Negotiation secrets: Get the best price on parts and supplies
> Get more from your CMMS with nested PMs