



Measuring Maintenance Effectiveness

7 Data Capture Methods for Effective Decision Making



Asset Reliability | Operations | Shutdowns & Turnarounds
Organisation, Leadership & People
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Introduction

Many years ago, the typical cause-and-effect diagram (the fishbone) had four categories for its branches: Manpower, Materials, Method, and Machine. The four Ms. As companies have become more analytical through using SPC, Lean, Six Sigma, etc., there has been a realization that a fifth M needed to be added: Measurement. What we will review in this eBook is whether we are using the right measures to give us the information we need. First of all, it would be good if we could agree on a common definition for the purpose of measuring – I'll give you mine and it's the premise for this eBook:

“ The purpose of measuring is to enable managers to make the most informed decision they can ”

Introduction

When so many decisions are being made based on the information gained from the process, it becomes obvious that the correct and most relevant measures need to be taken. Whether they are called limits, goals, targets or Key Performance Indicators (KPIs) doesn't matter as long as you are measuring those things that have the greatest impact on your business and you use the measurements to drive continuous improvement. The way of ensuring that you are doing what is necessary is to confirm that you are setting up the KPI's or goals in the right way. The goals should start at the strategic level – what is it that your organization hopes to achieve and how will they measure it? The next level down is what performance level your plant is required to deliver in order to clearly support the goals at the strategic level and how they are connected. This then flows to the departmental level where the same criteria apply as at the plant level. There also needs to be a clear indication of the impact of the actions of each level in driving the effort to achieve the goals that have been set.

Introduction

There is one truism about KPIs and measures and that is that they will drive behaviours, our role as managers is to ensure that the drive is in the right direction. A word of warning at this point - if you're not going to manage it, don't bother measuring it. There is no bigger waste of time and effort than measuring for the sake of measuring. As we seek to control maintenance, we need to determine which measurements we should be making in order to identify the areas ripe for improvement.

There are many measurements that can be applied in the maintenance field, ranging from the all-encompassing Overall Equipment Efficiency (OEE) to the more obscure

Total Productive Maintenance (TPM) measure of 'Critical Equipment with Failure

Mode Effect and Criticality Analysis' ratio. Let's take a look at some of the most common and often used measures:



METHOD 1

BEST IN CLASS STANDARDS

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Benchmarking against world-class standards or best-in-class is a good start but it is fraught with traps and misleading direction. It is almost impossible to identify exactly how different organizations calculate their measures- what they include in the calculations and what they leave out. I know of one Canadian Newspaper that had set up a benchmarking exercise with Newspapers in United Kingdom, South Africa and Australia.

They were happy with most of their performance when compared with the other newspapers, except for one measure where the Australian newspaper was hitting a much higher performance level. They tried to figure out what they could be doing differently and even asked the Australians for advice – though it appeared that they were doing the same things. It wasn't until they visited the Australian press room that they saw that the Australians had a press that they didn't appear to be using.

BEST IN CLASS STANDARDS

When they asked the Australians what they used the press for they were told that when they had a problem with any of their other presses they had found it far quicker and more efficient just to move everything over to the spare press and run rather than wait for the problem to be fixed.

It became apparent that the actual performance wasn't any better – in fact they seemed to have more failures and that was what had driven them to using the spare press – but it was how things were being measured and what was going into the mix that caused the difference. So if you are going to use benchmarks then you need to ensure that you are comparing apples with apples not pineapples because there is a difference!

Comparing with a sister plant certainly takes away one very important hidden difference when benchmarking and that's organizational culture. At least you can believe that you are operating under the same constraints and controls which may impact the way you operate, spend money and behave.

BEST IN CLASS STANDARDS

Perhaps the simplest and most effective method of comparison is to use yourself as the model. Decide those measures that are important to you and establish the level of performance you are currently at - then decide on where you want to be (as described in fig 1). You then need to create a map of those things you are going to do to close the gap between 'current state' and 'desired state'. You then simply measure your progress - you can be sure it's important to you and that there are no hidden items in the measure!

Another interesting question is, "whom do 'best in class' companies benchmark against?" The answer usually is "Themselves," so why not start out that way?



METHOD 2

OVERALL EQUIPMENT EFFICIENCY

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One of the most widely used measures is Overall Equipment Efficiency, as it is a combination of measures of availability, the ability to run at the desired speed, with minimal defects. Obviously, without a well-maintained piece of equipment, this number would be low.

A world-class measure for OEE is 85% (although, as with all world-class measures, there is variation between industries, countries, etc so please remember the note about starting by comparing with yourself). This number is usually thought to be comprised of the typical measures of Availability (90%) x Speed or Production rate (95%) x Quality (99%), but in organizations where Six Sigma controls are applied, the OEE standard jumps dramatically.

In organizations that have implemented Total Productive Maintenance, OEE is the driver and very often requests for expenditure or for a focus team is completely based on intended OEE gain.

OVERALL EQUIPMENT EFFICIENCY

In most organizations, it is believed that maintenance's biggest influence is on availability as measured in downtime - the world class mark being 2.8%, although this varies from situation to situation. What very often is missed is the reduced run speed due to 'shake, rattle and roll', things upon which maintenance can have a major influence.

Many times operations will limp by rather than shutdown to carry out a repair as they would rather produce at lower levels than not produce at all. This is quite often driven by incorrect KPIs. Often times this results in increased maintenance costs and higher eventual downtime as the situation has continued to degrade and there is secondary damage. The quality aspect can also be affected by faulty equipment but the same operational approach of 'keep running' is very common.

MEAN TIME BETWEEN FAILURES (MTBF)

Mean Time Between Failures (MTBF) is simplistically derived from Total Scheduled Operating Time divided by the Number of Failures. This is usually used as a high level measure that is lagging and reflects past performance. The danger of using this measure in isolation is that it doesn't really take into consideration any weighting that may occur. There may be a predominant failure mode or a rogue piece of equipment or changes that have been made to the process or equipment.

If we look at an example in a paper mill where in one area there were 15 pumps, the mill had been running for five years and they had experienced six failures and so the MTBF was calculated simplistically as:

$$\frac{15 \text{ pumps} \times 5 \text{ years} \times 52 \text{ weeks}}{6 \text{ failures}} = \frac{3900}{6} = 66 \text{ weeks}$$

MEAN TIME BETWEEN FAILURES (MTBF)

When we start to investigate and dig a little deeper we start to find some interesting facts.

In the first SIX months of operation there were FOUR failures each of which were attributed to poor lubrication practices. This prompted a complete retraining of the lubrication team with special emphasis on the failures. Since the retraining there have been ZERO lubrication caused failures.

In Month 18 and Month 19 there was ONE failure in each month – they both were in the same location. Two failures in the same location had been the trigger for a Root Cause Analysis exercise and what they found was that there had been a change to the process at this location. The original design installation was now too small to handle the load that the process was presenting. The solution was to change out the pump for a larger more robust model and there have been ZERO failures since.

MEAN TIME BETWEEN FAILURES (MTBF)

So if we look at this example we have a MTBF of 66 weeks for these pumps whereas the reality is that TEN of the pumps have NEVER failed. There has not been a pump failure in the last 224 weeks so the question becomes – ‘What exactly does MTBF tell us?’

For MTBF to be of any use it needs to be used in a more focused manner. Rather than measuring the MTBF of the pumps, what would measuring the MTBF of the failure modes have told us? We would have seen that there were in fact only two failure modes experienced and very quickly we would have seen that they had been addressed. But let’s assume that the organization wasn’t quite so proactive and hadn’t implemented the solutions – would it have been easier to wade through numerous work orders and then organizing and analysing them because you had a generic MTBF or would it have been better to look at MTBF for the failure modes to understand what was causing you the most pain? Of course this takes upfront work and correct set up of your CMMS.



METHOD 4

MEAN TIME TO REPAIR (MTTR)

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Mean Time To Repair (MTTR) is an indication of how quickly equipment is returned to service and is found by calculating Total Downtime Caused by Failures divided by The Number of Failures – it is considered the best measure of maintainability.

As my focus has always been to prevent failures, I believe that time and energy should only be spent on this measure when you are fairly certain that all approaches to prevent or mitigate the failures have been explored. It's a little like buying a new fire truck so that the fires can be put out more quickly, rather than hiring a fire prevention officer. I understand that if you have a fire at your home it's important to put the fire out as quickly as possible but I think everyone would agree that not having any fires at your home is preferable.

If you are in reactive mode then the tendency may be to concentrate on getting things back up and running as quickly as possible. There's nothing wrong with this but if it is done at the expense of getting to the root cause of why the failures occurred in the first place and developing solutions, then it is futile. You will just get better at doing the wrong thing and are more likely to stay in the downward spiral of despair.

MEAN TIME TO REPAIR (MTTR)

The concentration should be on identifying root causes and then finding ways of preventing or mitigating them. This will involve you in moving toward more planned preventive or predictive maintenance and it may be a good time to start measuring the percentage of time you are spending on each.

When you have moved out of the reactive mode you can start to take advantage of the measure of MTTR – at first, you will probably want the whole time spent on the work order. This will include waiting for spares or permits etc. As you analyse the times for the work orders you can identify if better spares management, kitting, planning, scheduling, or simply communication is required. When you feel that you have all of those influences under control you may want to focus on the actual tool time to try and reduce it. Again just looking at the numbers may tell you what is happening but seldom will it tell you why.

MEAN TIME TO REPAIR (MTTR)

Borrowing a Lean tool Single Minute Exchange of Dies (SMED) can help with reducing MTTR. It breaks down the work into distinct elements and the first review is: 'Does that actually need to be done during the repair?' Something like having to switch fittings or installing couplings could be done beforehand and so reduce the repair time. Having tools, rigging, spares, etc ready and on hand will be highlighted by SMED.

Comparing MTTR between shifts or craftsmen can often tell a story but beware! The shortest MTTR is not necessarily the best. I have seen situations where set-up has been missed through lack of training or shortcuts taken (again incorrect KPIs) and so using MTTR in conjunction with a rework or MTBF measure is preferable. Of all KPIs, MTTR has the greatest possibility of driving the wrong behaviour. Unless it is closely managed then quick fixes or incomplete repairs will start to crop up.

METHOD 5

BACKLOG LIST & WORKFLOW

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BACKLOG LIST & WORKFLOW

The backlog list can also be used to measure how effective your work flow is by simply establishing a goal for the time each work order priority level should take. For example, measuring from the time the work order is raised until the time the work order is closed and then comparing the actual performance with that standard.

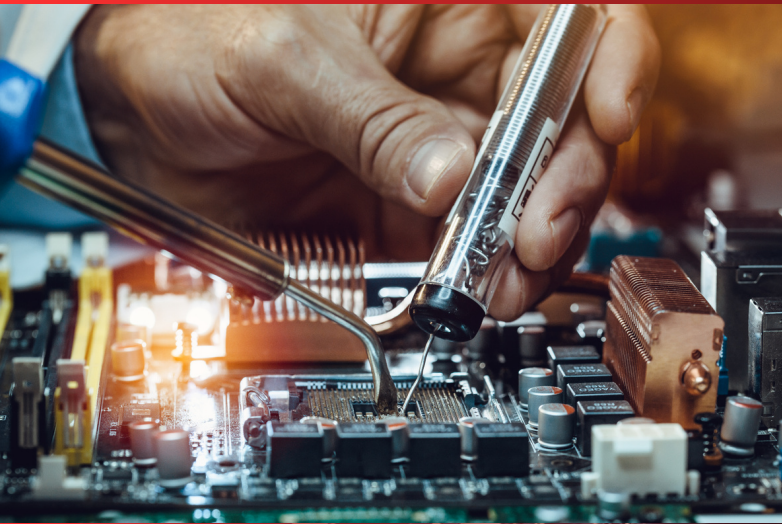
For the work orders that take considerably longer than the standard to be completed, the next step would be to investigate the reasons for delay. Again full use of the CMMS and delay codes will help provide the focus and identify the solution. It may be that stores don't have the correct level of stock and so there was a delay due to parts, there may be a work order that requires a special skill that is not always available.

The solution may be to increase stocking levels, to have an agreement for 'just in time' delivery, or to train people so that the skill is readily available. Keep in mind that the whole purpose of the measure is to allow effective management of workflow.

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METHOD 6

COST

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Cost is another measure of maintenance effectiveness and, as with failures, can be measured in different ways. The most relevant method in a business sense is the cost per unit produced or Maintenance Costs divided by Total Units Produced (tons, sq ft, cars, etc.). This is the most relevant measure because it is the one that measures the impact on the bottom line and so the profitability of the organization. If we were to simply measure maintenance spend as compared to budget what would that tell us?

It would tell us if we have spent what we said we would spend. But what if we haven't produced what we intended to produce? Even though we would meet our budget numbers, our cost per unit produced may be far higher than intended. So which is more important? Hopefully, by following the procedure for setting goals we will decide on the one that has the greatest impact on the organization's well-being – and it's seldom the meeting of absolute budget numbers.

COST

The challenge for maintenance managers is to identify any maintenance issues that affect output and address them. For those times when the reduction in output is outside of maintenance control, find ways of becoming more cost-effective. Here are some common cost-related measurements you might consider using:

➡ Cost per Unit Produced can obviously be influenced by many factors outside of maintenance, such as production schedules, changeovers, waste, etc. and so involving your partners from operations purchasing, production planning in clear communication will benefit all.

➡ Costs per Piece of Equipment is a good indicator to be benchmarked. If you are able to compare similar pieces of equipment within the plant or company, the ones that are the problem pieces will become apparent.

COST

➔ With a fully functioning computerized maintenance management system (CMMS) you will be able to monitor the Cost per Repeat Repair which will point toward the possibility of the need for Root Cause Analysis. It also will indicate that you are only dealing with the symptoms and not the problems.

➔ Perhaps one of the most pertinent cost measures is the Cost per Failure Code. This will identify the failures that you need to focus on. If you add hours per failure code and count per failure code it will give you a great picture of what is happening the most often, what has taken most of your department's time, and what is costing you the most. Each may require a different solution and seldom are the same failure codes at the top of each list.

➔ Overtime Cost is another common measure that is closely monitored, although the blind reduction of overtime can cause more problems than it solves. For example, at a paper mill, the average overtime cost in the maintenance department was 12%, which was considered acceptable, except for the truck repair area, where overtime was running in excess of 30%.

COST

As this department was staffed by two truck mechanics on the day shift who responded to calls on the off-shifts, the solution seemed simple: one mechanic was put on the afternoon shift, reducing the reliance on overtime by 50%. When, after three months, the overtime number came down to 15%, it was declared a success.

However, in the fourth month, the mill was shut down for 10 hours on two occasions because no trucks were available to load the conveyors. The average downtime at the mill was costed at \$150 per minute, totalling \$180,000 - three times the wages of a truck mechanic. It transpired that the jobs that normally took two men to do were left aside until there were so many trucks in need of repair that the mill had to be shut down.

METHOD 7

PM COMPLIANCE

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This measure merely tells you if you are doing what you said you would do on time. A rule of thumb is +/- 10% of frequency as being considered on time. It does nothing to measure the performance of the PM. There is quite often a suspicion that PMs are not carried out to the detail required, sometimes known uncharitably as 'pencil whipping'. It does nothing to address the effectiveness of the PM nor the applicability of the PM – it just says that the work was done when scheduled.

If you categorize the PMs by 'failure modes intended to be mitigated or prevented' and make sure that the choices align with your failure codes, you can start to measure the effectiveness of your PMs, far more relevant than just measuring whether they were done on time.

Conclusion

The decision as to what measures should be taken can only be made by those involved in the process. Each company has a culture and a strategy that will determine what is important to them and as long as they cascade through the organization they can be assured that they are measuring and focusing on the most relevant items. The only common theme throughout all industries is to not look at one measure in isolation. Remember that measures will inevitably drive behaviours, so when choosing your measures, be sure they will drive the behaviours you really want.

ABOUT THE AUTHOR



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Cliff has worked in the steel, pulp, and paper industries as well as for food giants Coca-Cola, Kraft, and Wrigleys. Cliff's focus has always been on developing the systems and people he has worked with – whatever the industry. His belief is that success is achieved through the synergies of the teams he has worked with.

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