Chapter 6.3 in
"Rules of Thumb for Maintenance and Reliability Engineers"
by Ricky Smith and Keith Mobley

KEY PERFORMANCE INDICATORS

Measuring and Managing the Maintenance Function

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Maintenance Key Performance Indicators

Introduction

"It is not possible to manage what you cannot control and you cannot control what you cannot measure!" (Peter Drucker)

Performance measurement is a fundamental principle of management. The measurement of performance is important because it identifies current performance gaps between current and desired performance and provides indication of progress towards closing the gaps. Carefully selected key performance indicators identify precisely where to take action to improve performance.

This paper deals with the identification of key performance indicators for the maintenance function, by first looking at the ways that maintenance performance metrics relate to manufacturing metrics. Since performance measurements for maintenance must include both results metrics and metrics for the process that produces the results, this document presents a representation for the business process for maintenance. The document then identifies typical business process and results metrics that can be used as key performance indicators for the maintenance function.

Physical Asset Management

The purpose of most equipment in manufacturing is to support the production of product destined to downstream customers. Ultimately the focus is on meeting customer needs. This is illustrated in *Figure 1*. Customer expectations are normally defined in terms of product quality, on-time delivery and competitive pricing. By reviewing the composite requirements of all current customers and potential customers in those markets we wish to penetrate, the performance requirements of our physical assets can be defined. Manufacturing performance requirements can be associated with quality, availability, customer service, operating costs, safety and environmental integrity.

To achieve this performance there are three inputs to be managed. The first requirement is ***Design Practices***. Design practices provide capable equipment "by design" (inherent capability), to meet the manufacturing performance requirements.

The second requirement is ***Operating Practices*** that make use of the inherent capability of process equipment. The documentation of standard operating practices assures the consistent and correct operation of equipment to maximize performance.

The third requirement is ***Maintenance Practices*** that maintain the inherent capability of the equipment. Deterioration begins to take place as soon as equipment is commissioned. In addition to normal wear and deterioration, other failures may also occur. This happens when equipment is pushed beyond the limitations of its design or operational errors occur. Degradation in equipment condition results in reduced equipment capability. Equipment downtime, quality problems or the potential for accidents and/or environmental excursions are the visible outcome. All of these can negatively impact operating cost.

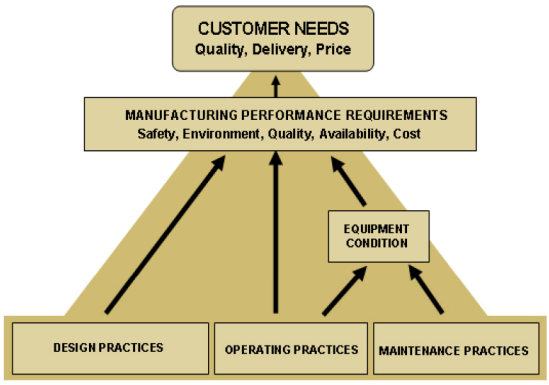

Figure 1: Managing manufacturing performance requirements to meet customer needs

Manufacturing key performance indicators provide information on the current state of manufacturing. Asset capability, operating practices and the maintenance of asset condition all contribute to the ability to meet these performance requirements.

Some typical key performance indicators for manufacturing include operating cost; asset availability, lost time injuries, number of environmental incidents, OEE and asset utilization.

Consider asset utilization, as depicted in *Figure 2*. Asset utilization is a manufacturing level key performance indicator. It is a function of many variables. For example, asset utilization is impacted by both maintenance and non-maintenance related downtime. Non-maintenance related downtime may be attributed to lack of demand, an interruption in raw material supply or production scheduling delays beyond the control of the maintenance function. Asset utilization is also a function of operating rate, quality and yield losses, etc. In each of these areas maintenance may be a factor but it is not the only contributor. In order to maintain and improve performance each function in the organization must focus on the portion of the indicators that they influence.

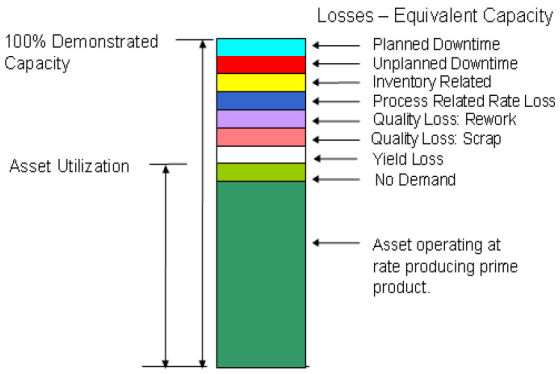

Figure 2: Asset Utilization is an example of a manufacturing level key performance indicator.

Similarly, other manufacturing level performance indicators are not only a function of maintenance. They are affected by causes beyond the control of the maintenance function. Asset capability, operating practices and the maintenance of asset condition all contribute to the ability to meet performance requirements. If a manufacturing level indicator is used to measure maintenance performance, improved maintenance may not result in a proportional improvement in the manufacturing metric. For instance, in the asset utilization example, cited above, the maintenance contributors may all be positive and yet the resulting asset utilization may not improve due to other causes.

A key principle of performance management is to measure what you can manage. In order to maintain and improve manufacturing performance each function in the organization must focus on the portion of the indicators that they influence. Maintenance performance contributes to manufacturing performance. The key performance indicators for maintenance are children of the manufacturing key performance indicators.

Key performance indicators for maintenance are selected ensuring a direct correlation between the maintenance activity and the key performance indicator measuring it. When defining a key performance indicator for maintenance a good test of the metric validity is to seek an affirmative response to the question; “If the maintenance function does ‘everything right’, will the suggested metric always reflect a result proportional to the change; or are there other factors, external to maintenance, that could mask the improvement?”

This paper focuses on defining key performance indicators for the maintenance function, not the maintenance organization. much larger business process responsible for managing the total enterprise.

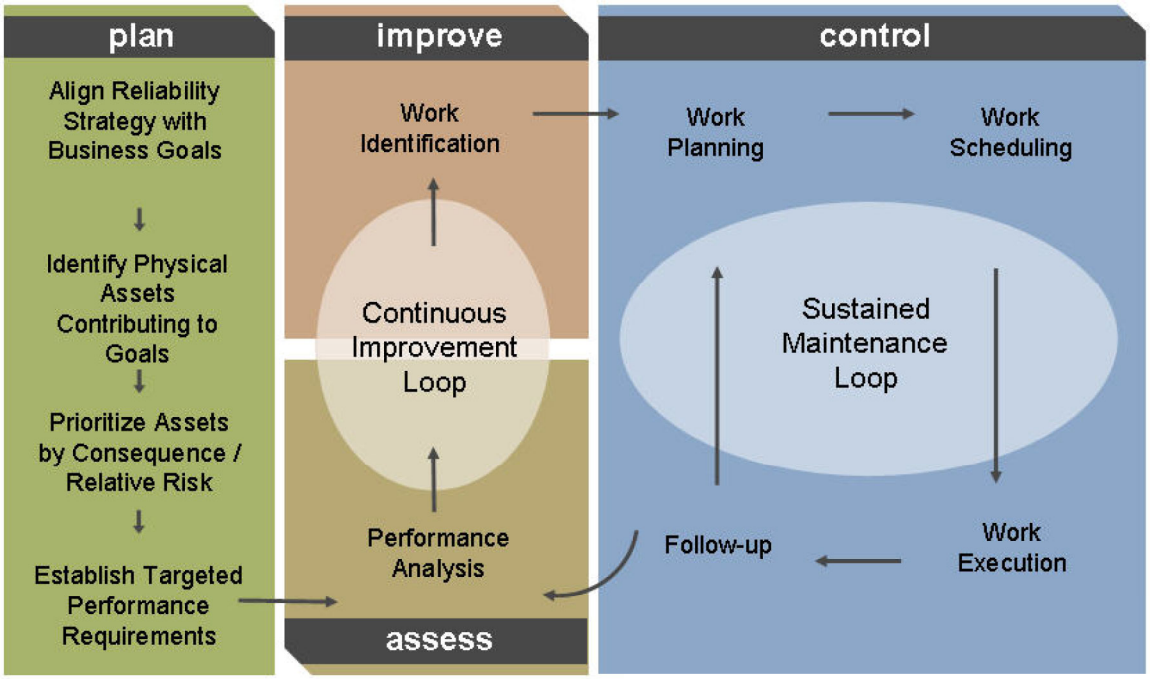

Figure 3: The Asset Reliability Process identifies what's required to manage the maintenance function.

The maintenance function can involve other departments beyond the maintenance organization. Similarly, the maintenance department has added responsibilities beyond the maintenance function and, as such, will have additional key performance indicators to report. The key performance indicators for the maintenance organization may include key performance indicators for other areas of accountability such as health and safety performance, employee performance management, training and development, etc.

The Asset Reliability Process

The management of physical asset performance is integral to business success. What we manage are the business processes required to produce results. One of these business processes is responsible for the maintenance of physical asset reliability. The Asset Reliability Process is shown in Figure 3. It is an integral part of a

A proactive Asset Reliability Process, represented by the seven (7) elements in the model aims to deliver the performance required by the enterprise to meet all of its corporate objectives. Each element within the maintenance process is in itself a sub-process. A brief description of each element follows:

Business Focus, represented by the green box on the left, focuses the maintenance of physical asset reliability on the business goals of the company. The potential contribution of the asset base to these goals is evaluated. The largest contributors are recognized as critical assets and specific performance targets identified.

Work Identification, as a process, produces technically based Asset Reliability Programs. Program activities identify and control failure modes impacting on the equipment's ability to perform the intended function at the required performance level.

Activities are evaluated to judge if they are worth doing based on the consequences of failure.

Planning develops procedures and work orders for these work activities. The procedures identify resource requirements, safety precautions and special work instructions required to execute the work.

Scheduling evaluates the availability of all resources required for work "due" in a specified time frame. Often this work requires the equipment to be shut down. A review of production schedules is required. Resources are attached to a specific work schedule. The use of resources is balanced out.

In the ***Execution*** process, trained, competent personnel carry out the required work.

The ***Follow-up*** process responds to information collected in the execution process. Work order completion comments outline what was done and what was found. Actual time and manpower, to complete the job, is documented. Job status is updated as complete or incomplete. Corrective work requests, resulting from the analysis of inspection data, are created. Requests are made for changes to drawings and procedures.

The process of ***Performance Analysis*** evaluates maintenance program effectiveness. Gaps between actual process performance and the required performance are identified. Historical maintenance data is compared to the current process performance. Maintenance activity costs are reviewed. Significant performance gaps are addressed by revisiting the Work Identification function.

Each element is important to provide an effective maintenance strategy. Omitting any element will result in poor equipment performance, increased maintenance costs or both.

For example, Work Identification systematically identifies the Right Work to be performed at the Right Time. Without proper Work Identification, maintenance resources may be wasted. Unnecessary or incorrect work will be planned. Once executed, this work may not achieve the desired performance results, despite significant maintenance costs. Without Planning the correct and efficient execution of the work is left to chance. The Planned Maintenance Process is a cycle. Maintenance work is targeted to achieve required asset performance. Its effectiveness is reviewed and improvement opportunities identified. This guarantees continuous improvement in process performance impacted by Maintenance.

Within the Planned Maintenance Process two internal loops exist. Planning, Scheduling, Execution and Follow Up make up the first loop. Once maintenance activities are initially identified, an asset maintenance program, based on current knowledge and requirements, is initiated. The selected maintenance activities will be enacted upon at the designed frequency and maintenance tolerance limits. The process is self-sustaining.

The second loop consists of the Work Identification and Performance Analysis elements. This is the continuous improvement loop. Actual asset performance is monitored relative to the required performance (driven by business needs). Performance gaps are identified. The ‘cause’ of these gaps is established and corrective action recommended.

Performance Metrics for the Maintenance Function

The Asset Reliability Process represents the collection of ‘all’ tasks required to support the maintenance function. The process is a supply chain. If a step in the process is skipped, or performed at a substandard level, the process creates defects known as failures. The output of a healthy reliability process is optimal asset reliability at optimal cost.

Asset Reliability Process measures are leading indicators. They monitor if the tasks are being performed that will ‘lead to

results'. For example a leading process indicator would monitor if the planning function was taking place. If people are doing all the right things then the results will follow. The leading 'process' indicators are more immediate than results measures.

Result measures monitor the products of the Asset Reliability Process. Result measures include maintenance cost (as a contributor to total operating cost), asset downtime due to planned and unplanned maintenance (as a contributor to availability) and number of failures on assets (the measure of reliability: this can then be translated into mean time between failures). Results measures lag. Failure is a good example. Typically the same piece of equipment doesn't fail day after day. Take a pump for example. Say the pump fails on average once every 8 months. If we improve its reliability by 50% it will now fail every 12 months. You have to wait at least 12 months to see the improvement.

Key performance indicators for the maintenance function need to include both leading (maintenance process) measures and lagging (result) measures. This paper focuses on identifying both leading and lagging measures of maintenance performance. Collectively, these measurements are the key performance indicators for the maintenance function.

Reliability Process Key Performance Indicators – Leading Measures

The maintenance process is made up of elements. All elements are required to complete the supply chain. Key performance indicators of the maintenance process are process assurance measures. They answer the question 'how do I know that this maintenance process element is being performed well?' The day-to-day execution of maintenance is addressed through the seven elements of the Reliability Process; Business Focus, Work Identification, Work Planning, Work Scheduling, Work Execution, Follow-up and Performance Analysis. Key performance indicators for each element are recommended.

It should be noted that variations of these metrics may be defined or additional performance metrics may be used. The metrics presented here provide a clear indication if the requirements of each element are being satisfied and, if not, what action should be taken to correct the lack of maintenance process adherence.

Work Identification

The function of work identification is to identify the 'right work at the right time.

1. Work Requests

Initiating a work request is one method of identifying work. Once a work request is submitted it must be reviewed, validated and approved before it becomes an actual work order ready to be planned. If the work request process is performing well, the validation and approval/rejection of work requests should occur promptly.

A suggested measure for the work request process is:

- The percentage of work requests remaining in "Request" status for less than 5 days, over a specified time period (for example the last 30 days). The world class maintenance expectation is that most work (>80%) requests would be reviewed and validated within a maximum of 5 days.

Work requests rely on the random identification of problems or potential problems and bringing them to the attention of maintenance to address them. In a world class organization, work identification is not left to chance.

2. Proactive Work

The 'Asset Maintenance Program' is designed to identify potential failure conditions, changes in state of hidden functions and known age related failure causes. The development of the Asset Maintenance Program defines the routine maintenance tasks that must be executed to achieve the performance levels required to meet business requirements. If the 'Asset

Maintenance Program' is effective, it will successfully identify and address most maintenance preventable causes of failure.

If the 'Work Identification' function is working well, the majority of work performed by maintenance would consist of executing the Asset Maintenance Program (AMP) tasks and the corrective work originating from it.

The key performance indicator for the work identification element is:

- The percentage of available man-hours used for proactive work (AMP + AMP initiated corrective work) over a specified time period. The world class maintenance target for proactive work is 75 to 80%. Recognizing that 5 -10% of available man-hours should be attributed to improvement work (non-maintenance) this would leave approximately 10% - 15% reactive work.

Work Planning

The primary function of the Work Planning element of the maintenance process is to prepare the work to achieve maximum efficiency in execution.

3. Amount of Planned Work

In general terms, planning defines how to do the job and identifies all the required resources and any special requirements to execute the work. A properly planned work order would include all this information. Maximizing maintenance efficiency requires a high percentage of planned work.

A measure of whether planning is taking place is:

- The percentage of all work orders, over a specified time period, with all the planning fields completed (ex. Labor assignments, task durations, work priority, required by date, etc). The world class expectation is that >95% of all jobs should be planned.

4. Responsiveness of Planning

Another key performance indicator for planning is the time it takes a work order to be planned. A suggested measure of this is:

- The percentage of work orders in 'planning status' for less than 5 days, over a specified time period. A world class performance level of at least 80% of all work orders processed in 5 days or less should be possible. Some work orders will require more time to plan but attention must be paid to 'late finish or required by date'.

5. Quality of Planning

These key performance indicators for planning do not reflect the quality of the planning being done. A critical aspect of planning is estimating resources. The quality of planning can be measured by monitoring the accuracy of estimating. Labor and material resources are the dominant resources specified on a work order.

The accuracy of estimating labor can be measured by:

- The percentage of work orders with man-hour estimates within 10% of actual over the specified time period. Estimating accuracy of greater than 90% would be the expected level of world class maintenance performance.

A second metric of planning quality, addressing material estimates, would be:

- The percentage of planned, scheduled and assigned work orders, where execution is delayed due to the need for materials (spare parts) over the specified time period. The world class maintenance expectation is that less than 2% of all work assigned will have a material deficiency (due to planning).*Note: this assumes the job should not have been scheduled if the materials were not available. Therefore, the problem is that the work order did not account for all the required materials.*

Work Scheduling

Good planning is a prerequisite to scheduling. The primary function of scheduling is to coordinate the availability of the asset(s) to be maintained with all the required resources; labor, material and services creating a schedule to execute 'the right work at the right time'. The schedule is a contract between operations and maintenance. The 'right work at the right time' implies that this work must be executed within the specified time period to achieve the desired level of performance. Failure to execute within the schedule period will increase the risk of failure.

With good work identification, planning and scheduling in place, the weekly maintenance schedule should be produced several days in advance of the beginning of the schedule period. There should be confidence that this schedule reflects the work that will be completed through the schedule period.

6. Quality of Scheduling

A key performance indicator for the scheduling function is:

- The percentage of work orders, over the specified time period, that have a scheduled date earlier or equal to the 'late finish or required by date'. A world class maintenance target of >95% should be expected in order to ensure the majority of the work orders are completed before their 'late finish or required-by date.'

A second measure of the quality of scheduling is:

- The percentage of work orders assigned "Delay" status due to unavailability of manpower, equipment, space or services over the specified time period.

Volume of Scheduled Work

The scheduling of properly planned work is also important to maximize maintenance efficiency. We would anticipate that a high percentage of the available maintenance man-hours would be committed to a schedule. A second scheduling key performance indicator measures:

- The percentage of scheduled available man-hours to total available man-hours over the specified time period. A world class target of >80% of man-hours should be applied to scheduled work.

It is not desirable to schedule 100% of available man-hours within a schedule period, because we recognize that additional work will arise after the schedule has been cast. This includes both emergency work and other schedule write-ins that must be accommodated during the schedule period.

Work Execution

Work execution begins with the assignment of work to the people responsible for executing it and ends when the individuals charged with responsibility for execution provide feedback on the completed work.

7. Schedule Compliance

With a high quality of work identification, planning and scheduling, maintenance resources should execute according to the plan and schedule. Therefore, a key performance indicator of execution is schedule compliance. Schedule compliance is defined as:

- The percentage of work orders completed during the schedule period before the late finish or required by date. World class maintenance should achieve >90% schedule compliance during execution.

8. Quality of Work Execution

Work execution quality is measured by:

- The percentage of rework. World class levels of maintenance rework are less than 3%.

9. Work Order Completion

The purpose of identifying maintenance process key performance indicators is to help manage the maintenance process. The

ability to successfully monitor and manage the process and measure the results of the process is highly dependent on gathering correct information during work execution. The vehicle for collecting this information is the work order. Work orders should account for 'all' work performed on assets. This is necessary to gather accurate maintenance cost and history data, enabling the management of the physical asset through its life cycle.

A returned work order should indicate the status of the job (complete, incomplete), the actual labor and material consumed, an indication of what was done and/or what was found and recommendations for additional work. In addition, information about process and equipment downtime and an indication of whether the maintenance conducted was in response to a failure should be provided.

The idea that the job is not done until the work order is completed and returned is a significant challenge to many organizations. For this reason it is also important to have a key performance indicator on work order completion. This metric should look at:

- The percentage of work orders turned in with all the data fields completed. World class maintenance organizations achieve 95% compliance.

Follow-up

In the Follow-up element of the maintenance process, actions are initiated to address the information identified during execution. Some key follow-up tasks include reviewing work order comments and closing out completed work orders, initiating corrective work and initiating part and procedural updates as required.

10. Work Order Closure

Timely follow-up and closure of completed work orders is essential to maintenance success. A key performance indicator for follow-up is:

- The percentage of work orders closed within a maximum of 3 days, over the specified time period. The expectation is that >95% of all completed work orders should be reviewed and closed within 3 days.

Performance Analysis

The performance analysis element of the maintenance process evaluates maintenance effectiveness by focusing on key performance indicators of maintenance results. Gaps between the actual and required performance of the maintained asset are identified. Significant performance gaps are addressed by initiating work identification improvement actions to close the performance gap.

11. Presence of Performance Analysis

One indication that performance analysis is being executed is the existence of the maintenance result metrics described under the next section of this paper entitled key performance indicators of maintenance effectiveness (result measures).

12. Quality of Performance Analysis

From a maintenance process perspective it is important that these results are driving action. Therefore, a key performance indicator for performance analysis is a measure of:

- The number of reliability improvement actions initiated through performance analysis during the specified period. No absolute number is correct but no number suggests inaction.
- A second measure is the number of asset reliability actions resolved over the last month. In other words, a measure of how successful the organization is in performance gap closure.

Key Performance Indicators of Maintenance Effectiveness (Result Measures)

The product of maintenance is reliability. A reliable asset is an asset that functions at the level of performance that satisfies the needs of the user. Reliability is assessed by measuring failure.

Failures

The primary function of maintenance is to reduce or eliminate the consequences of physical asset failures. The definition of functional failure is anytime that asset performance falls below its required performance. Therefore a key performance indicator for maintenance effectiveness is some measurement of failure on the asset(s). If the maintenance function is effective, failures on critical assets and thus their consequences should be reduced or eliminated.

Failure consequence impacts manufacturing level key performance indicators. Failure classification by consequence identifies the contribution of maintenance function to manufacturing level performance.

Failure consequences are classified into the following categories:

1. Hidden Consequence – there is no direct consequence of a single point failure other than exposure to the increased risk of a multiple failure (a second failure has to occur to experience a consequence).
2. Safety Consequence – a single point failure results in a loss of function or other damage which could injure or kill someone.
3. Environmental Consequence –a single point failure results in a loss of function or other damage which breaches any known environmental standard or regulation;
4. Operational Consequence – a single point failure has a direct adverse effect on operational capability (output, product quality, customer service or operating costs in addition to the direct cost of repair).
5. Non-Operational Consequence – a single point failure involving only the cost of repair.

Therefore, it is important to track:

- The number and frequency of asset failures by area of consequence. *There is no universal standard for this metric because of the diversity of industries and even plants within industry segments. It is however reasonable to expect a downward trend and to set reduction targets based on current performance levels and business needs.*

Maintenance Costs

Maintenance costs are another direct measure of maintenance performance. Maintenance costs are impacted by both maintenance effectiveness and the efficiency with which maintenance is performed.
Maintenance maximizes its effectiveness by ensuring that it performs “The Right Work at the Right Time”. Proactive maintenance means intervening before the failure event occurs. The impact of proactive maintenance is not only to minimize the safety, environmental and operational consequences of failure but also to reduce the cost of maintenance by reducing secondary damage. For example, if the potential failure of a pump bearing was detected proactively, the catastrophic failure of the bearing could be prevented. The catastrophic failure of the pump bearing would likely result in damage to the casing, wear rings, impeller, mechanical seals, etc. The corrective repair would require an extensive pump rebuild. Utilizing a proactive task such as vibration monitoring to detect the bearing deterioration permits the scheduled replacement of the bearing prior to the occurrence of secondary damage. Less secondary damage means that it takes less time to repair (labor savings) and consumes fewer parts (material savings). The overall effect is the repair costs much less.

Maintenance costs are also impacted by increasing the efficiency of maintenance. These efficiency gains are achieved through improved planning and scheduling of "the right work at the right time". Published data suggests that companies with estimated wrench times of 25% to 30% can increase wrench time to between 40% and 60% through better planning and scheduling.

There are several useful maintenance cost related measures:

- Maintenance Cost: The target maintenance cost depends on the asset and its operating context (how the asset is applied and used).
- Maintenance Cost / Unit Output: The target maintenance cost depends on the asset and its operating context (how the asset is applied and used).
- Maintenance Cost / Replacement Asset Value of Plant and Equipment: This metric is a useful benchmark at a plant and corporate level. The world class benchmark is between 2% and 3%.
- Total Maintenance Cost / Total Manufacturing Cost: This metric is a useful benchmark at a plant and corporate level. The world class benchmark is <10% to 15%.
- Total Maintenance Cost /Total Sales: This metric is a useful benchmark at a plant and corporate level. The world class benchmark is between 6% and 8%.

Maintenance Related Downtime

The maintenance function's impact on asset availability is through minimizing downtime attributed to maintenance. This includes both scheduled and unscheduled maintenance related downtime. A key objective of proactive maintenance is to identify potential failures with sufficient lead-time to plan and schedule the corrective work before actual failure occurs. If the maintenance function is successful unscheduled maintenance related downtime will be reduced.

It is equally important to measure scheduled downtime. The work identification element of the maintenance process strives to eliminate unnecessary scheduled maintenance by focusing on only performing the 'right work at right time'.

Through more formal work identification and enhanced planning and scheduling shutdown overruns should be minimized.

Useful key performance indicators associated with asset downtime attributable to maintenance are:

- Unscheduled downtime (hours)
- Scheduled downtime (hours)
- Shutdown overrun (hours)

Note: It is useful to distinguish between 'equipment down' where a specific piece of equipment is unavailable and 'process down' where production has stopped.

The Importance of the Work Order

Implementation of the suggested key performance indicators for the maintenance function requires a reliable source of data on asset failures, maintenance costs and downtime. Any time maintenance is performed on an asset a record should be kept. The vehicle for collecting this data is the maintenance work order.

Whenever maintenance is performed against an asset, work order completion data should include the following information:

- Identification of the asset at the level in the asset hierarchy where the work was performed.
- Date, time and duration of the maintenance event.
- An indication if failure has occurred: yes or no (no if proactive)
- When failure has occurred, identification of the failure consequence: {hidden, safety, environment, operational (product quality, throughput, customer service, operating costs) or non-operational involving only the cost of repair only}

- actual costs (labor, materials, services, etc)
- process downtime (loss of production)
- asset downtime (equipment out of service but process still able to produce)

Queries in your computerized maintenance management system can then be developed to track and report key performance indicators for asset failure, maintenance costs and downtime.

Reporting and Use of Key Performance Indicators

Key performance indicators should be aligned with defined roles and responsibilities for the maintenance function against the assets for which they apply. For example, a planner responsible for 'Area A' would be responsible for the planning function key performance indicators for the 'Area A' assets.

The manager responsible for 'Area A' assets would monitor all process and result metrics for Area A. Each metric should roll up the asset hierarchy, in alignment with individual responsibility for the assets. Management action is directed at improving compliance with the requirements of Work Identification, Planning, Scheduling, Execution and Follow-up. In this way, the process is managed leading to world class results. This logic is repeated at each level of management in the organization. At the plant and/or corporate level, management is exercising accountability for plant-wide maintenance metrics, both process and results.

Conclusion

Maintenance and reliability business process metrics (leading indicators) provide a clear indication of compliance to the maintenance business process. They indicate where to take specific action because of a gap in the way maintenance is being performed.

This gap in the execution of the maintenance process will 'eventually' lead to asset failure(s). The consequence of these failures translates into poor manufacturing performance.

Therefore, maintenance, reliability, engineering and operations need to work together to define and measure the leading indicators for the Asset Reliability Process (the seven elements required to support the maintenance function). The result will be optimal asset reliability at optimal cost – the output of a healthy Asset Reliability Process.

Appendix 1: Summary of Maintenance Key Performance Indicators

	Type of Measure	Measuring	Key Performance Indicator	World Class Target Level
1	Result Lagging	Cost	Maintenance Cost	Context specific
2	Result Lagging	Cost	Maintenance Cost / Replacement Asset Value of Plant and Equipment	2 - 3%
3	Result Lagging	Cost	Maintenance Cost / Manufacturing Cost	< 10 – 15%
4	Result Lagging	Cost	Maintenance Cost / Unit Output	Context specific
5	Result Lagging	Cost	Maintenance Cost / Total Sales	6 - 8%
6	Result Lagging	Failures	Mean Time Between Failure (MTBF)	Context specific
7	Result Lagging	Failures	Failure Frequency	Context specific
8	Result Lagging	Downtime	Unscheduled Maintenance Related Downtime (hours)	Context specific
9	Result Lagging	Downtime	Scheduled Maintenance Related Downtime (hours)	Context specific
10	Result Lagging	Downtime	Maintenance Related Shutdown Overrun (hours)	Context specific
11	Process Leading	Work Identification	Percentage of work requests remaining in “Request” status for less than 5 days, over the specified time period.	80% of all work requests should be processed in 5 days or less. Some work requests will require more time to review but attention must be paid to 'late finish date' or required by date.
12	Process Leading	Work Identification	Percentage of available man-hours used for proactive work (AMP + AMP initiated corrective work) over a specified time period.	Target for proactive work is 75 to 80%. Recognizing 5 -10% of available man-hours attributed to redesign or modification (improvement work) this would leave approximately 10% - 15% reactive.
13	Process Leading	Work Identification	Percentage of available man-hours used on modifications over the specified time period.	Expect a level of 5 to 10% of man-hours spent on modification work.
14	Process Leading	Work Planning	Percentage of work orders with man-hour estimates within 10% of actual over the specified time period.	Estimating accuracy of greater than 90% would be the expected level of performance.
15	Process Leading	Work Planning	Percentage of work orders, over the specified time period, with all planning fields completed.	95% + should be expected. Expect a high level of compliance for these fields to enable the scheduling function to work.
16	Process, Leading	Work Planning	Percentage of Work Orders assigned “Rework” status (Due to a need for additional Planning) over the last month.	This level should not exceed 2 to 3%.
17	Process, Leading	Work Planning	Percentage of Work Orders in “New” or “Planning” status less than 5 days, over the last month.	80% of all work orders should be possible to process in 5 days or less. Some work orders will require more time to plan but attention must be paid to 'late finish date'.
18	Process, Leading	Work Scheduling	Percentage of work orders, over the specified time period, having a scheduled date earlier or equal to the late finish or required by date.	95%+ should be expected in order to ensure the majority of the work orders are completed before their 'late finish date.'
19	Process, Leading	Work Scheduling	Percentage of scheduled available man-hours to total available man-hours over the specified time period.	Target 80% of man-hours applied to scheduled work.
20	Process, Leading	Work Scheduling	Percentage of Work Orders assigned “Delay” status due to unavailability of manpower, equipment, space or services over the specified time period.	This number should not exceed 3 to 5%.

	Type of Measure	Measuring	Key Performance Indicator	World Class Target Level
21	Process, Leading	Work Execution	Percentage of Work Orders completed during the schedule period before the late finish or required by date.	Schedule compliance of 90%+ should be achieved.
22	Process, Leading	Work Execution	Percentage of maintenance work orders requiring rework.	Rework should be less than 3%.
23	Process, Leading	Work Execution	Percentage of work orders with all data fields completed over the specified time period.	Should achieve 95%+. Expectation is that work orders are completed properly.
24	Process, Leading	Work Follow-up	Percentage of work orders closed within 3 days, over the specified time period.	Should achieve 95%+. Expectation is that work orders are reviewed and closed promptly.
25	Process, Leading	Performance Analysis	Number of asset reliability improvement actions initiated by the performance analysis function, over the specified time period.	No number is correct but level of relative activity is important. No actions being initiated when lots of performance gaps exist is inappropriate.
26	Process, Leading	Performance Analysis	Number of equipment reliability improvement actions resolved, over the specified time period. (Did we achieve performance gap closure)	This is a measure of project success.

Appendix 2: Example of How Maintenance KPI's Are Used