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ESTABLISHING MAINTENANCE PERFORMANCE INDICATORS

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Establishing Maintenance Performance Indicators

Introduction

Maintenance Performance Indicators (PI) specify where the maintenance department is and which direction it is going allowing for a quick and accurate assessment of the performance of the Maintenance Management Program (MMP). Establishing PI's for the maintenance department will allow a measure of productivity and a means of feedback for methods improvement. Effective performance of the maintenance department directly effects plant profitability. Improvements in the quality and productivity of the maintenance work force will significantly reduce maintenance costs. The level of performance attained by the maintenance work force is usually guessed at. Guessing will not identify areas needing improvement or help to initiate a corrective action. Maintenance PI's are required for maintenance departments whose goal is to control maintenance costs while increasing productivity. The application of basic statistical methods will allow a maintenance department to know where they are and which direction they are going.

The data presented in this paper is a representation of indicators used in industry as well as developed indicators to establish a complete maintenance performance indicator program. The methodology used in developing this program can be used as a way to manage a cost effective maintenance management program.

Budget Performance Indicators

Budget Performance Indicators specify where maintenance dollars should be spent within the Maintenance Management Program. These indicators quantify that maintenance dollars are being spent on maintenance that gives you the most "bang for your buck." They should be tracked and analyzed **annually** by the **Maintenance Manager** so that adjustments can be made the following budget year. The maintenance organization should have a budget of 8% of the total site operating budget to assure that enough funds are available to properly staff and maintain the facilities. The Maintenance costs within each MMP PI element are made up of 50% labor, 40% parts/materials and 10% for overhead.

1. Equipment Maintenance $= \frac{\text{Cumulative Equipment Maintenance Cost}}{\text{Total Equipment Investment}} * 100$

Optimal = 9 % Replacement Ratio

The Cumulative Equipment Maintenance Cost (EM) consists of Preventive Maintenance (PM), Corrective Maintenance (CM), Predictive Maintenance (PDM) and Emergency Maintenance (EMM) consisting of labor, parts/material and overhead. This PI analyzes the total maintenance cost expended on a piece of equipment compared to its original investment cost. The objective is to minimize the amount of maintenance spent maintaining the equipment by performing maintenance that is the most effective. The EM PI should not exceed 9 % to ensure that an excessive amount of maintenance is not being spent maintaining the equipment compared to the original equipment investment cost. The optimal time to replace equipment is when the EM PI equals 9 %.

2. Preventive Maintenance $= \frac{\text{PM Program Annual Cost}}{\text{Annual Maintenance Budget}} * 100$

Optimal = 56 %

PM utilizes scheduled routine inspections and service adjustments to keep equipment running to manufacturers specifications and to prolong its useful life. Increasing PM decreases equipment CM repairs. The maintenance organization should be funding 56 % of the maintenance budget to the PM program to assure that equipment is being maintained on a pro-active basis. The objective is to minimize the amount of maintenance dollars spent maintaining equipment by performing the maintenance that is the most cost effective.

3. **Predictive Maintenance** $= \frac{\text{PDM Program Annual Cost}}{\text{Annual Maintenance Budget}} * 100$

Optimal = 9 % Critical Equipment Only

PDM compiles and analyzes equipment condition data to warn of impending failure by identifying defective parts. Increasing PDM increases equipment maintenance costs but does not directly decrease CM repairs. Performing PDM directly reduces EMM repair. The maintenance organization should be funding no more than 9 % of the maintenance budget to the PDM program to predict failure of critical equipment. The objective is to minimize critical equipment failures and schedule repairs at predetermined times.

4. **Corrective Maintenance** $= \frac{\text{CM Program Annual Cost}}{\text{Annual Maintenance Budget}} * 100$

Optimal = 33 %

CM repairs equipment on a planned and scheduled basis. Equipment failure is the most costly scheduled maintenance performed. CM repairs decrease with increased PM. The maintenance organization should be funding no more than 33 % of the maintenance budget to the CM program. The objective is to minimize the amount of scheduled equipment repairs.

5. **Emergency Maintenance** $= \frac{\text{EMM Annual Cost}}{\text{Annual Maintenance Budget}} * 100$

Optimal = 2 %

EMM repairs equipment immediately after failure because of its criticality. EMM is the most costly maintenance performed. EMM decreases with effective PM. Effective PDM eliminates EMM repairs. The maintenance program should be funding no more than 2 % of the maintenance budget to EMM repair. The objective is to minimize equipment failure.

6. **Contract Maintenance** $= \frac{\text{COM Annual Cost}}{\text{Annual Maintenance Budget}} * 100$

Optimal = 2 %

Contract maintenance (COM) is utilized when it is more cost effective for a contractor to perform maintenance because the maintenance is too specialized for in-house craftsmen to accomplish. An objective of a MMP is to centralize all maintenance activities performed on site into one line organization to allow for proper control of the maintenance being performed. Without control over what, when and how maintenance is performed only assures that maintenance is not accomplished on time and at the least possible cost. The maintenance program should be funding no more than 2% of the maintenance budget to COM support. The objective is to maximize the amount of maintenance performed in-house to assure proper control over the maintenance activities being performed.

Full Time Equivalent Performance Indicators

A Full Time Equivalent (FTE) represents one employee for one year. FTE PI's are required to specify which maintenance elements are utilizing maintenance employees. The objective is to staff each MMP element with the correct number of FTE's to allow for the maintenance mission to be accomplished. These PI's should be tracked and analyzed **annually** by the **Company President** and **Maintenance Manager** so that adjustments can be made the following year.

1. **Maintenance FTE** = $\frac{\text{Total Maintenance FTE's}}{\text{Total Plant FTE's}} * 100$

Optimal = 18 %

The Maintenance FTE PI specifies whether enough maintenance employees are available to adequately maintain all equipment and facilities. The plant management should be allotting 18% of the total plant FTE's to the maintenance department to assure that enough maintenance personnel are dedicated to effectively maintain the plant.

2. **Preventive Maintenance** = $\frac{\text{FTE's Dedicated To PM}}{\text{Total Maintenance FTE's}} * 100$

Optimal = 62 %

The Preventive Maintenance FTE PI is used to establish the number of FTE's required to effectively run the PM program. The maintenance organization should be allotting 62% of the maintenance work force to the PM program to assure that equipment is being maintained on a pro-active basis. The objective is to staff enough FTE's into the maintenance element that is most effective.

3. **Predictive Maintenance** = $\frac{\text{FTE's Dedicated To PDM}}{\text{Total Maintenance FTE's}} * 100$

Optimal = 10 %

The Predictive Maintenance FTE PI is used to establish the number of FTE's required to effectively run the PDM program. The maintenance organization should be allotting 10% of the maintenance work force to the PDM program to predict critical equipment failure. The objective is to staff enough FTE's to effectively analyze critical equipment operations and to predict component failures.

4. **Corrective Maintenance** = $\frac{\text{FTE's Dedicated To CM}}{\text{Total Maintenance FTE's}} * 100$

Optimal = 36 %
Optimal = 8 % Overtime
Optimal = 2 % Specialized Contract Maintenance

The Corrective Maintenance FTE PI is used to establish the number of FTE's required to effectively maintain all planned equipment repairs. The maintenance organization should be allotting 36% of the maintenance work force to perform planned equipment repairs. Additionally, 8% overtime should be allotted for CM repairs and 2% for specialized contract maintenance repairs. All EMM repair should be performed by in-house CM craftsmen and should not exceed 3% of the total maintenance FTE's. The objective is to staff enough FTE's to effectively handle repairs and to manage the CM backlog at an acceptable level.

Time Allocation Performance Indicators

Time Allocation PI's specify where the maintenance department is spending its time within the MMP. These indicators quantify that the maintenance organization is spending its time performing the maintenance that is the most effective and has the highest criticality. Each PI should be tracked for identified critical and non-critical equipment. These PI's should be analyzed **monthly** by the **Maintenance Manager** so that adjustments can be made the following month.

1. Total Hours PM = $\frac{\text{Total Monthly Hours PM}}{\text{Total Monthly Hours Available}} * 100$

Optimal = 57 %

2. Total Hours PDM = $\frac{\text{Total Monthly Hours PDM}}{\text{Total Monthly Hours Available}} * 100$

Optimal = 10 %

3. Total Hours CM = $\frac{\text{Total Monthly Hours CM}}{\text{Total Monthly Hours Available}} * 100$

Optimal = 31 %

4. Total Hours EMM = $\frac{\text{Total Monthly Hours EMM}}{\text{Total Monthly Hours Available}} * 100$

Optimal = 2 %

5. Total Hours COM = $\frac{\text{Total Monthly Hours COM}}{\text{Total Monthly Hours Available}} * 100$

Optimal = 2 %

6. Overtime Hours = $\frac{\text{Total Monthly Hours OT}}{\text{Total Monthly Hours Available}} * 100$

Optimal = 8 %

Work Order Performance Indicators

Work Order PI's analyze the maintenance work received compared to the maintenance work completed. These PI's quantify the turnaround time (in days) of maintenance jobs. Each PI should be tracked for identified critical and non-critical equipment. They should be analyzed **monthly** by the **Maintenance Manager, Department Supervisor** and **Department Planner** so that adjustments can be made the following month.

1. Number of PM WO's > 30 Days Old

Optimal = 0

2. Number of PDM WO's > 30 Days Old

Optimal = 0

3. Number of CM WO's > 30 Days Old (Critical Equipment)

Optimal = 0

4. **Number of CM WO's (Non-Critical Equipment):**

> **> 30 Days Old : Optimal = 40 %**
> **> 60 Days Old : Optimal = 30 %**
> **> 90 Days Old : Optimal = 20 %**
> **> 120 Days Old : Optimal = 10 %**
> **> 150 Days Old : Optimal = 0 %**

5. **Number of Rework Maintenance Jobs** $= \frac{\text{\# of Rework Jobs}}{\text{Total \# of Maintenance Jobs}} * 100$

Optimal = 0 %

Schedule Compliance

6. **PM Ratio** $= \frac{\text{\# PM WO's Completed Per Month}}{\text{\# of PM WO's Scheduled Per Month}} * 100$

Optimal = 100 %

7. **PDM Ratio** $= \frac{\text{\# PDM WO's Completed Per Month}}{\text{\# of PDM WO's Scheduled Per Month}} * 100$

Optimal = 100 %

8. **CM Ratio** $= \frac{\text{\# CM WO's Completed Per Month}}{\text{\# of CM WO's Scheduled Per Month}} * 100$

Optimal = 100 % Critical Equipment
Optimal = 60 % Non-Critical Equipment

Support Level Performance Indicators

Support Level PI's specify the level of support that each maintenance job category is providing to the MMP. The objective is to staff each job category with the correct number of FTE's that allows for adequate support of the MMP. These PI's should be tracked and analyzed **annually** by the **Maintenance Manager** so that adjustments can be made the following year.

1. **Supervisor Support Level** $= \frac{\text{First Line Supervisors}}{\text{Total Craft Population}} * 100$

Optimal = 8 % : 1 Supervisor To 12 Craftsmen

The Supervisor Support Level PI is used to establish the optimal number of craftsmen to assign to a single supervisor. The supervisor is responsible for providing technical oversight and administration for the craftsmen. The supervisor should be dedicating 80% of their time to field support of the craftsmen. The objective is to staff the supervisor with enough craftsmen to allow for adequate technical oversight and supervision.

2. **Planner Support Level** = $\frac{\text{Total Planner Population}}{\text{Total Craft Population}} * 100$

Optimal = 7 % : 1 Planner To 15 Craftsmen

The Planner Support Level PI is used to establish the optimal number of craftsmen to assign to a single planner. The planner is responsible for identifying and organizing the essential requirements of maintenance jobs so that they can be performed in the most efficient manner. The objective is to staff enough planners with the appropriate background to plan maintenance jobs that allow the craftsmen to perform their job more efficiently.

3. **Inventory Support Level** = $\frac{\text{Warehouse and Purchasing Population}}{\text{Total Craft Population}} * 100$

Optimal = 10 % : 1 Warehousemen To 10 Craftsmen

The Inventory Support Level PI is used to establish the optimal number of warehouse personnel required to effectively manage maintenance equipment, parts and materials. The maintenance warehouse is responsible for identifying, organizing, stocking, staging and delivering maintenance equipment and materials. The objective is to staff the warehouse function with the appropriate number of FTE's to allow for an optimal operation.

4. **Scheduling Support Level** = $\frac{\text{Total Scheduler Population}}{\text{Total Craft Population}} * 100$

Optimal = 2 % : 1 Scheduler To 55 Craftsmen

The Scheduler Support Level PI is used to establish the optimal number of craftsmen to assign to a single scheduler. The scheduler is responsible for coordinating the essential requirements of maintenance jobs so that they can be performed in the most efficient manner. The objective is to staff enough schedulers with the appropriate background to coordinate maintenance jobs that allow the craftsmen to perform their job more efficiently.

5. **Engineering Support Level** = $\frac{\text{Maintenance Engineering Population}}{\text{Total Craft Population}} * 100$

Optimal = 5 % : 1 Maintenance Engineer To 20 Craftsmen

The Engineering Support Level PI is used to establish the number of Maintenance Engineers required to effectively provide technical support to the maintenance organization. The Maintenance Engineers are responsible for providing technical oversight and root cause analysis of equipment failure. The Maintenance Engineers should consist of Industrial, Civil, Mechanical and Electrical Engineers. The objective is to staff enough engineers to provide technical assistance to maintenance related equipment failures and to perform facility condition assessments.

Productivity Performance Indicators

Productivity PI's quantify how well the MMP is managing maintenance activities. Maintenance can be quantified by measuring the work performed and is necessary to achieve high labor productivity. These indicators are used to quantify the overall effectiveness of the maintenance program and are derived from the use of Engineered Performance Time Standards. These PI's should be tracked and analyzed **weekly** by the **Maintenance Manager, Department Supervisor** and **Department Planner** so that adjustments can be made the following week.

1. **Performance** = $\frac{\text{Standard Time}}{\text{Time Charged - Delays}} * 100$

Optimal = 100 %

Performance is the measure of speed with which the craftsmen works.

2. **Utilization** = $\frac{\text{Time Charged - Delays}}{\text{Time Charged}} * 100$

Optimal = 90 %

Utilization is the measure of how much of the available time is spent working.

3. **Effectiveness = Performance x Utilization**

Optimal = 90 %

Effectiveness is the measure of how well the MMP manages the maintenance activities.

4. **Productivity = Performance x Utilization x Effectiveness**

Optimal = 80 %

Productivity is the measure of how well the MMP is structured to assist the craft work force in performing maintenance in the most efficient way possible with the minimum amount of delays. Productivity will be high when the maintenance work is well organized, craftsmen are properly directed, attitudes and motivation is good, appropriate tools and equipment are available and the work is measured and controlled.

Backlog Performance Indicators

Backlog PI's quantify how well the MMP is managing the maintenance work activities. The maintenance backlog is defined to be any deferred and outstanding maintenance activity associated with preventing or repairing a facility, system, or equipment and begins as soon as a work order has been initiated and continues until all actions have been completed. The backlog should be divided into a planned and unplanned backlog. The planned backlog consists of all work that is planned by a Planner (Priorities have been established, Standard times assigned, materials ordered and received, and equipment and tools assembled). The unplanned backlog consists of all maintenance work waiting to be planned. Separating the planned from unplanned backlog enables an optimal CM backlog to be established. The optimal CM backlog is 6 weeks of planned work. This means that 6 weeks of planned CM work has been established so that the CM work force has enough work for 8 hours a day for 6 weeks. By establishing this "pool" of planned work will allow proper scheduling of maintenance activities based on priorities and is required to effectively run a MMP. These PI's should be tracked and analyzed **monthly** by the **Maintenance Manager, Department Supervisor** and **Department Planner** so that adjustments can be made the following month.

1. **Backlog in Hours of PM**

Optimal = 0

2. **Backlog in Hours of PDM**

Optimal = 0

3. **Backlog in Hours of Planned CM of Critical Equipment**

Optimal = 1 Week of Craft Size Availability

4. **Backlog in Hours of Planned CM of Non-Critical Equipment**

$$\text{Backlog} = \frac{\text{CM Backlog in Hours of Non-Critical Equipment}}{\text{(\# of CM Craftsmen) x Performance x 240}} * 100$$

Optimal = 100 %

Common Performance Indicators

Common PI's are used to effectively manage the MMP. They should be tracked and analyzed **weekly** so that adjustments can be made the following week.

1. **Scheduled Work** $= \frac{\text{Hours Scheduled}}{\text{Total Hours Worked}} * 100$

Optimal = 98 %

The Schedule Work PI is used to establish the amount of maintenance work that is covered by a formal schedule. Scheduling is the process of deciding when the maintenance jobs should be worked. Scheduling helps to ensure high productivity by providing a method for assigning each craftsmen 8 hours of planned work per day. The scheduling systems objective is to coordinate all maintenance activities based on manpower availability, materials and priorities. This PI should be analyzed **weekly** by the **Maintenance Manager, Department Supervisor** and **Department Planner.**

2. **Planned Work** $= \frac{\text{Hours Planned}}{\text{Total Hours Worked}} * 100$

Optimal = 95 %

The Planned Work PI is used to establish the amount of maintenance work that is covered by a formal job plan. Maintenance Planning is used to identify the work required, craft type, materials, tools and engineered time standard needed to accomplish the job. Planning is the most important element of maintenance management and significantly contributes to better productivity. The objective of planning is to plan most maintenance work with the exception of emergencies. This PI should be analyzed **weekly** by the **Maintenance Manager, Department Supervisor** and **Department Planner.**

3. **Delays** $= \frac{\text{Hours of Delays}}{\text{Total Hours Worked}} * 100$

Optimal = 1 %

The Delay PI is used to establish the amount of time the craft work force spends waiting. Delays are typically a result of poor planning and scheduling coordination. The objective is to minimize the delays down to an acceptable level. This PI should be analyzed **weekly** by the **Maintenance Manager, Department Supervisor** and **Department Planner.**

4. **Downtime Ratio** $= \frac{\text{Unplanned Downtime}}{\text{Scheduled Downtime}} * 100$

Optimal = 2 %

The Downtime Ratio PI is used to establish the amount of equipment downtime that is caused by emergency repairs. The objective is to effectively schedule equipment downtime repairs on a predetermined basis. This PI should be analyzed **weekly** by the **Maintenance Manager, Department Supervisor** and **Department Planner.**

5. **Planner Performance** $= \frac{\text{\# of Unplanned Jobs}}{\text{Total \# of Planned Jobs}} * 100$

Optimal < 5 %

The Planner Performance Indicator is used to quantify the speed at which Planners plan maintenance jobs. The objective is to keep the unplanned backlog down to an acceptable level while increasing the planned backlog. This PI should be analyzed **weekly** by the **Maintenance Manager, Department Supervisor** and **Department Planner.**

Conclusion

High productivity levels are expected from maintenance departments which implement a strong Maintenance Management Program. Maintenance Performance Indicators allow the maintenance department to control maintenance costs while increasing the productivity of the craft work force. Measuring maintenance work is required to specify where the MMP is and which direction it is going.

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