Ethiopian TVET-System

Electro Mechanical Equipment Operation and Maintenance

Level –IV

Based on March, 2017G.C. Occupational Standard

Module Title: Plan and Monitor Electro-Mechanical Equipment Maintenance

TTLM Code: EIS EME4TTLM0920 v1

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This module includes the following Learning Guides

LG 39: **Plan maintenance activities**
LG Code: **EIS EME4 M09 L0 01-LG-39**

LG 40: **Schedule work activities and finalize maintenance plan**
LG Code: **EIS EME4 M09 L0 02-LG-40**

LG 41: **Check new and used equipment**
LG Code: **EIS EME4 M09 L0 03-LG-41**

LG 42: **Check implementation of maintenance plan**
LG Code: **EIS EME4 M09 L0 04-LG-42**

LG 43: **Improve work process and staff**
LG Code: **EIS EME4 M09 L0 05-LG-43**

LG 44: **Notify completion of work**
LG Code: **EIS EME4 M09 L0 06-LG-44**

Instruction Sheet	Learning Guide #01: Plan maintenance activities

This learning guide is developed to provide you the necessary information regarding the following content coverage and topics

- Setting objectives
- Identifying and categorizing Maintenance activities
- Determining Workload
- Communicating Action plan
- Developing Follow up and evaluation mechanism

This guide will also assist you to attain the learning outcome stated in the cover page. Specifically, upon completion of this Learning Guide, you will be able to –

- Set objectives
- Identify and categorize Maintenance activities
- Determine Workload
- Communicate Action plan
- Develop Follow up and evaluation mechanism

Learning Instructions:

1. Read the specific objectives of this Learning Guide.
2. Follow the instructions described in number 3 to 20.
3. Read the information written in the “Information Sheets 1”. Try to understand what are being discussed. Ask you Instructor for assistance if you have hard time understanding them.
4. Accomplish the “Self-check 1” in page __.
5. Ask from your Instructor the key to correction (key answers) or you can request your Instructor to correct your work. (You are to get the key answer only after you finished answering the Self-check 1).
6. If you earned a satisfactory evaluation proceed to “Information Sheet 2”. However, if your rating is unsatisfactory, see your Instructor for further instructions or go back to Learning Activity #1
7. Submit your accomplished Self-check. This will form part of your training portfolio.

8. Read the information written in the “Information Sheet 2”. Try to understand what are being discussed. Ask you Instructor for assistance if you have hard time understanding them.

9. Accomplish the “Self-check 2” in page __.

10. Ask from your Instructor the key to correction (key answers) or you can request your Instructor to correct your work. (You are to get the key answer only after you finished answering the Self-check 2).

11. Read the information written in the “Information Sheets 3 and 4”. Try to understand what are being discussed. Ask you Instructor for assistance if you have hard time understanding them.

12. Accomplish the “Self-check 3” in page __.

13. Ask from your Instructor the key to correction (key answers) or you can request your Instructor to correct your work. (You are to get the key answer only after you finished answering the Self-check 3).

14. If you earned a satisfactory evaluation proceed to “Operation Sheet 1” in page _. However, if your rating is unsatisfactory, see your Instructor for further instructions or go back to for each Learning Activities.

Information Sheet-1	Setting objectives

General Objectives of Planning Maintenance

- To help boost labor productivity;
- To provide the supervisor and technicians useful information for helping control their work;
- To reduce delay times and put technicians on their tools.
- To Maximize trade(Efficient tool use of workforce)time
- To ensure quality work-first –time done(Effective right use of resources)

The Specific Purpose of Scheduling Maintenance

1. Make sure maintenance is done so failure is prevented
2. Least production disruption
3. Right resources and people to the job on-time

Operations can delay preventive maintenance (PM) because they are focused on getting production out. We know that unnecessary, costly production failures will occur if PM is never done. If there is no specific strategy within Production to allow its equipment maintenance to be planned, it is almost bound to be neglected in a busy factory, which is just when it is most needed. So to control the risk of production neglecting their own equipment because they are too busy, the maintenance work must be planned and scheduled by the maintenance group.

In this course we focus on the only two aspects of maintenance planning that are truly important for a business, the efficient use of limited resources and the delivery of highly reliable plant and equipment. Unless maintenance work is efficient and is done right so that it adds value to a company, it is destroying value through wasted effort and pointless rework.

Tool time is when technicians and artisans are contributing their knowledge and expertise to the upkeep and improvement of the business. Right-first-time means their work is done expertly, using quality craftsmen skills, to deliver highly reliable machinery with long, long periods between problems. The Planners job is to help their maintenance people maximize tool time and maximize quality workmanship.

Maintainers contribute most value to the operation when they are performing maintenance. There is no value from them if they need to stand at the store waiting for parts, they can offer no value if they are waiting for the right information to do a job. If you want maximum value from your maintenance crew, you must develop systems and methods that keep them working on keeping the operation running at full capacity and maximum reliability.

When men are not contributing to making a company run better they are wasting its energy and money and destroying their own self-worth.

Self-Check 1	Written Test

Directions Answer all the questions listed below and write your answer on the space provided

1. Explain General objective of Monitoring and planning electromechanical equipment maintenance schedule? (describe at least two of them)(5pts)
2. What are the specific objectives of Monitoring and planning electromechanical equipment maintenance schedule? Discuss briefly with your group. (4pts)

Answer Sheet

Name: _____ Date: _____

Score = 9pts

Rating: _____

Short Answer Questions

1. _____

   _____

2. _____

   _____

   _____

Information Sheet-2	Identifying and categorizing Maintenance activities

Different Types of Equipment Maintenance Practices

Companies hold several assets, both high and low in value. If you choose a single restorative plan, you might end up spending a lot more on an asset than what its actually worth.

To filter out items which can be easily replaced instead of getting repaired, a company should run several types of repair and service events. Different organizational workflows need different types of maintenance:

1. Planned maintenance

It refers to scheduled maintenance to cope with equipment failures before they actually occur. It can be further broken down into *preventive* and *predictive maintenance*.

- **Preventive maintenance** is carried out at predetermined intervals by following prescribed criteria. It is time-driven and based on the assumption that usability of a mechanical component will decline over its useful life-cycle. It includes activities like regular equipment inspection, partial or complete overhauls, oil changes and lubrication etc.

- **Predictive maintenance** is different from preventive maintenance such that it depends on the working condition of the machinery rather than its average life expectancy. It requires monitoring equipment during its normal operations to see if it's working at its best. Some companies use periodic vibration to continuously monitor high value assets and simply check them in for maintenance when their vibration fluctuates.

2. Corrective maintenance

This type of maintenance restores any failed pieces of equipment. It is typically performed at irregular intervals since technicians don't know when a certain machine will break down. The main aim here is to fix a problem in the shortest possible time using three steps: *diagnosis, repair* and *verification.*

3. Routine maintenance

Not dependent on any broken parts or downtime, it includes some necessary activities such as cleaning, lubricating and replacing batteries on small-scale assets or equipment. This is generally performed on a weekly basis.

Self-Check 2	Written Test

Directions Answer all the questions listed below and write your answer on the space provided

1. Define, in the scope of electromechanical mechanical equipment technology, maintenance(5pts)
2. List down maintenance categories and describe each one of them briefly with your group. (6pts)

Note: Satisfactory rating –6 points **Unsatisfactory - below 6 points**

Answer Sheet

Name: _____ Date: _____

Score = 11pts

Rating: _____

Short Answer Questions

1. _____

   _____

2. _____

   _____

   _____

Information Sheet-3	Determining Workload

1. Maintenance Workload

When people discuss workload in aircraft maintenance they can be viewing the subject from two different perspectives:

- workload required, expected, planned for and experienced by the maintenance organization, or
- workload demanded of, and experienced by, individual maintenance employees.

Both organizational and human factors impact on each other and it is the responsibility of the maintenance organization to ensure that manpower available is more than adequate to meet all necessary tasks.

2. Maintenance Workload Forecasting

Maintenance Load

- Maintenance forecasting and capacity planning are two important functions for the design of an effective maintenance system.
- Maintenance load forecasting comprises the estimation and predication of the maintenance load. This maintenance load represents the driving force of the whole maintenance system

Types of Maintenance Load:

- **Planned maintenance works:** which involves all the works that are characterized by their ability to be planned and scheduled.
- **Unplanned maintenance:** works which involves all works that are very difficult to be planned and scheduled. (These works depend primarily on the failure pattern and they are a major source of uncertainty in the planning process)

The sum of maintenance load in these two categories is a random variable and it is the major factor in determining the maintenance capacity.

Capacity Planning Involves the determination of the maintenance resources that are needed to meet the maintenance load in order to achieve the organizational objectives such as:

1. Availability
2. Reliability
3. Quality rates
4. Delivery dates

The Essential Element of the Capacity Planning is the determination of :

- Skills of craftsmen
- The exact number of various type of craftsmen
- Types of maintenance equipment and tools
- The exact number of maintenance equipment and tools
- Spare parts and materials
- The right level of backlog
- Overtime capacity
- Contract maintenance

Forecasting techniques for determining maintenance load can be divided into:

- **Qualitative techniques:** based on the expert or engineering experience and judgment. Such techniques are:
  - Surveys
  - Delphi method: a group of experts respond individually to a questionnaire, providing forecasts and justifications. Results are combined, summarized, and returned to experts to revise. The process is repeated until consensus is reached
- **Quantitative techniques:** based on mathematical models that drive from historical data estimates for future trends. They are either time series- based (moving average) or structural (regression models).

3. Maintenance Capacity Planning

The objective of maintenance capacity planning is to determine the optimum level of resources needed to meet the demand for maintenance work in each period. The demand for maintenance work is stochastic in nature. Effective maintenance capacity planning is influenced by many factors that include the knowledge about the characteristic of maintenance workload, availability of resources, and the flexibility in deploying resources. Availability of the right resources in terms of quantity and quality is critical for responding to changes in demand for maintenance. Demand management in terms of forecasting the maintenance load, scheduling resources, and monitoring performance is part of overall capacity planning.

The process of maintenance capacity planning can be briefly described as follows:

1. Estimate (forecast) the total required maintenance capacity (maintenance workload) for each time period.
2. Select a model to determine the required resources over time. These models include deterministic mathematical programming models, and stochastic queuing and simulation models.
3. Assess the determined capacity plan using reliable performance measures.
4. Adjust the capacity if needed.

The usual objective of maintenance capacity planning is to minimize the total cost of labor, subcontracting, and delay (backlogging). Other objectives include the maximization of profit,

availability, reliability, or customer service. Capacity planning techniques are generally classified into two main types: deterministic and stochastic techniques [1].

Deterministic techniques assume that the maintenance workload and all other significant parameters are known constants. Three deterministic techniques that are presented in [1] and [2] are:

1. Heuristic techniques
2. The modified transportation tableau method; and
3. Mathematical programming techniques, including linear and integer programming.

Stochastic capacity planning techniques assume that the maintenance workload is a random variable. Statistical distribution-fitting techniques are used to identify the probability distributions that best describe these random variables. Since uncertainty always exists, statistical techniques are more representative of real life. However, statistical models are generally more difficult to construct and solve. The three most popular stochastic models and approaches are:

1. Stochastic programming;
2. queuing models; and
3. Stochastic simulation.

After determining the capacity plan using any given approach, it should be assessed regularly using reliable performance measures. The following measures are suggested to assess the adequacy of the maintenance capacity [1]:

1. Utilization of resources (labor utilization);
2. Response time;
3. Mean time to repair;
4. Maintenance backlog;
5. Inventory turnaround.

If the values of theses performance measures are outside the desired band, then an action to adjust the capacity plan is necessary.

4. Forecasting Maintenance Load

Prior to capacity planning or designing a new maintenance organization, an essential activity is to estimate the expected maintenance load. The load consists of the following components:

1. Failure and emergency maintenance workload. This can be forecasted using actual historical workloads and the appropriate techniques of forecasting that include moving average, regression, and exponential smoothing [1, 3].
2. Preventive maintenance and predicative maintenance workload. This mostly planned work will be obtained from planned maintenance program. This includes routine inspections and lubrications.
3. Deferred corrective maintenance. This can be forecasted based on historical records and future plans.

4. A forecast for overhaul of removed items and fabrication. This can be estimated from historical records coupled with future plans for improvements.
5. Shutdown, turnarounds, and design modifications. This can be obtained from actual historical records and the future maintenance schedule.

The forecasting of the maintenance load for a new plant is more difficult and must rely on similar plants' experiences, benchmarking, management experience, and manufactures' information.

After the maintenance load is forecasted, the forecast should be evaluated using standard error measures such as the Mean Absolute Percent Error (MAPE). Based on this evaluation, the forecast could be revised if necessary [1].

5. Methods and Approaches for Capacity Planning

In this section, the approaches and models for capacity planning are presented. The focus is on deterministic models because they are more practical and easy to implement in real life. A brief outline of stochastic models is also provided.

A. Deterministic Approaches

The deterministic techniques include the transportation method, linear programming ad integer programming models [1, 2, 4]. In production planning, products from the current period can be kept in inventory to satisfy demands in future periods. However, this is not the case in maintenance planning.

In maintenance, unfinished work is backlogged and performed in future periods at a higher cost. It is possible to divide the maintenance load into several categories by skill or priority and to perform capacity planning separately for each category. For example, Table 1 shows a tableau for a three-period maintenance plan for one kind of maintenance work, which is the mechanical workload. A similar table can be constructed for other types of maintenance work. The notation in the tableau is defined below.

C_r = cost per hour of in-house mechanical maintenance labor in regular time,
C_o = cost per hour of in-house mechanical maintenance labor in overtime,
C_s = cost per hour of subcontracted mechanical maintenance labor,
π = cost of backordering (doing work late) by one time unit
R_t = capacity of in-house regular time in period t
O_t = capacity of in-house overtime in period t
S_t = capacity of subcontracting in period t
M_t = forecasted mechanical maintenance load in period t.

If a work is backlogged from period (t) and performed at period ($t + i$) with regular in-house labor, it will have a higher cost of $Cr + i\pi$ per hour. Table 1 shows the data needed for a three-period planning horizon. The table shows the costs, capacities and maintenance load.

The symbol ∞ in the cost cell means that a work cannot be done in this period. For example, if work came in period (t + 1), then it cannot be performed in period t.

A simple least-cost heuristic method can be used to compute the allocation of the maintenance load to different sources of labor supply. The least-cost method provide a good solution, however if the optimal solution is needed the stepping stone method can be employed.

In general, the transportation tableau method requires the following data:

- cost of maintenance for each source per man-hour for each period;
- cost of advancing (early maintenance) per man-hour per unit time,
- cost of backordering (late maintenance) per man-hour per unit time;
- maintenance demand (required workload) in each period.

bTable 1 Transportation tableau with 3 periods and 3 resources

Execution Periods	Resource used	Demand Periods 1	2	3	Capacity
1	Regular Time	c_R	∞	∞	R_1
	Overtime	c_O	∞	∞	O_1
	Subcontract	c_S	∞	∞	S_1
2	Regular Time	$c_R + \pi$	c_R	∞	R_2
	Overtime	$c_O + \pi$	c_O	∞	O_2
	Subcontract	$c_S + \pi$	c_S	∞	S_2
3	Regular Time	$c_R + 2\pi$	$c_R + \pi$	c_R	R_3
	Overtime	$c_O + 2\pi$	$c_O + \pi$	c_O	O_3
	Subcontract	$c_S + 2\pi$	$c_S + \pi$	c_S	S_3
Maintenance Workload		M_1	M_2	M_3	

B. Stochastic Approaches

Stochastic approaches that may be used for maintenance capacity planning include:

1. Stochastic programming.
2. Queuing models.
3. Stochastic simulation.

The driver behind these models is the stochastic nature of the demand for maintenance work. To use them effectively, these models require probability distribution identification and large amounts of data. Experience has shown limited use and application of stochastic

models in maintenance capacity planning. Therefore, these models are not presented in detail in this paper.

Self-Check 3	Written Test

Directions Answer all the questions listed below and write your answer on the space provided

1. What is maintenance workload? Discuss with group on the advantages of determining/forecasting maintenance workload (5pts)
2. List down maintenance workload forecasting/ determining approach and methods? Discuss briefly with your group. (4pts)

Note: Satisfactory rating –5 points Unsatisfactory - below 5 points

Answer Sheet

Name: _____ Date: _____

Score = 9pts

Rating: _____

Short Answer Questions

1. _____
   _____
2. _____
   _____
   _____

Information Sheet - 4	Communicating Action plan

Maintenance Arises from Operating Risk Management and Safety Strategy

Much of the work that becomes the computer maintenance management system (CMMS) generated work orders, rounds and routines is developed out of the strategies put into place

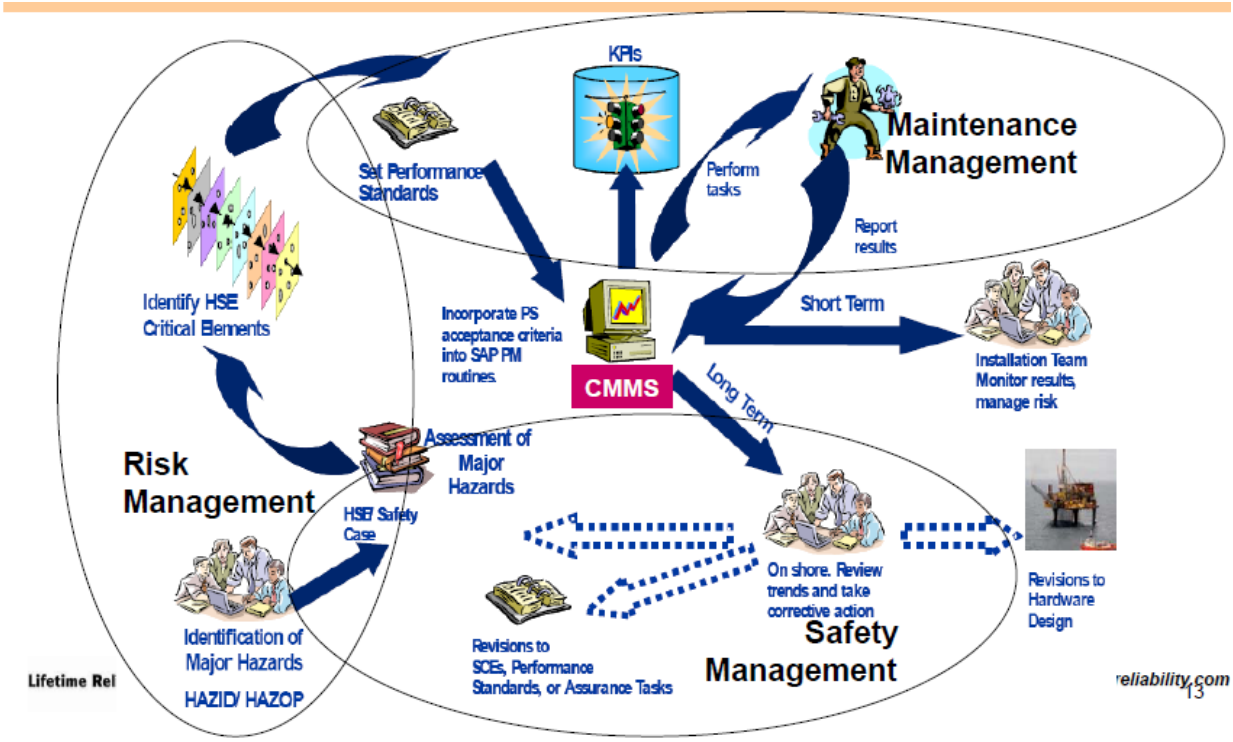


Figure 2.8 Maintenance Arises from Operating Risk Management and Safety Strategy

to control the risks that prevent achievement of the business operating and production objectives.

Putting Maintenance Strategy into Action

The long-term maintenance plan is a compilation from several sources. These include the PM- 10 improvement activities, the computerised maintenance management system (CMMS) preventative maintenance work orders and decisions from equipment failure

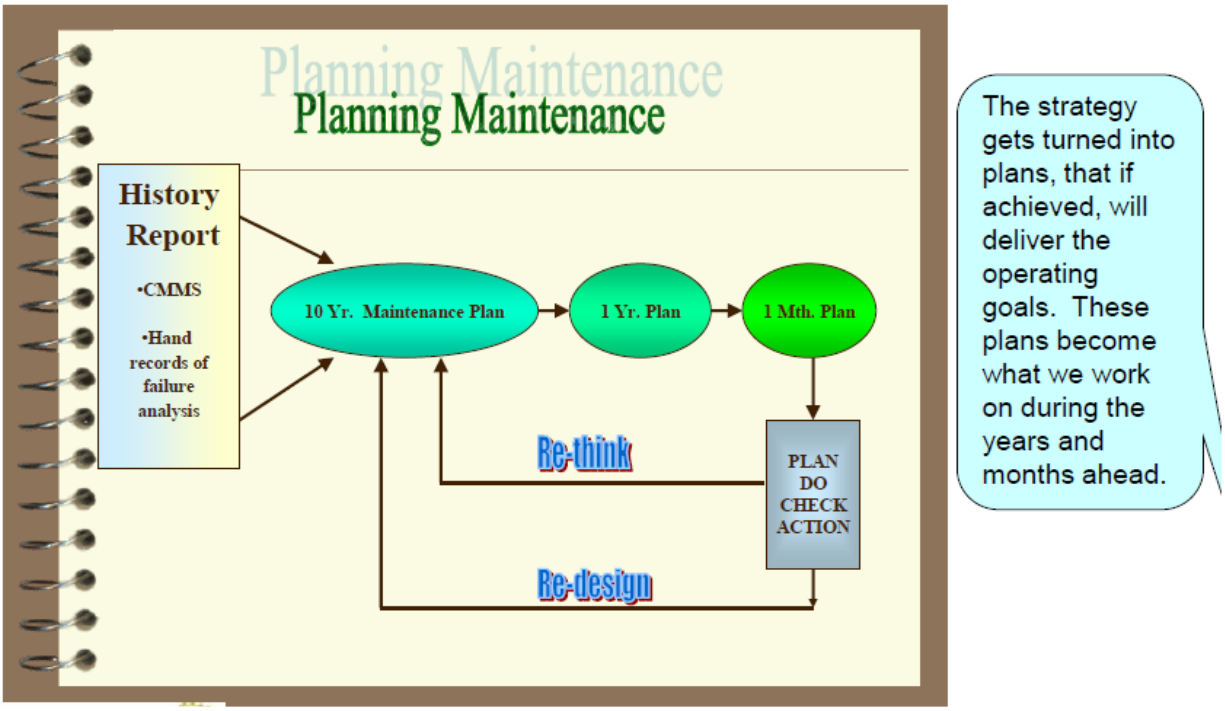


Figure 2.10 Putting Maintenance Strategy into Action

analyses conducted after equipment failures.

The long-term plan cascades down into the annual plan, which in turn is separated into the monthly plan. The monthly planned work is performed and the self-improvement 'Plan-Do-Check-Action' process is applied to feed improved methods and ideas back into the long-term plan.

Turning the Planning of Maintenance into a Standardized Business Process

Maintenance Planning performs the service of preparing a business' people and resources to perform maintenance work effectively (doing the right work, rightly) and efficiently (doing the work quickly and accurately).

The success of a job is directly related to how well it was planned and prepared. Follow the 2500 year old advice of Confucius – *"In all things success depends on previous preparation, and without such preparation there will be failure."*

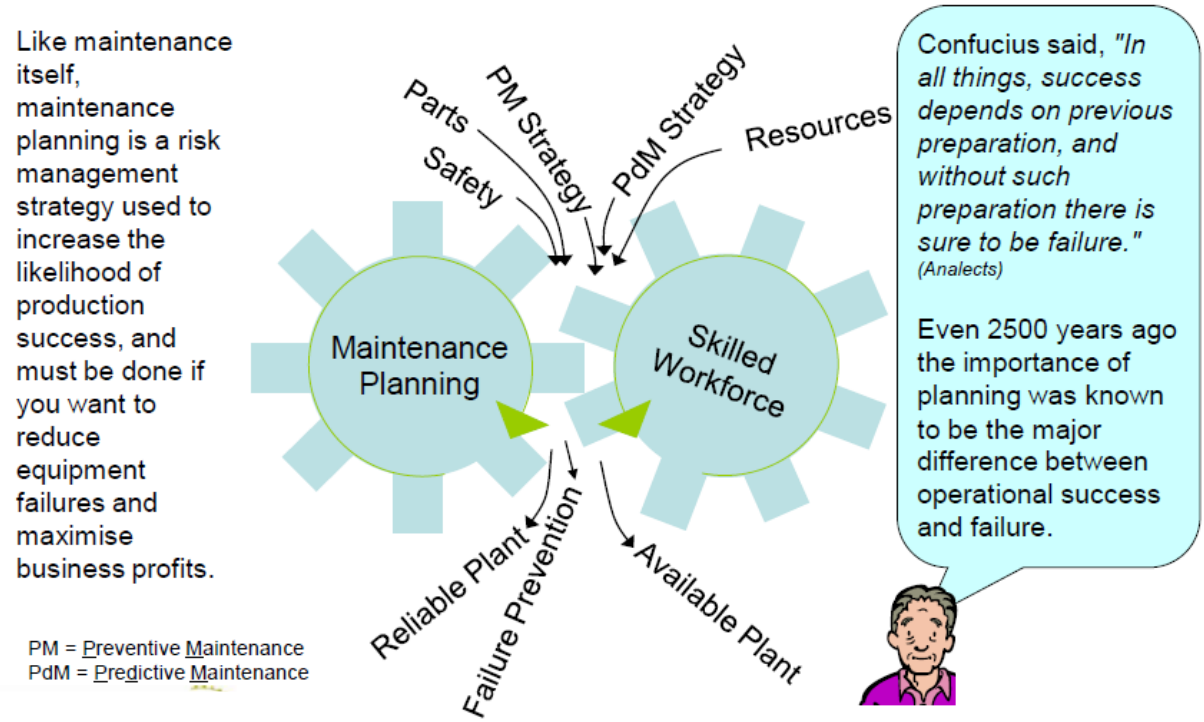


Figure 2.11 Turning the Planning of Maintenance into a Standardized Business Process

Planning maintenance is a 'mechanical' process involving standard duties and practices that when performed applies an organisation's asset management strategy to deliver high operating plant and equipment performance. It can be seen as a 'machine like process' that turns the company's asset management strategy, resources and systems into well operating, highly reliable plant and equipment.

In order to foster and support this sort of thinking it is necessary that senior management first approve and condone the resulting necessary actions by writing an appropriate policy and publicly stating their intention and support for it.

Maintenance Planners covert strategy into actions that the crew does to deliver the objective

The Maintenance Planner is the link between corporate asset life-cycle management strategy and the workforce. They are the person responsible to convert plans into actions that people use to deliver the objectives.

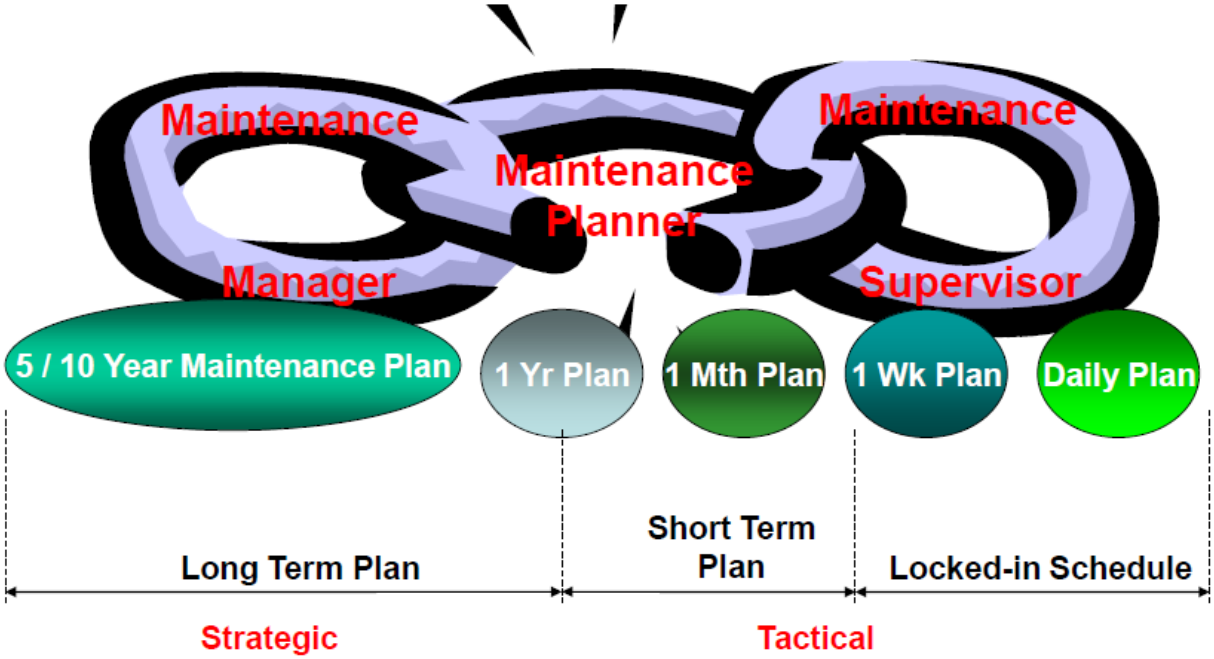


Figure 2.12 Maintenance Planners covert strategy into actions that the crew does to deliver the objective

To get the degree of control needed when doing maintenance work you need a job planned out step-by-step in no more than 30 minute intervals—15 minute intervals would be better.

Self-Check 4	Written Test

Directions: Answer all the questions listed below and write your answer on the space provided

1. Discuss how maintenance action plan is communicated? Hint: consider time periods ranged between weekly to annaual (5pts)
2. How to change maintenance plan strategy in to business? What is/are the benefits?. (6pts)

Note: Satisfactory rating –6 points **Unsatisfactory - below 6 points**

Answer Sheet

Name: _____ Date: _____

Score = 11pts

Rating: _____

Short Answer Questions

1. _____

   _____

2. _____

   _____

   _____

Information Sheet - 5	Developing Follow up and evaluation mechanism

What Is An Evaluation Plan?

An evaluation plan is a written document that describes how you will monitor and evaluate your program, as well as how you intend to use evaluation results for program improvement and decision making. The evaluation plan clarifies how you will describe the "what," the "how," and the "why it matters" for your program.

- The "what" describes your program and how its activities are linked to its intended effects. It serves to clarify the program's purpose and anticipated outcomes.
- The "how" addresses the process for implementing a program and provides information about whether the program is operating with fidelity to the program's design.
- The "why it matters" provides the rationale for your program and its intended impact on public health. This is also sometimes referred to as the "so what?" question. Being able to demonstrate that your program has made a difference is critical to program sustainability.

An evaluation plan is similar to a roadmap. It clarifies the steps needed to assess the processes and outcomes of a program. An effective evaluation plan is more than a list of indicators in your program's work plan. It is a dynamic tool that should be updated on an ongoing basis to reflect program changes and priorities over time.

Why Do You Want An Evaluation Plan?

Just as using a roadmap facilitates progress on a long journey, an evaluation plan can clarify the direction of your evaluation based on the program's priorities and resources and the time and skills needed to accomplish the evaluation. The process of developing a written evaluation plan in cooperation with an evaluation stakeholder workgroup (ESW) will foster collaboration; give a sense of shared purpose to the stakeholders; create transparency through the implementation process; and ensure that stakeholders have a common vision and understanding of the purpose, use, and users of the evaluation results. The use of evaluation results must be planned, directed, and intentional and should be included as part of the evaluation plan.[10]

What Are the Key Steps in Developing An Evaluation Plan Using Standards' Framework For Program Evaluation?

There are numerous ways in which you can frame your evaluation plan. We use the STANDARDS's "Framework for Program Evaluation in Public Health" as a guide for the planning process and outlining considerations for what to include in the written evaluation plan.[8] The STANDARDS framework is a guide on how to effectively evaluate public health

programs and on using your evaluation's findings for program improvement and decision making (Figure 1). There are countless ways to organize your evaluation plan. Using the framework to organize your plan will facilitate including concrete elements that promote transparent and thoughtful implementation of the evaluation. The workbook and this abridged version of the workbook provide needed resources on how to use the framework for implementing an evaluation to develop the plan itself. Though the framework is described in terms of steps, the actions are not always linear and are often completed in a cyclical nature. The development of an evaluation plan is an ongoing process; you may need to revisit a step during the process and complete several steps concurrently.

Figure 2.2 sample Framework for Program Evaluation (CDC's)

Figure 1 The STANDARDS framework for program evaluation (color figure available online).

Step 1: The Process of Participatory Evaluation Planning or Engaging the Stakeholders

A primary feature of an evaluation plan is the identification and acknowledgement of the roles and responsibilities of an ESW. The ESW includes members who have a stake or vested interest in the evaluation findings and those who are the intended users of the evaluation. The ESW may also include others who have a direct or indirect interest in program implementation. Engaging stakeholders in the ESW enhances intended users' understanding and acceptance of the utility of evaluation information. Stakeholders are much more likely to buy into and support the evaluation if they are involved in the evaluation process from the beginning.

How are Stakeholder's Roles described in the Plan?

For the ESW to be truly integrated in the development of the evaluation plan, ideally, it will be identified in the evaluation plan. The form this takes may vary based on program needs. If it is important politically, a program might want to specifically name each member of the workgroup, their affiliation, and specific role(s) in the workgroup. Being transparent about the role and purpose of the ESW can facilitate buy-in for the evaluation plan. In addition, you may want to include the preferred method of communication and the timing of that communication for each stakeholder or group. A stakeholder chart or table can be a useful tool to include in your evaluation plan.

Step 2: Describing the Program in the Evaluation Plan

The next step in the evaluation plan is to describe the program. A program description clarifies the program's purpose, stage of development, activities, capacity to improve health, and implementation context. A shared understanding of the program by health educators, program staff, evaluators, and the ESW and what the evaluation can and cannot deliver is essential to implementation of evaluation activities and use of evaluation results. A narrative description in the written plan is helpful to ensure a full and complete shared understanding of the program and a ready reference for stakeholders. A logic model may be used to succinctly synthesize the main elements of a program. The program description is essential for focusing the evaluation design and selecting the appropriate methods. Too often groups jump to evaluation methods before understanding what the program is designed to achieve or what the evaluation should deliver. The description will be based on your program's objectives and context but most descriptions include at a minimum:

- A statement of need to identify the health issue addressed
- Inputs or program resources needed to implement program activities
- Program activities linked to program outcomes through theory or best practice program logic
- Stage of development of the program to reflect program maturity
- Environmental context within which the program is implemented

In terms of describing the stage of development of the program, the developmental stages that programs typically move through are planning, implementation, and maintenance. For policy or environmental initiatives, which programs and health educators often evaluate, the stages might look somewhat like this:

Planning

- 1 Environment and asset assessment
- 2 Policy or environmental change development
- 3 Policy or environmental change developed but not yet approved

Implementation

- 4 Policy or environmental change approved but not implemented
- 5 Policy or environmental change in effect for less than 1 year

Maintenance

- 6 Policy or environmental change in effect for 1 year or longer

When it comes to evaluation, the stages of development are not always a "once-and-done" sequence of events. For example, once a program has progressed past the initial planning stage, it may experience occasions where environment and asset assessment are still

needed. Additionally, in a multiyear program, the evaluation plan should consider both future evaluation data sets and baseline information that will be needed so that the evaluators can be prepared for more distal impact and outcome projects.

Step 3: Focusing Your Evaluation Plan and Your ESW

In this part of the plan, you will articulate the purposes of the evaluation, its uses, and the program description. This will aid in narrowing the evaluation questions and focusing the evaluation for program improvement and decision making. The scope and depth of any program evaluation is dependent on program and stakeholder priorities and the feasibility of conducting the evaluation given the available resources. The program staff should work together with the ESW to determine the priority and feasibility of the evaluation's questions and identify the uses of evaluation results before designing the evaluation plan. In this step, you may begin to notice the iterative process of developing the evaluation plan as you revisit aspects of step 1 and step 2 to inform decisions made in step 3.

Even with an established multiyear plan, step 3 should be revisited with your ESW annually (or more often if needed) to determine whether priorities and feasibility issues still hold for the planned evaluation activities. This highlights the dynamic nature of the evaluation plan. Ideally, your plan should be intentional and strategic by design and generally cover multiple years for planning purposes, but the plan is not set in stone. It should also be flexible and adaptive. It is flexible because resources and priorities change and adaptive because opportunities and programs change. For example, you may have a new funding opportunity and a short-term program added to your overall program. The written plan can document where you have been and where you are going with the evaluation as well as why changes were made to the plan.

Budget and Resources

Discussion of the budget and the resources (financial and human) that can be allocated to the evaluation will be included in your feasibility discussion. In the Best Practices for Comprehensive Tobacco Control Programs, it is recommended that at least 10% of your total program resources be allocated to surveillance and program evaluation.[5] The questions and subsequent methods selected will have a direct relationship to the financial resources available, evaluation team members' skills, and environmental constraints. Stakeholder involvement may facilitate advocating for the resources needed to implement the evaluation necessary to answer priority questions. However, sometimes you might not have the resources necessary to fund the evaluation questions you would most like to answer. A thorough discussion of feasibility and recognition of real constraints will facilitate a shared understanding of what the evaluation can and cannot deliver. The process of selecting the appropriate methods to answer the priority questions and discussing feasibility and efficiency is iterative. Steps 3, 4, and 5 in planning the evaluation will often be visited concurrently in a back-and-forth progression until the group comes to consensus.

Step 4: Planning for Gathering Credible Evidence

Now that you have solidified the focus of your evaluation and identified the questions to be answered, it will be necessary to select and document the appropriate methods that fit the evaluation questions you have chosen. Sometimes evaluation is guided by a favorite method and the evaluation is forced to fit that method. This could lead to incomplete or inaccurate answers to evaluation questions. Ideally, the evaluation questions inform the methods. If you follow the steps in this outline, you will collaboratively choose the evaluation questions with your ESW that will provide you with information that will be used for program improvement and decision making. The most appropriate method to answer the evaluation questions should then be selected and the process you used to select the methods should be described in your plan. Additionally, it is prudent as part of the articulation of the methods to identify a timeline and the roles and responsibilities of those overseeing the evaluation implementation, whether it is program or stakeholder staff.

To accomplish this step of choosing appropriate methods to answer your evaluation questions, you will need to:

- keep in mind the purpose, logic model/program description, stage of development of the program, evaluation questions, and what the evaluation can and cannot deliver.
- determine the method(s) needed to fit the question(s). There are a multitude of options including, but not limited to, qualitative, quantitative, mixed methods, multiple methods, naturalistic inquiry, experimental, and quasi-experimental.
- think about what will constitute credible evidence for stakeholders or users.
- identify sources of evidence (e.g., persons, documents, observations, administrative databases, surveillance systems) and appropriate methods for obtaining quality (i.e., reliable and valid) data.
- identify roles and responsibilities along with timelines to ensure the project remains on time and on track.
- remain flexible and adaptive and, as always, transparent.

Evaluation Plan Methods Grid

One tool that is particularly useful in your evaluation plan is an evaluation plan methods grid (Table 1). Not only is this tool helpful for aligning evaluation questions with methods, indicators, performance measures, data sources, roles, and responsibilities, it can also facilitate a shared understanding of the overall evaluation plan with stakeholders. Having this table in the evaluation plan helps readers visualize how the evaluation will be implemented, which is a key feature of having an evaluation plan. The tool can take many forms and should be adapted to fit your specific evaluation and context.

Table 1 Example Evaluation Plan Methods Grid

Evaluation Question	Indicator/ Performance Measure	Method	Data Source	Frequency	Responsibility

What process leads to implementation of policy?	Interview description of process steps, actions, and strategies	Case study, interviews, document reviews etc.	Site visits and reports	Pre and post funding period	Contractor

Step 5: Planning for Conclusions

Justifying conclusions includes analyzing the information you collected, interpreting, and drawing conclusions from your data. This step is needed to turn the data collected into meaningful, useful, and accessible information. It is critical to think through this process and outline procedures to be implemented and the necessary timeline in the evaluation plan. Programs often incorrectly assume that they no longer need the ESW integrally involved in decision making around formulating conclusions and instead look to the "experts" to complete the analyses and interpretation of the program's data. However, engaging the ESW in this step is critical to ensuring the meaningfulness, credibility, and acceptance of evaluation findings and conclusions. Actively meeting with stakeholders and discussing preliminary findings helps to guide the interpretation phase. In fact, stakeholders often have novel insights or perspectives to guide interpretation that evaluation staff may not have, leading to more thoughtful conclusions.

Planning for analysis and interpretation is directly tied to the timetable begun in step 4. Errors or omissions in planning this step can create serious delays in producing the final evaluation report and may result in missed opportunities (e.g., having current data available for a legislative session) if the report has been timed to correspond with significant events (e.g., program or national conferences).

Moreover, it is critical that your evaluation plan includes time for interpretation and review of the conclusions by stakeholders to increase transparency and validity of your process and conclusions. The emphasis here is on justifying conclusions, not just analyzing data. This is a step that deserves due diligence in the planning process. A note of caution: As part of a stakeholder-driven process, there is often pressure for data interpretation to reach beyond the evidence when conclusions are drawn. It is the responsibility of the evaluator and the ESW to ensure that conclusions are drawn directly from the evidence. This is a topic that should be discussed with the ESW in the planning stages along with reliability and validity issues and possible sources of biases. If possible and appropriate, triangulation of data should be considered and remedies to threats to the credibility of the data should be addressed as early as possible.

Step 6: Planning for Dissemination and Sharing of Lessons Learned

Another often overlooked step in the planning stage is step 6, which encompasses planning for use of evaluation results, sharing of lessons learned, communication, and dissemination of results.

Based on the uses for your evaluation, you will need to determine who should learn about the findings and how they should learn the information. Typically this is where the final report is published. The impact and value of the evaluation results will increase if the program and the ESW take personal responsibility for getting the results to the right people and in a usable, targeted format. This absolutely must be planned for and documented in the evaluation plan. It will be important to consider the audience in terms of timing, style, tone, message source, and method and format of delivery. Remember that stakeholders will not suddenly become interested in your product just because you produced a report. You must sufficiently prepare the market for each product and for use of the evaluation results.

Communication and Dissemination Plans

An intentional communication and dissemination approach should be included in your evaluation plan. As previously stated, the planning stage is the time for the program and the ESW to begin to think about the best way to share the lessons you will learn from the evaluation. The communication–dissemination phase of the evaluation is a 2-way process designed to support use of the evaluation results for program improvement and decision making. In order to achieve this outcome, a program must translate evaluation results into practical applications and must systematically distribute the information through a variety of audience-specific strategies.

The first step in writing an effective communications plan is to define your communication goals and objectives. Given that the communication objectives will be tailored to each priority audience, you need to consider with your ESW who the primary audience(s) are (e.g., the ESW, the funding agency, the general public, and some other groups).

Once the goals, objectives, and priority audiences of the communication plan are established, you should consider the best ways to reach the intended audiences by considering which communication–dissemination methods or formats will best serve your goals and objectives. Will the program use newsletters/fact sheets, oral presentations, visual displays, videos, storytelling, and/or press releases? Carefully consider the best tools to use by getting feedback from your ESW, by learning from others' experiences, and by reaching out to priority audiences to gather their preferences.

Complete the communication planning step by establishing a timetable for sharing evaluation findings and lessons learned. The communication and dissemination chart provided in Table 2 can be useful in helping the program to chart the written communications plan.

Table 2 example communication and dissemination chart

Target Audience (Priority)	Goals	Tools	Timetable

Program Implementation Team	Inform them in real time about what's working well and what needs to be quickly adjusted during implementation	Monthly meetings and briefing documents	Monthly
Program Stakeholders	Promote program progress	Success stories	Annually
Funding Decision Makers	Continue and/or enhance program funding	Executive summary; Targeted program briefs	Within 90 days of conclusion of funding

It is important to note that you do not have to wait until the final evaluation report is written in order to share your evaluation results. A system for sharing interim results to facilitate program course corrections and decision making should be included in your evaluation plan.

Communicating results is not enough to ensure the use of evaluation results and lessons learned. The evaluation team and program staff need to proactively take action to encourage the use and widespread dissemination of the information gleaned through the evaluation project. It is helpful to strategize with stakeholders early in the evaluation process about how your program will ensure that findings are used to support program improvement efforts and informed decision making. Program staff and the ESW must take personal responsibility for ensuring the dissemination of and application of evaluation results.

ONE LAST NOTE

The impact of the evaluation results can reach far beyond the evaluation report. If stakeholders are involved throughout the process, communication and participation may be enhanced. If an effective feedback loop is in place, program improvement and outcomes may be enhanced. If a strong commitment to sharing lessons learned and success stories is in place, then other programs may benefit from the information gleaned through the evaluation process. Changes in thinking, understanding, program and organization may stem from thoughtful evaluative processes. The use of evaluation results and impacts beyond the formal findings of the evaluation report start with the planning process and the transparent, written evaluation plan. In addition, all of the above facilitate the actual use of evaluation data, which is a core component of essential, foundational, and functioning program infrastructure as defined by the CMI.

Self-Check 4	Written Test

Directions: Answer all the questions listed below and write your answer on the space provided

1. discuss purpose developing maintenance plan evaluation & followup? (describe at least five of them)(5pts)
2. what are the key steps of developing maintenance plan evaluation? Discuss briefly on them with your group. (6pts)

Note: Satisfactory rating –3 points Unsatisfactory - below 3 points

Answer Sheet

Name: _____ Date: _____

Score = 11pts

Rating: _____

Short Answer Questions

1. _____
   _____
2. _____
   _____
   _____

Operation Sheet-4	Develop Follow up and evaluation mechanism

Name: _____ Date: _____
Time started: _____ Time finished: _____

Direction: Develop Follow up and evaluation mechanism

Equipment, tools and materials:

Manufacturer's maintenance manual, Procedures, paper, pen, pencil, learning guide

Instruction:

Group Interested in an Evaluation	What Is to Be Evaluated	How Will the Results Be Used	Evaluation Purpose Statement

Operation Sheet 1	Planning Maintenance activities

Name: _____ Date: _____
Time started: _____ Time finished: _____

Direction: Select any of appropriate materials, stationary tools and equipment used for planning maintenance activities that is appropriate for you

Procedures:

1. Set an objective-make it general and specific
2. Identify and categorize Maintenance activities-
3. Determine Workload-use appropriate approaches and methods
4. Communicate Action plan
5. Develop Follow up and evaluation mechanism

LAP Test	Plan maintenance activities

Name: _____ Date: _____

Time started: _____ Time finished: _____

Direction: complete the following job and report to your instructor

Job 1: Carry out complete preparation used to carry out engine inspection and services

Instruction Sheet	Learning Guide #02: Schedule Work Activities and Finalize Maintenance Plan

This learning guide is developed to provide you the necessary information regarding the following content coverage and topics

- Identifying and prioritizing tasks/work activities
- Breaking down Tasks/work activities into stages
- Coordinating Schedule of work activities
- Allocating resources
- *Coordinating Schedule of work activities*
- Preparing plan
- Identifying work methods and practices
- Identifying Monitoring and performance evaluation
- Determining and Agreeing upon Feedback mechanism
- Reviewing, finalizing and presenting plan
- Evaluating Recommended changes to the plan
- Delivering Finalized plan

This guide will also assist you to attain the learning outcome stated in the cover page. Specifically, upon completion of this Learning Guide, you will be able to –

- Identify and prioritize tasks/work activities
- Break down Tasks/work activities into stages
- Coordinate Schedule of work activities
- Allocate resources
- *Coordinate Schedule of work activities*
- Prepare plan
- Identify work methods and practices
- Identify Monitoring and performance evaluation
- Determine and Agree upon Feedback mechanism
- Review, finalize and present plan
- Evaluate Recommended changes to the plan
- Deliver Finalized plan

Learning Instructions:

1. Read the specific objectives of this Learning Guide.
2. Follow the instructions described in number 3 to 20.
3. Read the information written in the “Information Sheets 1”. Try to understand what are being discussed. Ask you Instructor for assistance if you have hard time understanding them.
4. Accomplish the “Self-check 1” in page __.
5. Ask from your Instructor the key to correction (key answers) or you can request your Instructor to correct your work. (You are to get the key answer only after you finished answering the Self-check 1).
6. If you earned a satisfactory evaluation proceed to “Information Sheet 2”. However, if your rating is unsatisfactory, see your Instructor for further instructions or go back to Learning Activity #1
7. Submit your accomplished Self-check. This will form part of your training portfolio.
8. Read the information written in the “Information Sheet 2”. Try to understand what are being discussed. Ask you Instructor for assistance if you have hard time understanding them.
9. Accomplish the “Self-check 2” in page __.
10. Ask from your Instructor the key to correction (key answers) or you can request your Instructor to correct your work. (You are to get the key answer only after you finished answering the Self-check 2).
11. Read the information written in the “Information Sheets 3 and 4”. Try to understand what are being discussed. Ask you Instructor for assistance if you have hard time understanding them.
12. Accomplish the “Self-check 3” in page __.
13. Ask from your Instructor the key to correction (key answers) or you can request your Instructor to correct your work. (You are to get the key answer only after you finished answering the Self-check 3).

14. If you earned a satisfactory evaluation proceed to “Operation Sheet 1” in page _. However, if your rating is unsatisfactory, see your Instructor for further instructions or go back to for each Learning Activities.

Information Sheet-1	Identifying and prioritizing tasks/work activities

1. **Maintenance tasks prioritization to daily equipment maintenance management**

The development of the method to prioritize corrective and preventive maintenance tasks started with the definition of some requirements by the project team, as follows:

- The method should not be time consuming so that the prioritization process is cost-effective.
- Contrary to what is presented in the literature, the criticality assessment should be done at the task level, not at the equipment level, since a failure mode of critical equipment may not be critical.
- Concerning corrective maintenance tasks, the machines with higher utilization and

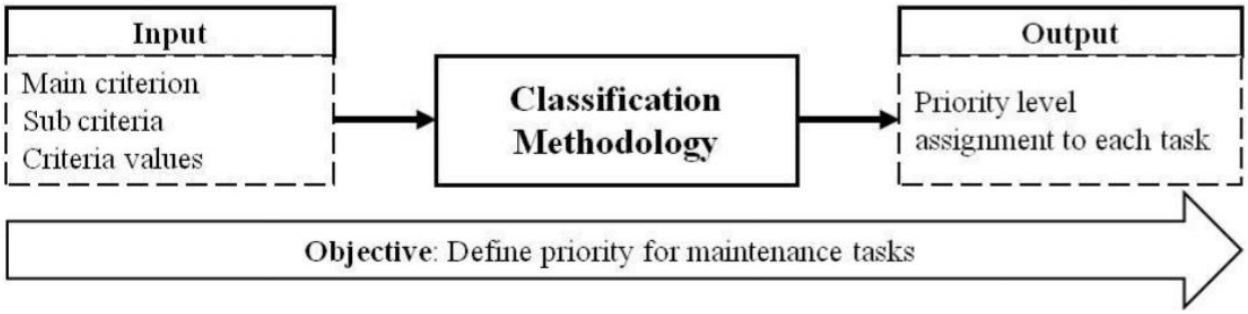


Figure 2.1 Tasks prioritization process

the repairs that have more impact in production have to be prioritized over the others since, in these cases, the production process has less capacity to recover and meet deadlines.

- For the same reason of the previous requirements, preventive maintenance tasks should also be performed first on machines whose potential failures have the greatest impact on productivity.

Taking into account the requirements, it was defined that the proposed method should use a set of criteria to first assign a criticality to the machine, considering the combination of values taken in each criterion (Figure 1). Then, for each type of maintenance tasks, corrective or time-based, other criteria should be subsequently added, to define its criticality.

The definition of criteria for equipment criticality determination was made taking into account the impact in productivity of equipment stoppage, since the aim is to define priorities to allow the fulfillment of the current production requests. The assignment of a low priority means that the maintenance task will wait longer to be performed.

Therefore, the criterion designated by Business Impact Rating (BIR), which assesses the impact of downtime on productivity, was defined. This approach is similar to that proposed by Li and Ni [18] that assigns a high priority to PM tasks of bottleneck station. Taghipour et

al. [12] use a similar factor called “Mission criticality” as part of their method for medical device selection to be included in the maintenance program of a hospital.

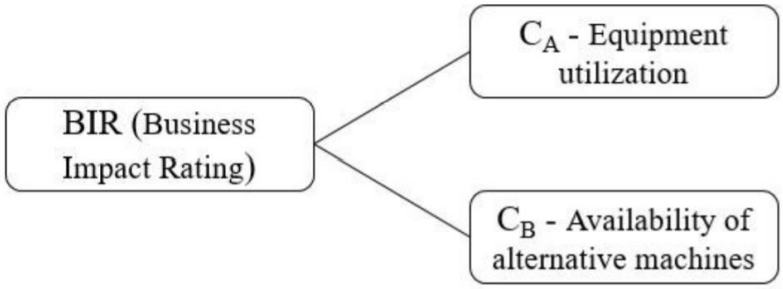


Figure 2.2 Selected criteria for equipment

The BIR criterion is composed by two sub-criteria, equipment utilization (CA) and availability of alternative machines (CB), as presented in Figure 2.2 and its value is set by the use of rules.

The “equipment utilization” sub-criterion (CA) expresses the criticality or importance of the production line where the equipment operates. A line that is being used more than other lines is more critical since it has less time available for maintenance tasks and has less capacity slack to be able to recover from downtimes and meet deadlines, when delays occur. This sub-criterion quantifies the utilization time of the equipment per week. The sub-criterion “availability of alternative machines” (CB) intends to indicate if there are machines in the production line that can do the same operations as the machine that is being assessed. The existence of alternative machines can decrease the impact of a breakdown since production can continue, using or increasing productivity of the other machines.

The ranges for each sub-criterion and the corresponding levels for the case study company,

			C_B	
			1	2
			Has at least an alternative machine	Single machine
C_A	1	≤ 84h per week	1	2
	2	> 84h and ≤ 126h per week	2	3
	3	> 126h per week	3	4

Figure 2.3 Business Impact Rating value and criteria ranges

de-fined with its support, are presented in Figure 2.3.
During the development of the method, each combination of levels of the two criteria was analyzed in order to define rules that would allow assigning a classification to each machine. After the analysis of the criteria combinations, a classification with four levels was assigned, obtaining the values for the BIR criterion, as presented in Figure 2.3. For some combinations, the same BIR value has been associated since it was considered that it represents Situations with similar impact on productivity. For corrective maintenance tasks prioritization, the BIR value of the equipment is considered together with a criterion related to failure impact on production, as shown in Figure 2.4.

Since the main objective of the classification is to prioritize corrective tasks, the impact that the failure has in the production line has to be considered. The failure impact is assessed by the criterion CC “ma-chine status after failure” that intends to transmit the effect that each failure has in production. The indication of the impact of failures on production will be informed by the operator or by the line head at the same time they communicate the failure to maintenance department and register its occurrence in the CMMS. The criterion CC is composed by four levels, as presented in Table 2.2, which represent the different possible consequences of a failure. Level 1 and level 4 represent respectively the smallest and greatest impact in terms of productivity. The intermediate levels represent two different failure consequences when equipment is still working. For level 2, the impact is verified by a reduction in machine speed or by small downtimes and for level 3, the production of nonconforming products reduces the machine yield. In situations where both impacts are verified, level 3 should be selected since it implies additional costs associated with rework or scrap of nonconforming products.

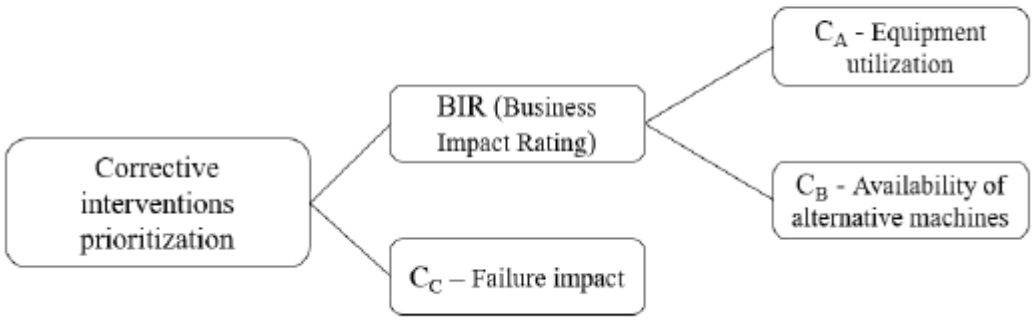


Figure 2.4 Criteria for corrective tasks prioritization

The combination of BIR value and Cc criterion was analyzed by the project team and the prioritization for corrective maintenance was defined as shown in Figure 2.5. Hence, taking into account this classification grid for corrective actions, if several machines need a corrective maintenance task at the same time, the machines with higher classification will be repaired first. Four levels of priority have been defined by the combination of the criteria: “very urgent”, “urgent”, “standard” and “Non-urgent”. The defined classification allows the reduction of the impact of unscheduled maintenance on productivity since machines most requested or occupied have priority in performing repairs and this priority is higher depending on the impact of failure on production. As indicated by figure 2.5, failures with a higher impact (Cc level) or machines with higher BIR value have a higher priority.

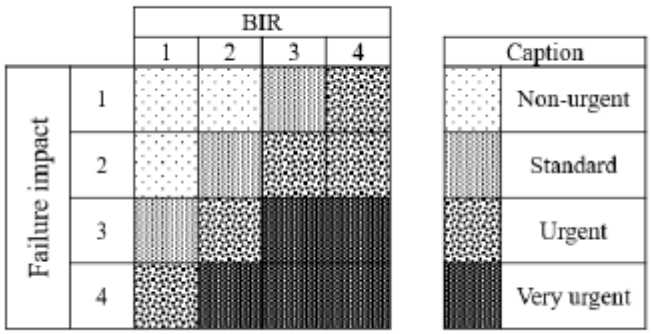


Figure 2.5 Classification grids for corrective actions

Failures that do not originate a production stoppage have the lowest priority when verified in machines with a BIR value of 1 or 2, since it will not com-promise the achievement of production objectives.

This classification for repair requests is useful to establish priorities automatically and in real time.
The defined classification allows the reduction of the impact of unscheduled maintenance on productivity since machines most requested or occupied have priority in performing repairs and this priority is higher depending on the impact of failure on production. As indicated by figure 2.5, failures with a higher impact (Cc level) or machines with higher BIR value have a higher priority. Failures that do not originate a production stoppage have the lowest priority when verified in machines with a BIR value of 1 or 2, since it will not com-promise the achievement of production objectives.

This classification for repair requests is useful to establish priorities automatically and in real time. Based on the record made by the operator requiring a maintenance task, the CMMS will inform technicians about the machines that have to be repaired first and the technicians' coordinator does not have to do this prioritization as he did in the case study company. This information can be highlighted in different colors in CMMS to an easy identification of priorities.

The classification grid for corrective actions was tested using data concerning corrective actions from the automotive company. For the application case, a set of 9 maintenance tasks associated to different machines and production lines was considered and is presented in Table 2.3. For each maintenance task the BIR (Business Impact Rating) and a Cc (Failure Impact) criteria are registered in the table. The table includes the designation of the corrective maintenance tasks as recorded by the maintenance technicians in the CMMS and represents the performed actions to solve the reported failure.

The combination of the BIR value and Cc criteria was analyzed taking into account the classification grid for corrective tasks presented in Figure 2.5. The final priority classification for each corrective maintenance task is presented in Table 2.3.

Table 2.1 Ranges and corresponding levels of Cc

Level	Cc - Machine status after failure
1	Working (100%)
2	Performance loss
3	Working with high probability of quality problems
4	Stopped

The corrective tasks considered in the application case represent different possible combinations of the criteria. From Table 2.3, the classification identified that tasks associated to the GP01, GP02 and ASY10_0010 machines have priority over the remaining maintenance tasks. However, the method does not differentiate between the "very urgent" tasks when this priority level is assigned to more than one task. In this case, the choice may be taken based on the task that is expected to have a shorter duration or on other information about the line or production order, such as the delivery time or the estimated production loss per unit of time.

The three members of the automotive company belonging to the project team approved this method recognizing that the priorities as assigned enable the fulfillment of their goals.

Concerning preventive (or time-based) maintenance tasks, a similar classification process was done to support maintenance scheduling. In the case study company, as in many other companies [32], the frequency of preventive maintenance is defined based on manufacturer recommendations and adjusted based on technicians' experience. Therefore, the objective of preventive tasks scheduling is to avoid de-lays compared to the predefined dates. The ordering of preventive tasks is the first step in the maintenance scheduling activity. After, for the scheduling period, the priority tasks should be scheduled first in the machines downtime intervals. The BIR indicator will be used for the ordering of tasks. A machine with a high BIR value means that this machine has less opportunity to stop and has short stoppages. Therefore, as-associated critical preventive maintenance tasks should be performed as needed and as soon as possible in the machine planned downtime. As presented in Figure 2.6, the BIR will be used together with two other criteria: due date and task criticality. Task criticality indicates the state of the machine if the failure is not avoided. The task criticality will have the same levels as the factor Cc. However, the task criticality is not indicated by the operators when the failure occurs as for Cc, it is an information that should be recorded associated to each failure mode. In companies that adopt the FMEA tool for reliability analysis, the impact of each failure mode is recorded to define the value of the severity factor of the RPN indicator. Therefore, the task criticality can be obtained from this tool.

For preventive maintenance tasks prioritization, a decision tree will be used considering the three factors (BIR; due date and tasks criticality). Concerning the due date factor, the ranges should consider the time interval between preventive tasks since the impact of delays is dependent of this period. Therefore, the delay factor can be de-fined as a percentage of the interval between preventive tasks. Each company should define its suitable ranges and corresponding decision tree.

Table 2.3 Application of the classification grid for corrective actions

Equipment			Maintenance Tasks		
Line	Designation	BIR	Designation	Cc	Priority
2N16	GP01	4	Replacing the stator and rotor of the dispensing Pump	3	Very Urgent
2M05	VT17	4	Cleaning the flow tank	1	Non Urgent
2N16	GP02	4	Curtains replacement in EPM's	4	Very Urgent
2N05	ASY10_0010	3	Replacing Vacuum Pumps (suc-tion cups)	3	Very Urgent
2N05	FCT50_0010	2	Replace interface needles	3	Urgent
2N05	FCT50_0015	2	Internal cleanliness	2	Standard
2I05	BUR50_0301	1	Bolting of guides and suction cups	1	Non Urgent
2I05	BUR50_0310	1	O-ring replacement	3	Standard
2I05	BUR50_0301	1	Cleaning the oven glasses	1	Non Urgent

This prioritization of PM tasks is not yet implemented in the company, since tasks criticality

should be recorded, integrated in the FMEA tool, and this record will be made progressively since a great amount of equipment and therefore a great amount of tasks is involved.

To start using the BIR indicator for maintenance tasks prioritization, information about the machine and the line where it is integrated should be recorded and available in the CMMS. Whenever a new production line is deployed or whenever changes are made in a current line in terms of machines that integrate it, the information must be recorded or changed, i.e., the machines should be associated with the respective production line and machines with the same function should be identified. In addition, concerning the CA factor, the operating time per week must be recorded and updated whenever this operating time changes. Regarding the failure impact, the information required to implement the presented method is introduced by the production line leader and has to be accurate because it has a great impact on the method results. The options about production line status that are presented to line leader may be suggested by the system depending on the type of failure reported.

- Replacing the stator and rotor of the dispensing Pump
- Cleaning the flow tank Curtains replacement in EPM's
- Replacing Vacuum Pumps (suction cups)
- Replace interface needles internal cleanliness
- Bolting of guides and suction cups
- O-ring replacement cleaning the oven glasses

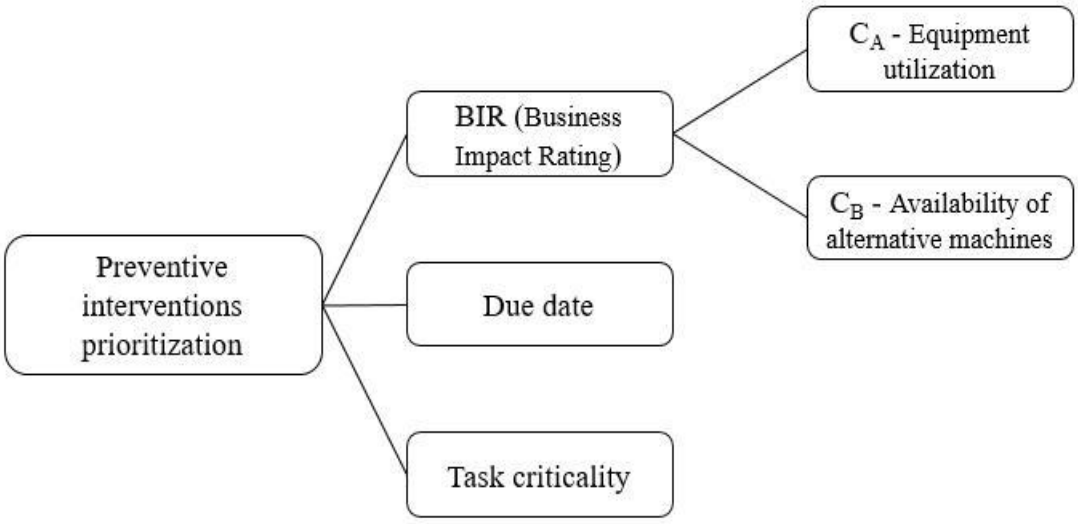


Figure 2.6 Factors for preventive tasks prioritization

2 Equipment ranking based on performance for improvement actions prioritization

The equipment performance ranking proposed in this paper consists of a general evaluation of equipment performance that is able to identify the worst-performing equipment. This ranking aims to prioritize improvement actions on equipment considering its current

performance. In this section, the assessment methodology is first explained and then applied to a set of machines of the automotive company.

3. Development of maintenance priority systems

In many organizations the priority of general repair tasks is reactive and responds to either breakdown which appears to be giving the greatest problems or to silence those who complain the loudest. In the right context responsive or breakdown maintenance is an acceptable strategy. There are some items whose failure is not predictable and do not cause great inconvenience whilst waiting to be repaired. When the work is random and low cost it may be cheaper to repair on breakdown than to take preventive action on all similar items some of which may have different rates of failure rendering the preventive strategy uneconomic.

For more substantial maintenance activities a management strategy is imperative.

The ranking system had four main groupings with a sub-set of deciding factors, usually applied to the two highest classes. (See Table 2 below).

Table 2: 2 level prioritization system sample

Class		Level	Description
Main Classifications	Priority	Priority 1	UNAVOIDABLE SERVICES: Schemes which cannot be deferred without breaching statutory obligations, health and safety or seriously affecting occupier's operations and functions.
		Priority 2	ESSENTIAL SERVICES: Schemes which cannot be deferred without serious penalties such as damage to property or increased costs.
		Priority 3	URGENT SERVICES: Schemes which are highly desirable to maintain the value and utility of the estate.
		Priority 4	DESIRABLE SERVICES: Schemes which are necessary to maintain property standards or which would show a saving in running or operational costs.
Priority		(a)	Meet Statutory obligations
Sub-classifications			
		(b)	Meet Health and Safety requirements
		(c)	Avoid serious disruption

An example of the approach adopted in the priority classification system in Table 2 would be an electrical distribution centre with a leaking roof causing damage to the switchgear. this would be priority 1 as it is essential to sustain the power supply to the site. It would have an (a) sub-code because of the legal requirement to keep high voltage systems safe and a contractual duty to maintain supply to occupiers. A (c) sub-code would also be appropriate as loss of power supply would disrupt the activities of occupiers; also some switch gear has to be built to order so it is imperative to stabilize the environment to reduce the risk of failure.

The two most urgent classes (Levels 1 & 2 in Table 2) usually need to be addressed within two years. However, certain work needs preparatory activities, for example in depth appraisals or design studies. Often these cannot be prepared in a short time. In such situations holding repairs may be required but for complex works the time factors and cost of preparing option studies and designs for major repair work need to be built into the work programme and the general maintenance policy.

When the most urgent work has been identified the period of time over which less urgent work may be placed can be determined. Start years can be allocated to work items shown in condition surveys or other appraisals as being justified to be new starts within the next five years. Start dates for projects which are forecast to occur more than 5 years hence may become nominal as they may have , in any event, to be rescheduled to accommodate more urgent work which may identified in the intervening period.
The nominal start dates for later start jobs have some value as it permits expenditure over time curves to be drawn. In an estate of varied age and type which has not been grossly neglected the profile may tend to taper off after a few years or may undulate. In such cases smoothing by shifting some starts may be desirable.

If the property portfolio has several similar buildings of roughly the same age expenditure curves may rise suddenly when the buildings are about 20 years old raising the scepter of a “maintenance time bomb”. The cause is often related to simultaneous expiry of external elements such as windows or felt flat roofs with engineering items such as heating plant and light fittings.

4. Use of other attributes for prioritizing maintenance

The use that the building or accommodation is put to, may influence the prioritization of work as much as its physical condition. Indeed six major criteria have been identified. These criteria are Equipment Status, Physical Condition, Importance of Usage, Effect on Users, Cost Implications and Effects on Service Provision.

Such attributes enable rankings and weightings to be placed on individual schemes and provide the basis for decision making and finer tuning of programmes. A score range of 5 is usually adequate for most criteria to cover the range from essential to desirable but not critical. It is imperative that the order of ascendancy of the score is uniform to permit them

to be added. If all other criteria are of rising importance; very poor physical condition must be 5 rather than using the high score to mean ‘excellent no work required’.

These standard attributes may need to be expanded to accommodate special features of the building. Additional points can, however, be added to cover specific buildings or needs such as legal requirements, keeping historic buildings in good order, maintaining a facility of regional or national importance or to avoid criticisms or political consequences of repeating previous failures. If it is believed criteria are not of equal relative importance they can be separated by weighting factors. Generally condition or cost scores will tend to have a low rating than those related to usage or public service factors.

It should be noted that the attributes used to fine tune priorities relate more to how the building is used than to physical condition or cost. Maintenance managers require a good understanding of how the buildings are used and should involve the users in the decision making process.

Self-Check 1	Written Test

Directions: Answer all the questions listed below and write your answer on the space provided

1. What is maintenance tasks prioritization? How do you make prioritization of the works? (5pts)
2. What are factors of equipment maintenance prioritization?. (4pts)

Note: Satisfactory rating –5 points **Unsatisfactory - below 5 points**

Answer Sheet

Name: _____ Date: _____

Score = 9pts

Rating: _____

Short Answer Questions

1. _____

_____

_____

_____

_____

Information Sheet #-2	Breaking down Tasks/work activities into stages

Breaking Down Maintenance Planning and Scheduling

The 34th president of the United States and an American army general, Dwight D. Eisenhower is famous for making the paradoxical statement, "In preparing for battle, I have always found that plans are useless, but planning is indispensable." He essentially was saying that plans often don't work out the way you lay them out once an actual emergency arises; however, the planning process makes you thoroughly explore all possible options and possibilities. The knowledge you gain from planning is vital when it comes to choosing appropriate actions.

In the modern world of manufacturing, higher productivity that produces quality products at the lowest cost possible is what companies strive for to stay ahead of the competition. Maintenance planning and scheduling are two different functions that, when used together, form a maintenance program.

Maintenance planning can be defined as an end-to-end process that identifies and addresses any possible issues ahead of time. This involves identifying the parts and tools necessary for jobs and making sure they're available and laid out in the appropriate areas, having a planner write out instructions on how to complete a job, and even determining and gathering the necessary parts and/or tools before a job is assigned. Maintenance planning also includes tasks related to parts like:

- Handling reserve parts
- Ordering nonstock parts
- Staging parts
- Illustrating parts
- Managing breakdowns and vendor lists
- Quality assurance (QA) and quality control (QC)

Maintenance planning should define the "what," "why" and "how." This means specifying what work needs to be done with what materials, tools and equipment; why a particular action was chosen (why a valve is being replaced instead of a seat); and how the work should be completed.

New call-to-action

Maintenance scheduling refers to the timing of planned work, when the work should be done and who should perform it. It offers details of "when" and "who." Scheduling is meant to:

- Schedule the maximum amount of work with the available resources
- Schedule according to the highest priority work orders
- Schedule the maximum number of preventive maintenance jobs when necessary
- Minimize the use of contract and outside resources by effectively using internal labor

When implemented together, maintenance planning and scheduling should have a significant benefit in multiple areas of your organization. These can include:

- Help with budgeting by controlling resources associated with maintenance
- A reduction in equipment downtime
- A reduction in spare parts
- Improved workflow
- Improved efficiency by minimizing the movement of resources between areas

Maintenance Planning and Scheduling Principles

As discussed earlier, the purpose of maintenance planning is to determine the correct maintenance jobs and get them ready for scheduling. To do this, a designated planner develops a work plan (sometimes called a job plan) for each work request. These work plans detail everything a technician must do and use to accomplish the task. There are six maintenance planning principles to guide planning in the appropriate direction.

Maintenance Planning Principles

Protect the planner: Planners are removed from the maintenance crews and put into separate groups to facilitate specialized planning techniques and focus on future work. By removing planners from the maintenance crew for which they plan and having them report to a different supervisor, the planning function is protected. As difficult as it may be at times, planners should never be used as field technicians to help complete work, so they can focus solely on planning for future work.

Focus on future work: This principle states that the planning group should only focus on future work – work that hasn't been started yet – so it can give the maintenance department at least one week of backlogged work that is already planned and ready to go. Having this backlog allows for the creation of a weekly schedule. With the exception of emergencies, job supervisors or the technicians themselves – not the planner – should resolve any problems that come up during the job.

Once a job is completed, the supervisor or lead technician should provide feedback to the planning group. Feedback should include things like problems encountered and changes in the work plan. In other words, if the crew encounters a problem, they should work it out themselves and finish the job. Once the job is completed, they can discuss issues with the planning group to offer helpful information about what went wrong to aid in planning for future work.

The reason for planners to be solely focused on future work is because it's easy to get caught up in helping with other tasks. For example, say a planner comes into work on a Monday morning needing to plan for the coming weekend's crew. She also needs to file work orders for a number of jobs completed last week. Two technicians come by her office to ask if she can help them run tickets to get parts out of inventory. Another technician calls her for help finding spare parts for a draft fan. Before long, she has spent most of her morning tracking down the manufacturer and getting sidetracked.

Component-level files: The planning group should maintain a simple, secure file system based on equipment tag numbers. In other words, planners should not file on a system

level but rather on an individual component level. This helps planners use the equipment data obtained from previous jobs to prepare and improve future work plans. This especially holds true with repetitive tasks, since most maintenance tasks are repetitive over an extended period of time.

When a component-level file or "mini-file" is made for each piece of equipment after the first time work is completed, data can be gathered and compared over time. Once a new piece of machinery is made available or is first worked on, planners make it a mini-file, labeling it with the same component tag number attached to the equipment in the field. Planners can use the information gathered over time to improve future processes.

Use planner judgment for time estimates: Planners should use their experience and skills in addition to file information to determine time estimates for work orders. Time estimates should be reasonable with what a technician might require to complete a job without any issues. This means planners should have technical, communication and organizational data skills to make a reasonable estimate. This principle requires planners to be chosen from the organization's best technicians, possibly ones with the most seniority.

For example, someone with 15 years of technician experience who accepted a planner position might notice in a previous work order file that a pump alignment took eight hours. He knows from experience that, when done by a competent mechanic, this task should only take around five hours, so he uses the five-hour estimate when creating the job plan for this task.

Recognize the skill of the techs: Planners need to be aware of and recognize the skills of their craft technicians when determining job plans. Planners should determine the scope of the work request and plan the general strategy of the work, including a preliminary procedure if there isn't one, around skill level. The technicians then complete the task and work together with the planner on repetitive jobs to improve procedures and checklists. A common issue with this principle is making a choice between producing highly detailed job plans for technicians with minimal skills or creating minimally detailed job plans for technicians with highly skilled technicians.

How much detail should be included in a job plan? A good rule of thumb is to develop a general strategy for 100 percent of the work hours. This will be better than a detailed plan for only 20 percent of the work hours. If there is a procedure already in the file or notes from people who have previously worked on the equipment, include those in the job plans.

Finding the best way to leverage the skills of the technicians and ensuring they are doing what they were trained to do allows planners to be confident that they will get a task done efficiently.

Measure performance with work sampling: This principle states that wrench time is the primary measure of workforce efficiency and of planning and scheduling effectiveness. Wrench time is defined as the time in which technicians are available to work and are not being kept from working on a job site by delays such as waiting for an assignment or parts and tools, obtaining clearance, travel time, etc. Planned work decreases unnecessary delays during jobs, while scheduling work reduces delays in between jobs.

Maintenance Scheduling Principles

You can have a great planning department working hard to outline planning procedures and work plans, but that doesn't mean more work will get done. That's because planning makes it easier to complete individual jobs. If one job that previously took four hours to complete, now only takes two, you've still only completed one job. This is where scheduling comes in. Scheduling helps increase productivity based around six principles:

Job plans are needed for scheduling: Job plans should include the number of technicians required, the minimum skill level, work hours per skill level and information on job duration. Maintenance needs this information to schedule work, and job plans provide it in an efficient way. Does the job require welding? How many welders are needed? How many assistants does the engineer require? Asking questions like these during the creation of job plans helps determine scheduling requirements.

Schedules and job priorities are important: The weekly schedule and the priorities that help determine this schedule are essential to improving productivity. Weekly scheduling frees up crew supervisors to focus on the current week without worrying about the backlog. Maintenance and operations use the weekly schedule for coordinating their tasks in advance, so it's critical to properly determine the priority levels of new work orders to see if they should become part of the daily or weekly schedule.

Prioritizing advanced scheduling helps make sure sufficient workloads are assigned, which increases productivity and ensures critical work orders are completed first.

Schedule based on the projected highest skills available: This principle states that a scheduler should develop a one-week schedule for each crew based on the available technician hours, the highest skill levels available, job priorities and details from the job plans. Schedulers should select a week's worth of work from the plant backlog by using information on priority and job plan details. They should then use a forecast of the maximum capabilities of the technician crew for the coming week. After several weeks have passed, technicians should have a better idea about the amount of work they're responsible for in a given week and become more productive.

Schedule for every available work hour: Bringing the previous principles together, this guideline details how much work to schedule. The scheduler should assign work plans for the technicians to complete a task during the following week for 100 percent of the forecasted hours. So, if a crew has 800 labor hours available, the scheduler would give them 800 hours' worth of work. Scheduling for 100 percent of the forecasted work hours prevents over- and under-scheduling.

Daily work is handled by the crew leader: The crew leader or supervisor should develop a daily schedule based on the one-week schedule, current job progress and any new high-priority jobs that may arise. The supervisor should assign daily work to technicians based on skill level and work order requirements. In addition to the current days' workload, the supervisor should handle emergencies and reschedule assignments as needed. Daily scheduling is almost always fluid thanks to the progress of the work being performed. This makes it difficult to schedule precise job times very far in advance. Inaccuracy of individual time estimates and reactive maintenance are the two biggest factors contributing to this issue.

Measure performance with schedule compliance: Scheduling success is measured by the adherence to the one-week schedule and its effectiveness. Wrench time is the ultimate measure of workforce efficiency and planning and scheduling effectiveness. Planning work before assigning it reduces unnecessary delays, while scheduled work reduces delays between jobs.

How to Implement Maintenance Planning and Scheduling

Now that you understand the guiding principles of maintenance planning and scheduling, let's take a look at how to implement them. Start-to-finish implementation can be viewed in six phases:

Maintenance planning and scheduling phases

Phase 1 - Setup: This phase encompasses all the steps needed to ensure your organization is onboard with implementing maintenance planning and scheduling. You should have made your case to leadership by exposing the issue of low productivity, explaining how planning and scheduling can help solve that issue, calculating the value of productivity improvement, and presenting the results in the form of return on investment (ROI).

Phase 2 - Define and analyze the situation: Phase two involves your team looking at your current situation and identifying problems currently faced in maintenance execution. During this phase, you should have representation from all levels of the maintenance process — technicians, key managers or supervisors, and even representatives from procurement, finance and the warehouse. This workshop-like environment should outline the current maintenance planning and scheduling process.

Ask questions, such as: How are work orders initiated? How do you prioritize work? Where do you access documents like technical drawings and equipment manuals? How are materials acquired? Do you run a weekly schedule? How are planners getting feedback on their job plans? If you currently use planning and scheduling software, ask questions like: Is your CMMS set up to meet your needs? Can you tag work orders by their priority level? Can you track performance metrics like schedule compliance?

The purpose of mapping your current processes is to highlight all the inefficiencies, making them the subject for discussion on how to improve them.

Phase 3 - Develop and prepare for delivery: Phase three involves planners and supervisors working to establish supporting documentation and process maps as well as defining in detail new processes, roles and responsibilities. You should also make any necessary changes to your computerized maintenance management system (CMMS) and develop training and coaching programs. Conducting a single overview training session followed by a role-specific training program is the most efficient way to go about training. This will prevent people from having to attend training sessions that don't pertain to them.

Phase 4 - Implement: Once everything is in place, it's time to roll out the new maintenance planning and scheduling processes. The goal here is to embed the new standards and procedures into the daily routines of all those involved until they become the new normal. It's generally accepted to allow for a three-month coaching period, where

individuals are assessed and receive help to close any gaps in performance. If you operate a shift system, six months should be sufficient. Remember, planners should only work on the processes, not in the processes.

Phase 5 - Review: This is sometimes called the "close-out" phase. Here, you want to ensure the new maintenance planning and scheduling process won't disintegrate when the training and one-on-one time is over.

- Celebrate successes and make sure people are aware of how their hard work is paying off.
- Review what is going well and what could be better, and document these for the next meeting with the planning department.
- Develop sustainable procedures.

Phase 6 - Sustain: This phase is considered "evergreen," as processes and procedures should always be improving. Be sure you have:

- All performance metrics in place and review them in meetings, verifying that they are meeting long-term trends.
- Clearly defined procedures or job plans for each technician performing certain tasks.
- Ensure new technicians are properly trained on these job plans.
- Standardized, up-to-date and easily accessibly documentation in place.
- A set time for conducting process reviews to assess what is working and what isn't. This is also the time to go over how processes can be improved.

Maintenance Planning and Scheduling Tools

Many people consider planning to be a maintenance tool. While not solving all maintenance issues by itself, planning integrates with other elements and helps synchronize all aspects of maintenance. Let's take a look at some other tools that work together with maintenance planning and scheduling.

Work order systems: A work order system is one of the most powerful tools a maintenance team can use. It acts as centralized, automated way to request and record work done within an organization. Work order systems are important because of the amount of work maintenance supervisors need to track. If a supervisor is responsible for eight technicians, each of those technicians might complete two or three tasks a day, totaling around 40 to 60 assignments in a five-day workweek. Work order systems give crews and supervisors a single method of communication. In addition to an integrated communication platform, a work order system lets supervisors organize workloads, assign tasks and track completion.

Equipment history and data: The equipment's history and data should also be considered a tool because this information helps you figure out the proper maintenance required based on up-to-date or even real-time data, as opposed to relying on memory or experimentation. Recording maintenance data over time essentially gives you a photo album of the life of the machine.

Maintenance metrics: Maintenance metrics refer to the measurements and scores of maintenance activities or results. They include the selecting, collecting, analyzing and presenting of maintenance data. The amount of work orders in your backlog is a common

example of a maintenance metric. Metrics can help with everything from clarifying situations to planning for key performance indicators (KPIs), coverage, work type, schedules, compliance and backlog work hours.

Maintenance Planning and Scheduling Tips

Effective maintenance planning and scheduling revolves around prioritizing and organizing tasks so they are completed as efficiently as possible. To do this, consider the following:

Choose a good maintenance planner: As briefly touched on earlier, effective maintenance planners typically are crew technicians with seniority, have a good rapport with coworkers and know the plant well. They should be highly skilled and have a solid knowledge base of maintenance planning principles and practices.

Properly train the planner: Be sure the maintenance planners know how to use your plant's work order software, including pulling data and reports, so they will have the appropriate knowledge of equipment maintenance history.

Understand the difference between planning and scheduling: This was discussed earlier, but it's important to reiterate that planning and scheduling should be kept separate. Planning involves figuring out which maintenance tasks need to be performed, how they will be completed, and which parts and tools are required. Scheduling involves determining when you're going to complete a task. Planners should plan the work but never schedule it or complete the tasks themselves.

Ensure job plans are clear and concise: Technicians should be able to complete tasks without having to stop to find additional information. To avoid this, job plans should include things like the amount of time a task is expected to take and any special tools or materials required. Instructions should be simple enough for the lowest-skilled technician to understand.

Provide feedback on completed tasks: Relevant, up-to-date data is key for making efficient maintenance plans. Once technicians complete a task, they should provide comprehensive feedback – good or bad – to the planning department via the work order system software. Simply saying "complete" or "fixed" isn't providing quality information to identify what's working and what isn't.

Make changes based on feedback: Technicians offer feedback for a reason. It's important for planners to consider all feedback to ensure work orders are improved or remain effective. It also shows technicians that their voices are being heard, which encourages them to continue providing good feedback.

For instance: below are Questions & Answers with Simmons Feed Ingredients

To get a look at how an organization implements maintenance planning and scheduling, we reached out to Tim Newman, maintenance manager at Simmons Feed Ingredients, for a short Q&A session.

2. Can you provide a snapshot of Simmons' current maintenance planning and scheduling process from start to finish?

"All work except breakdowns and filler work is planned out seven days in advance with engineering, the senior director of operations, maintenance, millwrights and electricians. We have a daily YTT (yesterday, today, tomorrow) meeting with the same group of people, except we add the shift production manager and the director. At the beginning of the week, we have meetings with operations to make sure our schedule is on point or if a production need has changed."

3. How does your team handle work order backlog?

"Most of our backlog is filler work. However, the team is not allowed to let work orders go more than four months."

4. What is the best practice for developing your own maintenance planning schedule?

"This highly depends on your CMMS system. For us, it is simple using the priority code generated by our CMMS. It tells us the assets at the most risk for failure, and we make those a priority. Then we take fill-in work from the backlog and fill in the other hours."

5. For those looking to start maintenance planning and scheduling, what tips do you have?

"Work with your production team. Get them highly involved in the process, because you cannot plan properly without their help. It takes a while to get written job plans for everything. Get your planner extra help until he has a good library of job plans."

6. What noticeable benefits/improvements have you seen from implementing a maintenance planning and scheduling process?

"We went from a six-month backlog of work to running out of jobs for the craftsmen to do, and from 10 percent planned work to 88 percent planned work. Additionally, the techs' morale has been higher, and they are striving to meet all the schedules. It helps for them to know what they are doing each day without any surprises."

Self-Check 2	Written Test

Directions: Answer all the questions listed below and write your answer on the space provided

1. Explain maintenance scheduling and planning phases(5pts)
2. Describe for equipment maintenance works activities breaking down task. (4pts)
3. What are maintenance principles? Discuss briefly. (6pts)

Note: Satisfactory rating –8 points **Unsatisfactory - below 8 points**

Answer Sheet

Name: _____ Date: _____

Score = 15pts

Rating: _____

Short Answer Questions

1. _____
   _____
2. _____
3. _____
   _____

Information Sheet-3	Allocating resources

Planning System Necessities

You need to build information management and inventory systems that let you bring all the details together fast. Turn the bullet points in this list into the standardized procedures that you follow.

- Standardized Planning Work Process
- Information Database Management System *(can be computerized)*
- Purchasing Specifications
- Inventory Management
- Job Plans and Job Procedures
- Work Order Costing
- Plant and Equipment Information
- Planning Documents and their Control
- Equipment Records and their Control
- Job History Records and their Control
- Equipment Performance Trending
- Job Performance Trending
- Track Planning Performance & Benefits
- Job, Work and Personnel Safety
- Planning System Maintenance

This module summarizes the processes Maintenance Planners need at their disposal in a maintenance planning systems. Each part of the system will need to contain full and accurate details that can be instantly put to use. These system requirements may take several months to develop as information is added from numerous and various planning tasks the Planner will conduct. In time, the system will be highly valuable to the organization and to all the planners that follow.

Each system requirement listed will need to have a written procedure explaining in detail what it contains, how it works and how to use it. Unless you have written procedures to explain the system to people they will do what they think is best and eventually the planning system will fail and become unusable because there will be so many variations. Always have a comprehensive user guide (i.e. full content and well writing things rightly).

You only have a usable system when you have solid procedures that explains it to everyone else.

Production factors and Resource Allocation

We mentioned that resources are production factors. These production factors are scarce and are considered essential for all businesses. There are four production factors. These are land, labour, capital, and entrepreneurship. These inputs are essential for producing output. At a larger scale, you could say that production factors produce all goods and services within a nation's economy. The sum of all goods and services is called the Gross Domestic Product (GDP).

Land as a production factor

Land as a production factor refers to all natural resources that are available to produce supplies. It includes untreated properties and everything that comes from the earth. This can also be non-renewable resources, such as oil and gold. Renewable resources, such as wood, are also part of the land production factor. When people change the condition or composition of land, it becomes a capital good. Crude oil is an example of a natural raw material, while petrol is a capital good as it has been refined. A grassy meadow in the Alps is a natural resource, but the adjacent farm is a capital good.

The income of this production factor, or the reward, is called land interest.

Labour as a production factor

Labour is the second production factor and encompasses all the work done by people. The value of the worker depends on their level of education, skills, and motivation. Productivity is also an important gauge for the success of labour. Productivity measures how much output is produced every hour.

The reward of the labour production factor is wages.

Capital as a production factor

Capital is the third production factor and includes all capital goods, such as machines, chemicals, equipment, and more that are used for the production of goods or services. There is a clear distinction between capital goods and consumable goods. Capital goods are intended to support production, while consumable goods are the output of the production process. Examples of capital goods are industrial or commercial buildings, or an airline's aircraft. A private jet is usually not a capital good, since it isn't used to produce a good or service.

The income that owners receive on capital goods is called interest.

Entrepreneurship as a production factor

Entrepreneurship is the final production factor that's essential for the production of goods or services. Entrepreneurship is what drives people to turn an idea into a successful and profitable business. An entrepreneur combines the other three production factors and adds his own entrepreneurship to expand the supply of goods and services.

The income entrepreneurs earn is called profit.

Scarcity

Scarcity refers to a foundational economic problem: the gap between scarce resources and the theoretically limitless needs and desires of consumers. The situation requires that people such as managers and entrepreneurs make choices about how to effectively

allocate resources to supply as many consumers as possible with their basic needs, as well as as many additional desires as possible.

Money and time are prime examples of scarce resources. Most people have too little of one, too little of the other, or too little of both. An unemployed person has lots of time, but little money. A successful manager may be able to retire a little earlier than lower-level employees, but will have had little free time during their working life. People with lots of money and lots of time are rare.

In a hypothetical world in which every resource such as water, expertise, land and food was in abundance, economists would have nothing to study. It wouldn't be necessary to decide how to allocate resources. Things work differently in the real world. Everything costs something. In other words, all resources and production factors are scarce to some degree. Most resources are therefore scarce. This means society (as well as individual businesses) has to make decisions about what to produce and how.

Frequently used resources in business

The following types or resources are often used in business. The categories are derived from the Business Model Canvas.

Physical resources

Physical resources includes assets such as buildings, machines, vehicles, systems, distribution networks, and production facilities. Retailers in particular are highly dependent on physical resources. These are often capital intensive. Wal-Mart, for example, has a huge network of stores and related logistical infrastructure. Others have extensive IT solutions, warehouses, and logistical infrastructure.

Intellectual resources

Intellectual resources include brands, patents, copyrights, proprietary knowledge, and customer databases. These are becoming increasingly important components of a strong business model. Resources for intellectual property are hard to develop, but once developed, they offer significant value, usually. Companies like Microsoft and SAP are strongly reliant on knowledge and software for intellectual property.

Human Resources

Every company needs human resources, but some businesses rely on them more than others. Human resources are vitally important in creative or knowledge-intensive industries, for example. An average pharmaceutical company tends to rely strongly on human resources like highly-trained medical professionals. The business model of a company like this has an army of scientists and competent smart people at its core.

Financial resources

Financial resources include lines of credit, cash, financial sureties, or shares. The financial resources can be used to procure the other resources discussed earlier.

Self-Check 3	Written Test

Directions: Answer all the questions listed below and write your answer on the space provided

1. What are equipment maintenance plan resources? (describe at least five of them)(5pts)
2. How do we allocate equipment maintenance planning and scheduling resources? What are the benefits? Discuss briefly with your group. (6pts)

Note: Satisfactory rating –6 points **Unsatisfactory - below 6 points**

Answer Sheet

Name: _____ Date: _____

Score = 11pts

Rating: _____

Short Answer Questions

1. _____

_____

2. _____

_____

_____

Operation Sheet-3	Breaking down Maintenance work activities

Name: _____ Date: _____
Time started: _____ Time finished: _____

Direction: breaking down maintenance work activities

Equipment, tools and materials:
Manufacturer's maintenance manual, maintenance resources, paper, pen, pencil, learning guide

Instruction:
Scoping-out a Job

1. Start with a written work request
2. Check the activities on the request are correct
3. Talk to the Requester and get their version of events
4. Go to the job site and view for yourself (or send an experienced technician)
5. List down the job as if you will be doing it
6. Use a standard maintenance work breaking down that uses keywords to trigger thoughts, enquiries and information needs
7. Collect together engineering data, drawings and equipment history to review for critical information
8. Break down the work activities?
9. Write necessary job details into the Work Order
10. Set the standards and develop the Job Procedure for the work

Information Sheet-#4	Coordinating Schedule of work activities

Maintenance Scheduling

Scheduling is the function of coordinating all of the logistical issue around the issues regarding the execution phase of the work. Scheduled of maintenance jobs basically deals with answering two questions—'Who' and 'When' of job, *i.e*., "who would do the job" and "when the job would be started and done".

Effective scheduling essentially needs realistic thinking, based on substantial data and records. Majority of scheduling work needs to occur in areas such as overhead labour hours safety and toolbox meetings, break times and training times etc. Addition of corrective and approved improvement actions as dictated by the prioritization system and operations plan etc.

Requirements for Schedulers

A scheduler should also have knowledge about job, techniques, facilities, analytical ability and judgmental courage. The scheduler must obtain knowledge/information about following ability and judgmental courage. The scheduler must obtain information about following facts, before starting his job:

1. Manpower availability by trade, location, shift, crew arrangement and permissible overtime limit etc.
2. Man hour back log on current or unfinished jobs.
3. Availability of the equipment or area where the work has to be performed.
4. Availability of proper tools, tackles, spares, consumables, structural and other required materials.
5. Availability of external manpower and their capabilities; these may be from other shops/ departments of the plant or from contractors (local, nearby, ancillary etc).
6. Availability of special equipments, jigs/fixtures, special lifting and handling facilities and cranes etc. This should also include labour and time saving devices like pneumatic hammers and excavators etc.
7. Starting date of the job; also often completion time of total job is predetermined and, in that case, resources are to be arranged accordingly.
8. Past schedules and charts (updated) if the same job has been done earlier, etc.

Maintenance Schedule Techniques

Different types of schedules are made suiting the respective job plans and different techniques are used for making and following those schedules. The first step of all

scheduling is to break the job into small measurable elements, called activities and to arrange them in logical sequences considering the preceding, concurrent and succeeding activities so that a succeeding activity should follow preceding activities and concurrent activities can start together.
Arranging these activities in different fashion makes different types of schedules. They are as follows:

1. **Weekly general schedule** is made to provide weeks worth of work for each employee in an area.
2. **Daily schedule** is developed to provide a day's work for each maintenance employee of the area.
3. **Gantt charts** are used to represent the timings of tasks required to complete a project.
4. **Bar charts** used for technical analysis which represents the relative magnitude of the values.
5. **PERT/CPM** are used to find the time required for completion of the job and helps in the allocation of resources.

A Maintenance job plan lists

List every task down on the job plan in the sequence the work will flow. For each task list all its milestone activities. If necessary invent suitable milestones so that there are benchmark performance measures against which to track progress.

This will prevent you from skipping over what seems to be simple and unimportant information that you think others should already know. Your plan is the only time that someone will think through the job in great detail, and if you miss anything important there is a very good chance that the job will go badly when it is done because the work plan does not work.

With a job plan that has tasks and activities which are no longer than 30 minute intervals you can walk out to the work face and see how the job is going. As soon as you check progress against the plan you immediately know its completion status. If at

To control a maintenance job, you need to remove the risk of things going wrong and encourage those outcomes that need to be done right. This needs a detailed job plan.

Line of Sight Map from Start to End

Task	Time minutes Best/Worst	By	Cost Best/Worst	Comments
Job: Replace Impeller on Process Chemical Pump R987				
Plan and prepare work pack	60/90	Planner	$150/$225	
Materials in Store rack Bin 3C day prior	30/45	Storeman	$1,500	Parts listed on WO M2435
Pick-up parts from Store Bin 3C	15/25	Tech	$30/40	Check all parts against WO
Local Hazard Analysis (Process Plant Pump)	15/20	Tech	$30/40	'Take 5' in Work Pack
Bunting, floor protection, rubbish bin	15/20	Tech	$30/40	Store provides in Bin 3C
Isolations (6 valves, 2 power supplies)	30/40	Operator	$60/80	Procedure I26 in Work Pack, Tags by Control Rm Super
Drain pump and piping	20/30	Op & Tech	$40/50	Acid PPE
Handover	10/15	Op & Tech	$15/20	Permit by Control Rm Super
Undo suction flange	15/20	Tech	$30/40	Procedure F03 in Work Pack
Lifetime Reli: Etc, Etc, Etc				

Figure 2.13 Detailed in full in the Planning Procedure with process flow diagrams and descriptions)

the time of your visit the job is running late—i.e. it is behind where it is scheduled to be—you know it straight away and can act to address the problem.

Analyse the repair time recorded on maintenance work orders (also known as Mean Time To Repair – MTTR). Long repair times mean equipment was not available for production. Where the average times to do a job varies greatly, an investigation and analysis of the work order times will identify problems and allow people to propose solutions for issues affecting the work. It is always useful to meet after a job goes particularly well, or particularly poorly, to learn its lessons and include them into the work procedure and then do necessary training.

Job Plan to ±10% Cost and Time Accuracy (Detailed in full in the Planning Procedure with process flow diagrams and descriptions)

A job plan lists the milestones to complete a job from start to finish. It must be detailed enough to provide a line-of-sight map/plan to get through all the work in the correct way and proper order. Each maintenance job requires planning in detail to identify possible

problems and put into place the actions and responsibilities needed to ensure the work goes right.

The way I do job plans is different because my job plans show and cost all the resources needed to turn a job request into a completed job. That includes putting down the Planner's time to collate the work pack, Operator time for isolations and handover, Storeman time to get parts together for the job, along with the time and cost needed for all manpower resources used in doing the work order.

This is the correct way to think about planning work. A business will pay for all costs. The work plan has to reflect with ±10% accuracy in costs and time how the job will be completed. It must show what needs to be done by which resources at what time and for what duration. Every action and every cost needs to be known for each and every task and activity in a job.

Providing enough details

No job will ever be done exactly on time, to the minute. It is more meaningful to know the spread of times from worst outcome to best outcome. Once you see the distribution you recognize if a task is highly variable. Those tasks with wide distributions must be looked at more closely because the size of the distribution indicates complexity and risk of unknown problems. The Planner's role is to reduce the uncertainty so that at the end of the whole job it is completed to within ±30 minutes of schedule.

Once time estimates are accurate to within ±30 minutes then budgeted job costs can be accurate to within ±10% of actual costs.

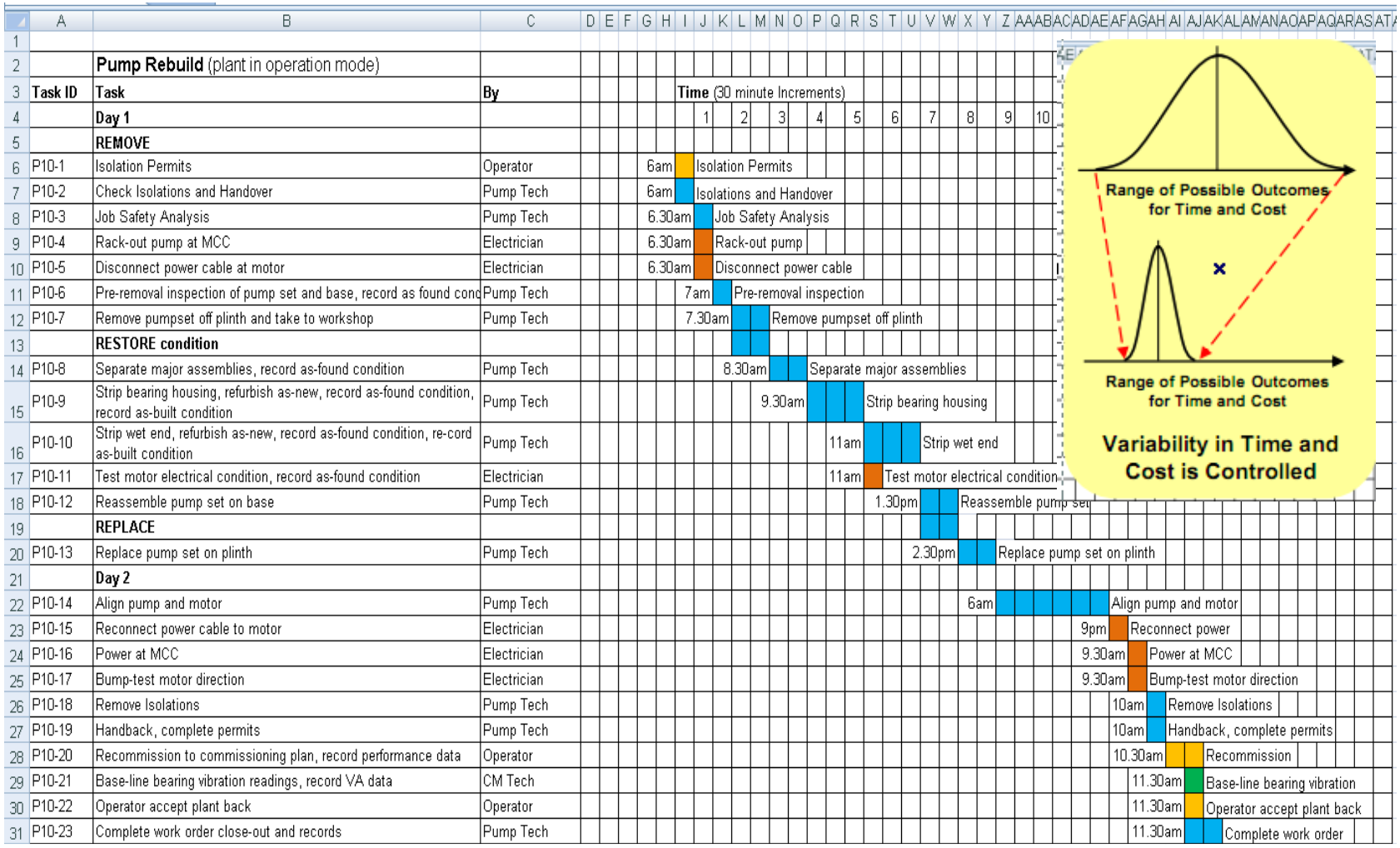


Figure 2.13 Full details of each task.

Now you know exactly how the job is meant to run, how long it will take, and when it is in trouble…

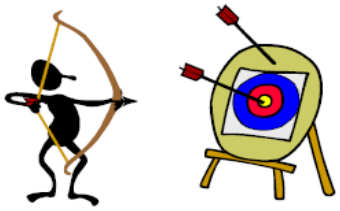
A job schedule itself is a timeline of the tasks involved in doing a job from the first minute of job preparation to the last minute of the record completion. The job schedule lists the detail necessary to track the job progress and makes clear the responsibilities of the persons involved.

The Job Schedule is laid out into three broad sections – REMOVE, RESTORE, REPLACE. The value of this is that the progress of a job can be quickly categorized. If many jobs are being tracked their progress can all be identified on a bar chart by advising the category which each job is currently at.

This is where the Maintenance Planner makes the greatest difference for their people.

Help them to do expert work done faultlessly with world-class Job Procedures full of world-class content.

*The Maintenance Planner also gets **procedures written by their people**. From now on get every job documented by the technician as they do it. Ask them to also note how they know each task they do is done right. Whether 12 tasks long or 75 tasks long… record it all into a procedure.*



Colour coding trades and resources helps to quickly appraise the workface situation and identify discrepancies. Once problems are found the role of supervision is to address the issues and get the work back on schedule.

Without better than ±30 minute accuracy on each work order completion it will be impossible to control the allocation of people to do work or to schedule work for each day with a high degree of certainty that it will be done that day. if work order time estimates are unreliable then the scheduling will always be wrong and no one will trust or believe what is on the schedule.

A Maintenance Planner cannot estimate jobs with ±30 minutes completion accuracy unless they know what each task in the job entails. Planners who do not know the equipment being worked on, and/or the job that they are planning, must get advice from those people that can deliver ±30 minutes job completion accuracy. That often means the crew supervisor and/or the maintainer doing the job will need to be asked by the Planner to assistance in planning the work.

Self-Check 4	Written Test

Directions: Answer all the questions listed below and write your answer on the space provided

1. Discuss on methods of coordinating schedule work activities.(4pts)
2. Why job listing, detailing and sorting and using time lines is important in maintenance scheduling? (5pts)

Note: Satisfactory rating –5 points **Unsatisfactory - below 5 points**

Answer Sheet

Name: _____ Date: _____

Score = 9pts

Rating: _____

Short Answer Questions

- _____
  _____
  _____
- _____
  _____
  _____
  _____

Operation Sheet-4	Coordinating Schedule of work activities

Name: _____ Date: _____
Time started: _____ Time finished: _____

Direction: Coordinate Schedule of work activities

Equipment, tools and materials:
Manufacturer's maintenance manual, Procedures, paper, pen, pencil, learning guide

Instruction:
Coordinating-out a work activities

11. Start with a written work request
12. Check the details on the request are correct
13. Talk to the Requester and get their version of events
14. Go to the job site and view for yourself (or send an experienced technician)
15. Coordinate the job as if you will be doing it
16. Use a standard coordinating method that uses keywords to trigger thoughts, enquiries and information needs
17. Collect together engineering data, drawings and equipment history to review for critical information
18. Is there Opportunity Maintenance to be done?
19. Write necessary work activities details into the Work Order
20. Set the standards and develop the maintenance tasks Procedure for the work

To scope a job means to investigate and consider how it will be done safely and timely. Scope-out is the responsibility of the Planner and ideally the Planner does the scope, which means they need to be highly knowledgeable of the equipment construction and the production process it is used in. If the Planner cannot do the scope then someone else knowledgeable in the plant and process does the scope-out on their behalf.

Information Sheet-5	Preparing plan

Planning Description

Planning is only useful if the plan is followed. The plan is only useful if it delivers the necessary results and outcomes. A good plan makes it clear exactly what actions to do, and how to do them, so that they will produce the desired results. All that information is in the work pack that the maintenance planner is responsible to produce.

A Maintenance Planner needs a systematic approach so they can quickly compile the correct parts, tools and information needed to do the maintenance to high quality standards. This necessitates the Planner to develop specific information management systems for the quick identification and collation of large amounts of engineering facts, equipment history, job procedures, work standards, time estimates and cost estimates while ensuring the maintenance strategies are actually put into place.

Every company needs planning systems if they want to maximize performance and results from using their resources. The Maintenance Planner owns and is responsible for the maintenance planning system which they use to build and produce their 'product' a work pack for every job.

When the planning system is used the work packs are complete, correct and highly reliable for delivering the quality work needed for world class plant availability.

What is a Maintenance Planner expected to do?

Maintenance planning has two connotations. The first is of a strategic nature involving the selection of maintenance strategies from among alternative courses of action, for the enterprise as a whole. It is, in effect, deciding in advance what maintenance types to use to manage the various operating risks of the organization. Planning at this level assumes that rational processes can be used to nominate resources and define appropriate future action which will produce the desired outcomes (www.unisa.edu.au/pas/qap/planning/glossary.asp). To me this is what the Maintenance Manager is responsible to do.

The second view of maintenance planning is tactical in nature. It is takes a project management perspective and is the process of establishing the sequence and relationship of a series of actions and requirements prior to maintenance work commencing, along with procuring and providing the parts and resources

needed to deliver the work plan. This is the meaning of maintenance planning that I use when I talk about a maintenance planners duties.

This definition ties-in very well with the primary purpose of maintenance planning, which is to maximize tool time(Keep of the maintenance the maintenance guys on the move straight from crew. one job to the next.) This tactical work connects to the strategic work of the first definition by ensuring that the maintenance work performed delivers the organizations desired outcomes. Hence the secondary purpose of maintenance planning is to ensure the trades do quality work by providing all the parts, tools, information, procedures and check testing needed to deliver a quality job.

Scheduling is not planning. It is the setting of order and time for planned events. Scheduling involves taking decisions regarding the allocation of available capacity or resources (equipment, labour and space) to jobs, activities and tasks over time. Scheduling thus results in a time-phased plan, or schedule of activities. The schedule indicates what is to be done, when, by whom and with what equipment. Scheduling seeks to achieve several conflicting objectives: high efficiency, low inventories and good customer service

Maintenance Planning Horizons

The long-term maintenance plan cascaded down into the annual plan, which in turn is separated into the monthly plan. The monthly planned work feeds into the weekly schedule, which is set and is not altered.

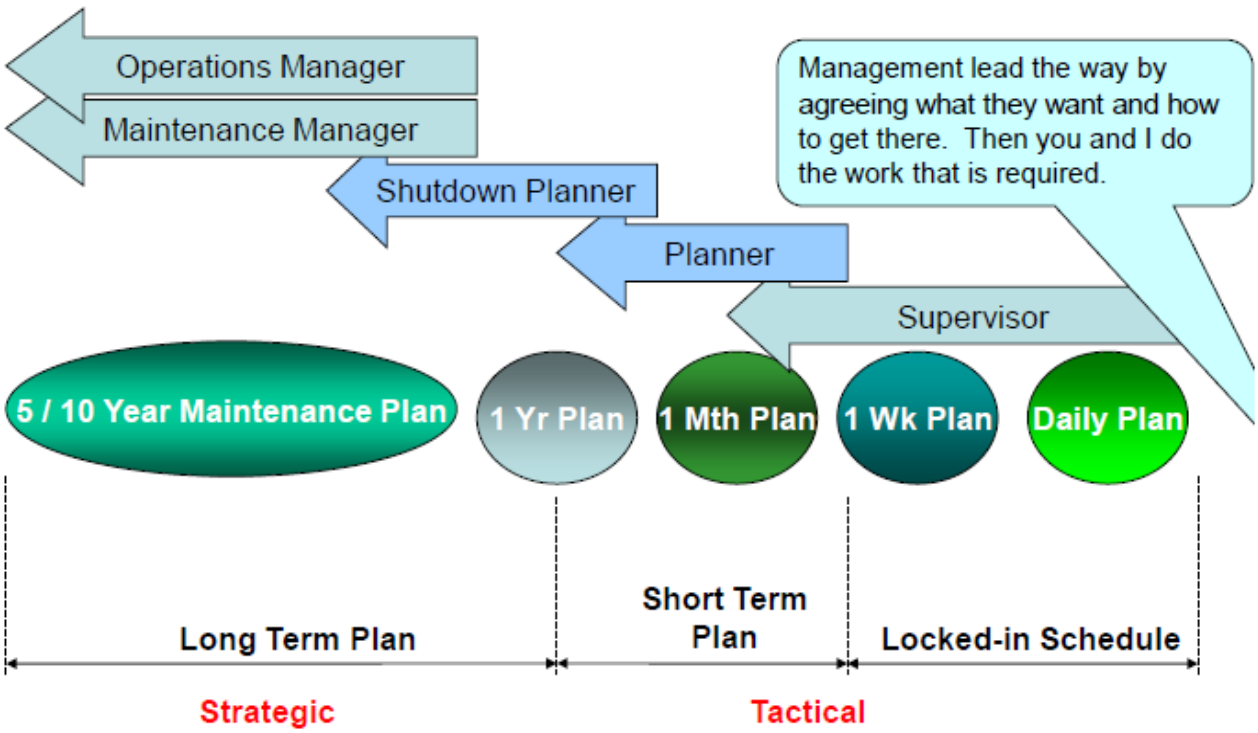


Figure 2.7 Maintenance planning Horizon

The module also shows the focus and time jurisdictions that people in the maintenance functions are responsible for.

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Self-Check 5	Written Test

Directions: Answer all the questions listed below and write your answer on the space provided

1. What are purposes of equipment maintenance planning? (3pts)
2. Discuss on the Maintenance planning horizon diagram? (6pts)

Note: Satisfactory rating –5 points **Unsatisfactory - below 5 points**

Answer Sheet

Name: _____ Date: _____

Score = 9pts

Rating: _____

Short Answer Questions

1. _____
   _____
   _____
2. _____
   _____
   _____
3. _____
   _____
   _____

Operation Sheet-5	Preparing plan

Name: _____ Date: _____
Time started: _____ Time finished: _____

Direction: Prepare plan

Equipment, tools and materials:
Manufacturer's maintenance manual, Procedures, paper, pen, pencil, learning guide

Instruction:

Information Sheet-6	Identifying work methods and practices

Maintenance activities fall into three general categories:

- **Routine Maintenance-**Activities that are conducted while equipment and systems are in service. These activities are predictable and can be scheduled and budgeted. Generally, these are the activities scheduled on a time-based or meter-based schedule derived from preventive or predictive maintenance strategies. Some examples are visual inspections, cleaning, functional tests, and measurement of operating quantities, lubrication, oil tests, and governor maintenance.

- **Maintenance Testing-**Activities that involve using test equipment to assess condition in an offline state. These activities are predictable and can be scheduled and budgeted. They may be scheduled on a time or meter basis but may be planned to coincide with scheduled equipment outages. Since these activities are predictable, some offices consider them “routine maintenance” or “preventive maintenance.” Some examples are governor alignments and balanced and unbalanced gate testing.

- **Diagnostic Testing –** Activities that involve using test equipment to assess the condition of equipment after unusual events, such as equipment failure/ repair/replacement or when equipment deterioration is suspected. These activities are not predictable and cannot be scheduled because they are required after a forced outage. Each office must budget for these events. Some examples are governor troubleshooting, unit balancing, and vibration testing.

Maintenance Planning and Scheduling Tools

Many people consider planning to be a maintenance tool. While not solving all maintenance issues by itself, planning integrates with other elements and helps synchronize all aspects of maintenance. Let's take a look at some other tools that work together with maintenance planning and scheduling.

Work order systems: A work order system is one of the most powerful tools a maintenance team can use. It acts as centralized, automated way to request and record work done within an organization. Work order systems are important because of the amount of work maintenance supervisors need to track. If a supervisor is responsible for eight technicians, each of those technicians might complete two or three tasks a day, totaling around 40 to 60 assignments in a five-day workweek. Work order systems give crews and supervisors a single method of communication. In addition to an integrated communication platform, a work

order system lets supervisors organize workloads, assign tasks and track completion.

Equipment history and data: The equipment's history and data should also be considered a tool because this information helps you figure out the proper maintenance required based on up-to-date or even real-time data, as opposed to relying on memory or experimentation. Recording maintenance data over time essentially gives you a photo album of the life of the machine.

Maintenance metrics: Maintenance metrics refer to the measurements and scores of maintenance activities or results. They include the selecting, collecting, analyzing and presenting of maintenance data. The amount of work orders in your backlog is a common example of a maintenance metric. Metrics can help with everything from clarifying situations to planning for key performance indicators (KPIs), coverage, work type, schedules, compliance and backlog work hours.

Maintenance Planning and Scheduling Tips

Effective maintenance planning and scheduling revolves around prioritizing and organizing tasks so they are completed as efficiently as possible. To do this, consider the following:

Choose a good maintenance planner: As briefly touched on earlier, effective maintenance planners typically are crew technicians with seniority, have a good rapport with coworkers and know the plant well. They should be highly skilled and have a solid knowledge base of maintenance planning principles and practices.

Properly train the planner: Be sure the maintenance planners know how to use your plant's work order software, including pulling data and reports, so they will have the appropriate knowledge of equipment maintenance history.

Understand the difference between planning and scheduling: This was discussed earlier, but it's important to reiterate that planning and scheduling should be kept separate. Planning involves figuring out which maintenance tasks need to be performed, how they will be completed, and which parts and tools are required. Scheduling involves determining when you're going to complete a task. Planners should plan the work but never schedule it or complete the tasks themselves.

Ensure job plans are clear and concise: Technicians should be able to complete tasks without having to stop to find additional information. To avoid this, job plans should include things like the amount of time a task is expected to take and any special tools or materials required. Instructions should be simple enough for the lowest-skilled technician to understand.

Modern Scientific Maintenance Methods

1. **Reliability centered maintenance:** Reliability centered maintenance (RCM) is defined as “a process used to determine the maintenance requirements of any physical asset in its operating context”.

Basically, RCM methodology deals with some key issues not dealt with by other maintenance programs. It recognizes that all equipment in a facility is not of equal importance to either the process or facility safety. It recognizes that equipment design and operation differs and that different equipment will have a higher probability to undergo failures from different degradation mechanisms than others. It also approaches the structuring of a maintenance program recognizing that a facility does not have unlimited financial and personnel resources and that the use of both need to be prioritized and optimized. In a nutshell, RCM is a systematic approach to evaluate a facility’s equipment and resources to best mate the two and result in a high degree of facility reliability and cost-effectiveness.

RCM is highly reliant on predictive maintenance but also recognizes that maintenance activities on equipment that is inexpensive and unimportant to facility reliability may best be left to a reactive maintenance approach. The following maintenance program breakdowns of continually top-performing facilities would echo the RCM approach to utilize all available maintenance approaches with the predominant methodology being predictive.

- <10% Reactive
- 25% to 35% Preventive
- 45% to 55% Predictive.

Because RCM is so heavily weighted in utilization of predictive maintenance technologies, its program advantages and disadvantages mirror those of predictive maintenance. In addition to these advantages, RCM will allow a facility to more closely match resources to needs while improving reliability and decreasing cost.

Advantages

a) Can be the most efficient maintenance program.
b) Lower costs by eliminating unnecessary maintenance or overhauls. (*c*) Minimize frequency of overhauls.
c) Reduced probability of sudden equipment failures.
d) Able to focus maintenance activities on critical components. (*f*) Increased component reliability.
e) (*g*) Incorporates root cause analysis.

Disadvantages

(a) Can have significant startup cost, training, equipment, etc.

(b) Savings potential not readily seen by management.

How to Initiate Reliability Centered Maintenance?

The road from a purely reactive program to a RCM program is not an easy one. The following is a list of some basic steps that will help to get moving down this path.

1. Develop a master equipment list identifying the equipment in your facility.
2. Prioritize the listed components based on importance to process.
3. Assign components into logical groupings.
4. Determine the type and number of maintenance activities required and periodicity using: l Manufacturer technical manuals
   - Machinery history
   - Root cause analysis findings— Why did it fail?
   - Good engineering judgment
1. Assess the size of maintenance staff.
2. Identify tasks that may be performed by operations maintenance personnel.
3. Analyze equipment failure modes and effects.
4. Identify effective maintenance tasks or mitigation strategies.

2. Six Sigma Maintenance

It is the application of six sigma principles in maintenance. Six sigma is a maintenance process that focuses on reducing the variation in business production processes. By reducing variation, a business can achieve tighter control over its operational systems, increasing their cost effectiveness and encouraging productivity breakthrough.

Six sigma is a term created at Motorola to describe the goal and process used to achieve breakthrough levels of quality improvement. Sigma is the Greek symbol used by statisticians to refer to the six standard deviations. The term six sigma refers to a measure of process variation (six standard deviations) that translates into an error or defect rate of 3.4 parts per million. To achieve quality performance of six sigma level, special sets of quality improvement methodologies and statistical tools developed. These improvement methods and statistical tools are taught to a small group of workmen known as six sigma champions who are assigned full-time responsibility to define, measure, analyze, improve and control process quality. They also facilitate the improvement process by removing the organizational roadblocks encountered. Six sigma methodologies improve any existing business process by constantly reviewing

and re-tuning the process. To achieve this, six sigma uses a methodology known as DMAIC (Define opportunities, Measure performance, Analyse opportunity, Improve performance, Control performance). This six sigma process is also called DMAIC process.

Six sigma relies heavily on statistical techniques to reduce failures and it incorporates the basic principles and techniques used in Business, Statistics, and Engineering. Six sigma methodologies can also be used to create a brand new business process from ground up using design for six sigma principles.

1. Six Sigma Maintenance Process

The steps of six sigma maintenance are same as DMAIC process. To apply six sigma in maintenance, the work groups that have a good understanding of preventive maintenance techniques in addition to a strong leadership commitment. Six sigma helps in two principal inputs to the maintenance cost equation: Reduce or eliminate the need to do maintenance (reliability of equipment), and improve the effectiveness of the resources needed to accomplish maintenance. Following are the steps involved in six sigma maintenance process.

a. Define

This step involves determining benchmarks, determining availability and reliability requirements, getting customer commitments and mapping the flow process.

b. Measure

This step involves development of failure measurement techniques and tools, data collection process, compilation and display of data.

c. Analysis

This step involves checking and verifying the data and drawing conclusions from data. It also involves determining improvement opportunities, finding root causes and map causes.

d. Improve

This step involves creating model equipment and maintenance process, total maintenance plan and schedule and implementing those plans and schedule.

e. Control

This step involves monitoring the improved programme. Monitor improves performance and assesses effectiveness and will make necessary adjustments for the deviation if exists.

3. Enterprise Asset Management (EAM)

Enterprise asset management is an information management system that connects all departments and disciplines within a company making them an integrated unit. EAM is also referred as computerised maintenance management system. It is the organized and systematic tracking of an organization's physical assets *i.e*., its plant, equipment and facilities. EAM aims at best utilisation of its physical assets. It ensures generation of quality data and timely flow of required

data throughout the organization. EAM reduces paper work, improves the quality, quantity and timeliness of the information and provides information to technicians at the point of performance and gives workers access to job specific information at the work site.

4. Lean Maintenance

Lean maintenance is the application of lean principle in maintenance environments. Lean system recognises seven forms of waste in maintenance. They are over production, waiting, transportation, process waste, inventory, waste motion and defects. In lean maintenance, these wastes are identified and efforts are made for the continuous improvement in process by eliminating the wastes**.** Thus, lean maintenance leads to maximise yield, productivity and profitability.

Lean maintenance is basically equipment reliability focussed and reduces need for maintenance troubleshooting and repairs. Lean maintenance protects equipments and system from the route causes of malfunctions, failures and downtime stress. From the sources of waste uptime can be improved and cost can be lowered for maintenance.

5. Computer Aided Maintenance

For effective discharge of the maintenance function, a well designed information system is an essential tool. Such systems serve as effective decision support tools in the maintenance planning and execution. For optimal maintenance scheduling, large volume of data pertaining to men, money and equipment is required to be handled. This is a difficult task to be performed manually. For a planned and advanced maintenance system use of computers is essential. Here programmes are prepared to have an available inputs processed by the computer. Such a computer based system can be used as and when required for effective performance of the maintenance tasks. There are wide varieties of software package available in the market for different types of maintenance systems.

A computerised maintenance system includes the following aspects:

- Development of a database
- Analysis of past records if available
- Development of maintenance schedules
- Availability of maintenance materials
- Feedback control system
- Project management.

Following are some computer based maintenance systems which can be implemented:

Job card system: It is essential to prepare a job card for each component to record the maintenance work carried out or the work to be done. Job card shows

the plant code, equipment code, the job code, the nature of the jobs, the start time and finishing time of the card, man-hour spent and etc. The use of computers facilitates the issue of job cards, recording of job history and control of manpower.

Spare part life monitoring system: Under this system, information about a spare part such as its description, anticipated life and date of its installation in equipment is recorded. As and when a particular sparepart is replaced during breakdown failures or scheduled maintenance, the updating of this information is done in their respective files stored in the computer. This helps to prepare the following reports:

- Spares repeatability in various machines indicating the performance of such spare parts.
- Comparisons of the actual life with the estimated life of the spare parts.

Spare parts tracking system: In most of the cases maximum time is consumed in procurement of spare parts. The total time required to rectify the breakdown is summation of the time to identify the cause of the failure, time to determine the requirements of spare parts, time to procure spare parts and the time to rectify the failure. In a computerised system, the spare part tracking system is beneficial in getting required material at the earliest. A spare part file is created that contains the information about the material code, spare part identification number, the assembly or sub-assembly number and the place where the spare part is used. This helps in knowing the current position about a particular spare part and facilitates timely requirement for future demands.

Self-Check 6	Written Test

Directions: Answer all the questions listed below and write your answer on the space provided

1. What are the jobs method in maintenance planning(5pts)
2. What are maintenance planning and scheduling tips? (4pts)

Note: Satisfactory rating –5 points **Unsatisfactory - below 5 points**

Answer Sheet

Name: _____ Date: _____

Score = 9pts

Rating: _____

Short Answer Questions

3. _____
   _____
   _____
4. _____
   _____
   _____
   _____

Operation Sheet-6	Identifying work methods and practices

Name: _____ Date: _____
Time started: _____ Time finished: _____

Direction: Identify work methods and practices

Equipment, tools and materials:
Manufacturer's maintenance manual, Procedures, paper, pen, pencil, learning guide

Instruction:

Information Sheet #-7	Identifying Monitoring and performance evaluation

Measure results and process adherence

Measuring, Measuring, Measuring

It is very difficult to visually appreciate how well a process is working unless you put some meaningful Key Performance Indicators in place. The idea of these is not to chase the "Green" compliant result but rather focus on the barriers to process adoption that are preventing the achievement of good outcomes. Often there will be circumstances that will see a KPI measure go backwards rather than the desired direction but it will alert all concerned that there is an issue that needs to be fixed in order to move forward.

Root Cause Analysis (RCA) and similar techniques can then be utilised to analyse the problem and pinpoint the issue. This may sometimes require a business case to Management for release of funds and labour to fix it. Without the accompanying measurement data it will be a very hard sell!

Once a process has been proven to work and the group is achieving the "green" result it is a great time to move onto a new measurement. There is a very real risk of complacency and you can think you are doing well but a deeper dive into the process will often show the opposite.

Keep challenging the status quo of KPI measures and if they are not meaningful or relevant why are we using them?

Self-Check 7	Written Test

Directions: Answer all the questions listed below and write your answer on the space provided

1. What is the benefits of measuring in maintenance planning? (4pts)
2. Discuss on PDCA cycle? (5pts)

Note: Satisfactory rating –5 points **Unsatisfactory - below 5points**

Answer Sheet

Name: _____ Date:_____

Short Answer Questions

Score = 9pts

Rating: _____

1. _____
   _____
   _____
2. _____
   _____
   _____

Information Sheet-#8	Determining and Agreeing upon Feedback mechanism

Provide feedback on completed tasks

Relevant, up-to-date data is key for making efficient maintenance plans. Once technicians complete a task, they should provide comprehensive feedback – good or bad – to the planning department via the work order system software. Simply saying "complete" or "fixed" isn't providing quality information to identify what's working and what isn't.

Make changes based on feedback

Technicians offer feedback for a reason. It's important for planners to consider all feedback to ensure work orders are improved or remain effective. It also shows technicians that their voices are being heard, which encourages them to continue providing good feedback.

Self-Check 8	Written Test

Directions: Answer all the questions listed below and write your answer on the space provided

1. Once the technician completes the task what they should do? (2pts)
2. What is the importance of feed back? Explain briefly its mechanism? (5pts)

Note: Satisfactory rating –4 points **Unsatisfactory – below45points**

Answer Sheet

Name: _____Date: _____

Short Answer Questions

Score = 7pts

Rating: _____

1. _____
   _____
   _____
   _____
2. _____
   _____
   _____

Information Sheet-9	Reviewing, finalizing and presenting plan

Concept of Reliability in Maintenance

Reliability is the probability of survival under a given operating environment. For example, the time between consecutive failures of a refrigerator where continuous working is required is a measure of its reliability. If this time is more, the product is said to have high reliability.

In a electromechanical industry, generally the light is maintained at a minimum specified level. To achieve this, let us assume that there are 100 bulbs in use and the guaranteed life time of these bulbs is 5000 hours. If we collect statistics about the number of bulbs survived till 5000 hours, we can compute the reliability of the bulbs. In this case,

$$\text{Reliability} = \text{Failurerate} = \frac{\text{Number of bulbs survived till the specified time limit}}{\text{Number of bulbs used}}$$

If the number of bulbs survived till 5000 hours is 80, then we can say that the reliability is 0.8 (*i.e.*, 80/100)

The reliability of common industry, water technology, and power plant are some of the interesting examples for demonstrating the reliability concept. In these cases, a failure will lead to heavy penalty.

The concept of reliability can be matched with systems concept. Generally, products/equipments will have many components which may function with serial relationship or parallel relationship. So, the individual component's reliability affects the reliability of the product. Hence, enough attention must be given at the design, stage such that the product's reliability is maximized. The cost of maintenance is also to be considered along with the reliability while improving it.

The general failure pattern of any product is given in Fig. 2.16. This is called bath-tub curve. In Fig. 2.16, there will be large number of failures in the early period. This is mainly due to non-alignment while shipping the product, or misfit while manufacturing (assembling), or very high initial friction between moving parts, etc.

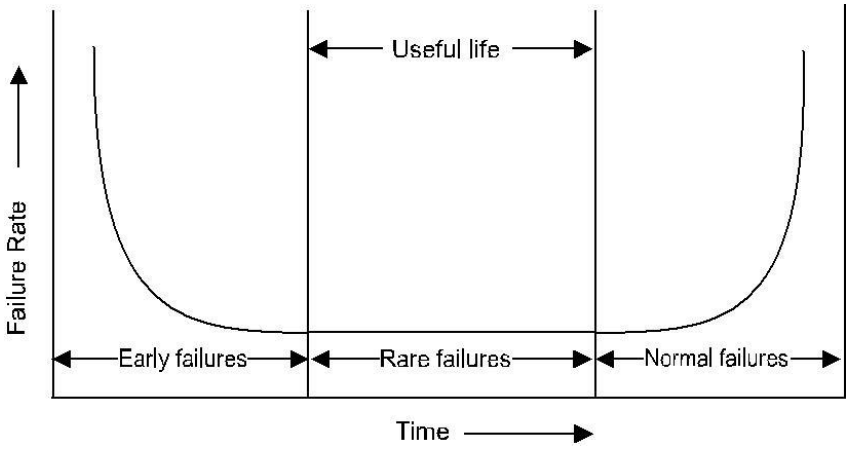


Fig. 2.16 *Product failure rate*

Reliability Improvement

The reliability of a system/product depends on many factors. So, we should concentrate at the grass root level to improve product's reliability.

Some of the ways of improving systems reliability are listed below:

- Improved design of components
- Simplification of product structure
- Usage of better production equipments
- Better quality standards
- Better testing standards
- Sufficient number of standby units
- Usage of preventive maintenance if necessary at appropriate time.

Self-Check 9	Written Test

Directions: Answer all the questions listed below and write your answer on the space provided

1. Why we need to review maintenance plan? (2pts)
2. What is reliability? (3pts)
3. What effect of failure? (2pts)

Note: Satisfactory rating –4 points **Unsatisfactory – below45points**

Answer Sheet

Name: _____

Date: _____

Short Answer Questions

Score = 7pts

Rating: _____

1. _____
   _____
2. _____
   _____
3. _____
   _____

Information Sheet-10	Evaluating Recommended changes to the plan

Forward schedule to an agreed period

From the forward log of work there will be an expectation from every organisation that you plan ahead to an agreed period. Some very mature organisations with reliable equipment and processes will demand a longer forecast period – in this case up to 12 weeks, or even longer for major shutdown work. However, this forecast period could be as little as 2 weeks. Regardless of the length of the forecast period the aim is to have fully planned and resourced tasks that can be executed during that period.

Getting all of the work in forward log fully planned and scheduled is the nirvana state as it will reduce the effort required to keep on top of this each week.

As an example: We have fully planned all work in forward log out to 8 weeks and have resourced the period to 85% of labour utilisation (to allow for breakdown work). In theory the planner will only need to keep up with new work that is generated during the week to keep the plan up to date. There will be a need to manipulate scheduled execution dates as emergent work is fitted into the forecast period. This will highlight the need for accurate priorities to be assigned to tasks. Overall, however, planner workload will diminish allowing more time to be spent on continuous improvement items.

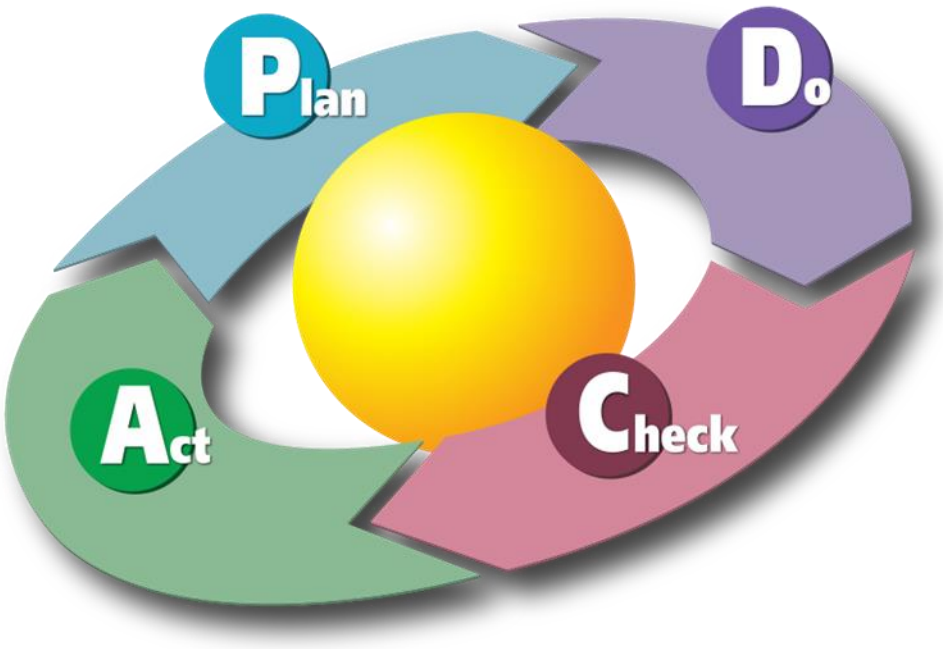
One thing to remember is that if your forecast is for over 12 weeks of work at very high labour utilisation this can indicate that the forecast workload is out of balance with the labour available for its execution. If this occurs the planner will spend a lot of time rescheduling work orders and deferring maintenance work to the point that it is unacceptable to the business. Additional maintenance labour may be required to bring future workload back to a manageable level.

Analyse completed work and continuously improve

This area is where business can get the “best bang for their buck” but is often hampered by time constraints on planners as they struggle to meet schedule deadlines.

As part of the Continuous Improvement Process, maintenance planners need to analyse the work performed with the responsible Supervisor(s) and quickly make changes to any items that need attention. Performing these changes will ensure that tasks will run smoothly when executed next time.

Why do we do this? A definition of insanity is to do the same thing over and over again expecting a different result! Items that may need changing would be:



Task Duration

Materials or quantity of materials

Work steps out of sequence

Labour requirements under/over resourced

3rd Part requirements: scaffold, hire equipment, cranes, extra labour

Master data changes to strategies and plans

Self-Check 10	Written Test

Directions: Answer all the questions listed below and write your answer on the space provided

1. Draw continuous improvement process? (2pts)
2. Discuss on each steps of continuous improvement cycle? (3pts)

Note: Satisfactory rating –3 points **Unsatisfactory – below 3points**

Answer Sheet

Name: _____ Date: _____

Score = 5pts

Rating: _____

Short Answer Questions

1. _____
   _____
2. _____
   _____

Operation Sheet-10	Evaluating Recommended changes to the plan

Name: _____ Date: _____

Time started: _____ Time finished: _____

Direction: Evaluating Recommended changes to the plan

Equipment, tools and materials:

Manufacturer's maintenance manual, Procedures, paper, pen, pencil, learning guide

Instruction:

1. Select and identify recommended changes to the plan
2. Prepare/collect evaluation form and procedures
3. Evaluate the recommended changes to the plan

Information Sheet-11	Finalizing plan

Incorporation into Existing Planning Mechanisms

Another important mechanism that is highly effective and low-cost is incorporation of the hazard mitigation plan recommendations and their underlying principles into other City plans and mechanisms. Where possible, plan participants will use existing plans and/or programs to implement hazard mitigation actions. Mitigation is most successful when it is incorporated into the day-to-day functions and priorities of government and development. This point is re-emphasized here. This plan update builds upon the momentum developed through previous and related planning efforts and mitigation programs and recommends implementing actions, where possible, through these other program mechanisms. These existing mechanisms include:

- Company general and master plans
- City Emergency Operations Plan
- City ordinances
- Flood/stormwater management/master plans
- Capital improvement plans and budgets
- Other plans, regulations, and practices with a mitigation focus

HMPC members involved in these other planning mechanisms will be responsible for integrating the findings and recommendations of this plan update with these other plans, programs, etc, as appropriate. As described in Section 7.1, incorporation into existing planning mechanisms will be done through the routine actions of:

- Monitoring other planning/program agendas
- Attending other planning/program meetings
- Participating in other planning processes
- Monitoring community budget meetings for other community program opportunities

The successful implementation of this mitigation strategy will require constant and vigilant review of existing plans and programs for coordination and multi-objective opportunities that promote a safe, sustainable community. Efforts should continuously be made to monitor the progress of mitigation actions implemented through these other planning mechanisms and, where appropriate, their priority actions should be incorporated into updates of this Local Hazard Mitigation Plan.

Self-Check 11	Written Test

Directions: Answer all the questions listed below and write your answer on the space provided

1. What are the considerations to be undertaken while finalizing plan? (5)

Note: Satisfactory rating –3 points **Unsatisfactory – below 3points**

Answer Sheet

Name: _____ Date: _____

Short Answer Questions

Score = 5pts

Rating: _____

1. _____
   _____
   _____
   ____

Information Sheet-12	Delivering Finalized plan

Self-Check 12	Written Test

Directions: Answer all the questions listed below and write your answer on the space provided

1. _____

Answer Sheet

Name: _____ Date:

Score = 5pts

Rating: _____

Short Answer Questions

1. _____

_____

Operation Sheet-12	Delivering Finalized plan

Name: _____ Date: _____

Time started: _____ Time finished: _____

Direction: Delivering Finalized plan

Equipment, tools and materials:

Manufacturer's maintenance manual, Procedures, paper, pen, pencil, learning guide

Instruction:

LAP Test	**Carry out** Schedule Work Activities and Finalize Maintenance Plan

Name: _____ Date: _____

Time started: _____ Time finished: _____

Direction: complete the following job and report to your instructor

Job 1: Carry out complete Engine Inspection task.

Instruction Sheet	Learning Guide #03: Check new and used equipment

This learning guide is developed to provide you the necessary information regarding the following content coverage and topics

- Making sure Materials and equipment
- Monitoring Availability of new and used equipments
- Inspecting Stock levels and order spare parts/consumables
- Maintaining Communication between operators, company and suppliers
- Checking Manufacturer's manuals/company procedures
- Organizing Equipment maintenance and service

This guide will also assist you to attain the learning outcome stated in the cover page. Specifically, upon completion of this Learning Guide, you will be able to –

- Make sure Materials and equipment
- Monitor Availability of new and used equipments
- Inspect Stock levels and order spare parts/consumables
- Maintain Communication between operators, company and suppliers
- Check Manufacturer's manuals/company procedures
- Organize Equipment maintenance and service

Learning Instructions:

1. Read the specific objectives of this Learning Guide.
2. Follow the instructions described in number 3 to 20.
3. Read the information written in the “Information Sheets 1”. Try to understand what are being discussed. Ask you Instructor for assistance if you have hard time understanding them.
4. Accomplish the “Self-check 1” in page __.
5. Ask from your Instructor the key to correction (key answers) or you can request your Instructor to correct your work. (You are to get the key answer only after you finished answering the Self-check 1).

6. If you earned a satisfactory evaluation proceed to “Information Sheet 2”. However, if your rating is unsatisfactory, see your Instructor for further instructions or go back to Learning Activity #1
7. Submit your accomplished Self-check. This will form part of your training portfolio.
8. Read the information written in the “Information Sheet 2”. Try to understand what are being discussed. Ask you Instructor for assistance if you have hard time understanding them.
9. Accomplish the “Self-check 2” in page __.
10. Ask from your Instructor the key to correction (key answers) or you can request your Instructor to correct your work. (You are to get the key answer only after you finished answering the Self-check 2).
11. Read the information written in the “Information Sheets 3 and 4”. Try to understand what are being discussed. Ask you Instructor for assistance if you have hard time understanding them.
12. Accomplish the “Self-check 3” in page __.
13. Ask from your Instructor the key to correction (key answers) or you can request your Instructor to correct your work. (You are to get the key answer only after you finished answering the Self-check 3).
14. If you earned a satisfactory evaluation proceed to “Operation Sheet 1” in page _. However, if your rating is unsatisfactory, see your Instructor for further instructions or go back to for each Learning Activities.

Information Sheet#1	Making sure Materials and equipment

Following Corporate Purchasing Procedures

- Companies have legal obligations, such as taxation laws, accounting standards and liquidity requirements, that they need to meet
- Companies control their money by installing necessary accounting and purchasing practices that are to be followed
- Usually two or three quotes are required unless there is a contract with a preferred Supplier (using a single supplier causes less problems)
- Typically there is a hierarchy of expenditure authorisation
- Before purchasing ensure the cost estimate is ± 10% accurate. Identify all costs… no surprises…

Parts, services and materials purchasing is a common activity that a Maintenance Planner does.

Typically they follow buying rules put in place by the Accounts Department to ensure the company meets its legal, commercial and taxation requirements. Often the rules require multiple quotes, which is not ideal for streamlining the supply of maintenance parts, materials and services. But because the Maintenance Planner works in a regulated company environment they need to follow the set rules.

Examples of maintenance plan-EQUIPMENT AND MATERIALS

- Material for Installation of new pipe line
- Plumbing Tools
- Set of Wrenches
- Pneumatic Jackhammer and Compressor
- Dewatering Pump
- Concrete Cutter
- Electric Concrete Breaker
- Shovel
- Crowbar
- Rammer
- Boring Tools
- Mallet
- Concrete Mixer
- Valve keys
- Portable Hydro testing Machine
- Portable Edger
- Portable Generator

A tool room consists of a special area where technicians can borrow tools that would not ordinarily be found in their tool boxes. From a crane to a come-a-long, the right special tools make technicians more effective. Certain tools should be managed. For example, a tool room could properly store ladders and have them ready for use. Depending on the size of the maintenance operation and the complexity of the tools, the tool room increases in complexity. For small groups, having one or two certain technicians responsible for the tool room in addition to their other duties might be fine. The tool room might simply be a storage room where all technicians have free access. Larger maintenance forces might benefit from having a restricted access or a check out counter arrangement. Some tool rooms might benefit from having a full staff with a

dediated manager. The staff issues the tools and manages the maintenance of the tools themselves.

The plant maintenance force benefits when a knowledgeable, experienced maintenance technician works in the tool room. Many times a technician will come to the counter and describe a problem. The tool room attendant can suggest the proper tool. One oil well service company places the job of tool room attendant above the field technician in the company's line of promotion. The tool room attendant knows what tools technicians need, why they are important, how they work, and how to keep them working.
In addition to a central tool room, certain areas of the plant may have specialized tool needs. The plant might benefit from having certain tools remotely kept near those areas. A secure shed could contain specialized turbine tools on the turbine deck of a steam plant. Such a secure area may have a counter with an attendant and open only during certain turbine work. Otherwise, limited access would be available to supervisors or certain technicians. A particular job on a burner deck might require specialized tools not used anywhere else in the plant. It would make sense to have the burner deck tools located in a tool box on the burner deck ready for use.

Equipment Tags
Many companies exist that can deliver generic or customized equipment tag numbers on many different types of tag material. Many plants find customized tags consisting of engraving on plastic tags suitable.
These tags can be obtained from local trophy shops. A plant would give the trophy shop a list of the tag numbers and equipment names along with the size tag desired for each. The plant might specify the need for having a 3/16-in hole drilled in the top right corner or both top corners to allow hanging with wire. The plant probably would elect to drill holes themselves later when attaching the tags. The plant might want to attach the tags without holes and wires by means of common silicone adhesive caulk. The plant should specify color tags. Appendix K, Equipment Schematics and Tagging, further discusses selection and utilization.

Self-Check 1	Written Test

Directions: Answer all the questions listed below and write your answer on the space provided

1. What corporate purchasing procedure? (2pts)
2. List down at least six maintenance plan equipment and materials? (3pts)
3. What is the purpose of making sure of new and used equipment? (4pts)

Note: Satisfactory rating –5 points **Unsatisfactory – below 5points**

Score = 9pts

Rating: _____

Answer Sheet

Name: _____ Date: _____

Short Answer Questions

1. _____
2. _____
3. _____

Information Sheet-#2	Monitoring Availability of new and used equipments

What is system availability?

System availability (also known as equipment availability or asset availability) is a metric that measures the probability that a system is not failed or undergoing a repair action when it needs to be used.

There are three qualifications that need to be met for an equipment/system to be available:

- **Functioning equipment**
  Not out of service for repairs or inspections
- **Functioning under normal conditions**
  Operates in an ideal setting at an expected rate
- **Functioning when needed**
  Operational at any time production is scheduled

System availability is used to gauge if an asset's production potential is being maximized, which has a direct impact on the financial health of a business.

Calculating system availability

System availability is calculated by dividing uptime by the total sum of uptime and downtime.

Availability = Uptime ÷ (Uptime + downtime)

For example, let's say you're trying to calculate the availability of a critical production asset. That asset ran for 200 hours in a single month. That asset also had two hours of unplanned downtime because of a breakdown, and eight hours of downtime for weekly PMs. That equals 10 hours of total downtime.

Here is how to calculate the availability of that asset:

- **Availability = 200 ÷ (200 + 10)**
- **Availability = 200 ÷ 210**
- **Availability = 0.952**
- **Availability = 95.2%**

World-class availability is considered to be 90% or higher.

Equipment/system availability

System availability has a direct impact on the bottom line. When equipment is running as much as possible, it means more products are made and more money is made. In other words, when system availability is high, revenue is also likely to grow.

Because availability is so tied to the financial health of a company, it is commonly used as a key business metric in production-heavy organizations. However, it's also heavily connected to what several other departments do, including maintenance. Availability is impacted by reliability and maintainability, which are influenced by the processes and tools of the maintenance team. Therefore, availability is used to measure and investigate the effectiveness of these processes and tools, and how they can be improved.

What does system availability mean for maintenance?

Downtime has the biggest impact on availability and is something maintenance has a lot of control over. Downtime can be broken down into planned vs. unplanned and frequency vs. length. Each component can be further broken down until an anomaly is identified. Once issues are pinpointed, they can be addressed and can improve availability.

It's easy to see which type of downtime (unplanned or planned) is causing an issue with availability.

If unplanned downtime makes up the lion's share of total downtime, you can start to analyze what is causing this unplanned downtime. It may be due to a lack of preventive maintenance, the age of the machine, or even a severe case of pencil whipping.

If planned downtime seems to be dragging availability downward, you can investigate how your PMs can get more efficient. Are you constantly waiting on parts? Are regular inspections taking longer because there are no checklists or SOPs available? How about the frequency of your PMs — can the asset function properly with fewer routine checkups?

The same logic applies to the frequency and length of downtime. If an asset breaks down a lot, but is fixed quickly, you can focus your efforts on finding why failure is occurring so often, such as too few PMs, age, or a broken PM process. It's also possible that you may be doing too much preventive maintenance on an asset.

If an asset isn't down as often, but takes a long time to fix or inspect, it's time to take a closer look at your maintenance processes. There are dozens of different ways preventive and reactive maintenance can get more efficient. For example, if technicians have to keep walking back and forth from an office to an asset to retrieve paper files, it can cost precious minutes or even hours. If there's a lack of failure codes, or if they aren't clear, this can prolong downtime and shrink availability.

Your business and system availability

A big part of your business's bottom line revolves around system availability. Although asset availability is bigger than maintenance, knowing how your team can influence this maintenance metric is incredibly important to keeping equipment working and production on schedule. Doing a system availability analysis allows you to explore new ways to decrease downtime and make your operation more efficient.

Self-Check 2	Written Test

Directions: Answer all the questions listed below and write your answer on the space provided

1. How is equipment/system availability used? (4pts)
2. What is expected from you if unplanned downtime takes lion's share of the total downtime? (3pts)
3. How is equipment/system availability is calculated? Discuss on each variables(4pts)

Note: Satisfactory rating –6 points **Unsatisfactory – below 6points**

Answer Sheet

Name: _____Date: _____

Short Answer Questions

1. _____
   _____
   _____
2. _____
   _____
   _____

Score = 11pts

Rating: _____

Information Sheet-3	Inspecting Stock levels and order spare parts/consumables

Storeroom and Rotating Spares

Maintenance must also consider inventory management when preparing for success. Five areas merit special comment. All of these areas concern interfaces between storeroom and maintenance groups and justify special attention. These areas are the control of the storeroom, identification of usage, standardization, use of critical spares, and use of open cribs.

First, many maintenance departments should but do not have authority over their storerooms. The companies position the management of the storerooms separate from even the plants in some cases under special storeroom departments or under the purchasing departments. The companies feel this arrangement provides a check and balance. The processes of operating a storeroom may be more similar to those of a retail store or purchasing group than to the running of large machinery in an industrial plant. The company is trying to protect against the storeroom operation not being managed properly as a storeroom.

Storeroom operations can demand sophisticated controls and procedures. In other cases, the company feels that the large monetary value of the storeroom justifies a separate management group. The value of storeroom facilities and inventories certainly is large enough in many plants to be treated as significant and managed with qualified personnel.

On the other hand, the less visible but real value of proper maintenance and reliable plant capacity nearly always favors the maintenance group having ultimate control over the storeroom.

In situations where the maintenance department does not control the storeroom, maintenance management must give constant vigilance to the interfaces between the storeroom and maintenance group.

Improvements within the group that a manager controls receive most of the attention and processes hopefully become smoothed out and efficient over time. Interfaces between groups receive much less attention and frequently offer major areas of improvement. Managers of store-rooms and maintenance must communicate and constantly watch over areas to avoid suboptimizing their individual systems to the overall higher expense to the company. Suboptimization might occur when the storeroom's major goal is to reduce inventory regardless of the cost to maintenance who might order parts frequently on an emergency basis or lose plant capacity.

Second, storerooms carry such a large value of stock that a natural tendency to reduce inventory exists. Stock is expensive, but less so than poor availability of plant capacity. A plant must have a handle on stock- outs before it can consider reducing stock. What is the

incidence of not having requested items? If a plant has frequent stockouts, it cannot yet consider reducing stock. Effectiveness must come before efficiency. A storeroom must adequately supply maintenance with parts before the storeroom can identify an overstocking problem. If a storeroom is not adequately supporting maintenance with the parts it needs, management might want to consider an aggressive program of identification and purchasing. The company priority order should be first an increase in plant reliability, second an increase in maintenance productivity, and third reduction in excessive inventory.

Maintenance may consider other options rather than keeping inventory on site. With a successful maintenance program that has few break-downs, a planning function should know the need for certain parts ahead of time. Under those circumstances a plant may decide not to stock items that are readily available on a 24-hour notice. A plant may also set up blanket purchase orders with suppliers for common materials to reduce purchasing efforts at the times maintenance needs the items. Management should be cautious not to lose control over having critical items available for circumstances that could suddenly restrict plant capacity.

Third, inventory store quantities may be excessive because the plant has so many different types of equipment performing the same service. Companies can easily determine the lowest purchase price for an individual pump and perhaps make an effective judgment of the operating cost in terms of energy used over several years of projected use.

Companies less often consider the maintenance cost or the cost of keeping spares on hand. These latter costs are very difficult to determine, but that does not mean they are insignificant. If the plant values reliability and the cost of inventory stores, it should consider some equipment standardization guidelines. Technicians enhance plant reliability when they can work enough on the same type equipment to develop a close familiarity and when they know that the storeroom has ready spare parts. A management convinced of the overall company benefit should allow maintenance to dictate certain equipment standards for purchasing and engineering to follow. Maintenance management should take on such a course of action as an important responsibility, not one simply to be recognized, but to be continually managed.

Many plants have decided that standardization is the most important key to reliability, high capacity, and profits. These companies have standardized and reduced entire assembly lines or processes to standardize as much as possible. They have even standardized or restricted allowable suppliers and vendors to a select few with whom they develop close relations and high expectations for consistency.

Another aspect of inventory standardization within the sole control of the storeroom concerns duplication. Many different suppliers deliver virtually identical parts, sometimes even from the same manufacturers.

Although identical, these parts arrive with different vendor identification numbers and the

storeroom stores them as different items. The storeroom may have eight categories of a certain type gasket with each bin containing ten gaskets. In reality the gaskets are the same and the plant keeps an excess of 80 gaskets on hand. The storeroom may have opportunities to reduce its inventory by intelligent identification of parts for plant use. Standardization of equipment and suppliers also reduces these problems of multiple part numbers.

Fourth, another success in the inventory area can be a rotating spares program especially for a plant designed with few equipment redundancies and limited physical room for adding them later. A rotating spares program identifies critical equipment whereby the plant purchases entire replacement assemblies to keep in stock. In the event of failure, maintenance can quickly exchange complete assemblies for failed equipment. Then under controlled, nonemergency conditions, the maintenance group can rebuild the failed components and put them into stock. The term rotating spares comes from the plants who usually find most of their critical spares have rotating elements such as pumps.

The term also could apply to the fact that the spares rotate to exchange places. One spare “rotates” into service as the failed assembly “rotates” into the shop for rebuilding and then into the storeroom to take the original stock item’s place. Some ships use an arrangement known as bulkhead mounted spares. The crew mounts the spare assembly right alongside the service equipment for easy use. In addition, a storeroom for a ship may not be readily accessible when needed. Most industrial plants, however, prefer spares be kept in the cleaner and better controlled environment of a storeroom rather than allow them to clutter an operating area.

The use of a rotating or critical spares program directly benefits plant capacity during emergency maintenance. If troubleshooting cannot quickly find an easy fix, the plant may suffer as extended diagnostic work or repair time drags on excessively. Yet with a rotating spare available, the supervisor may call for its use after only a few moments of unsuccessful troubleshooting to reduce the potential of an extended down period. The supervisor or manager makes an educated call. The supervisor might realize uncertainty of the in-place repair time that could last either 2 or 24 hours. On the other hand, exchanging the entire assembly would require a guaranteed 5 hours. The use of the rotating spare reduces plant uncertainty in emergencies. Moreover, the use of the rotating spare reduces uncertainty for scheduled maintenance. Consider a particular deficiency with the in-place equipment that has not yet caused a problem, but that maintenance needs to correct. The plant may decide to have the equipment exchanged with the rotating spare at the plant’s convenience. Then maintenance may carefully examine and maintain the removed equipment in a shop environment.

Management should consider the use of a rotating spares program to improve maintenance success.

Fifth, open cribs for certain inventory items as discussed for the tool room might be advantageous. The company must choose between specifically accounting for every minute

inventory transaction and reducing delays encountered by maintenance technicians having to wait for service.

Maintenance management might weigh the cost of having an extra counter clerk against the value of not only possible missing stock, but possible lower productivity and plant capacity. The plant might also want to consider if it sends contradicting statements to employees. The plant trusts and empowers the technicians in word, but in action does the company trust the technicians with easy access to any inventory items to increase productivity?

Planning drives the best use of the inventory stock. Rather than maintenance technicians determining what parts they need in the midst of a maintenance task, planning reserves likely parts before the crew begins the work. This manner of operation reduces stockouts at the time of work execution because of advance notice of part requirements.

Parts identification that occurs days in advance of execution also allows inventory reduction. Storeroom or tool room personnel directed by planning can make use of blankets to pick up certain items from local vendors in time before job execution begins. In addition, planning acts on technician feedback. Often a technician that had a difficult time obtaining the correct parts for a task may simply be relieved when the task is completed. But planning has the time to evaluate the technician's job feedback and work with the storeroom or other processes to determine if stock levels need adjustment. The planner fulfills a clerical or administrative role for the technician to keep the inventory system working well. Many times management implements a process of some sort without providing an ongoing administration of the process. With regard to the interface of the storeroom and the maintenance needs for specific parts, planning fills this role. Planning also has a broad enough view of maintenance to play a large role in the determination of likely equipment candidates for standardization. It also aids the planning effort when standardization helps technicians to be familiar with equipment rather than technicians frequently requiring equipment information about unusual repair procedures.

Figure xx some questions to get a better sense of your inventory purchasing process

Inventory control is an important tool of maintenance management. Certain areas of inventory management regarding interfaces warrant special mention. Management must continually be vigilant with respect to the effectiveness of the storeroom in supporting maintenance and plant reliability. Management should first ensure the availability of needed parts and materials before considering efficiency of storeroom operations. Standardization concepts help maintenance by reducing the incidence of unfamiliar, unique maintenance operations and allow store- rooms to concentrate on proper stocking of fewer parts. Finally, use of open cribs may help reduce delays for technicians. Planning plays a key role in guiding and administrating the usage of parts from its vantage point in having a broad view of maintenance and time to pursue inventory issues.

Parts acquisition

The cost of spare parts can add up quickly. That's why it's important to understand what you're spending on inventory and how you're spending it.

Ordering parts

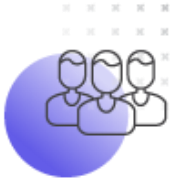
Here are some questions, as shown by figure below, you can ask yourself and your team to get a better sense of your inventory purchasing process:

Receiving parts

There are a lot of moving parts to think about when coordinating the delivery of inventory, and I'm not just talking about bearings or motors. Here are a few questions that will help you make this process go off without a hitch:

Is the maintenance storeroom staffed 24/7? If not, where are the parts stored after hours and how can they be accessed?

Is there a designated location in the building that vendors ship to?



Does your team accept partial orders?

Is it mandatory to check each part before entering it into your inventory system?

How does the reception process look? Is it tracked in a single system or multiple systems? Are these systems synced with each other?

That last question is particularly important. If a line goes down and you're rushing to fix it, you want to be sure that the inventory records are correct and the part is in working condition.

Self-Check 3	Written Test

Directions: Answer all the questions listed below and write your answer on the space provided

1. What a management should when a stockroom is inadequate? (3pts)
2. What is inventory? (2pts)
3. Discuss on procedure that a maintenance team should apply to maintain a maintenance stock level?

Note: Satisfactory rating –3 points **Unsatisfactory – below 3points**

Score = 5pts

Rating: _____

Answer Sheet

Name: _____ Date: _____

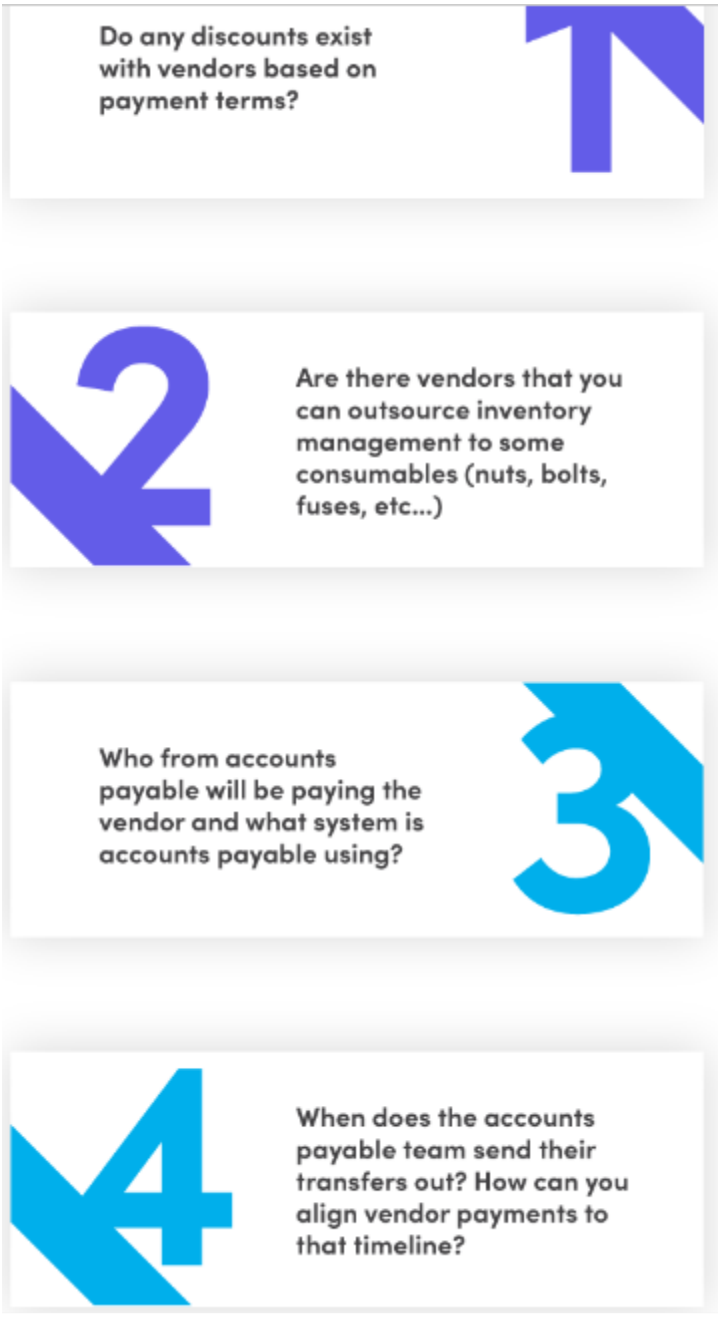
Short Answer Questions

1. _____
   _____
   _____
2. _____
   _____
   _____
3. _____
   _____
   _____

Information Sheet-4	Maintaining Communication between operators, company and suppliers

Working with vendors

There are some helpful questions, as shown by figure below, to ask yourself and your team to ensure you're getting the most out of the relationship you have with the vendors supplying your maintenance storeroom:



Figurexx Some helpful Questions to be considered to ensure good relationship with vendors

Having a good relationship with vendors can make or break your inventory management program. The last position you want to be in is delaying production while you wait for a critical part to be delivered because the vendor is not paid on time. Understanding all elements of the payment process, and doing frequent reviews of outstanding invoices, is important for communicating expectations to vendors and ensuring parts are delivered on time.

Self-Check 4	Written Test

Directions: Answer all the questions listed below and write your answer on the space provided

1.
2.
3.

Answer Sheet

Name: _____ Date: _____

Score = _____

Rating: _____

Short Answer Questions

1. _____
2. _____
3. _____

Information Sheet-5	Checking Manufacturer's manuals/company procedures

O&M manuals

Operation and maintenance manuals provided by the equipment manufacturers or suppliers giving basic details on operation and maintenance of the equipment. They usually included suggested preventive maintenance tasks, troubleshooting guides, and identification of parts and special tools.

Technical Files

The Technical Files consist of technical information from manufacturers for only the equipment in use at the facility. For example, there may be a valve manual with specifications and procedures to maintain several valves produced by a manufacturer. This manual would not be kept in the Equipment History Files because it pertains to valves in more than one system. When an individual valve is worked on and informationis used from the manual, the planner would copy over that specific information to that valve's minifile.

The maintenance department keeps the Technical Files in a section of the file area separate from the Equipment History Files. They are arranged from left to right, alphabetically by the manufacturer's name.

To hold small technical bulletins, the files contain pocket folders identified with the first few letters of manufacturers' names. In addition, there are file sections for specific O&M manuals filed by unit and certain other technical manuals or documents identified in the following sections of this chapter. As specific information is used on a job, the planner copies that information over to the equipment's minifile.

A point of considerable controversy surrounds whether the planner should routinely send O&M manuals or similar source documents into the field as attachments to work order plans. Ideally, the planner would find the information needed within such manuals and might attach a copy of only certain pages at best. In the real world, the planner sometimes only gives the technicians a head start with the most likely information needed. Often the technician must supplement the planner's information through personal expertise or research. Does this case make it sensible to have the equipment manual normally handy? Consider persons working on their own cars. Would they like to have the vehicle manuals available? One would think so. This reasoning suggests that the planner should routinely attach such source documents to job plans.

On the other hand, closer inspection gives another side to the issue. What are the most frequent maintenance tasks one performs on a car? These tasks include changing oil, filters, spark plugs, or coolant. Hardly anyone would think of referring to an owner's manual. Even in the case of changing water pumps and mufflers, one would more likely refer to the instructions in the box of the new water pump or muffler than to any vehicle owner's

manual. The same thing occurs in the maintenance of an industrial plant. One finds that reference to an O&M manual does not occur routinely during maintenance. Therefore, the preference is against the planner routinely sending O&M manuals or similar source documents into the field as attachments to work order plans.

Attachment files

Sometimes planning departments create small booklets of important equipment information that they keep in the minifiles. These booklets contain especially critical information culled from the more massive O&M manuals. Planners bind these booklets with report covers so that they can be sent out on jobs.

Such larger attachments may be attached by paper clamps to work orders or they may be kept in files in the planning department. The planning department might keep the attachment in a special “Attachments” file in the planning department. This file keeps attachments in the planning department filed by crew and work order number (they have a copy of the work order attached) where technicians can come get them when ready.

Vendor Files

The Vendor Files consist of ordinary sales catalogs from vendors. These catalogs are arranged left to right, alphabetically by the vendor name on the catalog. Vendor files are kept in another section of the file area. The Vendor Files may contain a set of Thomas Register® books or similar vendor reference. The plant may be looking into having CD-ROM versions or Internet links for this purpose.

The planner may research these files to find information for new equipment under consideration for purchase. Information for equipment already in place might also be found. For instance, a planner might find details for a particular valve by examining a vendor’s catalog of over 100 valves.

The planner would then copy the particular valve’s information sheet over to the minifile to avoid having to make similar searches in the future.

Equipment parts lists

Equipment parts lists or bills of materials are a very valuable resource for planners. Planners file this information in the minifiles. Planners must continually develop the listings of parts for equipment as it is maintained. Planners must insist on receiving parts information when new equipment is purchased.

Standard plans

Planners create standard plans for jobs where technicians might not be expected to remember particular sequences or job procedures as a normal part of their craft skill. These standard plans are not an attempt to dictate actions to technicians. Rather, they help the technician build upon past successful work. Planners store standard plans in their respective, equipment minifiles. The following two listings illustrate two styles of what might

constitute a standard plan. Planners might create much more complex standard plans including pertinent manu- facturer manual pages, exploded view diagrams, and vendor contact names, and other useful information. The planners might keep these standard plans available in special notebooks or binders to include as attachments to work orders.

Planning intends to create so-called standard plans for as many jobs as possible. The planner's intent is not to insult craft technicians, suppress unique skills available to trained craftpersons, or rob them of the opportunity to adjust to job conditions. The planners count on the technician skill level that the planner specifies in the job plan. The planner wants to capture the process of the job so that technicians can laterconcentrate on craft technique rather than unique equipment steps that may vary widely. Even specifying technique such as welding procedures should not insult technicians who help develop the procedures through giving feedback for future newer craftpersons. Finally, technicians "own" the jobs after receiving them. Crews and crafts are free to take the responsibility of deviating from the specified job instruction provided that they report actual actions they take instead.

The following are examples of standard plans for a somewhat complex job that might be developed initially or what might have developed after a few iterations of the maintenance job over time.

Self-Check 5	Written Test

Directions: Answer all the questions listed below and write your answer on the space provided

1)
2)

Answer Sheet

Name: _____ Date: _____

Score = _____

Rating: _____

Short Answer Questions

1. _____
   _____
2. _____
   _____

Information Sheet-6	Organizing Equipment maintenance and service

Implementing an equipment maintenance programme

Preventive maintenance

Preventive maintenance includes measures such as systematic and routine cleaning, adjustment and replacement of equipment parts at scheduled intervals. Manufacturers generally recommend a set of equipment maintenance tasks that should be performed at regular intervals: daily, weekly, monthly or yearly.

Following these recommendations will ensure that the equipment performs at maximum efficiency and will increase the lifespan of the equipment. This will also help to prevent:

- inaccurate test results due to equipment failure
- delays in reporting results
- low productivity
- large repair costs.

Maintenance plan

A maintenance plan will include preventive maintenance procedures as well as provision for inventory, troubleshooting and repair of equipment. When implementing an equipment maintenance program, some of the initial steps will include:

- assigning responsibility for providing oversight;
- developing written policies and procedures for maintaining equipment, including routine maintenance plans for each piece of equipment that specify the frequency with which all maintenance tasks should be performed;
- developing the format for records, creating logs and forms, and establishing the processes to maintain records;
- training staff on the use and maintenance of the equipment, and ensuring that all staff understand their specific responsibilities.

It is recommended that a label is attached to the instrument indicating when the next maintenance or service should be performed.

Equipment inventory

The organization should keep an inventory log of all equipment in the organization. The log should be updated with information on new equipment and include documentation of when old equipment is retired. For each piece of equipment, the equipment inventory log should have a record of:

- instrument type, make and model number, and serial number so that any problems can be discussed with the manufacturer;
- date the equipment was purchased, and whether it was purchased new, used or reconditioned;
- manufacturer/vendor contact information;

- presence or absence of documentation, spare parts and maintenance contract;
- warranty's expiration date;
- specific inventory number indicating the year of acquisition (this is especially useful for larger laboratories); for example, use the style "YY-number" (04-001, 04-002, etc.) where "YY-number" equals the last two numbers of the year followed by a number attributed in the year.

Spare parts and work orders

You deal with hundreds (or even thousands) of work orders, most of them having at least one spare part attached to it. That's a lot to keep track of and it can easily become a headache for you and your team. Fortunately, there are some measures you can take to prevent that from happening.

Issuing parts to work orders

These two questions will help you as parts are being used on work orders:

1. Who on your team is responsible for adding the part to a work order?
2. How are you monitoring parts usage on work orders to prevent part changes as the only means of troubleshooting?

Issuing parts on a work order immediately adds a cost to the work order. Ensuring costs are tracked accurately allows the leadership team to monitor costs across all maintenance activities and make decisions (like if you should buy new equipment or hire another technician) using solid data.

The way you set up this process is up to you. Some sites allow technicians to add parts to work orders while others allow only the maintenance storeroom employee to do this.

Staging parts for PMs

Preventive maintenance work orders deserve their own section as they can be an entirely different beast than reactive work orders. There are a couple of questions that will help you when planning parts usage for scheduled maintenance:

1. Is there a designated spot in the maintenance storeroom for preventative maintenance kits required for upcoming PMs?
2. Who is responsible for putting these kits together?

Kitting is typically a practice used to ensure all parts are prepared for the maintenance team's upcoming work. Setting aside these parts ensures you're setting up the maintenance team to be successful.

Securing your maintenance storeroom

People steal things. Others have good intentions, but lack the know-how. Those are some unfortunate facts of life. Your maintenance storeroom isn't immune to them. That's why securing your inventory area should be a top priority.

Access to the stockroom

Odds are, the parts in your maintenance storeroom total thousands or millions of dollars. Limiting access to your inventory areas keeps the risk of theft and misuse down, which goes a long way to lowering the cost of parts.

Here are some things to think about when securing your stockroom:

1. Who has access to the stockroom? Typically, the maintenance team and production supervisors have access, but as long as it is tracked and the responsibility is understood, you can expand access outside of those roles.
2. What device are you using to limit access to the stockroom?
3. Are there cameras in the stock room? How are those cameras located?

One of the most common ways to secure your maintenance storeroom is by implementing a key pass system that allows only certain people to access the shop. If your parts room is big enough, you can separate it into sections, with each area having different levels of access. This prevents theft and means maintenance isn't stuck paying for parts and supplies commonly used by people in other departments, like batteries.

Having a camera pointed at the entry points to the stock room allows you to investigate when a part was used if it goes missing or was not documented on a work order. This helps you track inventory spending, even if team members forget to log a part because of emergency situations.

Having a good relationship with vendors can make or break your inventory management program. The last position you want to be in is delaying production while you wait for a critical part to be delivered because the vendor is not paid on time.

Organizing your maintenance storeroom

Each facility is going to organize its maintenance storeroom differently. As long as you're making your parts accessible, easy to find, and safe from wear and tear, it's hard to go wrong. While there are dozens of ways to organize your space, we've outlined two common methods below.

Organizing parts by asset

This method arranges spare parts by the asset they're used with. This strategy has a few key benefits, including:

- Making it easy to get parts for planned maintenance
- Assembling kits for major rebuilds
- Finding the right part for an asset when emergency maintenance strikes

There is one major potential downside to storing parts by asset type: Duplication. If the same size bearing is used on more than one piece of equipment, it's necessary to store it in multiple locations, creating extra costs and requiring more storage space.

Organizing parts by type

This method arranges inventory by the type of part. All your bearings would be together, all the pumps would be in the same place, and so on. This method has a few advantages, such as:

- Being good for troubleshooting when you don't have enough of one part and need a short-term solution

- Allowing you to see how many motors, gearboxes, variable frequency drives, and other parts you have that carry a significant cost
- Finding storage units built for the same part, like a bearing cabinet that will keep bearings free of dust and debris.

There are some limitations as well. If you're in a rush and have to use a very specific type of bearing out of the dozens in your storeroom, it's easy to grab the wrong one. This mistake can lead to increased repair times and downtime. Having a QR code or barcode on storage containers helps reduce this risk.

Other things to consider when organizing your spare parts

There are a few more questions to ask yourself that will help you when organizing your maintenance storeroom:

1. What is the weight capacity needed for racking in the parts room?
2. Which parts are critical and will they be stored differently?
3. Will parts be stored high up? If so, is there a safe process for retrieving them?
4. Are certain parts sensitive to heat? How will those parts be stored?
5. Is a vendor-managed system being used to track smaller parts (bolts, fuses, etc.)?
6. What is the minimum amount of stock required? What is the maximum required?
7. Is there a standard make and/or model for any parts (for example, all controls are from a certain vendor)?

Odds are, the parts in your maintenance storeroom total thousands or millions of dollars. Limiting access to your inventory areas keeps the risk of theft and misuse down, which goes a long way to lowering the cost of parts.

Optimizing your inventory tracking

Making data-driven decisions about inventory not only helps you squeeze every last bit of value from your maintenance storeroom, it also leads to healthier assets and fewer headaches for everyone. That's a lot to promise, but it takes a lot of work to put the right processes in place to get there.

Critical spares

Figuring out your critical spares is just as crucial as doing a criticality analysis on your assets. It helps you purchase, organize, and maintain your inventory is a way that keeps equipment breakdowns from reaching nightmare proportions.

Determining your critical spare parts starts with understanding your facility's critical assets. This gives you a sense of which parts are important for keeping that piece of equipment running as well and as long as possible. This is an exercise that requires input from

maintenance personnel who are most familiar with these pieces of equipment to ensure all information is captured.

Cycle counts

Doing frequent inventory cycle counts gives you more control over your maintenance schedule and your maintenance budget. It ensures your records are accurate so you're not running out of critical spares or overspending on expensive parts. Completing periodic cycle counts also mitigates the reactive behaviours that have significant costs associated with it.

Doing cycle counts is especially important if you're using software to track parts. Ensuring the information in your system matches the actual number of parts you have helps the finance team and supports the maintenance team with their scheduled tasks.

When bolstering your cycle count program, ask yourself these questions:

1. How often are cycle counts occurring?
2. When a cycle count occurs how will you limit the usage of parts?
3. Who will do the cycle count? Who will be spot-checking that the count is accurate?

Reporting

Reporting on the amount of inventory value on a quarterly or monthly basis will give you insight, as a maintenance leader, into what is happening in the maintenance storeroom.

Ask yourself these questions when you're preparing inventory reports:

1. How often will the report run?
2. What information will the report look at?
3. Will the report show all parts or only a selection of the most expensive parts (like the top 50)?
4. Will the report show the change in inventory between two dates?

Inventory tracking: A pillar of exceptional maintenance

Managing and tracking inventory is a key pillar for any maintenance team. As you dive deeper into improving your maintenance storeroom, there are five takeaways that can guide you to success:

1. Have a process for receiving and ordering parts
2. Have people who can backfill for vacations, illnesses, and any other period of staff shortage
3. Run reports frequently enough that you have a general idea of the value of parts in the stock room
4. Carefully plan the way you're organizing your maintenance storeroom and ask for ideas from multiple people on your team
5. Always look for strengths and weaknesses in your inventory management and work to improve all areas

Self-Check 6	Written Test

Directions: Answer all the questions listed below and write your answer on the space provided

1.
2.

Answer Sheet

Name: _____ Date: _____

Short Answer Questions

Score = _____

Rating: _____

1. _____
   _____
   _____
2. _____
   _____
   _____

Operation Sheet-6	Organizing Equipment maintenance and service

Name: _____ Date: _____

Time started: _____ Time finished: _____

Direction: **Organize Equipment maintenance and service**

Equipment, tools and materials:

Manufacturer's maintenance manual, Procedures, paper, pen, pencil, learning guide

Instruction:

Name _____

Instructions: Follow the following procedures to make Final Inspection

LAP Test	Check new and used equipment

Name: _____ Date: _____

Time started: _____ Time finished: _____

Task 1: carry out checking new and used equipment

Instruction Sheet	Learning Guide #04: Check implementation of maintenance plan

This learning guide is developed to provide you the necessary information regarding the following content coverage and topics

- Monitoring maintenance activities and providing support maintenance schedule
- Implementing/observing made sure OHS procedures
- Evaluating and recommending Cost benefits of replacing defective equipment
- Identifying and recording Issues and problems
- Undertaking corrective action
- Arranging/Coordinating Sources
- Monitoring Personnel
- Preparing and submitting Required reports

This guide will also assist you to attain the learning outcome stated in the cover page. Specifically, upon completion of this Learning Guide, you will be able to –

- Monitor maintenance activities and providing support maintenance schedule
- Implement/observe made sure OHS procedures
- Evaluate and recommend Cost benefits of replacing defective equipment
- Identify and record Issues and problems
- Undertake corrective action
- Arrange/Coordinate Sources
- Monitor Personnel
- Prepare and submit Required reports

Learning Instructions:

1. Read the specific objectives of this Learning Guide.
2. Follow the instructions described in number 3 to 20.
3. Read the information written in the “Information Sheets 1”. Try to understand what are being discussed. Ask you Instructor for assistance if you have hard time understanding them.
4. Accomplish the “Self-check 1” in page __.
5. Ask from your Instructor the key to correction (key answers) or you can request your Instructor to correct your work. (You are to get the key answer only after you finished answering the Self-check 1).

6. If you earned a satisfactory evaluation proceed to “Information Sheet 2”. However, if your rating is unsatisfactory, see your Instructor for further instructions or go back to Learning Activity #1

7. Submit your accomplished Self-check. This will form part of your training portfolio.

8. Read the information written in the “Information Sheet 2”. Try to understand what are being discussed. Ask you Instructor for assistance if you have hard time understanding them.

9. Accomplish the “Self-check 2” in page __.

10. Ask from your Instructor the key to correction (key answers) or you can request your Instructor to correct your work. (You are to get the key answer only after you finished answering the Self-check 2).

11. Read the information written in the “Information Sheets 3 and 4”. Try to understand what are being discussed. Ask you Instructor for assistance if you have hard time understanding them.

12. Accomplish the “Self-check 3” in page __.

13. Ask from your Instructor the key to correction (key answers) or you can request your Instructor to correct your work. (You are to get the key answer only after you finished answering the Self-check 3).

14. If you earned a satisfactory evaluation proceed to “Operation Sheet 1” in page _. However, if your rating is unsatisfactory, see your Instructor for further instructions or go back to for each Learning Activities.

Information Sheet-1	Monitoring maintenance activities and providing support maintenance schedule

Self-Check 1	Written Test

Directions: Answer all the questions listed below and write your answer on the space provided

1.
2.
3.

Score = _____

Rating: _____

Answer Sheet

Name: _____ Date: _____

Short Answer Questions

1. _____
   _____
   _____
4. _____
   _____
   _____
5. _____
   _____

Information Sheet-2	Implementing/observing made sure OHS procedures

Safety, Health and Environment

Target

1. Zero accident,
2. Zero health damage, and
3. Zero fires.

In this area focus is on to create a safe workplace and a surrounding area that is not damaged by our process or procedures. This pillar will play an active role in each of the other pillars on a regular basis.

A committee is constituted for this pillar, which comprises representative of officers as well as workers. The committee is headed by senior vice President (Technical). Utmost importance to safety is given in the plant. Manager (safety) is looking after functions related to safety. To create awareness among employees various competitions like safety slogans, quiz, drama, posters, etc. related to safety can be organized at regular intervals.

Today, with competition in industry at an all time high, TOTAL PRODUCTIVE MAINTENANCE may be the only thing that stands between success and total failure for some companies. It has been proven to be a program that works. It can be adapted to work not only in industrial plants, but also in construction, building maintenance, transportation, and in a variety of other situations. Employees must be educated and convinced that TOTAL PRODUCTIVE MAINTENANCE is not just another 'program of the month' and that management is totally committed to the program and the extended time frame necessary for full implementation. If everyone involved in a TOTAL PRODUCTIVE MAINTENANCE program does his or her part, an unusually high rate of return compared to resources invested may be expected.

Self-Check 2	Written Test

Directions: Answer all the questions listed below and write your answer on the space provided

1.
2.
3.

Answer Sheet

Name: _____ Date: _____

Score = _____

Rating: _____

Short Answer Questions

1. _____
_____
_____

2. _____
_____
_____

3. _____
_____

Information Sheet-3	Evaluating and recommending Cost benefits of replacing defective equipment

Areas of benefit

The topic discusses the key benefits that should help maintenance planning including standardizing work processes, inventory control, information for metrics and reports, finding work orders, linking information to equipment, having a common database, helping with scheduling, and helping with PM generation. (The reader should not include any of these areas that are not significant drivers for the reader's situation.) A project charter should capture the scope as described below in the special tools section.

It would be helpful to include the word "additional" when discussing features of the CMMS project. The existing maintenance process and existing CMMS have certain features that genuinely help maintenance.

Users often take many of these features for granted. For example, the overall speed of the existing CMMS may be adequate, but the project team might not realize that the proposed newer system might be configured to slow down some processes to an unsatisfactory speed. The old system allowed scrolling through work order screens each in a fraction of a second. The new system might take over 4 seconds for each record, making it almost impractical to scan through a large amount of work. The maintenance group never insisted on a "speed specification" because it did not imagine that a new system would be worse in this critical regard.

Specifying that the new CMMS would provide the "additional" benefits over the old system helps the maintenance group discuss details with the IT group. It is not acceptable for the new CMMS to cripple existing satisfactory capabilities. On the other hand, new systems might well compromise certain old features in some respects, but maintenance would be overall better off going forward to the new system. (Careful CMMS selection up front can help reduce the likelihood of selecting altogether unsatisfactory systems.) A final note on specific features such as speed, system stability, and user-friendliness: If any desired features are specific reasons a plant is upgrading or changing a CMMS, the project should explicitly list them among the overall benefits expected. The existing system might simply be too slow. It might lose data consistently or be unavailable too many times. It might simply require too much computer expertise to use.

The specified benefits of the project should certainly include these areas. Value of benefits. COPQ stands for Cost of Poor Quality. Management wants the CMMS project to deliver an overall benefit. This means there exists a present opportunity to improve. The gap between the most improvement possible and the current situation represents waste and inefficiency known as "poor quality." COPQ represents this poor quality, usually in monetary terms.

COPQ does not represent the benefit value of the CMMS project, but the total wasted dollars in pertinent areas that are not perfect.

The project team should determine COPQ for each area and the potential value for the CMMS to help. Benefits include effectiveness such as plant availability and efficiency such as workforce productivity. Plant availability usually carries far more value than productivity, though each is significant and interdependent. For example, a power station might have an 85% equivalent availability factor. The 15% wasted availability might be worth $4.5 million/year to a 1000 MW power station in power transaction capability and $270 million in capital construction cost for the 150 MW “lost” by the low availability. The CMMS will not save all of this amount for the utility, but it does establish a basis for how much waste is available for improvement. The project team must decide how much of this COPQ the CMMS might help. It might be reasonable to expect that a new CMMS that improves plant areas with evident problems (listed as benefit areas above) could expect to take credit for a certain percentage increase in availability with a specific value.

The project team might decide how much process standardization and better planning information would contribute to maintenance productivity. For a 90-person workforce with average wages of $25/hour and 35% wrench time, the COPQ is 90 × 25 × 2080 (hr/yr) × (100% −35%)/35% = $8.7 million. Nothing will improve a workforce wrench time from 35 to 100%, but it would be reasonable that having a good CMMS over a poor CMMS or no CMMS might be responsible for 5% of an improved wrench time for a company with a good planning program. The planning program can be expected to help improve wrench time from 35 to 55%, but 5% of this could be due to other system factors including a good CMMS. It would be reasonable to attribute 5% to the CMMS as 90 × 25 × 2080 (hr/yr) × 5%/35% = $668,000 per year.

If better inventory control is an expected benefit, the project team might enlist the maintenance supervisors, purchasing agents, and storeroom personnel to consider the COPQ of the current process and how much improvement the CMMS might yield.

Similarly, the project team should consider each area of expected benefit to develop a COPQ and estimate how much the proposed CMMS might help reduce COPQ. Reports, metrics, PM generation, and similar benefits might claim a portion of the overall availability COPQ.

Finding work orders, scheduling, and similar benefits might claim a portion of the productivity COPQ.

Obviously, the potential value of a CMMS depends on the current COPQ of a particular plant and how a CMMS might help specific areas. Knowledge is power and the better a project team knows its individual situation, the better it can estimate the impact of the CMMS. Following a structured approach that breaks down each potential benefit into

COPQ's can help sort through information and build a more credible business case for the value of the CMMS.

Self-Check 3	Written Test

Directions: Answer all the questions listed below and write your answer on the space provided

1.
2.
3.

Score = _____

Rating: _____

Answer Sheet

Name: _____ Date: _____

Short Answer Questions

1. _____
   _____
   _____
2. _____
   _____
   _____
3. _____
   _____

Information Sheet - 4	Identifying and recording Issues and problems

Equipment Records and their Control

- Operating Set Points
- Operating Specifications
- Calibration Settings
- Modifications / Changes e.g. materials, parts
- Inspection Records
- Condition Monitoring Records (inc Operator watch keeping records)
- Past Work Orders
- Photographs
- Root Cause Failure Analysis Reports
- Safety Requirements / Hazards
- Special Access Requirements
- Special Tooling

Equipment Records are documents that contain measurements and evidence of historic facts applying to a piece of plant. You will want to keep them as proof that work was done to the required standard, as reference for future work, and for identification of changes over time.

This necessitates setting up a system and procedures to collect, collate, catalogue and retrieve the records. Remember, that without written procedures to explain the system you don’t have a usable system.

Self-Check 4	Written Test

Directions: Answer all the questions listed below and write your answer on the space provided

1.
2.
3.

Answer Sheet

Name: _____ Date: _____

Score = _____

Rating: _____

Short Answer Questions

1. _____
_____
_____

2. _____
_____
_____

3. _____
_____

Information Sheet - 5	Undertaking corrective action

Self-Check 5	Written Test

Directions: Answer all the questions listed below and write your answer on the space provided

1.
2.
3.

Answer Sheet

Name: _____ Date: _____

Score = _____

Rating: _____

Short Answer Questions

1. _____
   _____
   _____
2. _____
   _____
   _____
3. _____
   _____

Information Sheet - 6	Arranging/Coordinating Sources

How do you ensure Resource Allocation is done efficiently?

The scarcity of resources poses a major challenge for managers. How do you find the right people for the right job? Resource allocation in the workplace is often the diligent allocation of resources to tasks based on requirements, skills, and timelines. This forces managers to allocate resources based on a specific situation rather than that it's a purely strategic choice. Applying practices for effective resource management can make a big difference.

One of the methods is the optimising of the extent to which all involved resources are available. In addition, there has to be a focus on the visibility of resources. We'll discuss these methods in more detail and offer some tips below.

1. Apply redistribution

It's important to make room for strategic redistribution. This is a good first step. Reallocation doesn't mean that the work being done with an assignment of resources becomes strained. Strategic reallocation means looking for alternatives to get some extra manpower who can take on more responsibility. This way or reallocation is strongly dependent of the overall visibility of projects and resources. This is essential to employ staff optimally.

2. Diversify

It's always good to have resources and staff equipped with a broad range of skills, or who are used to performing different tasks. Therefore it's hugely important that managers recognise and cherish both primary and secondary skills. If the manager is aware of the abilities of their resources, he or she can quickly resolve any problems that may arise by making the right resources available in the right places.

Take an engineer at a pharmaceutical company, for example. This guy also minored in communication, and vlogs in his spare time. He could be a big asset for the internal marketing department. In addition to product knowledge and knowledge of the technical aspects of the production process, he can also add value to the company's branding.

This is also good for the employees themselves. Nobody likes to stagnate, and employees will be motivated when given the opportunity to diversify and grow. A good manager doesn't just understand this concept, but also applies it in his strategy for resource allocation.

3. Stimulate automation

One of the most obvious challenges when allocating resources is the complicated process managers have to comply with when they want to assign new resources to new tasks. This often involves multiple phone calls, email messages, or sending requests to other managers. An automated resource-allocation process is a special route by which managers can do this independently within a certain scope. Combined with visibility and transparency, valuable time can now be allocated in other areas. Furthermore, a streamlined process makes it easier to monitor which resources were allocated to which department. This prevents the confusion that can arise when resources cannot be traced.

4. Strive for optimal use of resources

Optimal use of resources means a healthy resource-allocation process. When the use and allocation level of resources is optimal, this means that under no circumstances are too many or too few resources being used. As a result, the output produced by the company is created as efficiently as possible. Optimal use of resources should be the overall result, rather than a lucky outcome. Each method that is used to allocate resources has to meet this criterion.

Resource management in practice

Allocating resources to the right departments is part of resource management. Resource management includes the planning, tracking, and optimising of the use of resources such as space, equipment, and personnel. This process covers planning and management, checking resources, planning start and end dates for certain projects and resources, conflict management, and regular monitoring to be able to implement any needed changes in a timely manner.

Self-Check 6	Written Test

Directions: Answer all the questions listed below and write your answer on the space provided

1.
2.
3.

Score = _____

Rating: _____

Answer Sheet

Name: _____ Date: _____

Short Answer Questions

1. _____
2. _____
3. _____

Information Sheet - 7	Monitoring Personnel

Office Total Productive Maintenance

Office Total Productive Maintenance should be started after activating four other pillars of Total Productive Maintenance. Office Total Productive Maintenance must be followed to improve productivity, efficiency in the administrative functions and identify and eliminate losses. This includes analyzing processes and procedures towards increased office automation. Office Total Productive Maintenance addresses twelve major losses. They are:

1. Processing loss;
2. Cost loss including in areas such as, procurement, accounts, marketing, sales leading to high inventories;
3. Communication loss;
4. Idle loss;
5. Set-up loss;
6. Accuracy loss;
7. Office equipment breakdown;
8. Communication channel breakdown, telephone and fax lines;
9. Time spent on retrieval of information;

Non availability of correct on-line stock status;

Self-Check 7	Written Test

Directions: Answer all the questions listed below and write your answer on the space provided

1.
2.
3.

Score = _____

Rating: _____

Answer Sheet

Name: _____ Date: _____

Short Answer Questions

1) _____
_____
_____

2) _____
_____
_____

3) _____
_____

Information Sheet - 8	Preparing and submitting Required reports

Self-Check 8	Written Test

Directions: Answer all the questions listed below and write your answer on the space provided

1.
2.
3.

Score = _____

Rating: _____

Answer Sheet

Name: _____ Date: _____

Short Answer Questions

1. _____
2. _____
3. _____

LAP Test	Check implementation of maintenance plan

Name: _____ Date: _____

Time started: _____ Time finished: _____

Direction: complete the following job and report to your instructor

Job 1: Check implementation of maintenance plan

Instruction Sheet	Learning Guide #05: Improve work process and staff

This learning guide is developed to provide you the necessary information regarding the following content coverage and topics

- Documenting Maintenance policy and procedures
- Planning and implementing Staff upgrading schemes
- Establishing Team spirit and favourable working environment
- Addressing and identifying Critical issues
- Recommending Work improvement and processes
- Accomplishing and submitting necessary documentation and reporting

This guide will also assist you to attain the learning outcome stated in the cover page. Specifically, upon completion of this Learning Guide, you will be able to –

- Document Maintenance policy and procedures
- Plan and implement Staff upgrading schemes
- Establish Team spirit and favourable working environment
- Address and identify Critical issues
- Recommend Work improvement and processes
- Accomplish and submit necessary documentation and reporting

Learning Instructions:

1. Read the specific objectives of this Learning Guide.
2. Follow the instructions described in number 3 to 20.
3. Read the information written in the “Information Sheets 1”. Try to understand what are being discussed. Ask you Instructor for assistance if you have hard time understanding them.
4. Accomplish the “Self-check 1” in page __.
5. Ask from your Instructor the key to correction (key answers) or you can request your Instructor to correct your work. (You are to get the key answer only after you finished answering the Self-check 1).
6. If you earned a satisfactory evaluation proceed to “Information Sheet 2”. However, if your rating is unsatisfactory, see your Instructor for further instructions or go back to Learning Activity #1

7. Submit your accomplished Self-check. This will form part of your training portfolio.
8. Read the information written in the “Information Sheet 2”. Try to understand what are being discussed. Ask you Instructor for assistance if you have hard time understanding them.
9. Accomplish the “Self-check 2” in page __.
10. Ask from your Instructor the key to correction (key answers) or you can request your Instructor to correct your work. (You are to get the key answer only after you finished answering the Self-check 2).
11. Read the information written in the “Information Sheets 3 and 4”. Try to understand what are being discussed. Ask you Instructor for assistance if you have hard time understanding them.
12. Accomplish the “Self-check 3” in page __.
13. Ask from your Instructor the key to correction (key answers) or you can request your Instructor to correct your work. (You are to get the key answer only after you finished answering the Self-check 3).
14. If you earned a satisfactory evaluation proceed to “Operation Sheet 1” in page _. However, if your rating is unsatisfactory, see your Instructor for further instructions or go back to for each Learning Activities.

Information Sheet-1	Documenting Maintenance policy and procedures

Detailed Job Procedures

"The more detailed the procedures and the more insistence on compliance with procedures an organisation becomes, the more precise and less error prone its maintenance will be." Jack Nicholas Jr., www.reliabilityweb.com

It's an incredibly wonderful and satisfying feeling when you do great work. Great work happens when you do a job expertly, to best-of-class standards. A Maintenance Planner can help their maintenance crew be world-class by developing world class job procedures.

You need to understand that Job Procedures are very special documents that play a most important role in the eventual success of your organization. Job Procedures let you write the script that everyone follows. If you want world-class performance in your operation, then write your Job Procedures with world-class content to world-class quality. It is as simple as that. Once you have world-class procedures, train your people to them so they can deliver world-class performance. If you have a team of world-class performers doing world-class workmanship, you will soon have a world-class performing business.

Self-Check 1	Written Test

Directions: Answer all the questions listed below and write your answer on the space provided

1.
2.
3.

Answer Sheet

Name: _____ Date: _____

Score = _____

Rating: _____

Short Answer Questions

1. _____
2. _____
3. _____

Information Sheet #-2	Planning and implementing Staff upgrading schemes

Training

It is aimed to have multi-skilled revitalized employees whose morale is high and who has eager to come to work and perform all required functions effectively and independently. Education is given to operators to upgrade their skill. It is not sufficient know only 'Know-How' by they should also learn 'Know-Why'. By experience they gain, 'Know-How' to overcome a problem what to be done. This they do without knowing the root cause of the problem and why they are doing so. Hence, it becomes necessary to train them on knowing 'Know-Why'. The employees should be trained to achieve the four phases of skill. The goal is to create a factory full of experts. The different phase of skills is:

Phase 1: Do not know.

Phase 2: Know the theory but cannot do.

Phase 3: Can do but cannot teach.

Phase 4: Can do and also teach.

Policy

1. Focus on improvement of knowledge, skills and techniques;
2. Creating a training environment for self-learning based on felt needs;
3. Training curriculum/tools/assessment etc. conducive to employee revitalization; and
4. Training to remove employee fatigue and make work enjoyable.

Target

1. Achieve and sustain downtime due to want men at zero on critical machines;
2. Achieve and sustain zero losses due to lack of knowledge/skills/techniques; and
3. Aim for 100% participation in suggestion scheme.

Steps in Educating and Training Activities

1. Setting policies and priorities and checking present status of education and training;
2. Establish of training system for operation and maintenance skill upgradation;
3. Training the employees for upgrading the operation and maintenance skills;
4. Preparation of training calendar;
5. Kick-off of the system for training; and
6. Evaluation of activities and study of future approach.

Self-Check 2	Written Test

Directions: Answer all the questions listed below and write your answer on the space provided

1.
2.
3.

Score = _____

Rating: _____

Answer Sheet

Name: _____ Date: _____

Short Answer Questions

1. _____
_____
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2. _____
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_____

3. _____
_____
_____

Information Sheet-#3	Establishing Team spirit and favourable working environment

Self-Check 3	Written Test

Directions: Answer all the questions listed below and write your answer on the space provided

1.
2.
3.

Answer Sheet

Name: _____ Date: _____

Score = _____

Rating: _____

Short Answer Questions

1. _____
_____
_____

2. _____
_____
_____

3. _____
_____

Operation Sheet-3	Establishing Team spirit and favourable working environment

Information Sheet-4	Addressing and identifying Critical issues

Quality Maintenance

It is aimed towards customer delight through highest quality through defect free manufacturing. Focus is on eliminating non-conformances in a systematic manner, much like Focused Improvement. We gain understanding of what parts of the equipment affect product quality and begin to eliminate current quality concerns, then move to potential quality concerns. Transition is from reactive to proactive (Quality Control to Quality Assurance).

QM activities is to set equipment conditions that preclude quality defects, based on the basic concept of maintaining perfect equipment to maintain perfect quality of products. The conditions are checked and measure in time series to very that measure values are within standard values to prevent defects. The transition of measured values is watched to predict possibilities of defects occurring and to take counter measures before hand.

Policy

1. Defect free conditions and control of equipments;
2. QM activities to support quality assurance;

Maintenance Management !

3. Focus of prevention of defects at source;
4. Focus on poka-yoke (fool proof system);
5. In-line detection and segregation of defects; and
6. Effective implementation of operator quality assurance.

Target

1. Achieve and sustain customer complaints at zero;
2. Reduce in-process defects by 50%; and
3. Reduce cost of quality by 50%.

Data Requirements

Quality defects are classified as *customer end* defects and *in house* defects. For customer-end data, we have to get data on:

1. Customer end line rejection; and
2. Field complaints.

In-house, data include data related to products and data related to process.

Data Related to Product

1. Product-wise defects;
2. Severity of the defect and its contribution—major/minor;
3. Location of the defect with reference to the layout;
4. Magnitude and frequency of its occurrence at each stage of measurement;
5. Occurrence trend in beginning and the end of each production/process/changes (like pattern change, ladle/furnace lining etc.); and

6. Occurrence trend with respect to restoration of breakdown/modifications/periodical replacement of quality components.

Data Related to Processes

1. The operating condition for individual sub-process related to men, method, material and machine;
2. The standard settings/conditions of the sub-process; and
3. The actual record of the settings/conditions during the defect occurrence.

Self-Check 4	Written Test

Directions: Answer all the questions listed below and write your answer on the space provided

1.
2.
3.

Answer Sheet

Name: _____ Date: _____

Score = _____

Rating: _____

Short Answer Questions

1. _____

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_____

2. _____

_____

_____

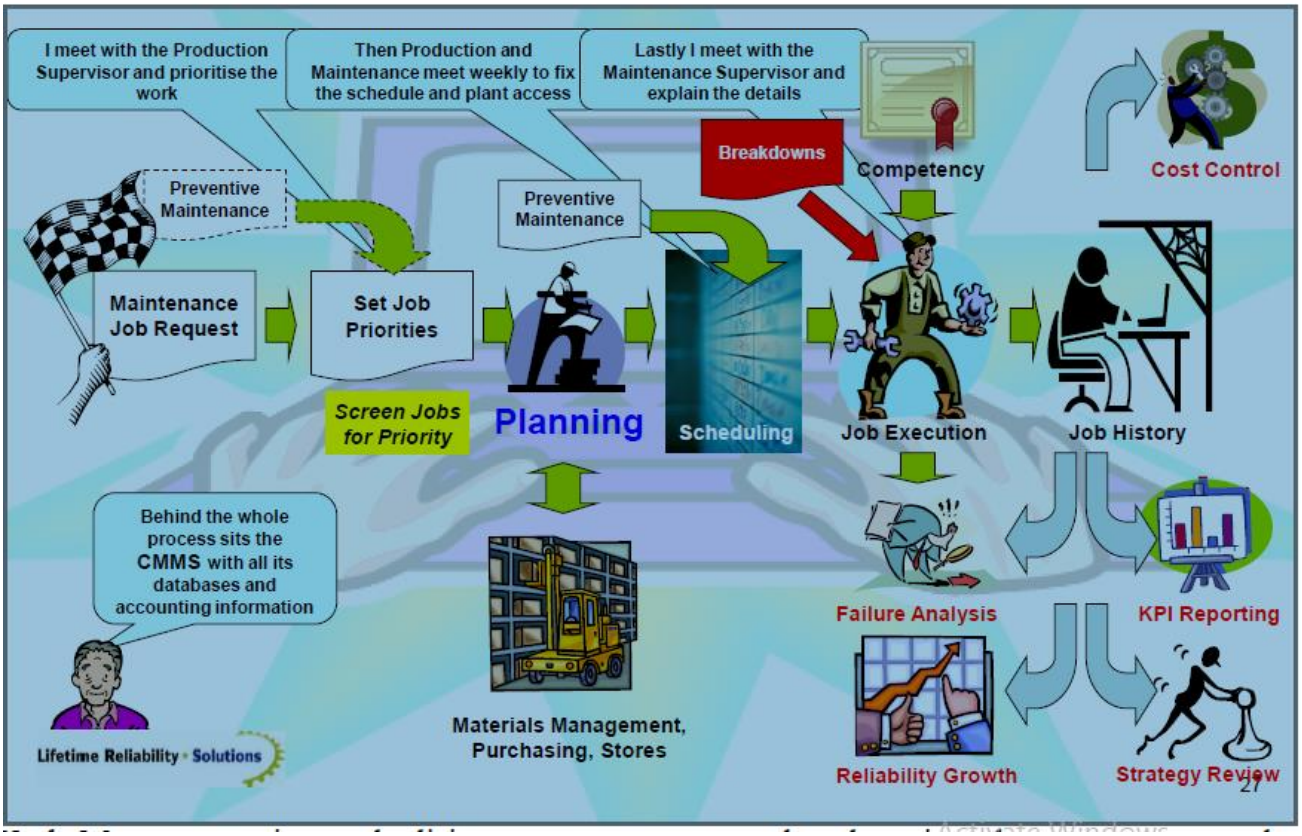
3. _____

_____

_____

Information Sheet #-5	Recommending Work improvement and processes

Standardized Maintenance Work Management Process



Work Management is standardizing your processes so that there is only one system used to handle all maintenance work. This prevents multiple methods developing, causing confusion and waste. Because maintenance is a timely activity, where time is of the essence using limited resources, it is particularly important that a systematic approach be developed and adopted by everyone.

Maintenance workflow management needs to be designed to give total consistency and uniformity in how the work process is done, and to provide some measurement points along the way for monitoring. The first task is to establish a shared need in the operation to have a simple, common approach to doing maintenance, and to agree on the goals and key elements of the Work Management process. The module highlights the key components and requirements of a typical maintenance work process.

The aim being to always do maintenance in a controlled way for sustainable improvement in equipment reliability. Some of the elements of the diagram are listed below.

- Maintenance Request comes into the system
- Prioritise the Maintenance Job Request
- Notification approval

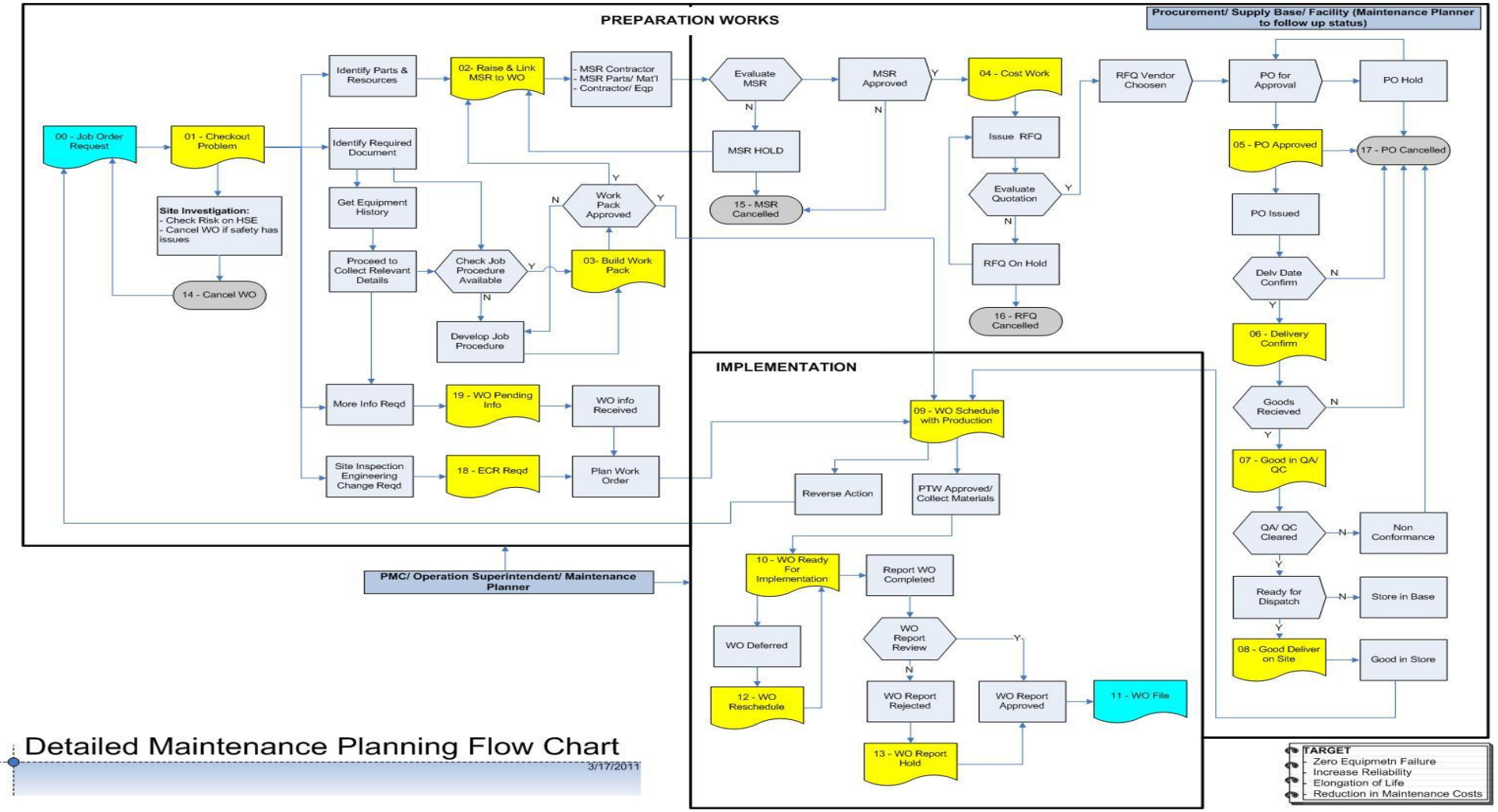
- Planning Jobs
- PM Work Order initiation (Will it go straight to scheduling, or will the Planner review each PM? Remember,-first-time you. want) right
- Scheduling Jobs
- Execution & History Collection
- Breakdown Management
- Performance Management (using the data collected)
    - KPI reporting
    - Failure Analysis
    - Maintenance Strategy Review
    - Budgeting and Cost Control

Underneath the overall diagram there are more detailed documents defining the system and each step, along with training and competency assessment systems.

The module is really about your own planning process and not about getting work orders completed. As a Planner you must also follow a designed process to do your work. Exactly how will you go about building a full and thorough work pack? That is the real purpose of having a documented process.

In terms of how that fits with the overall Work Management Process, you need to create a specific procedure and flow chart that covers just how to do the Planning of maintenance work and not anything else (one each for weekly planning and for shutdown planning).

A Maintenance Planning Process Flowchart



What you explain in your flow charts and procedures is the standardised way to do planning in your operation. You need to cover such things as: what you do for work order planning from scope out, through to job plan creation, trades selection and setting activity times, work plan reviews, through to purchasing services/components, the storage of parts and materials awaiting work allocation, allocating parts to jobs, etc. Since your 'product' is the work pack you need to design and describe what must be done to properly produce that work pack.

The planning procedure becomes it part of your company's document management system.
By the way, yes, you are responsible to make your system work better and if that means training people and teaching them what they need to know and do well, then it falls to you to do that.

The Strategy behind Maintenance Planning
Planning offers us a systematic method of equipment reliability improvement
A systematic method of equipment reliability improvement is adopted. It is based on the well-proven quality management 'Plan - Do – Check – Action' self-improvement approach.

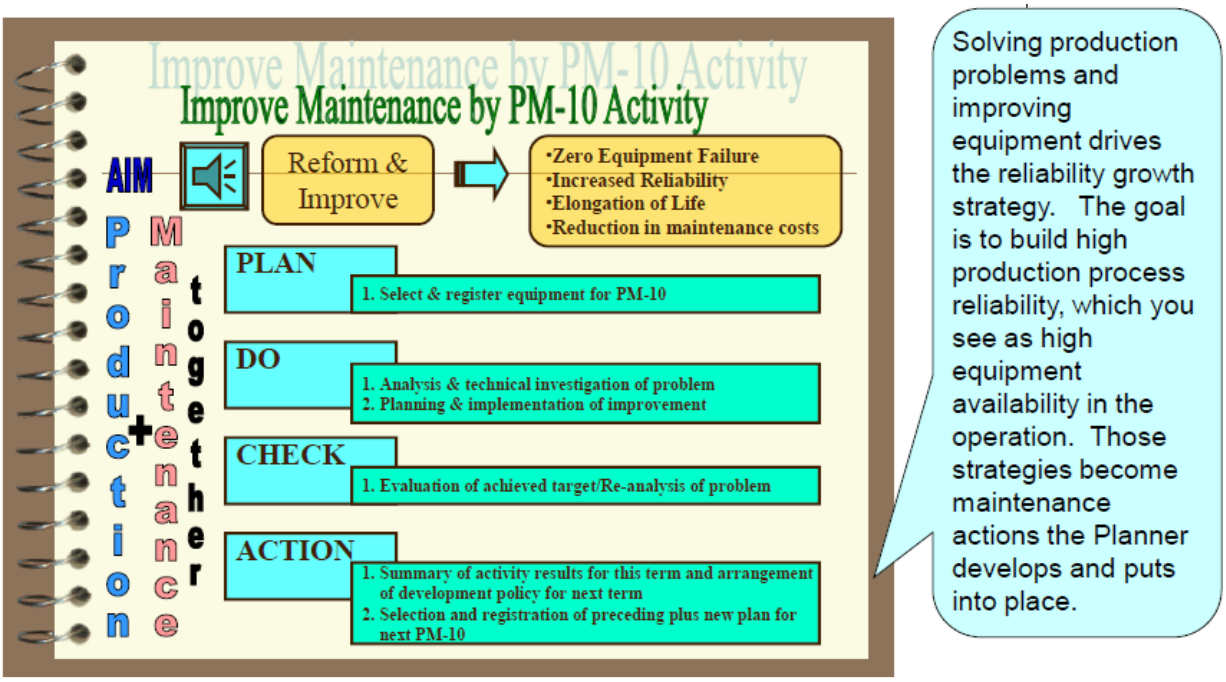


Figure 2.9 Systematic method of equipment reliability improvement

Consultation between Production and Maintenance Departments produces the PM-10 (Preventing Maintenance over 10 years) plan of production equipment to be investigated for improvement. The operating problems are scrutinized and analyzed and then corrective plans are put into place.

The improvement work is designed, organized and scheduled. The improvement may be a design-out, a process change or a simple procedural change. Continuous improvement was the normal way of thinking and living in this Japanese company.

Once the change is in place it is again evaluated against the originally intended aims. If the original problem has not been solved satisfactorily the issue is again reviewed. The plan for future improvement work is adjusted if further progress is needed on the problem.

If modifications and changes done in the past were successful then the problem can be seen to have disappeared. By reviewing past history and its impact on the operation it would be easy to justify which issues to transfer into the process.

Can you see how this would work? You know what has gone wrong with the equipment over the last eight years, it's listed right there in front of you. You can see how effective the past practices, methods and solutions have been. From that you can wisely decide what to do over the next two years to prevent reoccurrence of problems.

Instead of writing the usual 'blue sky' 5 or 10 year maintenance plan that no one believes anyway, you only plan for the believable two years ahead. You write down exactly what can really be done in the foreseeable future to reduce or prevent the real problems.

The plan for the next two years would include proposed modifications, equipment replacements, new condition monitoring plans, etc.

Now that is a great way to make next year's maintenance plan! It would be one that is totally defendable and fully justifiable to upper management because it is well thought out, rooted in getting the best return for your money and based on the important business requirements to continue in operation.

My suggestion to cover the period beyond the next two or three years (and only if it is necessary in your company), is to use the spreadsheet to make forecasts. Project ahead based on what you plan to do in the coming two to three years to fix the current problems. If you aren't going to fix the problems then don't assume less maintenance in the future. Remember that a forecast is not a plan! A forecast is a best-guess suggestion, often known as 'blue sky dreaming'. A plan is a set of action steps that in time produce a desired result. They are totally different to each other.

The great benefit of a PM-10 table is how it ensures that you never forget the past. All the failure history of each item of equipment is always right-in-your-face. If there has been too many failures the truth cannot be evaded. But most importantly the PM010 table lets you change the future. Because in it you can put your plans and actions to create a better future.

If I were you I would extend the PM-10 into the future for five years and not just two years ahead. I would then include the complete replacement of machines that are at the end of their lives. This would signal to upper management to put money aside in the relevant years to renew the old plant before it starts failing too often. You would have to regularly make the plan public at joint operations and maintenance meetings to get discussion going and to remind those managers present to put moneys into the forecast capital budgets. But proactive communication and foresight is part of a Maintenance Planners job.

Self-Check 5	Written Test

Directions: Answer all the questions listed below and write your answer on the space provided

1.
2.
3.

Answer Sheet

Name: _____ Date: _____

Score = _____

Rating: _____

Short Answer Questions

1. _____
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2. _____
_____
_____

3. _____
_____
_____

Information Sheet-#6	Accomplishing and submitting necessary documentation and reporting

Self-Check 6	Written Test

Directions: Answer all the questions listed below and write your answer on the space provided

1.
2.
3.

Answer Sheet

Name: _____ Date: _____

Score = _____

Rating: _____

Short Answer Questions

1. _____
_____
_____

2. _____
_____
_____

3. _____
_____
_____

Operation Sheet-6	Accomplishing and submitting necessary documentation and reporting

LAP Test	Improve work process and staff

Name: _____ Date: _____

Time started: _____ Time finished: _____

Direction: complete the following job and report to your instructor

Job 1: Carry out Improving work process and staff.

Instruction Sheet	Learning Guide #06: Notify completion of work

This learning guide is developed to provide you the necessary information regarding the following content coverage and topics

- Making final checks
- Notifying appropriate officer and staff
- Cleaning, checking and returning Tools, equipment and any excess resources and materials to storage area
- Cleaning up and making safe work area
- Accomplishing necessary documentation and reporting

This guide will also assist you to attain the learning outcome stated in the cover page. Specifically, upon completion of this Learning Guide, you will be able to –

- Make final checks
- Notify appropriate officer and staff
- Clean, check and return tools, equipment and any excess resources and materials to storage area
- Clean up and make safe work area
- Accomplish necessary documentation and reporting

Learning Instructions:

1. Read the specific objectives of this Learning Guide.
2. Follow the instructions described in number 3 to 20.
3. Read the information written in the “Information Sheets 1”. Try to understand what are being discussed. Ask you Instructor for assistance if you have hard time understanding them.
4. Accomplish the “Self-check 1” in page __.

5. Ask from your Instructor the key to correction (key answers) or you can request your Instructor to correct your work. (You are to get the key answer only after you finished answering the Self-check 1).
6. If you earned a satisfactory evaluation proceed to “Information Sheet 2”. However, if your rating is unsatisfactory, see your Instructor for further instructions or go back to Learning Activity #1
7. Submit your accomplished Self-check. This will form part of your training portfolio.
8. Read the information written in the “Information Sheet 2”. Try to understand what are being discussed. Ask you Instructor for assistance if you have hard time understanding them.
9. Accomplish the “Self-check 2” in page __.
10. Ask from your Instructor the key to correction (key answers) or you can request your Instructor to correct your work. (You are to get the key answer only after you finished answering the Self-check 2).
11. Read the information written in the “Information Sheets 3 and 4”. Try to understand what are being discussed. Ask you Instructor for assistance if you have hard time understanding them.
12. Accomplish the “Self-check 3” in page __.
13. Ask from your Instructor the key to correction (key answers) or you can request your Instructor to correct your work. (You are to get the key answer only after you finished answering the Self-check 3).
14. If you earned a satisfactory evaluation proceed to “Operation Sheet 1” in page _. However, if your rating is unsatisfactory, see your Instructor for further instructions or go back to for each Learning Activities.

Information Sheet#1	Making final checks

Self-Check 1	Written Test

Directions: Answer all the questions listed below and write your answer on the space provided

1.
2.
3.

Answer Sheet

Name: _____ Date: _____

Score = _____

Rating: _____

Short Answer Questions

1. _____
_____
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2. _____
_____
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3. _____
_____
_____

Information Sheet-#2	Notifying appropriate officer and staff

Self-Check 2	Written Test

Directions: Answer all the questions listed below and write your answer on the space provided

1.
2.
3.

Score = _____

Rating: _____

Answer Sheet

Name: _____ Date: _____

Short Answer Questions

1. _____

_____

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2. _____

_____

_____

3. _____

_____

_____

Operation Sheet-2	Notifying appropriate officer and staff

Problem: The engine cranks, but doesn't start. Fuel system and the mechanical engine parts are already tested and without fault.

Instruction: Refer to the starting and ignition system figure shown below to complete the following operation procedure.

Procedure:

Information Sheet-#3	Cleaning, checking and returning Tools, equipment and any excess resources and materials to storage area

Self-Check 3	Written Test

Directions: Answer all the questions listed below and write your answer on the space provided

1.
2.
3.

Score = _____

Rating: _____

Answer Sheet

Name: _____ Date: _____

Short Answer Questions

1. _____
   _____
2. _____
   _____
3. _____
   _____

Operation Sheet-3	Cleaning, checking and returning Tools, equipment and any excess resources and materials to storage area

Problem: The engine cranks, but doesn't start. Fuel system and the mechanical engine parts are already tested and without fault.

Instruction: Refer to the starting and ignition system figure shown below to complete the following operation procedure.

Procedure:

Information Sheet-#4	Cleaning up and making safe work area

1. Performance Standards

2.1. Performance Standards

All repairs made to occupied units shall be accomplished in a good and professional fashion. Materials and equipment shall be installed according to manufacturer's instructions and generally accepted methods.

2.2. Work Clean-Up

The following clean-up standard shall be maintained for work done in occupied units.

a) Remove debris from surfaces which have been affected by the work performed.
b) Use and remove temporary protection and labels not required to remain.
c) Clean finishes free of dust, stains, films, and other foreign substances.
d) Remove waste, foreign matter and debris. Disposal should not occur in tenants garbage containers. Hazardous materials must be disposed of in an appropriate manner.
e) Do not allow a hazard to exist at any time.
f) Restore occupied apartments to original condition at end of each work day. In the event that delays are necessary, the tenant and the Resident Manager (RM) must be advised in writing and informed when the work will be completed and when restoration will occur. A work order that is incomplete at the end of any work day shall be the first priority of work at the beginning of the next work day. A work order that cannot be completed before the end of the work day should generally be postponed to the next work day.
g) Any damage to tenant property must be reported to RM and Director of Property Management (DPM) immediately.

2.3. Work In Common Areas

If work in common areas presents any hazard, temporary barriers shall be used and alternate traffic and fire routes shall be posted. If work requires any interruption of basic utilities for more than thirty (30) minutes, the tenant(s) must be notified in advance. Twenty-four (24) hours advance posting shall constitute notice in buildings with only central water stops or central heat.

2. Work Areas And Equipment

2.1. Storage And Shop Areas

(a) **Security:** All storage and shop areas shall be kept locked at all times. These are restricted access areas and no tenants shall be allowed unsupervised access at any time. Whenever possible, storage areas will be located in a different area than the shop. Storage areas are to remain locked at all times.

(b) **Maintenance:** Storage and shop areas shall be kept clean at all times. Stored materials, tools, and equipment shall be properly stored and neatly organized. The Maintenance Service Program (MSP) staff shall be responsible for maintenance of main shop and storage areas. Any authorized user of shop areas shall be responsible for

keeping them clean and orderly at all times. The main shop is a principal work area for MSP staff.

All other building based storage and shop areas shall be maintained by the building's RM and Assistant Manager (AM). MSP staff may store supplies at specific buildings for convenience and efficiency after coordinating with the building's RM.

Self-Check 4	Written Test

Directions: Answer all the questions listed below and write your answer on the space provided

1.
2.
3.

Score = _____

Rating: _____

Answer Sheet

Name: _____ Date: _____

Short Answer Questions

1. _____
_____

2. _____
_____

3. _____
_____

Operation Sheet-4	Cleaning up and making safe work area

Problem: The engine cranks, but doesn't start. Fuel system and the mechanical engine parts are already tested and without fault.

Instruction: Refer to the starting and ignition system figure shown below to complete the following operation procedure.

Procedure:

Information Sheet-#5	Accomplishing necessary documentation and reporting

Self-Check 5	Written Test

Directions: Answer all the questions listed below and write your answer on the space provided

1.

2.

Answer Sheet

Name: _____ Date: _____

Short Answer Questions

Score = _____

Rating: _____

1. _____

_____

2. _____

_____

Operation Sheet-5	Accomplishing necessary documentation and reporting

Problem: The engine cranks, but doesn't start. Fuel system and the mechanical engine parts are already tested and without fault.

Instruction: Refer to the starting and ignition system figure shown below to complete the following operation procedure.

Procedure:

LAP Test	Notify completion of work

Name: _____ Date: _____

Time started: _____ Time finished: _____

Direction: complete the following job and report to your instructor

Job 1: Carry out notifying completion of work.

References

1) Lifetime Reliability -Solution: **Maintenance Planning and Scheduling for World Class Reliability and Maintenance Performance**
2) Richard D.Plamer: Maintenance planning and Scheduling Handbook-2nd edition
3) Facilities Instructions, Standards, and Techniques Volume 4-1A – Revised 2009 Maintenance Scheduling for Mechanical Equipment

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