Pillar 5: Work Management

5.6 Document work

- Create post work document process
- Record failure events and failure modes

Pillar 5: Work Management

5.6 Document work

Maintenance professionals must demonstrate their ability to create, update and manage work orders in a way that insures those who execute the work understand the tasks that need to be done including:

- What safety precautions need to be taken
- An estimate of the time
- An estimate of tools required
- Materials required.

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5.6 Document work

Instructions should be provided on:

- How to capture the as-found condition of the equipment
- What components were failed
- The steps that were taken to return the equipment to service.

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5.6 Document work

Accurate and detailed documentation of work will provide:

- Information on resource utilization (e.g. skill sets, tools, special equipment, delays, etc
- Actual costs of maintenance to support budget and planning efforts
- Enhance the ability of the reliability function to document and categorize trends.

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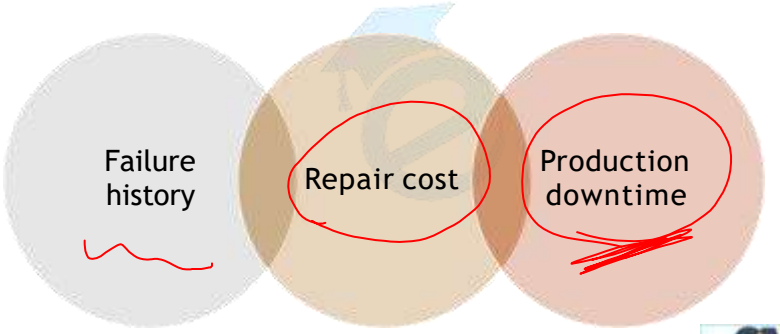
5.6 Document work

Effective and accurate documentation can be a tool for analyzing and comparing maintenance activities including :



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5.6 Document work

Example RACI Chart for failure KPI data

Tasks	Maint Supervisor	Maint Analyst	Maint Planner	Maint Technician	Maint Manager	Rel Specialist	CMMS Proj Engr
Inputting Failure Data	A	C	I	R		C	C
Work Order Completion	R	C	C	C	A	I	I
Work Order Close Out	C	R	C		I	I	A
QA of Failure Data Input	C	R	I	C	I	C	A
Analyze Failure Records	C	C	I	C	A	R	I
Maintenance Strategy Adjustments	C	I	I	C	A	R	R
Implementing New Strategies	R	I	R	C	A	I	I

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5.6 Document work

A maintenance professional should use a Computerized Maintenance Management System (CMMS) as the management tool to capture information after the maintenance tasks are completed.

Proper recording of information after the completion of work is essential for measuring and communicating maintenance performance, and for supporting the analysis of equipment failure.

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5.7 Analyze work and follow-up

- Compare actual work with plan
- Identify variances

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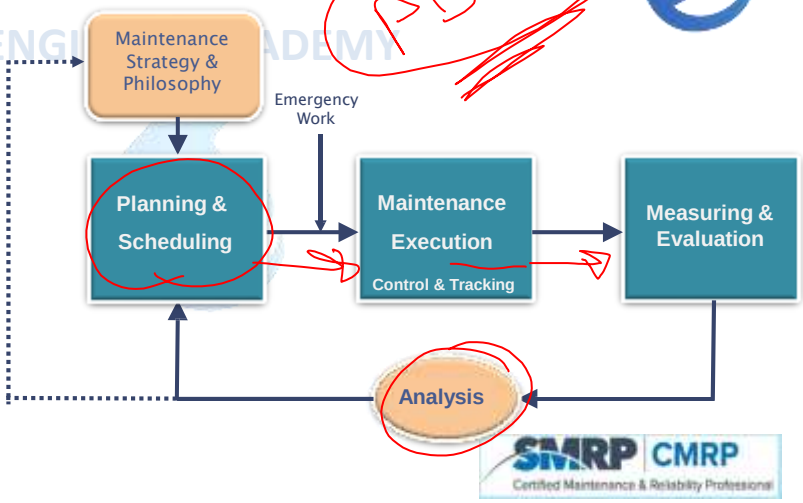
5.7 Analyze work and follow-up

Maintenance Cycle

The maintenance professional should be able to analyze work and compare the actual work with the plan set forth for the identified maintenance tasks.



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5.7 Analyze work and follow-up

Documentation of the work is used to determine when adjustments need to be made to measure the accuracy of the job plan in such areas as the estimated job duration, materials and tools required, etc

After completion, the work order should be analyzed and compared with the equipment history and to benchmark data, maintenance costs should be reviewed and improvements made to the work process.

This could be used as inputs to programs such as Failure Mode Effect Analysis (FMEA), Reliability Centered Maintenance (RCM), and/or Root Cause Failure Analysis (RCFA) that will assist in changing maintenance job plans and improve reliability.

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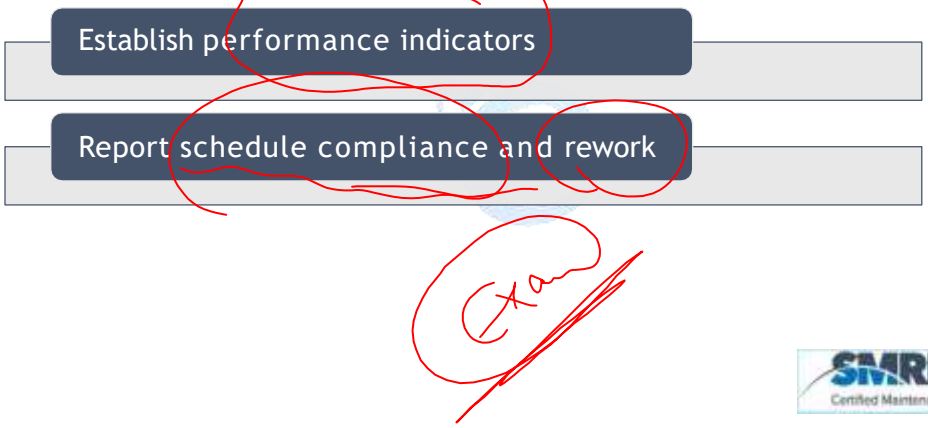
5.8 Measure work management performance



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5.8 Measure work management performance

Maintenance professional needs to understand and demonstrate maintenance performance metrics and how to apply them needs to be demonstrated.

The ability to identify and use complementary metrics to give a well-rounded assessment of performance and to support the needs of the business should be evident.

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5.8 Measure work management performance

It is important to identify and measure performance to:

- Determine the current state of the maintenance function
- Recognize the gaps against expectations or established benchmark information
- Develop a process affecting the necessary changes.

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5.8 Measure work management performance

The key principle of performance management is to ensure you are measuring what should be managed.

Appropriate and achievable metrics should be selected across all work management functions to support the needs of the business and lead the workforce to higher levels of performance.

Pillar 5: Work Management

5.8 Measure work management performance

Performance measures may include metrics for measuring the effectiveness of planning, scheduling and execution along with reliability and production measures.

Some of the metrics that can be utilized are percentage of planned work, schedule compliance, percentage of rework, etc.

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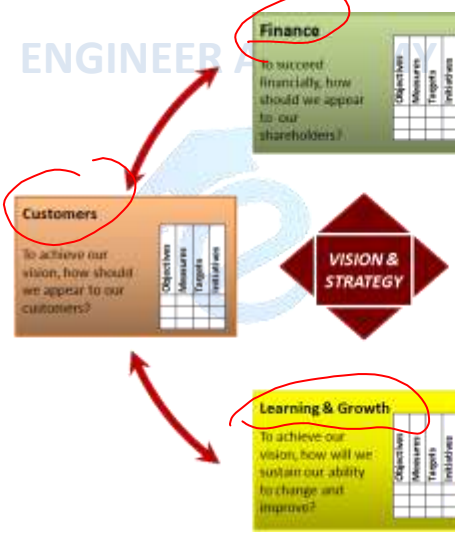
5.8 Measure work management performance

Balanced Score Card



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5.9 Plan and execute projects

- Define scope
- Estimate project and life cycle costs
- Apply critical path methods
- Track progress Coordinate staffing

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5.9 Plan and execute projects

The maintenance professional understands all the steps required to plan and implement a capital project.

What is needed for new plant, unit or asset

- Building Reliability Engineering for Maintenance
- Facilitating Asset Condition Management enablers
- Setting bases of Work Execution Management
- Being ready for Leadership for Reliability from early stages

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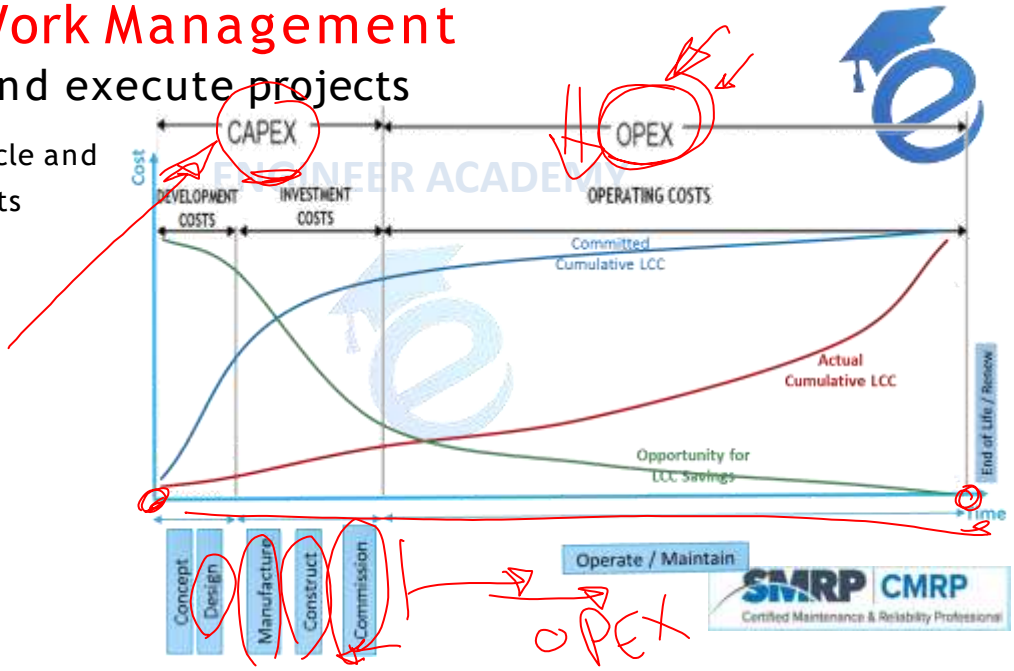
5.9 Plan and execute projects

Asset Lifecycle and Related Costs



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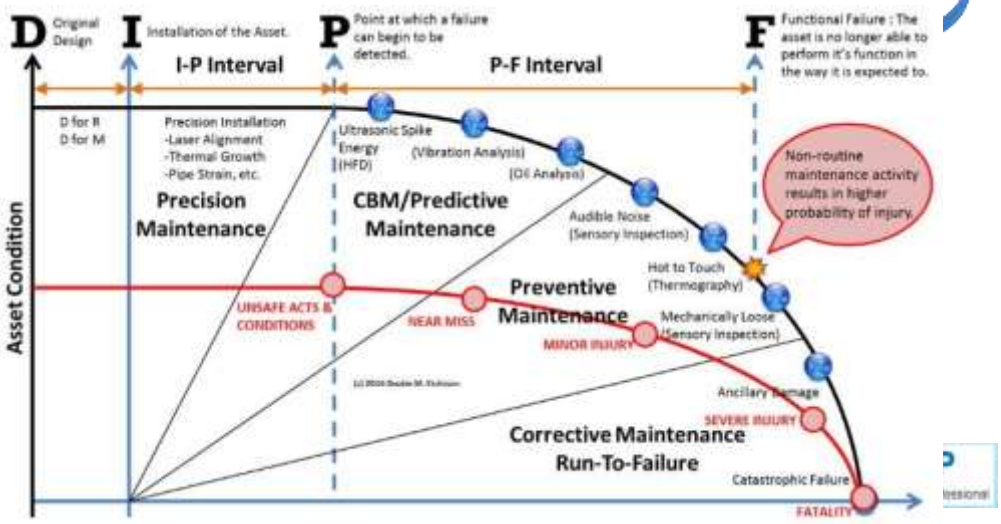
5.9 Plan and execute projects

DIPF Curve



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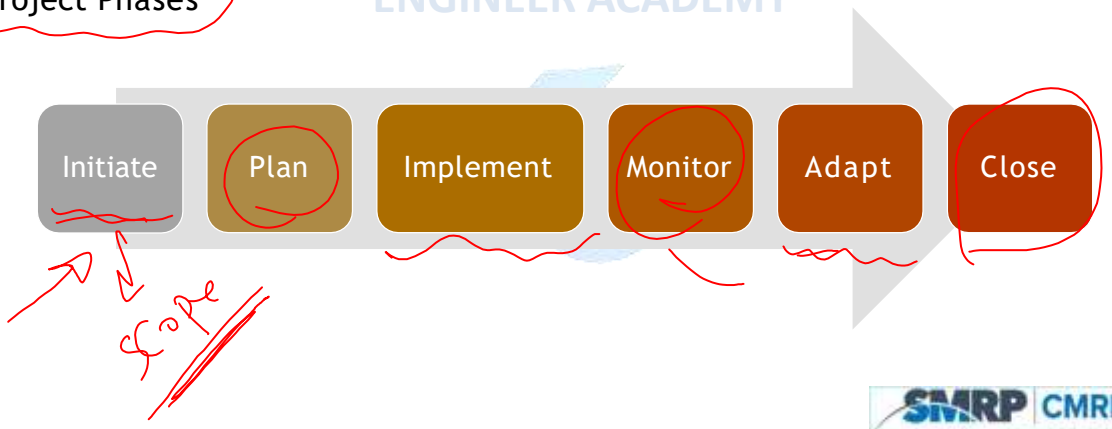
5.9 Plan and execute projects

Project Phases



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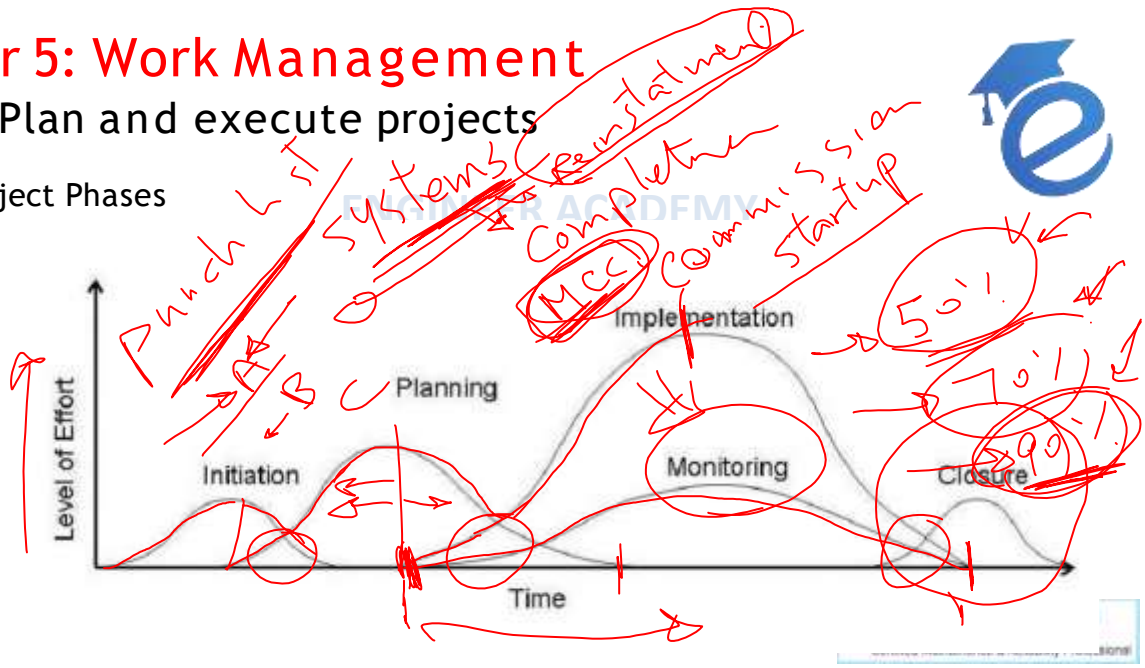
5.9 Plan and execute projects

Project Phases



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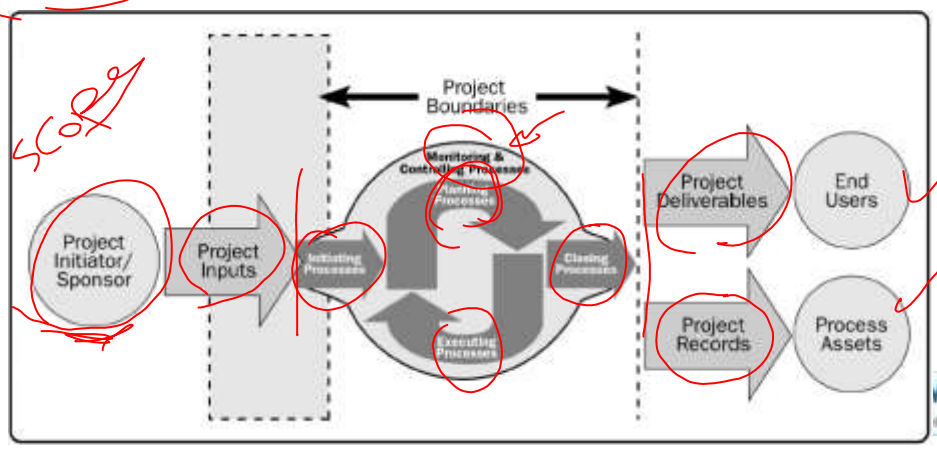
5.9 Plan and execute projects

Project Boundaries



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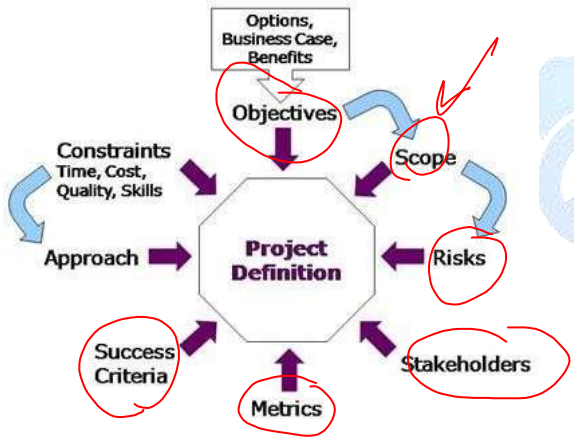
5.9 Plan and execute projects

Project Management



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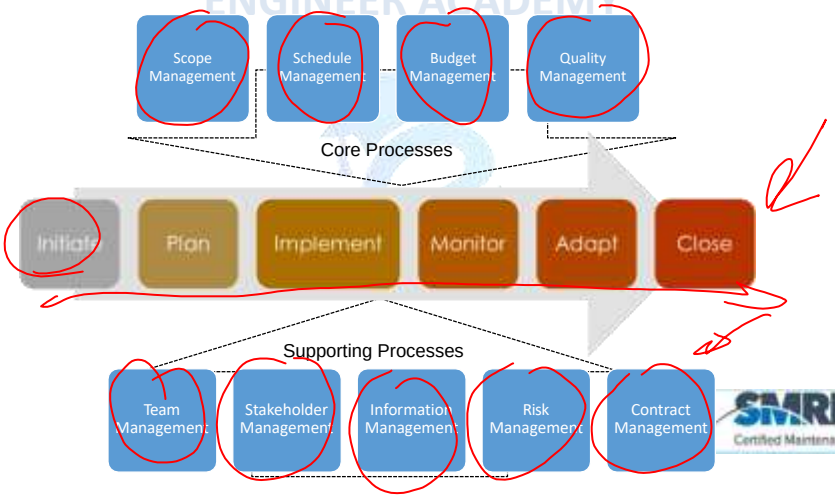
5.9 Plan and execute projects

Project Management



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5.9 Plan and execute projects

Project Constrains

- Scope, the boundaries of the project
- Schedule, the time to complete the project activities
- Budget, the funding available to cover all expenses of the project
- Quality, achieving the expectations of the

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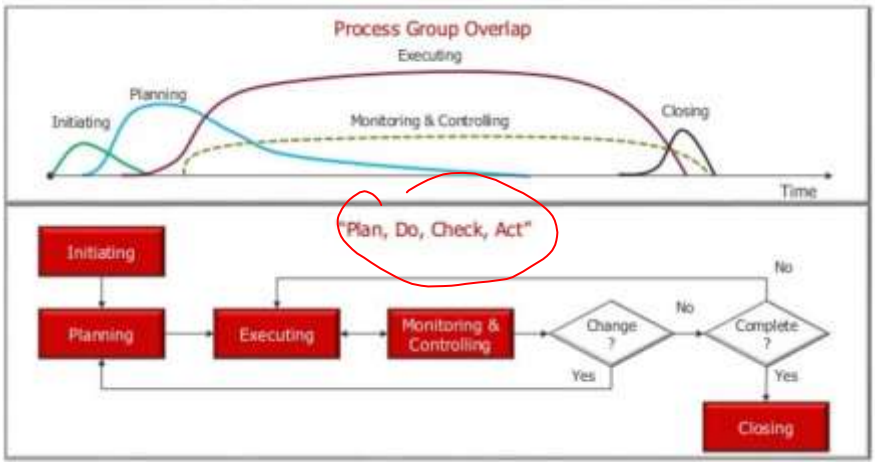
5.9 Plan and execute projects

Project Control



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5.9 Plan and execute projects

Project Control

The project scope, time to execute and cost should be defined taking into consideration the materials, plant configuration, spare parts (new and obsolete), manpower and financial requirements.

An analysis must be made of various activities required for project execution in order to identify a proper project team and define the responsibilities for each individual team member.

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5.9 Plan and execute projects

Project Control

The execution of the project should enable completion of the project on time and without rework or faults.

Project execution should be continuously monitored and reported.

Any deviations to the plan must be communicated in order to make adjustments to the project design, scope and resources.

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5.9 Plan and execute projects

Project Risk:

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5.9 Plan and execute projects

Project Risk:

- Example Risk Sources
  - Weather - affecting activities exposed to bad weather.
  - Materials/Spares - unavailability, defected or infant mortality.
  - Equipment/Tools - breakdown, unavailability, idle waiting time, etc.
  - Manpower - under staffing / unavailability, under skilled, etc.
  - Productivity - a slowing down due to fatigue, etc.
  - Complexity - high technicalities jobs, equipment age, etc.

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5.9 Plan and execute projects

Project Risk: Steps when Managing Project Risks

1 **Plan Risk Management**—The process of defining how to conduct risk management activities for a project.

2 **Identify Risks**—The process of determining which risks may affect the project and documenting their characteristics.

3 **Perform Qualitative Risk Analysis**—The process of prioritizing risks for further analysis or action by assessing and combining their probability of occurrence and impact.

4 **Perform Quantitative Risk Analysis**—The process of numerically analyzing the effect of identified risks on overall project objectives.

5 **Plan Risk Responses**—The process of developing options and actions to enhance opportunities and to reduce threats to project objectives.

6 **Control Risks**—The process of implementing risk response plans, tracking identified risks, monitoring residual risks, identifying new risks, and evaluating risk process effectiveness throughout the project.

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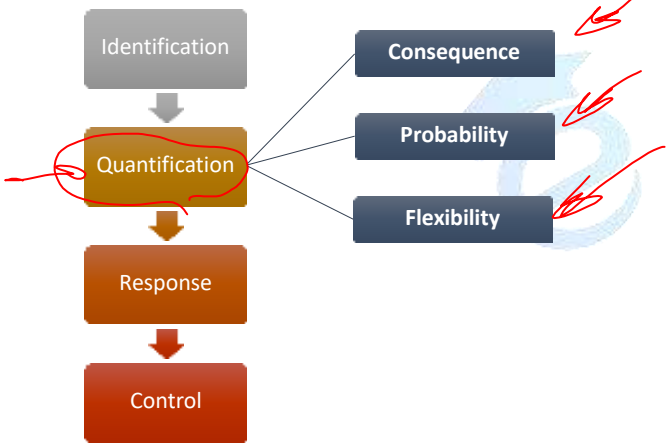
Project Risk: Risk Response Actions



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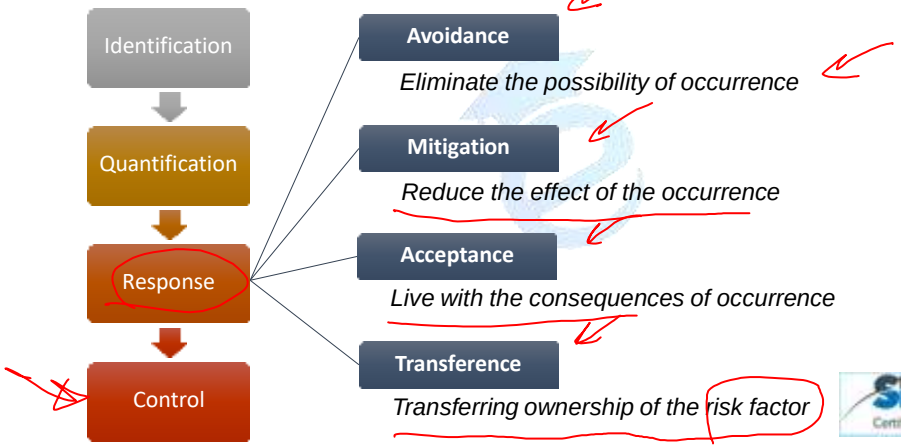
5.9 Plan and execute projects

Project Risk: Risk Response Actions



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5.10 Use information technologies effectively

- Leverage capabilities of data historian
- Process control systems
- Condition monitoring software
- EAM, CMMS systems functionality

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5.10 Use information technologies effectively

M&R professional and New Technologies and Tools:

- He shouldn't afraid of them.
- He should has the needed knowledge for them
- He should learn how to use them
- He should USE them to improve his work processes
- He should lead his organization and beers to do the same.

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5.10 Use information technologies effectively

The maintenance professional needs the ability to use a wide variety of computerized systems for the management of the information used in the management of the maintenance function

An understanding of the functionality of a Computerized Maintenance Management System as well as systems used to transfer or share data and documents between both people and various databases needs to be evident.

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5.10 Use information technologies effectively

The ability to manipulate data into information on a host of computerized systems commonly used by maintenance needs to be demonstrated.

An understanding of when and how to most appropriately use computerized tools to manage maintenance work, assess the health of equipment, and to guide improvement efforts should be part of the maintenance professional's abilities.

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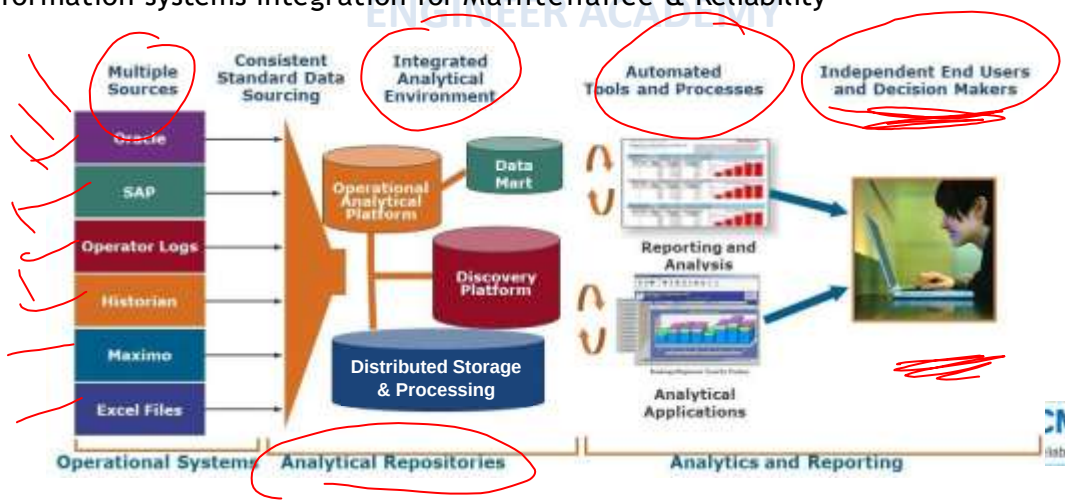
5.10 Use information technologies effectively

Information systems integration for Maintenance & Reliability



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5.10 Use information technologies effectively

CMMS / EAM :

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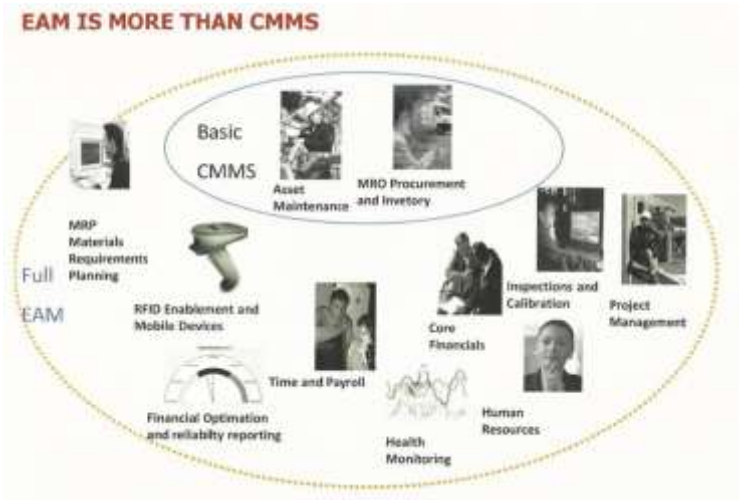
5.10 Use information technologies effectively

CMMS / EAM :



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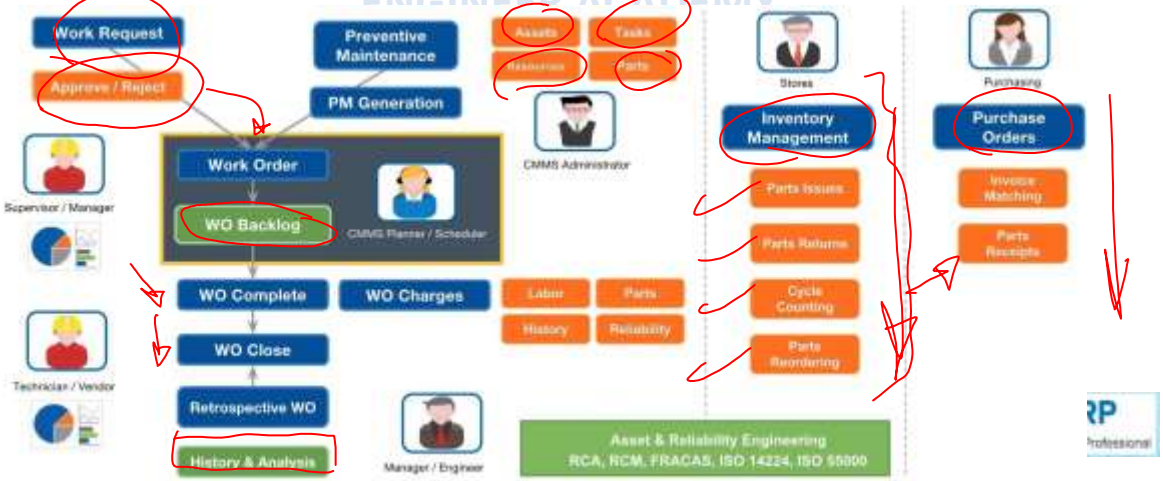
CMMS / EAM :



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5.10 Use information technologies effectively

CMMS / EAM : Goals for Computerization

- Provide a structure for standardizing maintenance / asset management processes
- Provide a "dashboard" or other analysis tools for maintenance / asset management information
- Provide a method for integrating maintenance information with other corporate business system.

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5.10 Use information technologies effectively

CMMS / EAM :

Benefits of EAM Systems and a Maintenance Master Plan

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5.10 Use information technologies effectively

CMMS / EAM System Benefits:

* *Increases:*
  - *Maintenance Productivity*
  - *Employee Morale*
  - *Maintenance Services*
  - *Equipment Life*
  - *Plant Productivity*
  - *Maintenance Information Reliability*

* *Reduces:*
  - *Craft Overtime*
  - *Outside Contract Costs*
  - *Maintenance Backlogs*
  - *Downtime*
  - *Cost per repair*
  - *Inventory*
  - *Paperwork*

1. Enhanced PMs - 76%
2. . Equipment history analysis -74%
3. . Inventory control - 58%

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5.10 Use information technologies effectively

Obstacles to CMMS / EAM Application:

Lack of understanding or commitment at any level of management
Resistance to change (Policies and procedures)
Lack of cost justification
Turf protection (Other affected departments)
Lack of job security (particularly hourly)
Lack of education
Resistance to organizational changes

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5.10 Use information technologies effectively

Internet of Things (IoT)

What is the IoT ?

Things, people and cloud services getting connected via the Internet to enable new use cases and business models

How is IoT different than M2M?

- M2M focused on connecting machines – mainly proprietary closed systems
- IoT is about harmonizing the way humans and machines connect using common public services

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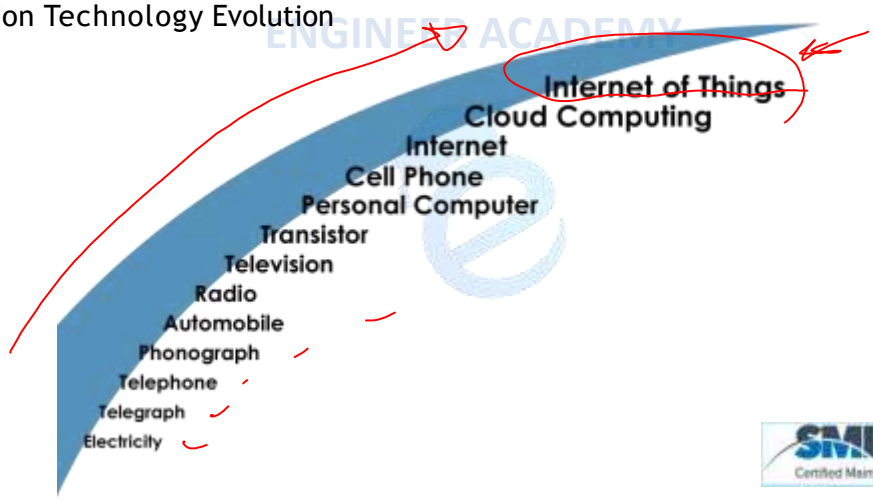
5.10 Use information technologies effectively

Information Technology Evolution



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5.10 Use information technologies effectively

Internet of Things (IoT)

IoT 2020 VISION:

212,000,000,000 Connected DEVICES

[IDC]

TRAFFIC FROM 1 HOUSE IN 2020

=ALL INTERNET TRAFFIC IN 2008

[Cisco]

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5.10 Use information technologies effectively

Internet of Things (IoT)

IoT CHANGES EVERYTHING

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5.10 Use information technologies effectively

Internet of Things (IoT)

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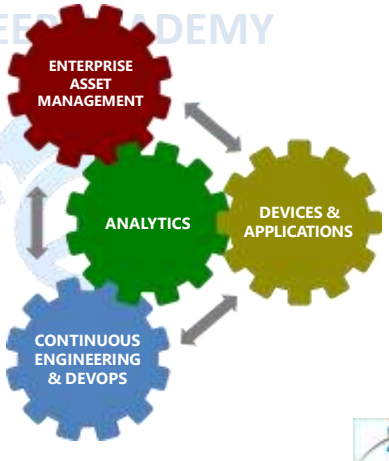

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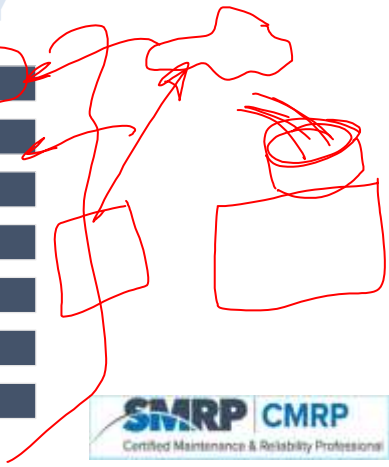
5.10 Use information technologies effectively

Internet of Things (IoT) Effect on Asset Management

- Greater Adoption of Predictive Maintenance
- Real-Time Data Analysis
- Accurate Performance Metrics
- Automatic Software Upgrades
- Recommended Repair Actions
- Tighter Parts and Inventory Control
- Remote Assets



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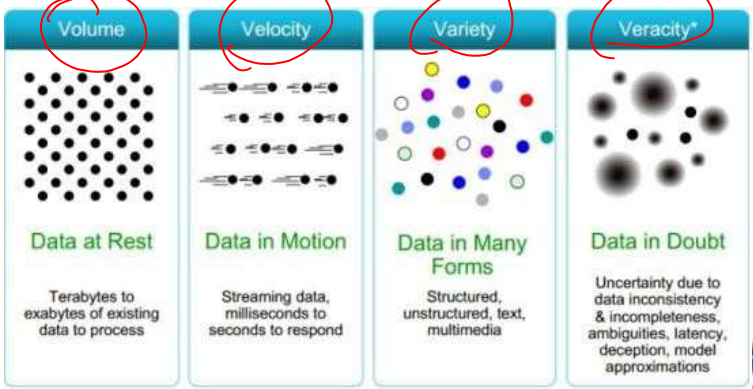
5.10 Use information technologies effectively

Big Data

The 4 V in Big Data



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5.10 Use information technologies effectively

Big data's big potential

The amount of data that's being created and stored on a global level is almost inconceivable, and it just keeps growing. That means there's even more potential to glean key insights from business information – yet only a small percentage of data is actually analyzed. What does that mean for businesses? How can they make better use of the raw information that flows into their organizations every day?

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5.10 Use information technologies effectively

Why Big data is Important

The importance of big data doesn't revolve around how much data you have, but what you do with it. You can take data from any source and analyze it to find answers that enable:

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5.10 Use information technologies effectively

Why Big data is Important

ENGINEER ACADEMY

When you combine big data with high-powered analytics, you can accomplish business-related tasks such as:

- Determining root causes of failures, issues and defects in near-real time.
- Generating coupons at the point of sale based on the customer's buying habits.
- Recalculating entire risk portfolios in minutes.
- Detecting fraudulent behavior before it affects your organization.

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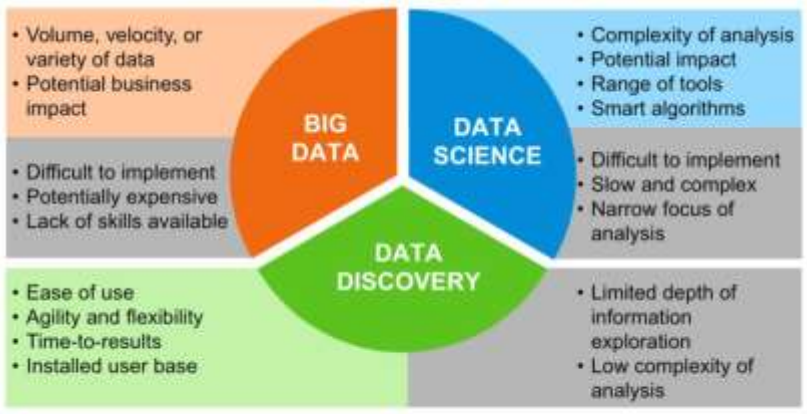
5.10 Use information technologies effectively

Big Data Discovery

According to Gartner, "Big Data Discovery" is the next big trend in analytics.

It's the logical combination of three of the hottest trends of the last few years in analytics: Big Data, Data Discovery, and Data Science.



Source: Gartner, Big Data Discovery is the combination of Big Data, Data Science, and Data Discovery.

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5.10 Use information technologies effectively

Reliability Engineering

- Legacy Tools
  - Reliability Centered Maintenance Analysis
  - Root Cause Analysis
  - "Reliability Engineering" Statistics
- New Skills for Reliability Engineers
  - Data Science
  - Machine Learning
  - Artificial Intelligence

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5.11 Manage resources and materials

M&R professional Use of Technologies and Tools:

- Control materials inventory
- Manage spares and equipment
- Establish MRO procurement process
- Manage contractors

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5.11 Manage resources and materials

The effective management of inventory (spare parts, tools, etc.) for maintenance activities is critical to the work management process.

When the procurement process is performed by another organization, the maintenance professional needs to support that process to ensure that what is purchased meets the over business needs of the organization (i.e. cost versus reliability).

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5.11 Manage resources and materials

When the inventory management system used to manage spare parts and materials is not a function of the CMMS, the maintenance professional should ensure that the methods and/or software used fully support the goals of the maintenance function.

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5.11 Manage resources and materials

The process should provide a framework of :

- What to buy
- When to buy
- What to keep in stock
- What inventory should be eliminated.

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5.11 Manage resources and materials

The process depends on accurate documentation of equipment components and parts in the CMMS along with recording information after completion of maintenance activities.

This will enable setting up stocking parameters and prioritizing inventory to support work planning and scheduling processes.

In addition to materials and spares, contract resources should also be documented in order to be requested, planned and scheduled for work.

Proper management of spares, tools and resources will facilitate continuous improvement of cost, workforce productivity and process availability.

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5.11 Manage resources and materials

MRO / Inventory Some Related Terms & Concepts

MRO:

Maintenance, Repair, and Operations. Sometime "O" is referred to as Overhaul.

Inventory Turnover Ratio (or Inventory Turns):

This ratio indicates how often an inventory turns over during the course of the year. Because inventories are the least liquid form of an asset, a high inventory turnover ratio is generally positive.

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5.11 Manage resources and materials

MRO / Inventory Some Related Terms & Concepts

Emergency Spares / Parts Replacement:

Parts required for critical assets and equipment that are kept in reserve in anticipation of outages caused by manmade or natural disasters.

The demand for these parts is unpredictable.

Usually their cost is high and they have long lead times to procure.

Not having these parts in stock may result in extended downtime and major production loss. Sometime these spare parts are called insurance spares.

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5.11 Manage resources and materials

MRO / Inventory Some Related Terms & Concepts

Just-in-Time Inventory (JIT)

A method of inventory management in which small shipments of stock are delivered as soon as they are needed. JIT minimizes stocking levels.

Service (Self-Service) Stock :

Commonly-used parts and maintenance supplies kept nearby in high maintenance areas or outside the storeroom. Withdrawal of this stock requires no requisition or paperwork. Sometimes referred to as Dime Store.

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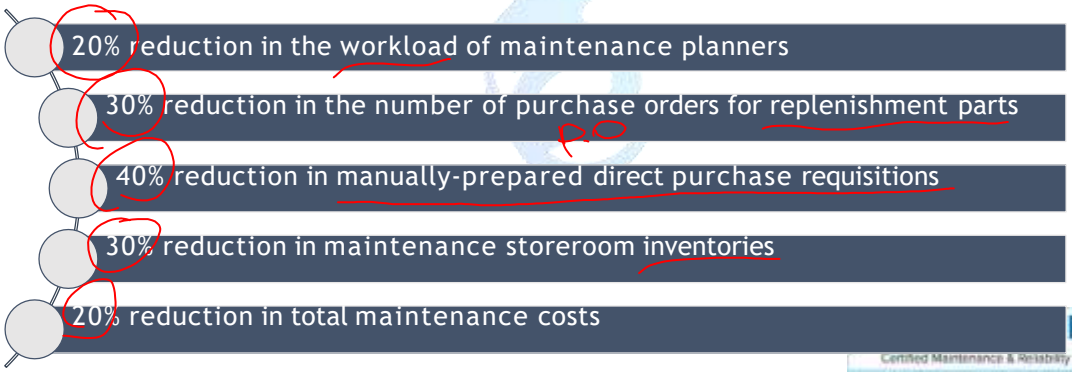
5.11 Manage resources and materials

In practice, application MRO & Inventory optimization techniques has produced the following results:



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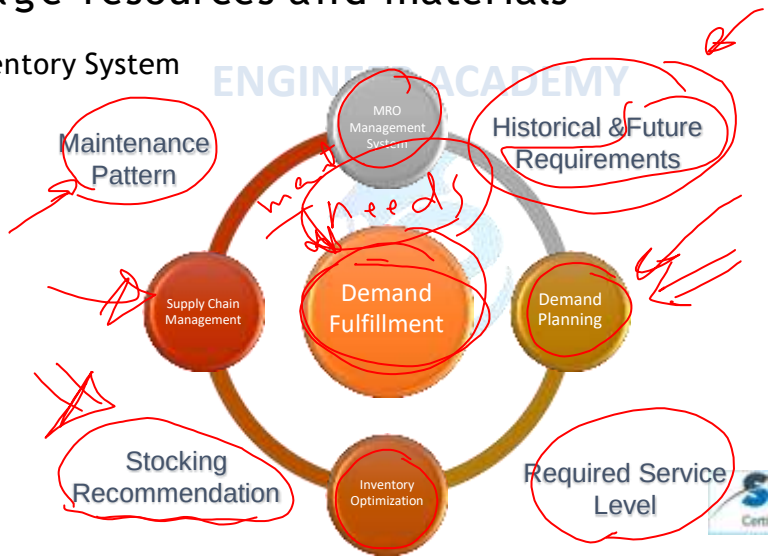
5.11 Manage resources and materials

MRO & Inventory System



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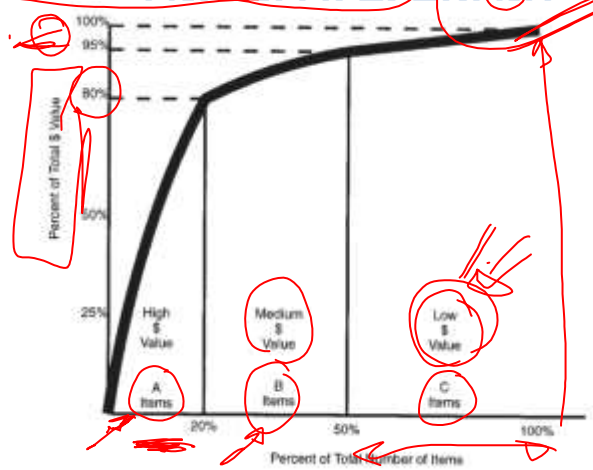
5.11 Manage resources and materials

MRO & Inventory System ABC Classification



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5.11 Manage resources and materials

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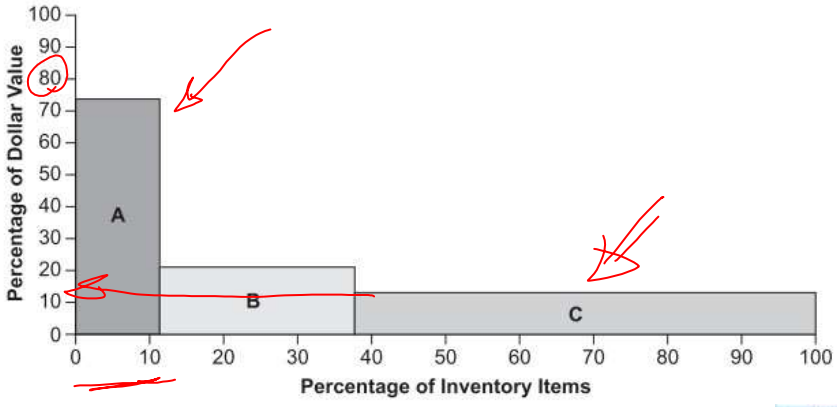

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5.11 Manage resources and materials

MRO & Inventory System ABC Classification

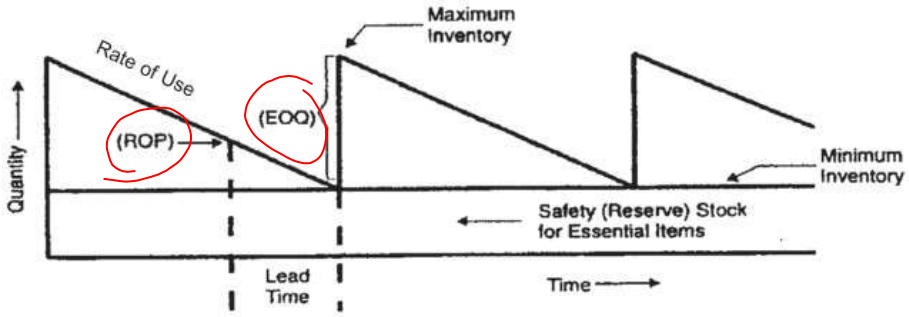
Stock Classification, ABC Analysis, and Essential Service Levels

Criticality	Stock Classification	Percent of Items	Percent of Value	Essential Service Level
A	Insurance Spares	20%	80%	100%
	Insurance Parts & Other			98%
	Critical Spares			
B	Standard Replacement Parts	30%	15%	95%
C	Hardware Items	50%	5%	90%
	Small Tools			90%
	General M&R Supplies			85%

Pillar 5: Work Management

5.11 Manage resources and materials

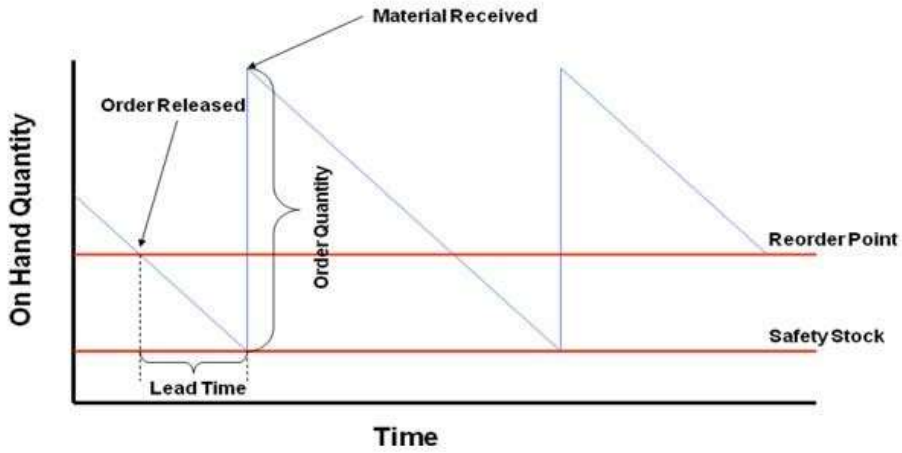
MRO & Inventory Reorder



Pillar 5: Work Management

5.11 Manage resources and materials

MRO & Inventory Reorder



Pillar 5: Work Management

5.11 Manage resources and materials

MRO & Inventory Reorder, Economic Order Quantity (EOQ)

$$EOQ = \sqrt{\frac{2DS}{H}}$$

where

D = Demand / Usage in units per year
S = Ordering cost per order
H = Inventory carrying cost per unit per year

Carrying Cost Also called holding cost, carrying cost is the cost associated with having inventory on hand. It includes the cost of space to hold and service the items. Usually this cost varies between 20-30% of the item's value on an annual basis.

Pillar 5: Work Management

5.11 Manage resources and materials

Reorder Point (ROP) in Units

The reorder point represents the inventory level at which a new order should be placed to avoid running out of stock.

Buffer stock = Safety stock = Minimum stock level

Formula:

ROP = (Average Weekly Demand × Lead Time) + Safety Stock

Example:

Average weekly demand = 100 units

Lead time = 2 weeks

Safety stock = 500 units

ROP = (100 × 2) + 500

ROP = 200 + 500

ROP = **700 units**

Question:

If the demand of one year is **5200 units**, the relevant ordering cost for each purchase order is **$210**, and the carrying cost of one unit of stock is **$24**, then the **economic order quantity (EOQ)** is:

A. 378 Packages

B. 358 Packages

C. 300 Packages

D. 30000 Packages

Correct Answer: C. 300 Packages

Explanation (optional):

EOQ formula:

EOQ = √(2DS / H)

Where:

D = Annual demand = 5200

S = Ordering cost = 210

H = Holding cost = 24

EOQ = √((2 × 5200 × 210) / 24)

EOQ ≈ **300 units**

Question:
When dealing with inventory management, buffer stock is _____.
A. Half of the actual stock
B. At which the ordering process should start
C. Minimum stock level below which actual stock should not fall
D. Maximum stock in inventory
Correct Answer: C. Minimum stock level below which actual stock should not fall

Question:
The maintenance manager of a pump seal manufacturer has asked you to calculate the **re-order point** of a spare part item. He has provided you with the following information:
Cost of the spare part = **$100**
Cost of carrying inventory = **20% of the cost of the part**
Cost of placing an order = **$40**
Annual demand = **5,200 units**
Average lead time for replenishment = **2 weeks**
Desired buffer stock = **500 units**
Average demand = **100 units per week**
What is the **re-order point in units** for this spare part?
A. 700
B. 1200
C. 350
D. 600
Correct Answer: A. 700
Explanation (optional):
Reorder Point (ROP) = (Average Demand × Lead Time) + Safety Stock
ROP = (100 × 2) + 500
ROP = **700 units**

Question:
When deciding if you should keep a part in stock, which of the following should be your primary concern?
A. Is the equipment it fits on the critical equipment list?
B. Does the manufacturer suggest stocking it?
C. Would plant (facility) output be affected?
D. Is the store's inventory too high?
Correct Answer: A. Is the equipment it fits on the critical equipment list?

Question:
The planning function should focus primarily on:
A. Accurate estimates.
B. Material availability.
C. Equipment records.
D. Future work.
Correct Answer: D. Future work.

Question:
For which of the following elements is the maintenance manager directly responsible?
A. Equipment failure probability
B. Equipment operating practices
C. Life cycle costs of equipment
D. Optimization of maintenance costs
Correct Answer: D. Optimization of maintenance costs

Question:
Which of the following is NOT an inventory classification?
A. Active Inventory (AI)
B. Rarely Used Inventory (RUI)
C. Never Used Inventory (NUI)
D. Infrequently Used Inventory (IUI)
Correct Answer: C. Never Used Inventory (NUI)

Question:
Which of the following statements best represents the primary objective of an inventory control system for maintenance materials?
A. Provide for accounting and managing of inventory.
B. Balance the cost of inventory with the risk of running out of stock.
C. Provide maintenance items when required and at the right price.
D. Reduce and sustain the maintenance costs of an organization.
Correct Answer: B. Balance the cost of inventory with the risk of running out of stock.

Question:
When dealing with inventory management, buffer stock is _____.
A. Half of the actual stock
B. At which the ordering process should start
C. Minimum stock level below which actual stock should not fall
D. Maximum stock in inventory
Correct Answer: C. Minimum stock level below which actual stock should not fall

The maintenance manager of a pump seal manufacturer has asked you to calculate the re-order point of a spare part item. He has provided you with the following information to facilitate your calculations:
•Cost of the spare part = $100
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•Annual demand = 5,200 units
•Average lead time for replenishment = 2 weeks
•Desired buffer stock = 500 units
•Average demand = 100 units per week
What is the re-order point in units for this spare part?
A. 700
B. 1200
C. 350
D. 600
Correct Answer: A. 700
Explanation (optional):
Reorder Point = (Demand during Lead Time) + Safety Stock
= (100 units/week × 2 weeks) + 500
= 200 + 500 = **700 units**

Pillar 5: Work Management

Pillar related metrics and KPIs

- Corrective Maintenance Cost
- Corrective Maintenance Hours
- Preventive Maintenance Cost
- Preventive Maintenance Hours
- Condition Based Maintenance Cost
- Condition Based Maintenance Hours
- Maintenance Shutdown Costs

Pillar 5: Work Management

Pillar related metrics and KPIs

Planned Work
Unplanned Work
Actual Cost to Planning Estimate
Actual Hours to Planning Estimate
Planning Variance Index
Planner Productivity
Reactive Work
Proactive Work

Pillar 5: Work Management

Pillar related metrics and KPIs

Schedule Compliance Hours
Schedule Compliance Work Orders
Standing Work Orders
Work Order Aging
Work Order Cycle Time
Planned Backlog
Ready Backlog
Preventive Maintenance (PM) & Predictive Maintenance (PdM) Work Orders Overdue

Pillar 5: Work Management

Pillar related metrics and KPIs

- PM & PdM Yield
- PM & PdM Compliance
- Craft Worker to Supervisor Ratio
- Craft Worker to Planner Ratio
- Direct to Indirect Maintenance Personnel Ratio
- Indirect Maintenance Personnel Cost
- Internal Maintenance Employee Cost
- Craft Workers on Shift Ratio
- Overtime Maintenance Cost
- Overtime Maintenance Hours

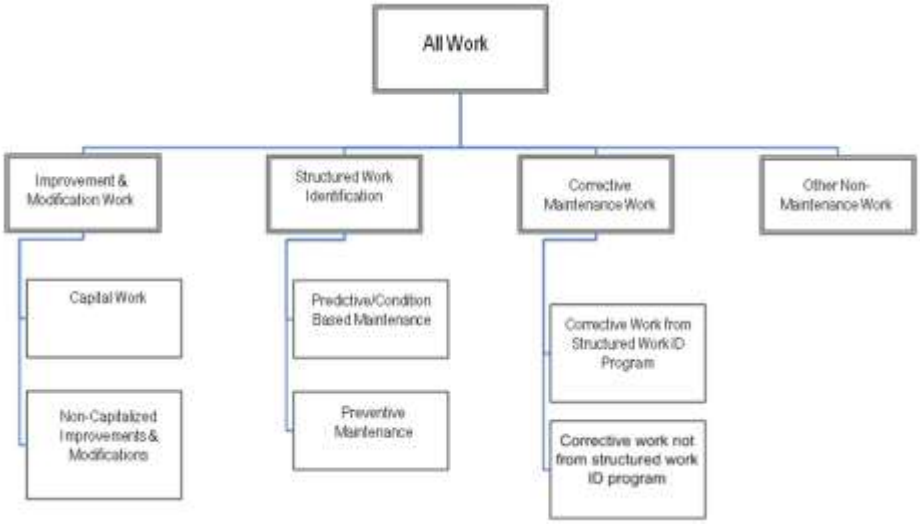
Pillar 5: Work Management

Pillar related metrics and KPIs

- Stores Inventory Turns
- Vendor Managed Inventory
- Stock outs
- Inactive Stock
- Storeroom Transactions
- Storeroom Records
- Maintenance Material Cost
- Contractor Cost
- Contractor Hours
- Wrench Time
- Continuous Improvement Hours

Pillar 5: Work Management

Pillar related metrics and KPIs



Pillar 5: Work Management

Pillar related metrics and KPIs

Corrective Maintenance Cost

This metric quantifies the financial impact of work done on corrective maintenance tasks. Trending corrective maintenance costs can provide feedback to evaluate the effectiveness of proactive activities.

To be used by: Maintenance management personnel to evaluate the effectiveness of proactive activities

Corrective Maintenance Cost (%) =
(Corrective Maintenance Cost ×100) ÷ Total Maintenance Cost

Pillar 5: Work Management

Pillar related metrics and KPIs

Preventive Maintenance Hours

Preventive Maintenance Hours (%) = (Preventive Maintenance Hours ÷ Total Maintenance Labor Hours) × 100

Provides the best data when used for evaluating the effectiveness of proactive maintenance and reliability activities when compared to other maintenance work types

SMRP's Best Practices Committee recommends a target range of 20 – 25 % of all maintenance hours.

Pillar 5: Work Management

Pillar related metrics and KPIs

Condition Based Maintenance Hours

Condition Based Maintenance Hours (%) = (Condition Based Maintenance Hours ÷ Total Maintenance Labor Hours) × 100

SMRP's Best Practices Committee recommends a target range of 45 – 50% of all maintenance hours.

Pillar 5: Work Management

Pillar related metrics and KPIs

Maintenance Shutdown Cost

Maintenance Shutdown Cost (%)
= [Maintenance Shutdown Cost ($) ÷ Total Maintenance Cost ($)] × 100

Maintenance Shutdown Cost The total cost incurred to prepare and execute all planned maintenance shutdown or outage activities. Include all staff costs incurred for planning and management of the maintenance activities performed during the shutdown. Include all costs for temporary facilities and rental equipment directly tied to maintenance activities performed during the shutdown.

Pillar 5: Work Management

Pillar related metrics and KPIs

Planned Work

Planned work is the amount of planned maintenance work that was completed versus the total maintenance labor hours, expressed as a percentage.

Planned Work means Jobs in which all labor, materials, tools, safety considerations and coordination with the asset owner have been estimated and communicated prior to the commencement of work.

Planned Work (%) = [Planned Work Executed (hrs) ÷ Total Maintenance Labor Hours (hrs)] × 100

BEST IN CLASS TARGET VALUE Greater than 90%

Pillar 5: Work Management

Pillar related metrics and KPIs

Actual Cost to Planning Estimate

This metric measures the accuracy to which work is planned and the efficiency of planned work execution.

Actual Cost to Planning Estimate =
[Actual Work Order Cost ($) ÷ Planned Cost ($)] × 100

Pl BEST IN CLASS TARGET VALUE
15% (between 85% to 115% of the estimate)

Actual Hours to Planning Estimate:10% (between 90% to 110% of the estimate)

Pillar 5: Work Management

Pillar related metrics and KPIs

- Planning Variance Index
  - This metric measures the percentage of planned work orders closed in which the actual cost varied within +/- 20% of the planned cost.
- Planner Productivity
  - This metric measures the average amount of planned work a maintenance planner prepares per month. This metric can be calculated as the number of planned labor hours or the number of job plans created per month.

Pillar 5: Work Management

Pillar related metrics and KPIs

- Schedule Compliance – Hours (>90%)
  - The metric is a measure of adherence to the maintenance schedule expressed as a percent of total time available to schedule.
- Schedule Compliance – Work Orders (>90%)
  - The metric is a measure of adherence to the weekly maintenance work schedule expressed as a percent of total number of scheduled work orders.

Pillar 5: Work Management

Pillar related metrics and KPIs

- Work Order Aging
  - This metric measures the age of active work orders by using the "Work Order Creation Date" and comparing it to "Today's Date" in order to calculate the work order age, expressed in number of days.
- Work Order Cycle Time
  - This metric is the time from the creation of work order until it is closed in the Maintenance Management System (MMS).

Pillar 5: Work Management

Pillar related metrics and KPIs

- Planned Backlog (4 to 6 Weeks)
  - This metric is the combination of the quantity of work that has been fully planned for execution but is not yet ready to be scheduled and work that is ready to be performed (also known as ready work).
- Ready Backlog (2 to 4 Weeks)
  - This metric is the quantity of work that has been fully prepared for execution, but has not yet been executed. It is work for which all planning has been done and materials have been procured. However, work is awaiting assigned labor for execution.

Pillar 5: Work Management

Pillar related metrics and KPIs

- Preventive Maintenance (PM) & Predictive Maintenance (PdM) Yield
  - The measure is the amount of repair and replacement work that is identified when performing PM or PdM work compared to the volume of PM or PdM work being done.
- Preventive Maintenance (PM) & Predictive Maintenance (PdM) Compliance
  - The metric is a review of completed preventive maintenance (PM) and predictive maintenance (PdM) work orders, in which the evaluation is against preset criteria for executing and completing the work.

Pillar 5: Work Management

Pillar related metrics and KPIs

- Craft Worker to Supervisor Ratio (12-15 : 1) (1st & 2nd quartile)
- Craft Worker to Planner Ratio (> 30:1)
- Direct to Indirect Maintenance Personnel Ratio (3.0 -5.0 to 1)
- Overtime Maintenance Cost / Time Less than (<) 5% (time 10% incase best practices applied)

Pillar 5: Work Management

Pillar related metrics and KPIs

- Stores Inventory Turns (> 1.0) & (> 3 without critical spares)
  - Value of stock purchased ÷ Value of stock on hand
  - This metric is used to measure the appropriateness of storeroom inventory levels.
  - A low stock out and low turn ratio would suggest that inventory levels are too high.
  - A high turn ratio on spare parts could indicate a reliability issue and/or reactive maintenance culture.

Pillar 5: Work Management

Pillar related metrics and KPIs

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Pillar 5: Work Management

Pillar related metrics and KPIs

- Vendor Managed Inventory
  - This metric is the ratio of the number of stocked items measured as individual stock keeping units (SKUs) that are managed by a vendor or supplier to the total number of stocked items held in inventory.
- Stock Outs (<) 2%
  - (Number of Inventory Requests with Stock Out ÷ Total Number of Inventory Requests) × 100
  - Integrated supply involves maintaining stock records in a storeroom inventory system, but storing items off-site at a vendor's site Stock outs can be measured in an integrated supply arrangement separately.

Pillar 5: Work Management

Pillar related metrics and KPIs

- Inactive Stock (<) 1%
  - This metric calculates the ratio of the number of inactive maintenance, repair and operating (MRO) inventory stock records (over 12 month) to the total number of MRO inventory stock records, excluding critical spares and non-stock inventory records.
  - Used by: MRO storeroom and maintenance management to identify and quantify potential for reducing working capital.

Pillar 5: Work Management

Pillar related metrics and KPIs

- Storeroom Transactions (100 to 140 per day per storeroom attendee)
  - Total Number of Storeroom Transactions ÷ Total Number of Storeroom Clerks
- Storeroom Records (5,000 per storeroom attendant)
  - Total Number of Inventory Stock Records ÷ Total Number of Storeroom Clerks
- Maintenance Material Cost (50%) (prevailing labor rates in the United States)
  - [Maintenance Material Cost ($) ÷ Total Maintenance Cost ($)] × 100
  - A high percentage of material cost to labor cost may indicate an ineffective PM/PdM program, while a high percentage of labor cost may indicate a lack of effective planning.

Pillar 5: Work Management

Pillar related metrics and KPIs

- Contractor Cost
  - [Contractor Maintenance Cost ($) ÷ Total Maintenance Cost ($)] × 100
- Contractor Hours
  - (Contractor Labor Hours ÷ Total Maintenance Labor Hours) × 100
- Wrench Time (50-55% for best practices applied)(30% for immature org.)
  - This metric is a measure of the time a maintenance craft worker spends applying physical effort or troubleshooting in the accomplishment of assigned work.
  - Wrench Time Percentage = [Wrench Time (hrs) ÷ Total Hours (hrs)] x 100
- Continuous Improvement Hours (>) 5 to 15%
  - (Maintenance Labor Hours Used for Continuous Improvement ÷ Total Maintenance Employee Hours) x 100

Pillar 5: Work Management

General Notes and Remarks on Metrics

- To understand failures (reliability)
  - Use MTBF for repairable assets and components
  - Use MTTF for non-repairable assets and components
  - Use MTBF and MTTF to evaluate asset/component design from reliability perspective
  - Use Failure Mode and Effects Analysis (FMEA) to improve asset/component design from reliability perspective

Pillar 5: Work Management

General Notes and Remarks on Metrics

- To understand maintenance processes (maintainability)
  - Use MTTR for repairable and non-repairable assets and components
  - Use MTBM to evaluate maintenance processes.
  - Use MTTR and MTBM to evaluate asset/component design from maintainability perspective
  - Use Root Cause Failure Analysis(RCFA) to improve asset/component design from maintainability perspective

Pillar 5: Work Management

General Notes and Remarks on Metrics

- To understand facility downtime (availability)
  - Use both reliability and maintainability “mean metrics” since availability can be improved from reliability and maintainability improvements.
  - Analysis should be performed to determine which type of “mean metric” (reliability or maintainability) should be evaluated first for potential improvements.

Pillar 5: Work Management

General Notes and Remarks on Metrics

- Direct Maintenance Personnel: Maintenance employees assigned to perform actual maintenance tasks, such as corrective and preventive maintenance. Examples include mechanics, electricians, pipe fitters, mobile equipment operators and hourly technicians.
- Indirect Maintenance Personnel: Maintenance employees required to support the overall maintenance operation, but not directly performing maintenance work. These personnel are generally charged to an overhead account. Examples include supervision, engineering, maintenance planning and scheduling, clerical, etc.

Pillar 5: Work Management

Pillar practice questions

Question:
Which one of the following is not a limitation of Risk-Based Inspection (RBI)?
A. Data dependency
B. Inspector expertise
C. Resource
D. Software of RBI for Data Collection
Correct Answer: D. Software of RBI for Data Collection

Question:
The task of developing procedures and making work orders for maintenance work activities, including identifying resource requirements, safety precautions, and special work instructions required to execute the work will be performed by a _____.
A. Scheduler
B. Technician
C. Planner
D. Maintenance team leader
Correct Answer: C. Planner

Question:
When should completed work orders be turned in to the supervisors?
A. At the end of the day
B. At the end of the shift
C. After completing a group of tasks
D. Upon completion of the work
Correct Answer: D. Upon completion of the work

All maintenance personnel's time is covered by work orders.
A. True
B. False
Correct Answer: A. True

Question:
Most emergency work orders should be written by production.
A. True
B. False
Correct Answer: A. True

Question:
All the following are desired outcomes of the reliability improvement process **except**:
A. Increase MTBF to as high as possible
B. Reducing wrench time (tool time) to as low as practicable
C. Reduce MTTR to as low as possible
D. Increasing equipment uptime to as high as possible
Correct Answer: B. Reducing wrench time (tool time) to as low as practicable

Question:
Most maintenance departments are faced with the following challenges **except**:
A. Wrench time is less than 25%
B. Lack of equipment to maintain
C. Lack of effective planning
D. Lack of effective scheduling
Correct Answer: B. Lack of equipment to maintain

Question:
Which list of elements below are the most important to be evaluated and coordinated during the planning phase of a major shutdown of your operating area (i.e., annual turnaround)?
A. Historical turnaround maintenance days, operations desired work list, prior turnaround work lists
B. Available turnaround budget, equipment condition, budgeted down-days
C. Condition and remaining life of critical equipment, value of production throughput, labor and materials availability and cost
D. Heavy lifting equipment availability, labor cost and availability, operations requested down-days
Correct Answer: D. Heavy lifting equipment availability, labor cost and availability, operations requested down-days

Question:
Planning and scheduling effectiveness is measured and tracked with KPIs. Which one of the following can be used as a measure for scheduling best practice?
A. Equipment availability
B. Maintenance cost variance
C. Wrench time and schedule compliance
D. None of the above
Correct Answer: C. Wrench time and schedule compliance

Question:
A maintenance technician was asked to perform maintenance on a rotating equipment at a jobsite 20 km from the workshop. In an 8-hour day, he spent 2 hours traveling back and forth to the work location, and 2 hours getting tools, parts, work permits, and doing Job Hazard Analysis (JHA). The remainder of his time was used to perform actual maintenance work. Estimate his wrench time expressed as a percentage.
A. 0.5
B. 0.25
C. 1
D. 0.75
Correct Answer: A. 0.5 (50%)

Question:
In a world-class maintenance organization, what is the estimated wrench time (productivity)?
A. 80–100%
B. 10–20%
C. 50%–55%
D. None of the above
Correct Answer: C. 50%–55%

Question:
Planning backlog in the best practice is:
A. 6 months
B. One year
C. 2–4 months
D. 4–6 weeks
Correct Answer: D. 4–6 weeks

Question:
The work orders which are executed and completed after the due date are called:
A. Job added
B. Work force
C. Rework
D. Outage
Correct Answer: D. Outage

Question:
For a given week, there were **135 work orders scheduled**. At the end of the week, **113 scheduled work orders** and **45 emergency work orders** were completed. Schedule Compliance is:
A. 55%
B. 64%
C. 84%
D. 90%
Correct Answer: C. 84%

Schedule Compliance = (Completed Scheduled Work Orders ÷ Total Scheduled Work Orders) × 100
= (113 ÷ 135) × 100 ≈ **84%**

Question:
Schedule Compliance in the best practice is:
A. 50%
B. 60%
C. 70%
D. 90%
Correct Answer: D. 90%

Question:
Estimation time and cost accuracy should fall within the range of _____ in best practice.
A. 5%
B. 10%
C. 15%
D. 20%
Correct Answer: C. 15%

Question:
What is the most preferred time for planning a shutdown?
A. Long lead time
B. Short lead time
C. Rigid lead time
D. Flexible lead time
Correct Answer: A. Long lead time

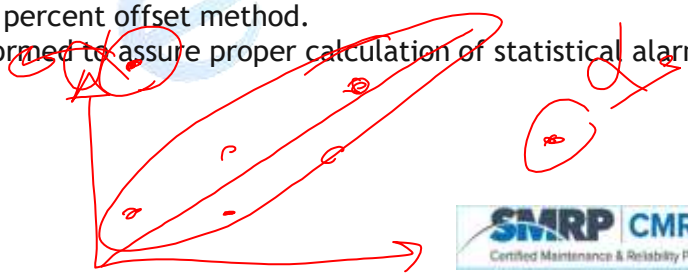
Question
A maintenance manager has a spreadsheet list of all of the equipment failures that have occurred at the plant (facility) over the past three years. Which of the following analytical methods or tools might be used to sort and prioritize the list?
A. Root Cause Failure Analysis
B. Life Cycle Cost Analysis
C. Total Cost of Ownership
D. Pareto Analysis
Correct Answer: D. Pareto Analysis

Question

Grouping of data into families and eliminating statistical outliers from a statistical alarm calculation:

A. Is not necessary as the standard deviation process corrects for all deviations.
B. Must be performed to assure proper calculation of statistical alarms.
C. Will only affect the bad data, but not affect the good data.
D. Can be dealt with by using the percent offset method.

Correct Answer: B. Must be performed to assure proper calculation of statistical alarms.



Question

Which of the following factors are considered when ranking failure by Criticality? Select the best answer.

A. Number of starts per year and cost of power to operate
B. Probability of failure and severity of consequences
C. Equipment age and annual maintenance cost
D. Probability of environmental consequences if a failure occurs and cost of failure

Correct Answer: B. Probability of failure and severity of consequences

Question
Which of the following methods best identifies maintenance problems caused by maintenance or operating work processes?
A. Root Cause Failure Analysis
B. Bottleneck Analysis
C. Weibull Analysis
D. Pareto Analysis
Correct Answer: A. Root Cause Failure Analysis

Question
Which answer is not one of the steps in performing an RCA (Root Cause Analysis)?
A. Track the recommended solutions to ensure effectiveness.
B. Develop solutions and recommendations.
C. Identify possible mitigating factors.
D. Define the problem or the failure.
Correct Answer: C. Identify possible mitigating factors.

Question
How to improve and monitor manufacturing performance?
A. Control Charts
B. Risk analysis
C. Failure analysis
D. None of the above
Correct Answer: A. Control Charts

Question
For a very stable and capable manufacturing process that is centered around the product specification, extremely low levels of defects may be identified by using:
A. Process control charts
B. Process visual inspections
C. Process automated inspections
D. Process stability charts
Correct Answer: A. Process control charts