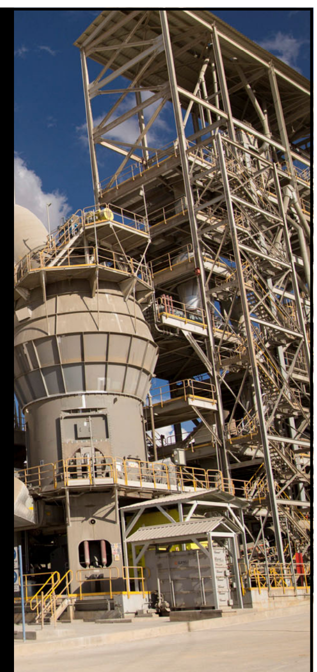
Reliability and Assets Management

Maintenance Management

Maintenance Management

- Maintenance Management
- What affects maintenance
- 12 areas of maintenance management discipline
- Maintenance management strategy
- Maintenance policies



WHAT IS MEANT BY THE TERM "MAINTENANCE" ?

1

Maintenance - any activity carried out on an asset to ensure that the asset continues to perform its intended functions or repair the equipment. Note that modifications are not maintenance, even though they may be carried out by maintenance personnel.

2

Maintenance - encompasses all those activities that maintain facilities & equipment in good working order so that a system can perform as intended.

3

Maintenance can also be termed as asset management system which keeps them in optimum operating condition.

4

Maintenance - normal support, periodic and minor in nature, required to sustain performance and functionality of an asset consistent with design, manufacturer, and operational requirements.

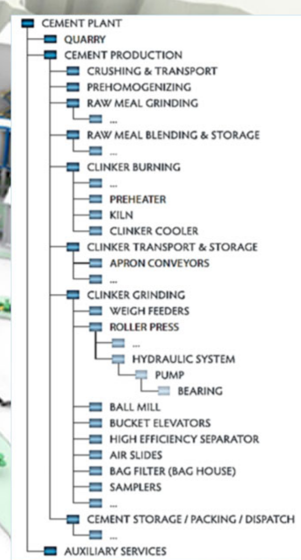
MAINTENANCE MANAGEMENT

Asset

- **Asset** - unlike in the accounting definition, in maintenance this is commonly taken to be any item of physical plant or equipment.
- It is the basic unit of maintenance.

Asset Management

- The systematic planning and control of a phy… resource throughout its life. … include … specification, design, and cons… operation, maintenance and … use, and its disposal when no…



MAINTENANCE MANAGEMENT

Maintenance Function

1. Maintenance of existing equipment.
2. Equipment inspection and services.
3. Equipment installation.
4. Maintenance storekeeping.
5. Craft administration.

MAINTENANCE MANAGEMENT

What is Management:

MAINTENANCE

- To keep in continuance
- To keep in existing state
- To preserve something

MANAGEMENT

- The act, art or manner of managing or controlling something
- Executive ability of controlling

MAINTENANCE MANAGEMENT

- The art or manner of managing to keep our physical assets in existing state of condition
- The art or science of managing maintenance resources
- Maintenance Management is defined as the organization of maintenance within an agreed policy.

MAINTENANCE MANAGEMENT

World class defined

The ability to compete anywhere in the world, to be able to meet and beat any competitor anywhere in the world with product, price, quality, and on-time delivery.

World class maintenance management

The art and science of managing maintenance resources are performed by best-in-class industries worldwide.

But the question arises, is it possible to manage maintenance, or has the pressure over maintenance been managing us for a long time?

WHAT AFFECTS MAINTENANCE ?

COST

- Spare parts cost
- Human Resources
- Manpower Overtime
- Commissioning Cost
- Repair & Maintenance Cost
- Investment & Modification

Goal is to reduce the cost of maintenance

- Spare Parts Management
- Study of Life Cycle Cost
- Modification and Redesign
- Proactive Maintenance
- Analysis on Top Spare Contributors

DOWNTIME

- Breakdown or Failure
- Set-Up & Conversion
- Minor Stoppages & Assists
- Design Speed Loss
- Start-Up Loss
- Defects & Reworks

Goal is to reduce equipment downtime

- Root Cause Failure Analysis
- Application of FMEA Techniques
- RCM/OER Application
- OEE/MTBF/MTBA Application
- Condition-Based Maintenance Techniques
- Monitor Equipment Indices & Metrics

SKILLS

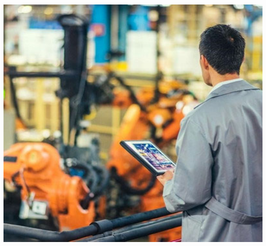
- Repair Skills
- Analytical Skills
- Multi-skills
- Technology Skills

Improve the skills of our human resources

- Conduct Training Needs Assessment
- Training & Education
- Coach & Educate Maintenance Personnel
- Improve procedures and MTTR Application

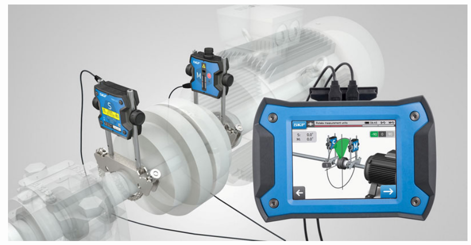
THE NEED FOR MAINTENANCE MANAGEMENT

- The Maintenance Department is one of the greatest profitability levers of any capital-intensive organization. An average of 40 to 50% of capital-intensive industries operating budgets is consumed by maintenance expenditure.



PREDICTIVE MAINTENANCE

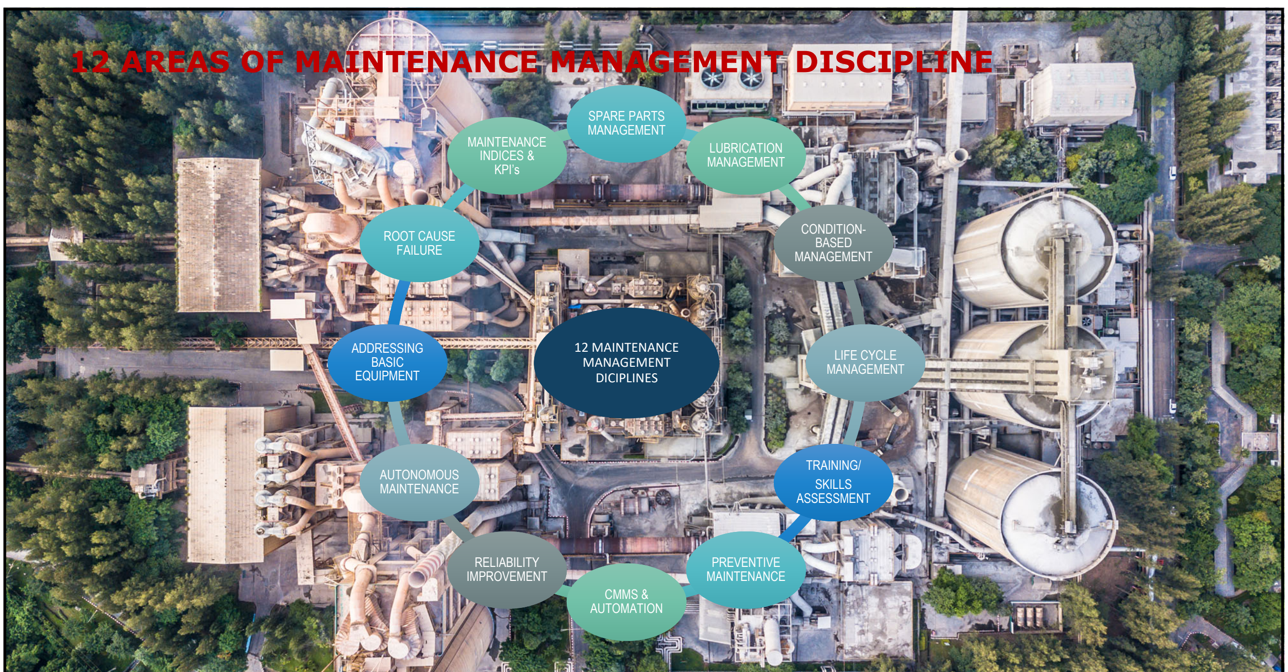
TRIBOLOGY



LASER ALIGNMENT

- With the advances in today's technology, these figures can be dramatically reduced as such maintenance is often an organization's most significant single controllable expense.

12 AREAS OF MAINTENANCE MANAGEMENT DISCIPLINE



12 AREAS OF MAINTENANCE MANAGEMENT DICIPLINE

- These 12 Areas for Maintenance Management Discipline will affect how well we perform maintenance on our equipment and how reliable our equipment will be.
- These Maintenance Management disciplines can be categorized into three:

BASIC	INTERMEDIATE	ADVANCE
▪ Addressing Basic Equipment Conditions ▪ Autonomous Maintenance ▪ Training and Skills Assessment ▪ Maintenance Indices and KPIs ▪ Preventive Maintenance	▪ Spare Parts Management ▪ Lubrication Management ▪ Life Cycle Management ▪ Root Cause Failure Analysis ▪ Reliability & Continuous Improvement	▪ Condition-Based Maintenance ▪ CMMS & Automation

MAINTENANCE POLICIES

Basic policies for the operation of a maintenance-engineering department.

While many of these policies overlap and are interdependent, they may be grouped in four general categories:

- ✓ ***Policies with respect to work allocation***
- ✓ ***Policies with respect to workforce***
- ✓ ***Policies with respect to interplant relations***
- ✓ ***Policies with respect to control***

Reliability and Assets Management

Asset Condition Management

LIFE CYCLE MANAGEMENT

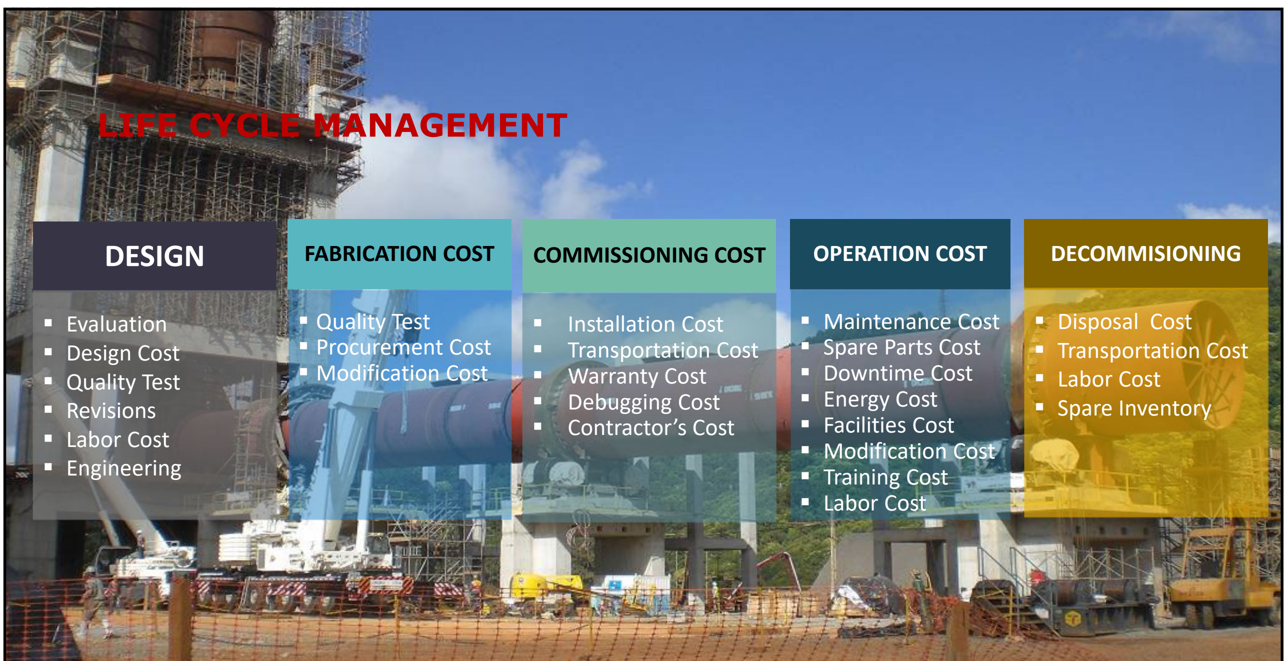
LIFE CYCLE MANAGEMENT

Life Cycle Cost refers to the total cost of equipment throughout its life. The US Management and Budget defines LCC as the sum of the direct, indirect, recurring, non-recurring, and other related costs of a large-scale system during its period of effectiveness.

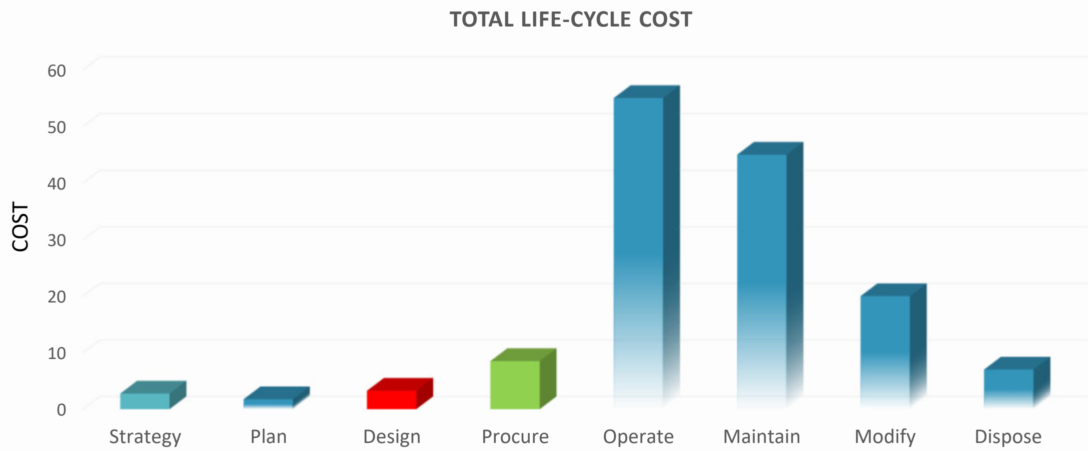
In terms of production equipment, LCC can be described more simply as design and fabrication cost, which is the initial or acquisition cost, plus the operation and maintenance cost which is the running costs.

The initial cost will always be easy to see, but the running cost is not. Failure to consider the running cost can lead to many problems. At least 80% of an equipment's LCC can be conceptualized at the design stage. Hence,

LCC = INITIAL COST + RUNNING COST



The decisions that we make in one stage influence the others



Three important cost dimensions

3
Production costs

- Maintenance vs. Non-maintenance costs
- Fixed vs. Variable costs
- Cash vs. Non-cash

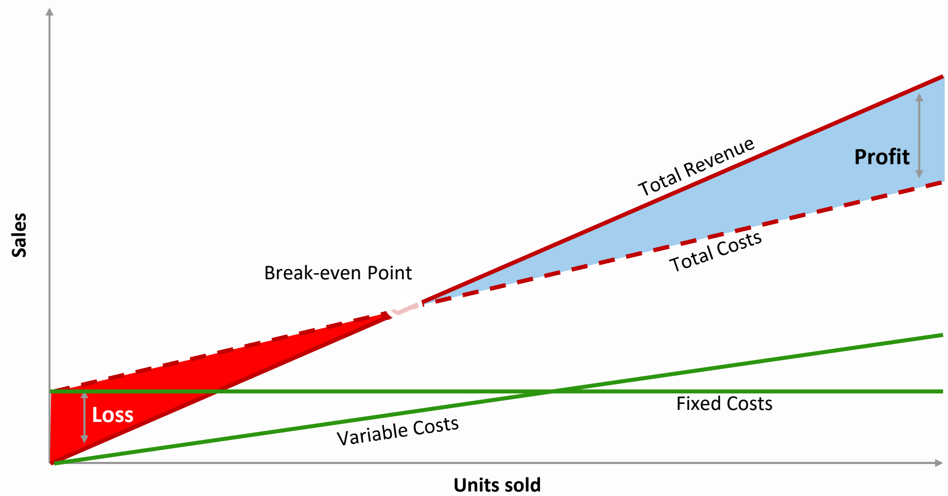
1
Life-cycle costs

The costs of the asset over time

2
Reliability costs

The impact of reliability on performance and quality

Fixed versus variable costs



LIFE CYCLE MANAGEMENT

Sometimes a higher-performance product costs less than a commodity-type product, even though the price is higher. To gauge whether this will be the case, we should look at the product life cycle cost rather than the product's purchase price or initial cost.

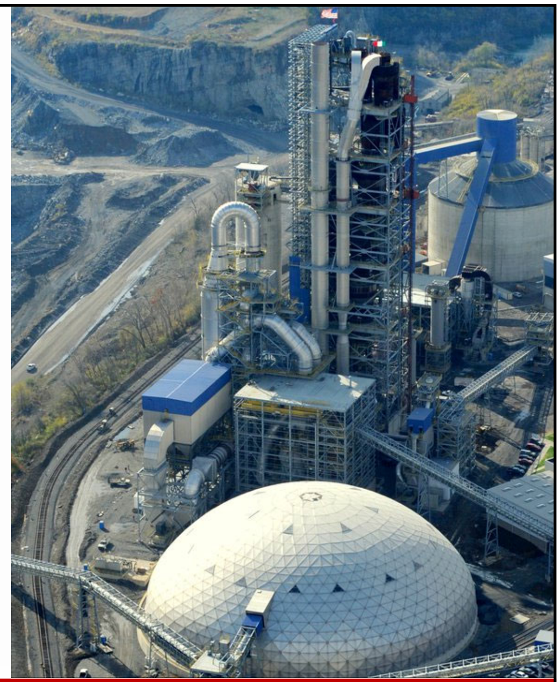
Life Cycle Costing is a way of analyzing equipment purchase choices. If the decision were based on several factors rather than its initial costs, we would make our selection based on the least amount to own over its entire life. It is all about Life Cycle Management.

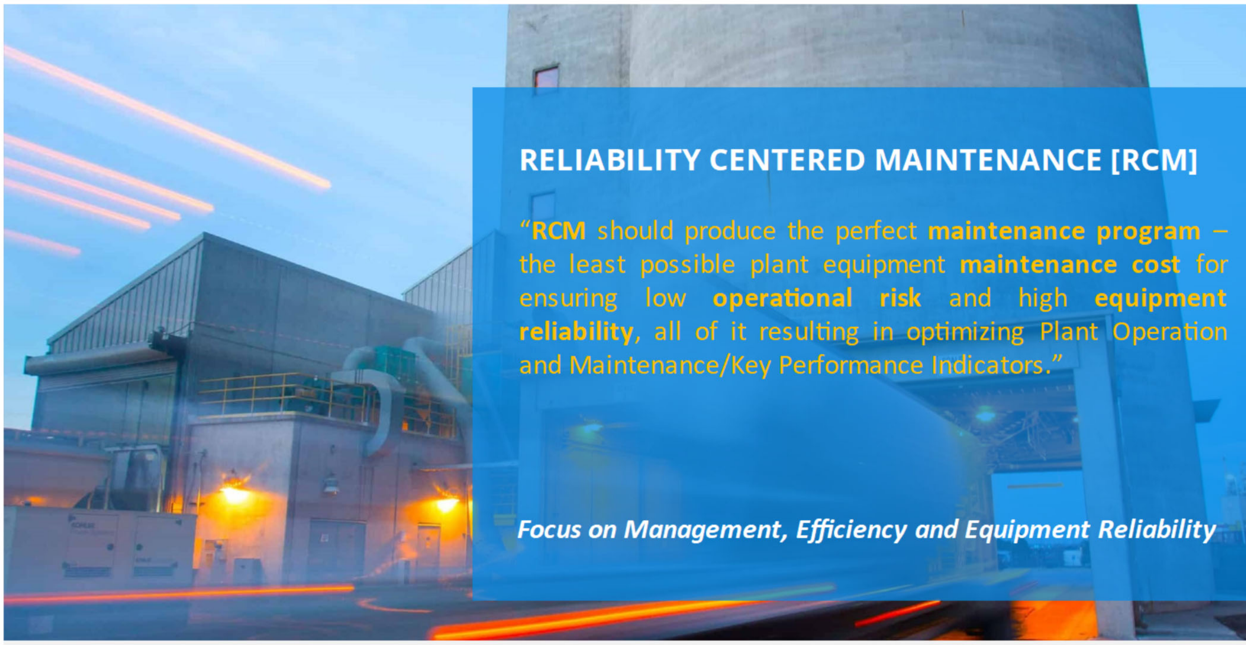
LIFE CYCLE MANAGEMENT

Equipment must not only be inexpensive in terms of its initial cost (also termed as procurement cost, fabrication cost) but also in terms of its running cost. This brings us to the key concept of Life Cycle Cost and Management. Our goal is, therefore, to develop and design equipment with the lowest possible Life Cycle Costs.

LCC must not only be looked upon entirely in purchasing new equipment but should also be used to select the right spare or component.

Most equipment designers emphasize equipment's initial cost over its running cost, but today more designers are now thinking in terms of LCC. They have now learned that the surest path to profitability lies in minimizing equipment's LCC.





RELIABILITY CENTERED MAINTENANCE
RCM History

- Two-thirds of the accidents that occurred at the end of 1950 in North American commercial aviation were caused by equipment failures. The fact that such a high number of casualties were provoked by equipment failure meant, at least initially, that equipment safety had to be addressed.

- The RCM was initially defined by the employees of United Airlines, Stanley Nowlan and Howard Heap, in their book **"Reliability Centered Maintenance,"** which gave name to the process. The two authors, troubled by the high aerial failure rate, dedicated themselves to defining an organized and systematic maintenance work process, which led to what is known today as RCM.

RELIABILITY CENTERED MAINTENANCE
RCM History

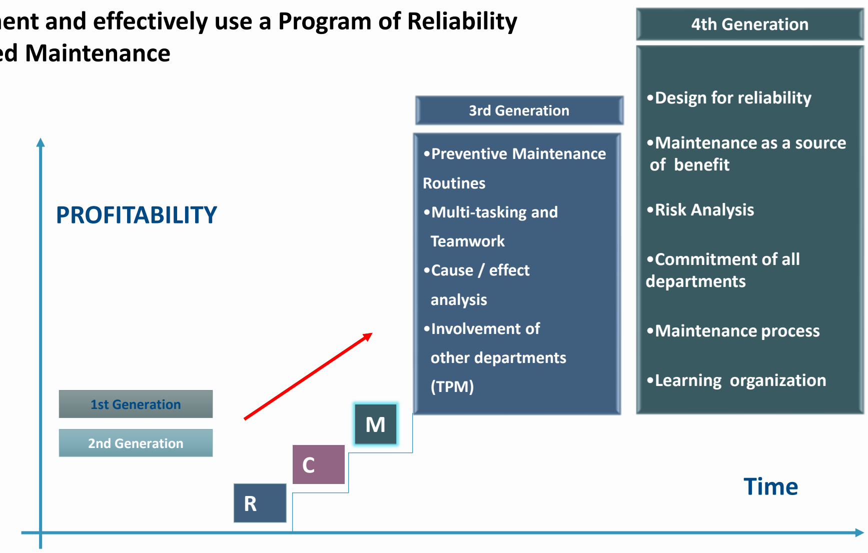
- **Stanley Nowlan** continued his research and, in 1983, started his collaboration with John Moubray to adopt RCM to the industry. This gave rise to RCM2™ (RCMII™), The Aladon Network, and John **Moubray's book Reliability-Centered Maintenance (RCMII). RCM2 was written by John Moubray** while being mentored by Stanley **Nowlan**, the writer of the original report. It attempted to bring RCM into line with what was needed for modern industrial **environments outside the aviation industry.**
- RCM2 is defined as a process used to determine what must be done to ensure that any physical asset continues to do what its users want it to do in its present operational context. The goal of RCM2 is consequence mitigation rather than failure avoidance.
- **SAE International, the world-leading technical standards coordinator, in its Standard SAE JA1011, latest revision 200908, sets the evaluation criteria for RCM processes.**

RELIABILITY CENTERED MAINTENANCE
Introduction

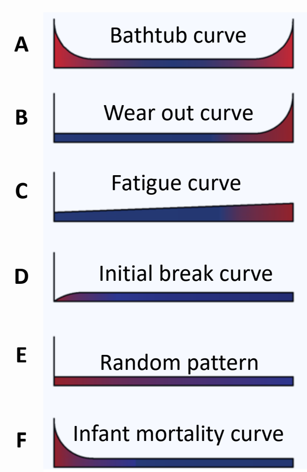
Reliability Centered Maintenance (RCM) is a corporate-level maintenance strategy implemented to **optimize** the maintenance program of a company or facility. The final result of an RCM program is the maintenance strategies that should be implemented on each facility's assets. The maintenance strategies are optimized so that the functionality of the plant is maintained using cost-effective maintenance techniques.

RCM BACKGROUND

Implement and effectively use a Program of Reliability Centered Maintenance



RCM BACKGROUND



Pattern A = 4 %
Pattern B = 2 %
Pattern C = 5 %

AGE RELATED for A to C

Pattern D = 7 %
Pattern E = 14 %
Pattern F = 68 %

RANDOM for D to F

RCM BACKGROUND

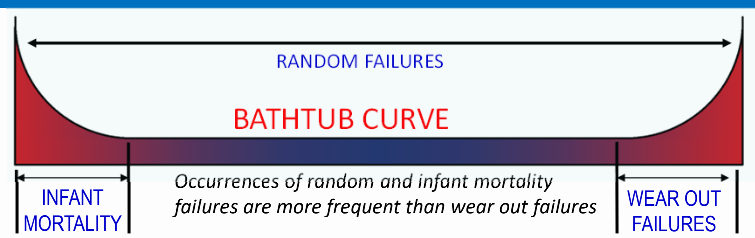
We need to understand that failure occur in 3 patterns . . . . .

1st - INFANT MORTALITY : Failure can occur at the beginning

2nd - RANDOM FAILURES : Failure can occur at any period

3rd - AGE-RELATED FAILURES : Failure will wear due to age

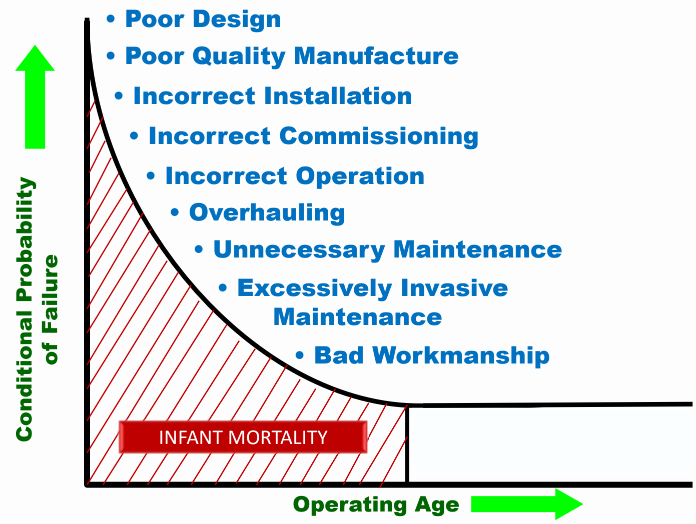
And most maintenance only focuses on the 3rd type of failure and disregards the understanding that infant mortality and random failures occur more frequently than wear-out failures.



RCM BACKGROUND

INFANT FAILURES ARE CAUSED BY HUMAN

- **Poor Design**
- **Poor Quality Manufacture**
- **Incorrect Installation**
- **Incorrect Commissioning**
- **Incorrect Operation**
- **Overhauling**
- **Unnecessary Maintenance**
- **Excessively Invasive Maintenance**
- **Bad Workmanship**



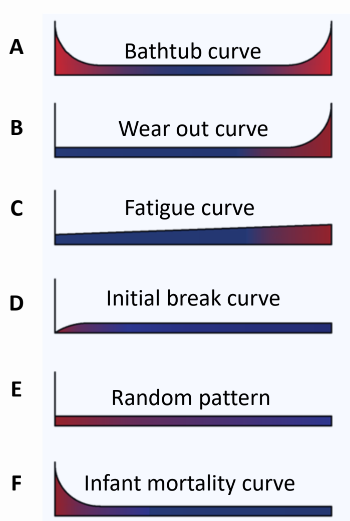
RCM BACKGROUND

RANDOM FAILURES :

Description	Causes	Strategy
Failures which occur at any period.	Dirt, materials-related problems, human errors, environment, lack of lubrication, premature fatigue, and short lifespan.	Run to fail for failures with minimal consequences. Predictive Maintenance can be applied for failures that provide signs and symptoms that it is on the verge of failing or nearing its rupture. Modification for failures with severe consequences and the possibility of changing the failure characteristic to wear out mode.

The problem with Random Failure is that the same parts or components can fail at any given period for various reasons; this is where PM overhauls and replacements would be at their weakest point.

RCM BACKGROUND



AGE = DETERIORATION

Then Preventive Maintenance is a good option; for example, tires, rollers, clutch, liners, etc., parts will wear out in relation to their age and usage.

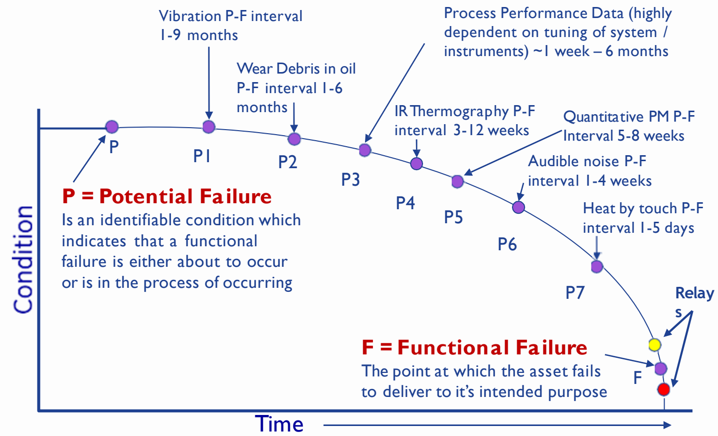
AGE ≠ DETERIORATION

Preventive Maintenance is not a good option; other tasks include Predictive Maintenance, Run to Fail, Proactive Maintenance, or simply redesigning the system.

The P-F interval

Mechanical Asset Example (Centrifugal Pump)

- This is the time between an asset's potential failure and its functional predicted failure. Your inspection interval must be smaller than the P-F interval so you can catch a failure after it's detectable but before it actually occurs.
- Time can be measured in seconds, minutes, days, months, or years.
- P1-Px indicates detectability intervals by various techniques or technologies.



RELIABILITY CENTERED MAINTENANCE

Introduction

The adequate maintenance tactics are the result of equipment criticality and failure mode(s):

Function criticality + **Failure mode** = **RCM tactic**

- **Fail detection** – Protections and stand-by equipment
- **Condition monitoring** – Predictable P-F interval
- **Scheduled restoration / replacement** – Time-based probability of failure
- **No scheduled maintenance** – Proactive maintenance is not effective + loss of function is not critical
- **Re-design** – Proactive maintenance is not effective + loss of function is critical

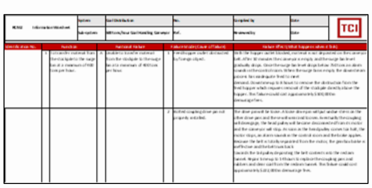
RELIABILITY CENTERED MAINTENANCE
Introduction

RCM DEFINITION

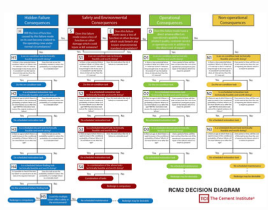
It is a methodology to allow the assets to perform the functions desired by their users in their current operational context. This methodology enables a proactive, systematic, objective, and documented analysis, optimizing the maintenance plan and improving **“productivity, safety, and environmental aspects."**

RELIABILITY CENTERED MAINTENANCE
Introduction

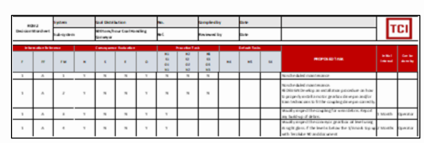
DEVELOPMENT WORK RCM



INFORMATION SHEET (FMEA)



DECISION DIAGRAM



DECISION SHEET

RELIABILITY CENTERED MAINTENANCE
Introduction

RCM OBJECTIVES:

- Increasing the equipment availability and performance.
- Optimization of maintenance cost.
- The analysis of an industrial plant by that method brings a number of results, for example:
- Increases understanding of equipment design and functioning.
- Increasing the availability and optimization of maintenance.
- Analysis of the industrial plant operated following RCM methodology provides many results as it analyses the system failure possibilities and develops mechanisms to prevent them, independently of failures caused by inherent equipment problems or human errors.
- Determining the number of actions that guarantee high plant availability, the safety of plant personnel, and the protection of the environment.

RELIABILITY CENTERED MAINTENANCE
Introduction

SAE JA-1011

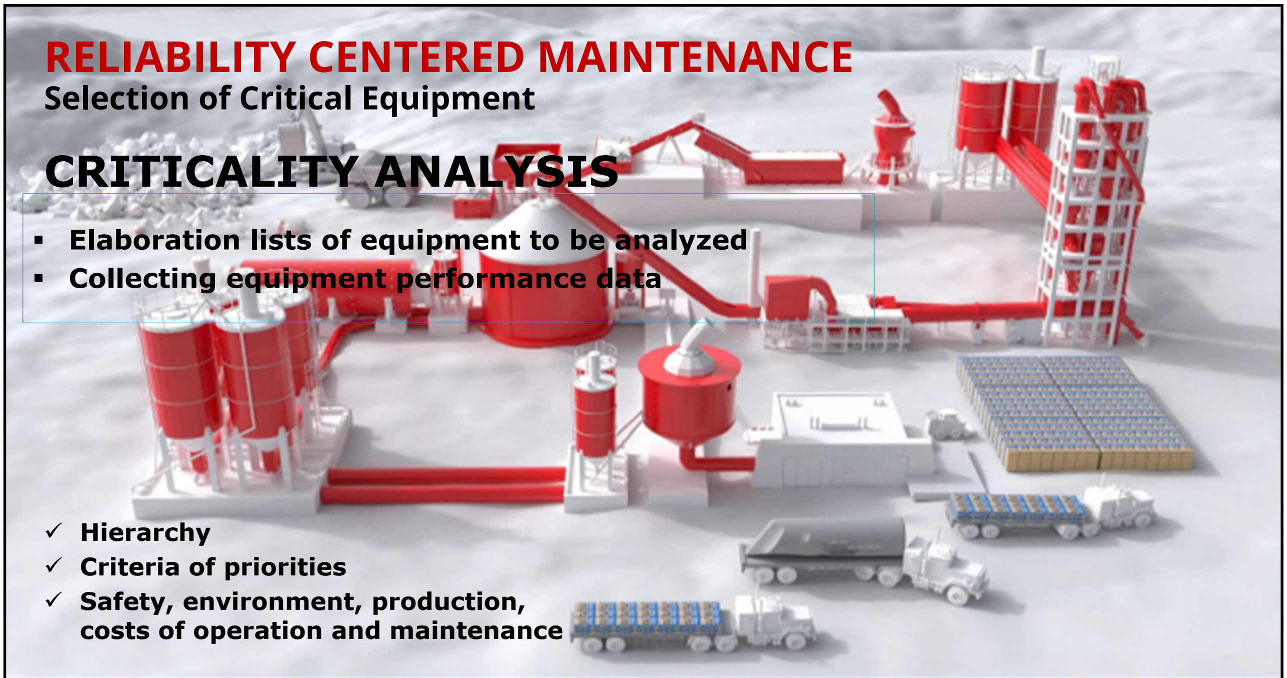
The RCM process that will be implemented complies with the **SAE JA1011 standard** "Evaluation Criteria for Reliability-Centered Maintenance Processes." The standard establishes criteria to be met by a process applied to maintaining an asset or a particular system to be considered RCM.

1	**What are the functions and operating parameters associated with the asset?**	Which is the function? (What the user wants done)
2	**How may fail to fulfill these functions?**	What is functional failure? How to stop doing what the user wants
3	**What causes each functional failure?**	What are the failure modes? Causes of failures
4	**What happens when the failure occurs?**	What is the effect of failure? What happens when failures occur.
5	**In what way each failure is important?**	What it is the consequence of failure? (hidden, safety, environment, operation)
6	**What can be done to predict or prevent each failure?**	¿What tasks can be done proactive? (CBM, cyclic Reconditioning, cyclic Replacement)
7	**What should be done if a suitable proactive task can not be found?**	¿Another type of task "in the absence of" a proactive task?(Faultfinding, designs, Maintenance "break”)

RELIABILITY CENTERED MAINTENANCE
Selection of Critical Equipment

CRITICALITY ANALYSIS

- Elaboration lists of equipment to be analyzed
- Collecting equipment performance data



- ✓ Hierarchy
- ✓ Criteria of priorities
- ✓ Safety, environment, production, costs of operation and maintenance

RELIABILITY CENTERED MAINTENANCE
Selection of Critical Equipment

Criticality analyses:

Operational perspective: we can determine the operational criticality of equipment (production, quality, repair costs), by combining two factors:

Consequence of Occurrence (Co)		
1	None	Full redundancy
2	Very low	Minor disruption
3	Low	Small repair costs
4	Low to moderate	Reduced PF
5	Moderate	Reduced efficiency
6	Moderate to high	Minor impact on quality
7	High	Large impact on quality
8	Very high	Loss of sales < 1 wk
9	Extreme	Loss of sales < 30d
10	Extreme	Loss of sales > 30d

Probability of Occurrence (Po)	
1	MTBF > 4 years
2	3 years < MTBF < 4 years
3	2 years < MTBF < 3 years
4	1 year < MTBF < 2 years
5	6 months < MTBF < 1 year
6	3 month < MTBF < 6 months
7	MTBF ≈1 month
8	MTBF ≈2 weeks
9	MTBF ≈1 week
10	MTBF ≈1 day

RELIABILITY CENTERED MAINTENANCE

Selection of Critical Equipment

CITERIA OF SEVERITY (CONSEQUENCES)

CONSEQUENCES					
W	Safety	Minor accident Immediate return to work	Accident with absence owing to illness up to 1 week	Accident with absence owing to illness up to 1 month	Death, permanent disability or absence owing to illness longer than 1 month
X	Environment	Damage to environment controllable, smaller than 40% of permissible level	Damage to environment controllable between 40% and 60% of permissible level	Damage to environment controllable, between 60% and 100 of permissible level	Damage to environment controllable higher than 100% of permissible level
Y	Operations	Production stop shorter than 8 hours	Production stop between 8 hr and 2 days	Production stop between 2 and 10 days	Production stop longer than 10 days
Z	Minor equipment repairs (cost examples)`	Cost of repair smaller than 10% of value of equipment below 3.000 $	Cost of repair between 10% and 30% of value of equipment between 6.000$ and 10.000$	Cost of repair between 30% and 60% of value of equipment between 6.000$ and 10.000$	Cost of repair higher than 60% of value of equipment over 10.000 $

RELIABILITY CENTERED MAINTENANCE

Selection of Critical Equipment

CITERIA OF SEVERITY (CONSEQUENCES)

Probability	Very High	Extreme	Extreme	Extreme	Extreme	Extreme
	High	Low	Medium High	High	Extreme	Extreme
	Medium	Low	Medium	Medium High	High	Extreme
	Low	Negligible	Low	Medium	Medium High	High
	Negligible	Negligible	Negligible	Low	Medium	Medium High
		Slight damage <10K	Minor damage 10-50K	Local damage 50-100K	Major damage 100k-1M	Extensive damage >1M

Economic	Not analyzed	Slight damage <10K	Minor damage 10-50K	Local damage 50-100K	Major damage 100k-1M	Extensive damage >1M
Health and Safety	Not analyzed	Slight injury	Minor injury	Minor injury	Single fatality	Multiple fatality
Environmental	Not analyzed	Slight effect	Minor effect	Localized effect	Major effect	Massive effect

RELIABILITY CENTERED MAINTENANCE
Application of RCM Methodology

The 7 steps:

1. Selection of equipment for RCM analysis
2. Define the boundaries and function of the systems that contain the critical equipment
3. Define the ways that the system can fail – the failure modes
4. Identify the root causes for the failure modes
5. Asses the effects of failure
6. Select a maintenance tactic for each failure
7. Implement and then regularly review the maintenance tactic that is selected

RELIABILITY CENTERED MAINTENANCE
Application of RCM Methodology

SAE JA-1011

1. What are the functions and performance standards for equipment?

In this stage, the requirements for the machinery or systems are to be compiled and analyzed; it can be performed in various ways:

1.
- Interviewing the plant personnel, specifically those related to operation and maintenance of the equipment in question.

2.
- Watching the functioning and performance of the equipment.
- Examining documents, most importantly those used for compiling or visualizing information.

3.
- Using equipment logbooks and verifying records traceability.

RELIABILITY CENTERED MAINTENANCE

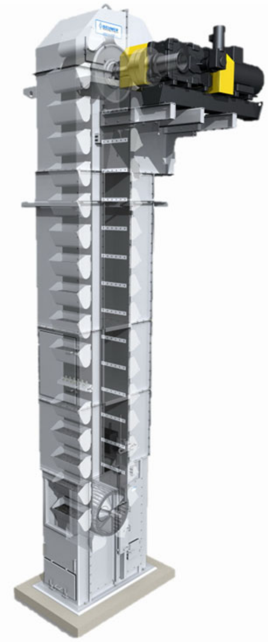
Application of RCM Methodology

SAE JA-1011

1. What are the functions and performance standards for equipment?

Primary functions: They define the reason for having acquired the equipment in the first place. Technical data as speed, temperature, pressure, output, transport or storage capacity, product quality are part of function description.

Example: Elevator function
Transferring material vertically from one point to another with nominal capacity (ton/hour, kw/ton, etc.)



RELIABILITY CENTERED MAINTENANCE

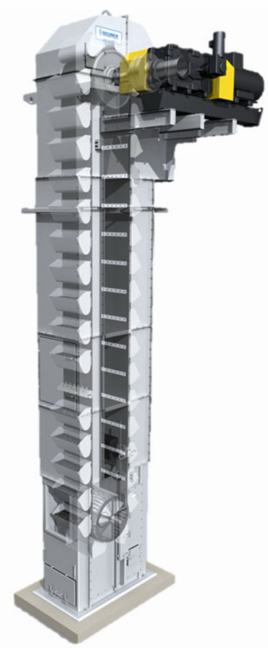
Application of RCM Methodology

SAE JA-1011

1. What are the functions and performance standards for equipment?

Secondary functions: They indicate that each equipment has expectations in areas as safety, control, prevention, comfort, structural integrity, economy, protection, operational efficiency, observing environmental standards and even aesthetics and appearance.

Secondary function:
- Safety of personnel (hot materials)
- Emission control
- Structural



RELIABILITY CENTERED MAINTENANCE
Application of RCM Methodology

Process of Task Selection:

- RCM provides simple criteria to decide for which tasks the proactive action is technically viable (if there are any) and to decide who is to perform it and with what frequency.
- Whether it is technically viable or not depends on technical characteristics of the task and the failure to be prevented.
- Whether to perform it or not depends on the solution of the consequences of failure.
- If no tasks are found, an alternative approach is to be taken.

RELIABILITY CENTERED MAINTENANCE
Application of RCM Methodology

EXAMPLE 2: Hydraulic system (hydraulic pack)

a. RCM analysis

Safety consequences? Yes, bursting hoses can cause injury and fire, and loss of power can result in loss of control over the load in cranes.
Production consequences? Yes, loss of production.
Economic consequences? Yes, cost of repair and fluid loss.
Hidden consequences? Yes, abnormal wear and contamination reduce component life.

b. Economic considerations:

In large systems holding a few thousand liters of hydraulic oil, an oil change can be extremely expensive. The oil should not be changed while it is still fit for service. Oil analysis can confirm oil integrity by testing the additive package, particle count, and the level of other contaminants. Minor particulate contamination can be removed by external on-site filtration.

RELIABILITY CENTERED MAINTENANCE

Application of RCM Methodology

EXAMPLE 2: Hydraulic system (hydraulic pack)

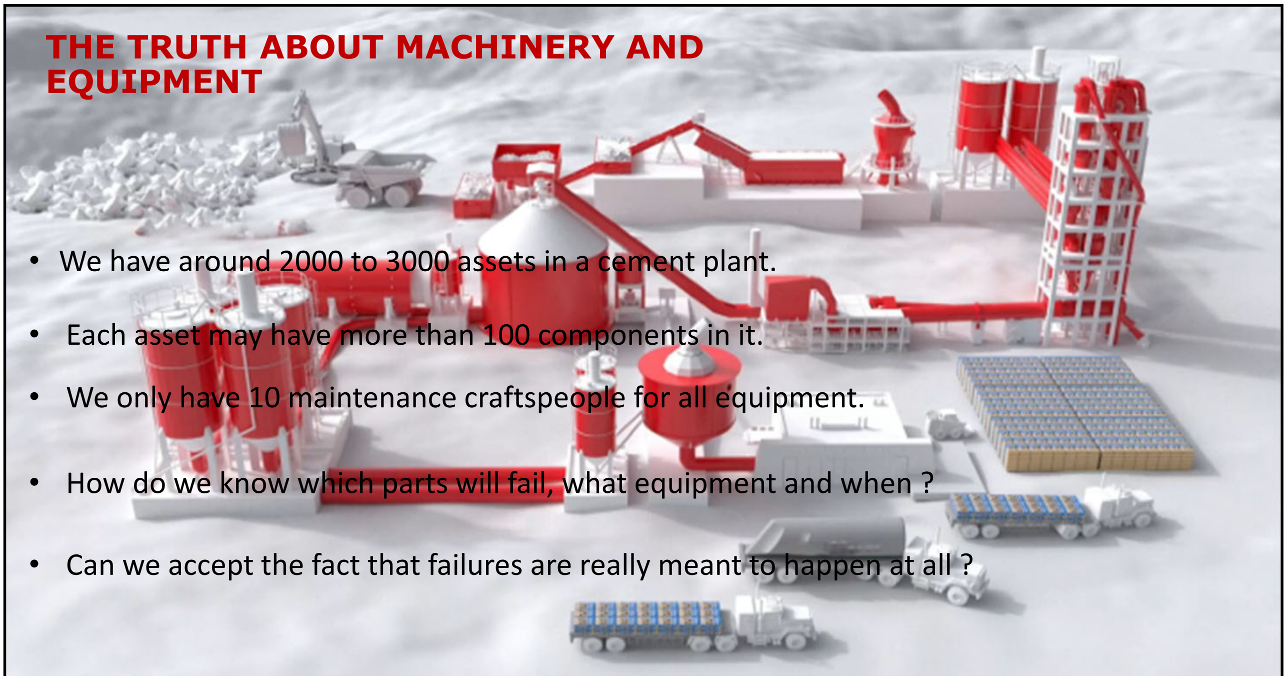
c. Initial scheduled maintenance program for the hydraulic system:

1. Visually inspect fluid level (weekly)
2. Visually inspect for leaks and flexible hose damage (weekly)
3. Check system operating pressure (weekly)
4. Check load cycle times (weekly)
5. Drain off water and sediment accumulation (weekly)
6. Perform fluid analysis to monitor fluid and machine conditions (every 3 months)
7. Perform filter analysis (every 3 months)

THE TRUTH ABOUT MACHINERY AND EQUIPMENT

Failures	Cost	Maintenance	Skills
Unexpected breakdowns and failures on our assets	High cost of doing maintenance	Day to day pressure of doing maintenance	Lack of skills and training. Maintenance Is left with no option but to put-out fires all the time

THE TRUTH ABOUT MACHINERY AND EQUIPMENT



- We have around 2000 to 3000 assets in a cement plant.
- Each asset may have more than 100 components in it.
- We only have 10 maintenance craftspeople for all equipment.
- How do we know which parts will fail, what equipment and when ?
- Can we accept the fact that failures are really meant to happen at all ?

THE TRUTH ABOUT MACHINERY AND EQUIPMENT

TO ADDRESS THIS ISSUE :

- ✔ Some people are deployed to perform maintenance work.
- ✔ We have some form of Preventive Maintenance that sort of schedules this equipment for some form of maintenance work.
- ✔ There are some overhauling and replacement that are being done.
- ✔ There are some inspections that we perform on our equipment from time to time.
- ✔ We even deploy a group called the sustaining or other names to perform repairs and troubleshooting.

I guess that's the way it is boss !

Despite our very best efforts machine still fails. **RIGHT?**

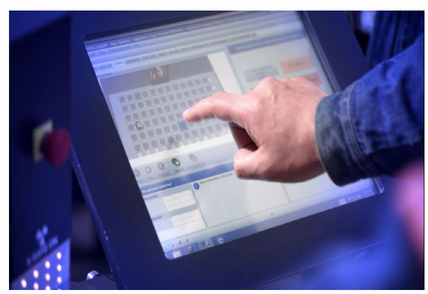
What Maintenance Can Actually Do

- *Prevent the Failure – Preventive Maintenance*
- *Predict the Failure – Predictive Maintenance*
- *Anticipate the Failure – Run to Fail*
- *Control and Prolong the Failure – Redesign/Modify*

Performing maintenance based on RCM methodology is about understanding that it is more important to reduce or eliminate the consequences of failure rather than eliminate the failure itself.

RELIABILITY DEFINED

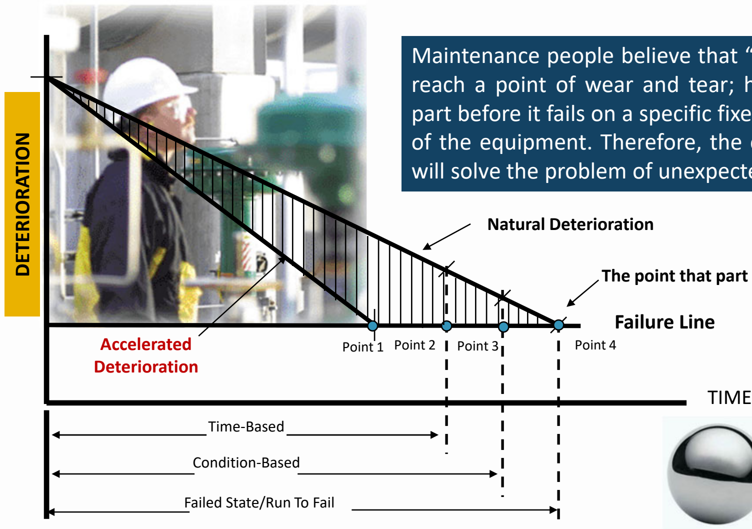
- FAILURE simply means the inability of equipment to perform its required function. The failure of a component is viewed as terminating its life.
- RELIABILITY is the probability that no failure will occur throughout a prescribed operating period.

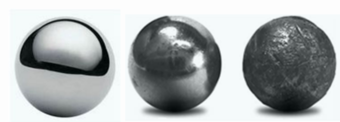


Maintenance is not about eliminating failures, but understanding that preserving the functions and understanding each consequence of failure is more important. To address these failures, we must thoroughly understand its diversit. . .

Common Belief : Does all parts will wear out ?

Maintenance people believe that "ALL" parts, after consistent use, will reach a point of wear and tear; hence, overhauling or replacing the part before it fails on a specific fixed schedule will ensure the reliability of the equipment. Therefore, the concept of Preventive Maintenance will solve the problem of unexpected failures, **RIGHT or WRONG?**





THE TRUTH ABOUT MACHINERY AND EQUIPMENT

Will these 10 types of equipment have the same amount of PM required?

Which machines will require a greater amount of maintenance?

Should we follow the specs, or we apply common sense to maintenance?

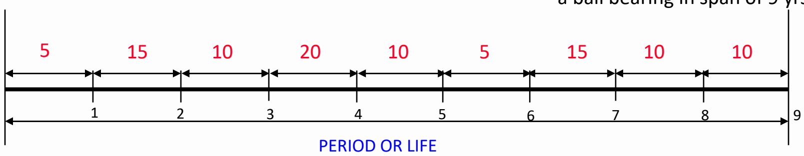
Before defining their tasks, maintenance must understand the operational context and the consequences of the equipment.

PATTERNS OF FAILURE

What period do we replace the bearings?

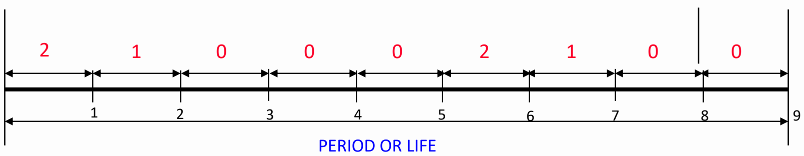
CASE 1 : RANDOM FAILURES

100 failures encountered on
a ball bearing in span of 9 yrs



CONCLUSION: Failure distribution is not symmetrical, and PM is not applicable.

CASE 2 : AGE-RELATED FAILURES



CONCLUSION: Failure distribution is almost age-related; for this case, the best period to perform replacement is eight months.

THE TRUTH ABOUT MACHINERY AND EQUIPMENT

Maintenance is done to keep things working the way they were meant to work. When the equipment is not maintained, we can guarantee it will fail sooner than expected.

The questions to asks will be :

1) How much maintenance do I need to perform on this equipment?
2) What are the right maintenance tasks to perform on this equipment?

Doing maintenance provides a means to reduce the likelihood of a failure to make the equipment reliable. Still, even before we can define a good maintenance management structure, we must change the way we think about failure itself since not all failures are created equal . . . . .

Understanding Maintenance Strategies

Companies that rely solely on reactive maintenance find they have:

- Costly downtime. Equipment fails with little or no warning, so the process could be down until replacement parts arrive, resulting in lost revenue.
- Higher maintenance costs. Unexpected failures can increase overtime labor costs and expedited delivery of replacement parts.
- Safety hazards. Failure with no warning could create a safety issue with the failing equipment or other units that might be affected.

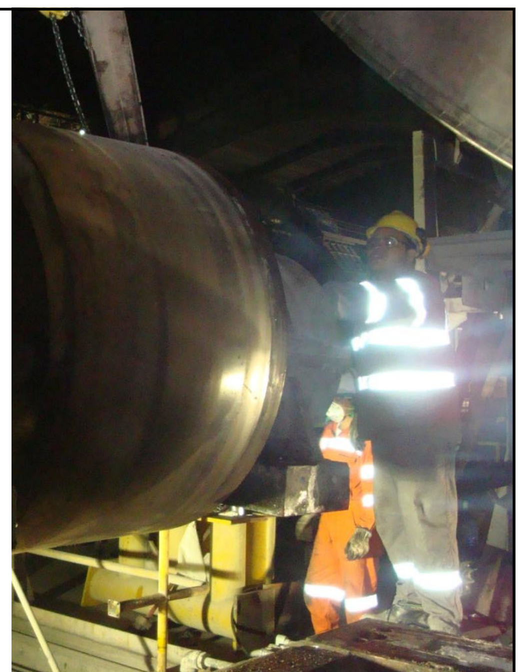
Understanding Maintenance Strategies

- Reactive maintenance can be appropriate in some circumstances, such as non-critical and low-cost equipment with little or no risk of collateral damage or lost production.
- It makes little sense to change a light bulb before it burns out. It's important, however, to make sure that a failure won't create a chain reaction to more critical equipment.

Understanding Maintenance Strategies

The adverse consequences of run to failure include:

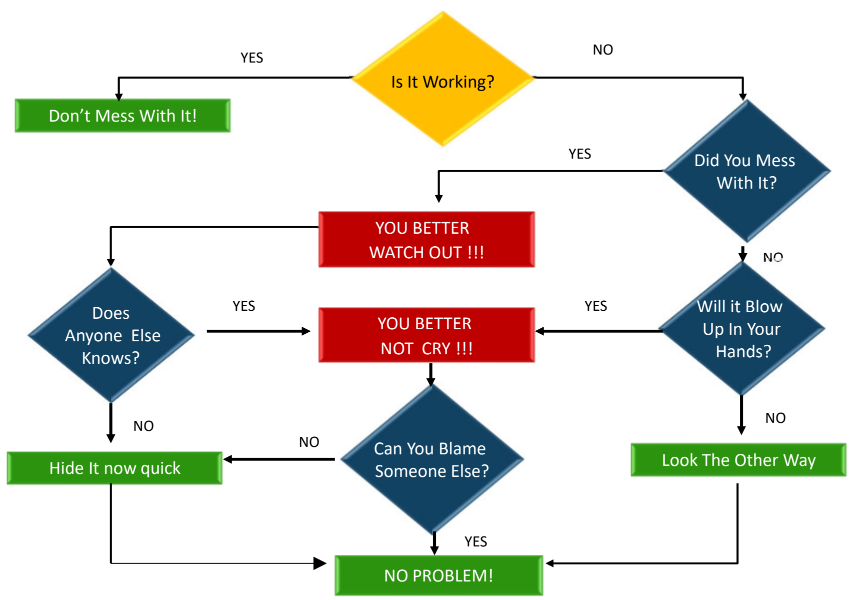
- Compromised safety or environmental compliance.
- Collateral damage where failure increases the cost of repair.
- Loss of product quality.
- Loss of process availability.
- Reduced throughput and Increased waste and rework costs.



What to expect in a reactive mode of maintenance? . . .

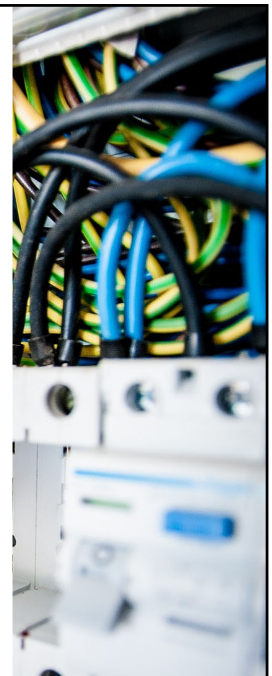
- Maintenance has no time for training.
- When maintenance goes home their children and even their wife are sleeping.
- During weekends, maintenance is not at home but working on the same old problems.
- When maintenance is at home, they need to turn on their cell for late calls.
- Their regular normal time will be from 8:00 am to 8:00 or 9:00 p.m.
- Maintenance always complains of one thing, they lack manpower resources.
- Maintenance having nightmares and dreaming of their work and boss.

SIMPLE FLOWCHART FOR REACTIVE ENVIRONMENT



Preventive Maintenance

- The preventive maintenance philosophy is also known as time-based or planned maintenance.
- The goal of this approach is to maintain equipment in a healthy condition. Selected service and part replacements are scheduled based on a time interval for each device — whether it needs it or not.
- For example, transmitter calibrations may be performed every six months in critical areas. While this approach may uncover possible problems, most checks are unnecessary because they're performed on healthy instrumentation.



Proactive Maintenance

- While predictive maintenance uses online condition monitoring to help predict when a failure will occur, it doesn't always identify the root cause of the failure.
- That's where proactive maintenance comes in. Proactive maintenance relies on information provided by predictive methods to identify problems and isolate the source of the failure.

Proactive Maintenance

- Take the case of a pump that has periodic bearing failures. A condition-monitoring program may apply vibration sensors to the bearings, monitor the bearing temperature, and perform periodic lube oil analysis.
- These steps will tell when but not why the bearings are failing.

Proactive Maintenance

- Proactive maintenance might add equipment balancing during installation to reduce bearing stress, lower failure rates, and extend bearing life. But it will also take the next step to find the sources of failures — for example, looking at cleaning procedures before tear-down to see if contamination during a rebuild is a root cause for early bearing failures.

Proactive Maintenance

- Determining these root causes and acting to eliminate them can prolong the equipment's life. It also eliminates many seemingly random failures — and avoids repairing the same equipment for the same problem again and again.

Learning the Correct Paradigm

All disciplines

are being exhorted

to adapt to changes in organization

design

technology, leadership skills, communication
- in fact, in virtually every aspect of working life.

Each of them on its own is sufficiently far-reaching to merit a great deal of attention in most organizations.

Together they amount to a whole new paradigm.

Paradigm 1

OLD

Maintenance is about preserving physical assets.

NEW

Maintenance is about preserving the functions of assets

Paradigm 2

OLD

Routine maintenance is about preventing failures.

NEW

Routine maintenance is about avoiding, reducing, or eliminating the consequences of failures.

Paradigm 3

OLD

The primary objective of the maintenance function is to optimize plant availability at minimum cost.

NEW

Maintenance affects all aspects of business effectiveness and risk - safety, environmental integrity, energy efficiency, product quality and customer service, not just plant availability and cost.

Paradigm 4

OLD

Most equipment becomes more likely to fail as it gets older.

NEW

Most failures are not more likely to occur as equipment gets older.

Paradigm 5

OLD

Comprehensive data about failure rates must be available before it is possible to develop a really successful maintenance program.

NEW

Decisions about the management of equipment failures will nearly always have to be made with inadequate hard data about failure rates.

Paradigm 6

OLD

There are three basic types of maintenance:
- predictive
- preventive
- corrective

NEW

There are four basic types of maintenance:
- predictive
- preventive
- corrective
- detective

Paradigm 7

OLD

The frequency of condition-based maintenance tasks should be based on the frequency of the failure and/ or failure the criticality of the item.

NEW

The frequency of condition-based maintenance tasks should be based on the failure period (also known as the "Potential Failure" or "P-F interval").

Paradigm 8

OLD

If both are technically appropriate, fixed interval overhauls/replacements are usually both cheaper and more effective than condition-based maintenance.

NEW

If both are technically appropriate, condition-based maintenance is nearly always both cheaper and more effective fixed interval overhauls/ replacements throughout the life of the asset.

Paradigm 9

OLD

Maintenance policies should be formulated by managers and maintenance schedules drawn up by suitably qualified specialists or external contractors (a top-down approach).

NEW

Maintenance policies should be formulated by the people closest to the assets. The role of management is to provide the tools to help them make the right decisions, and to ensure that the decisions are sensible and defensible.

Paradigm 10

OLD

Equipment manufacturers are in the best position to develop maintenance programs for new physical assets.

NEW

Equipment manufacturers can only play a limited (but still important) role in developing maintenance programs for new assets.

Paradigm 11

OLD

It is possible to find a quick, one-shot solution to all our maintenance effectiveness problems.

NEW

Maintenance problems are best solved in two stages: (1) change the way people think (2) get them to apply their changed thought processes to technical/ process problems - one step at a time.

If one takes a moment to review the breadth and depth

of the paradigm shift implicit in the foregoing paragraphs,

it soon becomes apparent just how far most organizations have to move in order to adopt the new maxims.

It simply cannot happen overnight.

In fact,

people who seek an effective,

enduring maintenance program which has universal support should not lose sight of the fact that improvement is a journey,

not a destination (the essence of the Kaizen philosophy).

Thank you