COVENANT UNIVERSITY
NIGERIA

TUTORIAL KIT
OMEGA SEMESTER

PROGRAMME: MECHANICAL ENGINEERING

COURSE: MCE 544

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MCE 544: Materials Handling and Equipment

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1. What is failure rate?

   Answer

   The failure rate is defined as the "probability of failure per day
2. State with illustrations the types of failure patterns.
3. State the types of maintenance and briefly explain two of them

   Answer

   (a) Predictive Maintenance
   (b) Corrective Maintenance
   (c) Preventive Maintenance
   (d) Operational Maintenance

   Predictive Maintenance

   Predictive maintenance (PdM) techniques are designed to help determine the condition of in-service equipment in order to predict when maintenance should be performed. This approach promises cost savings over routine or time-based preventive maintenance, because tasks are performed only when warranted. The main relevance of Predicted Maintenance is to allow convenient scheduling of corrective maintenance, and to prevent unexpected equipment failures. The key is "the right information in the right time". By knowing which equipment needs maintenance, maintenance work can be better planned (spare parts, people, etc.) and what would have been "unplanned stops" are transformed to shorter and fewer "planned stops", thus increasing plant availability.

   PdM evaluates the condition of equipment by performing periodic or continuous (online) equipment condition monitoring. The ultimate goal of PdM is to perform maintenance at a scheduled point in time when the maintenance activity is most cost-effective and before the equipment loses performance within a threshold.

   To evaluate equipment condition, predictive maintenance utilizes nondestructive testing technologies such as infrared, acoustic (partial discharge and airborne ultrasonic), corona detection, vibration analysis, sound level measurements, oil analysis, and other specific online tests. New methods in this area are to utilize measurements on the actual equipment in combination with measurement of process performance, measured by other devices, to trigger maintenance conditions.

   Corrective Maintenance

   Corrective maintenance is a maintenance task performed to identify, isolate, and rectify a fault so that the failed equipment, machine, or system can be restored to an operational condition within the tolerances or limits established for in-service operations.

   It can also be defined as

- maintenance which is carried out after failure detection and is aimed at restoring an asset to a condition in which it can perform its intended function.
- maintenance which is required when an item has failed or worn out, to bring it back to working order.

Corrective maintenance can be subdivided into "immediate corrective maintenance" (in which work starts immediately after a failure) and "deferred corrective maintenance" (in which work is delayed in conformance to a given set of maintenance rules).

Preventive Maintenance

Preventive maintenance (PM) has the following meanings:

1. The care and servicing by personnel for the purpose of maintaining equipment and facilities in satisfactory operating condition by providing for systematic inspection, detection, and correction of incipient failures either before they occur or before they develop into major defects.
2. Maintenance, including tests, measurements, adjustments, and parts replacement, performed specifically to prevent faults from occurring.

The primary goal of maintenance is to avoid or mitigate the consequences of failure of equipment. This may be by preventing the failure before it actually occurs. It is designed to preserve and restore equipment reliability by replacing worn components before they actually fail. Preventive maintenance activities include partial or complete overhauls at specified periods, oil changes, lubrication and so on. In addition, workers can record equipment deterioration so they know to replace or repair worn parts before they cause system failure.

Operational Maintenance

Operational maintenance is the care and minor maintenance of equipment using procedures that do not require detailed technical knowledge of the equipment's or system's function and design. This category of maintenance normally consists of inspecting, cleaning, servicing, preserving, lubricating, and adjusting, as required. Such maintenance may also include minor parts replacement that does not require the person performing the work to have highly technical skills or to perform internal alignment.

As the term implies, operational maintenance, is performed by the operator of the equipment. Its purpose is threefold: (1) to make the operator aware of the state of readiness of the equipment; (2) to reduce the delays that would occur if a qualified technician had to be called every time a simple adjustment were needed; and (3) to release technicians for more complicated work

Some operational maintenance responsibilities can be as simple as inspecting the machine to spot any changes or issues. This allows the operator to detect a potential danger, such as loose fasteners or debris that could contribute to an accident. Basic cleaning, including removing debris or excess grease from a machine, is also considered part of operational maintenance.

4. List the advantages and disadvantages are of planned and condition based maintenance
5. Discuss reliability centered maintenance

Answer

RCM is a cost-effective maintenance strategy used to address dominant causes of equipment failure. It is a systematic approach to defining a routine maintenance program composed of cost-effective tasks that preserve important functions.

It is generally used to achieve improvements in fields such as the establishment of safe minimum levels of maintenance, changes to operating procedures and strategies and the establishment of capital maintenance regimes and plans. Successful implementation of RCM will lead to increase in cost effectiveness, machine uptime, and a greater understanding of the level of risk that the organization is managing.

Reliability centered maintenance is an engineering framework that enables the definition of a complete maintenance regime. It regards maintenance as the means to maintain the functions a user may require of machinery in a defined operating context. It enables machinery stakeholders to monitor, assess, predict and generally understand the working of their physical assets. This is embodied in the initial part of the RCM process which is to identify the operating context of the machinery, and write a Failure Mode Effects and Criticality Analysis (FMECA). The second part of the analysis is to apply the "RCM logic", which helps determine the appropriate maintenance tasks for the identified failure modes in the FMECA. Once the logic is complete for all elements in the FMECA, the resulting list of maintenance is "packaged", so that the periodicities of the tasks are rationalized to be called up in work packages; it is important not to destroy the applicability of maintenance in this phase. Lastly, RCM is kept live throughout the "in-service" life of machinery, where the effectiveness of the maintenance is kept under constant review and adjusted in light of the experience gained.

It is defined by the technical standard SAE JA1011, Evaluation Criteria for RCM Processes, which sets out the minimum criteria that any process should meet before it can be called RCM. This starts with the 7 questions below, worked through in the order that they are listed:

1. What is the item supposed to do and its associated performance standards?
2. In what ways can it fail to provide the required functions?
3. What are the events that cause each failure?
4. What happens when each failure occurs?
5. In what way does each failure matter?
6. What systematic task can be performed proactively to prevent, or to diminish to a satisfactory degree, the consequences of the failure?
7. What must be done if a suitable preventive task cannot be found?

The RCM process recognizes three principal risks from equipment failures: threats

- to safety,
- to operations, and
- to the maintenance budget.

Modern RCM gives threats to the environment a separate classification, though most forms manage them in the same way as threats to safety.

RCM offers five principal options among the risk management strategies:

- Predictive maintenance tasks,
- Preventive Restoration or Preventive Replacement maintenance tasks,
- Detective maintenance tasks,
- Run-to-Failure, and
- One-time changes to the "system" (changes to hardware design, to operations, or to other things).

6. Define maintenance planning and scheduling
7. State the advantages of Maintenance planning

   Answer

   Advantages

   The benefits of good maintenance planning and scheduling are numerous and include:
   - Increased productivity of trades people;
   - Reduced equipment downtime;
   - Lower spare parts holdings;
   - Less maintenance rework etc.
8. State the basic steps in a good maintenance business process
9. What are the characteristics of underperforming maintenance departments?

   Answer
   - No formal process for identifying and defining work.
   - Maintenance activities are not focused on equipment criticality.
   - Effective planning does not always precede execution of work orders.
   - Most available maintenance hours are not scheduled.
   - Not all tradesmen receive assigned work orders.
   - Feedback on work quality is not provided.
   - Operate in 'fire fighting" or the "squeakiest wheel" mode.
   - Root causes of downtime issues are not well understood.
   - Work completion is not followed by thorough close-out and analysis.
   - CMMS is underutilized – perhaps only used for generating PMs or parts lists.
   - Constantly overwhelmed and behind the game with unmanageable WO backlogs
10. Discuss plant maintenance
11. What are the determinant factors responsible for the frequency and nature of maintenance?

    Answer

    Determinant factors responsible for the frequency and nature of maintenance
    - the manufacturer's recommendations
    - the intensity of use
    - operating environment (eg the effect of temperature, corrosion, weathering)
    - user knowledge and experience
    - the risk to health and safety from any foreseeable failure or malfunction
12. What is reliability?
13. State and briefly explain the indices of reliability

    Answer

    Indices of Reliability

    Reliability can be specified by two parameters namely:

    1. Mean time between failures (MTBF)

    MTBF is the critical characteristic for a repairable system and is the mean or average time between two successive failures of the system. MTBF can be obtained by running an item or equipment for a predetermined length of time under specified conditions and calculating the average length of time between failures. If for example, an item fails six times in an operating period of 60,000 hrs, MTBF is 10, 000 hrs. However, if the identical items operating under similar conditions are studied, MTBF is given by:

MTBF = (Total operating hours of all items)/Total number of failures that occur For example if 20 identical items operate for 5, 000 hrs during which 40 failures occur and are rectified,

MTBF can also be expressed as the inverse of failure rate, λ as follows:

MTBF = 1/λ

The exponential distribution, the most basic and widely used reliability prediction formula, models machines with the constant failure rate, or the flat section of the bathtub curve. Most industrial machines spend most of their lives in the constant failure rate, so it is widely applicable. Below is the basic equation for estimating the reliability of a machine that follows the exponential distribution,

where the failure rate is constant as a function of time:

Where:

R(t) = Reliability estimate for a period of time, cycles, miles, etc. (t).
e = Base of the natural logarithms (2.718281828)
λ = Failure rate (1/MTBF)

If for example, we assume a constant failure rate of 0.1 for a prime mover and running for six years without a failure, the projected reliability is 55 percent, which is calculated as follows:

R(6) = 2.718281828- (0.1* 6)
R(6) = 0.5488 = ~ 55%
In other words, after six years, about 45% of the population of similar prime mover operating in similar application can be expected to fail. It is worth reiterating at this point that these calculations project the probability for a population. Any given individual from the population could fail on the first day of operation while another individual could last 30 years. That is the nature of probabilistic reliability projections.

2. Mean time to failure (MTTF)
This is used for components or items that are not repairable such as filament lamps, fuses, resistors, capacitors, etc. The value of MTTF can be calculated from life test results, which can be obtained by stressing a large number of components under known conditions for a period and noting the number of failures.

MTTF = (Length of test time) / (Number of failures).

Another method which though is more accurate but costly is run to failure specified by number of components under specified conditions.

Where Ti = length of time taken by the ith specimen to fail
n = total number of specimens.

MTTF = 1/λ

where λ is failure rate and is independent of time

14. What is availability and state the formula for Availability Ratio
15. What is root cause analysis?

Answer

Root cause analysis (RCA) is a method of problem solving that tries to identify the root causes of faults or problems. RCA practice tries to solve problems by attempting to identify and correct the root causes of events, as opposed to simply addressing their symptoms.

16. Define failure mode effect analysis and state its advantages
17. State the systematic actions required for managing spare.

Answer

a. Identification of spare parts
b. Forecasting of spare parts requirement
c. Inventory analyses
d. Formulation of selective control policies for various categories
e. Development of inventory control systems
f. Stocking policies for capital & insurance spares
g. Stocking policies for rotable spares or sub- assemblies
h. Replacement policies for spare parts
i. Spare parts inspection
j. Indigenisation of spares
k. Reconditioning of spare parts
l. Establishment of spare parts bank
m. Computerization of spare parts management

18. State the information necessary for a spare parts catalogue
19. What are the commonly used inventory analyses?

Answer

Commonly used inventory analyses are:
(1) FSN Analysis
(2) ABC Analysis
(3) VED Analysis
(4) SDE Analysis
(5) HML Analysis

20. Show the illustration of failure patterns of machinery in relation with time