WEAR CHECK AFRICA

TECHNICAL BULLETIN

ISSUE 6

Implementing reliability-centred maintenance (RCM)

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This bulletin follows on from Technical Bulletin Issue 4 which focused on the philosophy behind reliability-centred maintenance (RCM). In this issue we describe the practical steps towards implementing an RCM programme.

Decisions to implement RCM are based on the consequences of functional failures.

Using RCM to develop an initial maintenance programme for new equipment as well as scheduled maintenance for existing plant, involves a structured decision-making process based on the consequences of functional failure of this equipment. RCM analysis produces a programme which includes all scheduled tasks - and only those tasks - necessary to ensure safety and operating economy. The decision-making logic behind RCM analysis applies to any complex equipment which requires a maintenance support programme aimed at maximising operating reliability at the lowest cost.

Objectives

The objectives of an RCM maintenance programme are:

- to realise the machinery's inherent safety and reliability levels
- to restore the machinery's inherent levels of safety and reliability once deterioration, malfunction or abnormal conditions have occurred
- to accomplish these objectives at a minimum cost.

RCM decision-making logic

This involves:

- identifying significant items
- defining functional and potential failures
- assessing failure consequences
- assessing the applicability of the proposed maintenance task
- evaluating the effectiveness of the proposed maintenance task
- selecting applicable and effective maintenance tasks
- establishing initial task intervals

Condition monitoring is characterised by the absence of preventive maintenance tasks.

- exploring optimum task intervals

Definitions

Before examining the RCM decision-making logic, it would be useful to review some maintenance terms.

Reliability-centred maintenance

A scheduled maintenance programme designed to realise the inherent reliability capabilities of equipment.

Significant item

A component whose functional failure can have safety, production or major economic consequences.

Applicability

The relevance of lubrication, servicing, inspection, restoration, discarding or monitoring an item is determined by its characteristics.

Effectiveness

The success of scheduled maintenance in achieving reduced failures, plant availability or cost-effectiveness.

Hidden-failure /malfunction

An abnormal condition which is not evident to the operating or maintenance staff during their normal duties and inspections. This includes contamination and abnormal wear.

Overhaul

A unit is completely disassembled and re-manufactured part by part to restore it to a "like new" physical condition.

Rework

A set of maintenance operations considered sufficient to restore the unit's original resistance to failure. Rework for specific items may range from replacement of a single part to complete remanufacture. Both overhaul and rework are considered restoration tasks.

Discard

The scrapping of an item when it has reached a safe-life limit (to avoid critical failures) or an economic-life limit (to avoid non-critical failures).

On condition

Scheduled inspections to detect potential failures. Units are removed or repaired "on the condition" that they do not meet the required standard. For an on condition task to be effective it must be possible to detect reduced failure resistance for a specific failure mode; it must be possible to define a potential failure condition which can be detected by an explicit task and there must be a reasonable time interval between the time of potential failure and functional failure.

Condition monitoring

A process characterised by the absence of preventive maintenance tasks. An item is maintained by condition monitoring if it is permitted to remain in service without preventive maintenance until a functional failure occurs. Failure-finding tasks such as oil analysis and performance monitoring may be assigned.

Cost-effectiveness

If the failure consequences only involve operational consequences and not safety, the cost of finding and correcting potential failures must be less than the combined cost of the operational consequences plus the cost of repairing the failed component.

Evaluating failure consequences

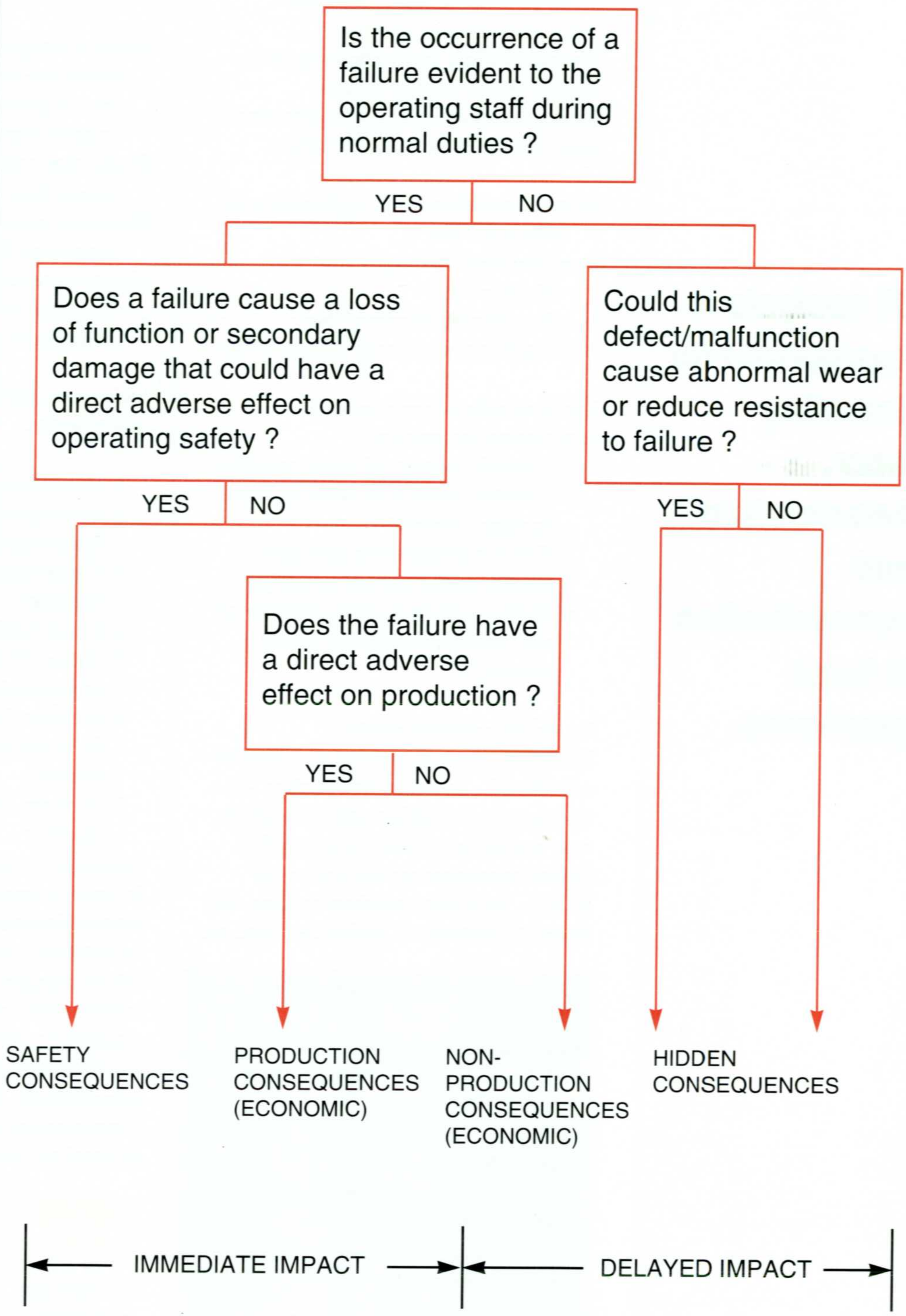
The first step in developing an RCM programme is to evaluate the consequences of equipment failure. This identifies significant items and determines the priorities of the maintenance effort. The different types of failure consequences include:

- safety consequences - possible fire, destruction or injury
- operational consequences - direct economic loss due to lost production plus cost of repair
- non-operational consequences - direct cost of repair only
- hidden consequences - reduced component life due to abnormal wear and contamination.

Failure consequences can be evaluated by using the flow chart below:

Evaluating failure consequences helps to identify significant items and maintenance priorities.

FAILURE CONSEQUENCES FLOW CHART

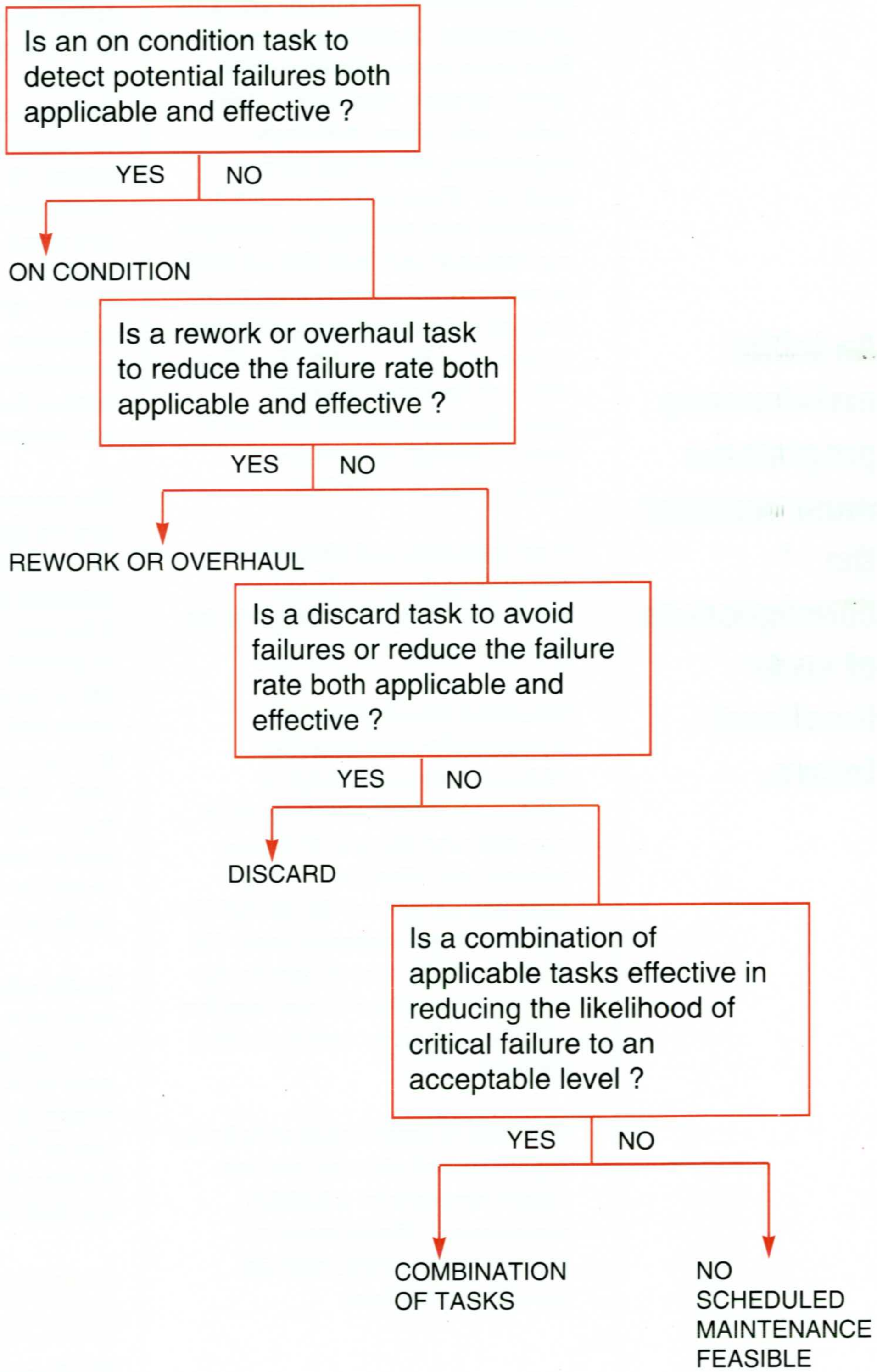


Evaluating maintenance tasks

The next phase of RCM analysis involves a systematic study of the different failure modes of each significant item to establish the benefits of scheduled maintenance. One needs to determine whether one of the basic maintenance tasks will satisfy both the criterion for applicability and the specific conditions for effectiveness. There is a specific order of preference to the use of preventive tasks as the Maintenance Task Flow Chart shows.

On-condition tasks allow all units to maximise their useful life.

MAINTENANCE TASK FLOW CHART



An initial maintenance programme must consider the consequences of each functional failure.

Scheduled on condition inspections directed at specific failure modes are the most desirable type of task. They are aimed at detecting reduced resistance to failure. The component remains in service until a potential failure is discovered. Where visual inspection is impractical, oil and filter analysis can detect abnormal wear and contamination.

On condition tasks include checking of pressures, temperatures, speeds, flow rates, output power, current draw, vibration, fluid levels, fluid leaks, cycle times, borescope inspections, and oil and filter analysis. These tasks discriminate between units that require corrective maintenance and those that are likely to survive until the next inspection (sample), thereby allowing all units to maximise their useful life. Thus, when on condition tasks are applicable and effective the cost of both scheduled and corrective maintenance is minimised.

If no applicable and effective on condition task can be found, scheduled rework or overhaul is the second choice.

Scheduled discard tasks are economically least desirable. Although lubricant change is considered a discard task, it can be cost-effective because of its low relative cost. However, in large recirculating systems the oil itself is a significant and expensive item. Oil analysis can be used to monitor the serviceability of the oil and lengthen oil drain periods as well as to check for wear.

If no task or combination of tasks are applicable and effective, the unit cannot benefit from scheduled maintenance. Replacement or product improvement/redesign should be considered.

Developing an initial programme

We are now ready to develop an initial maintenance programme for plant from the research that has been completed. We have already listed all the significant items that could benefit from maintenance, and a list of all known and envisaged functional failure modes for each component has been compiled.

We now consider the failure consequences of each functional failure. If a failure is found to have production consequences with plant downtime and loss of production predicted, the maintenance task flow chart is applied to that failure mode to determine applicable and effective maintenance tasks. The same logic is applied for safety, non-operational and hidden consequences.

The maintenance schedule should now be drawn up using conservative task intervals. Job cards are prepared detailing what tasks are to be done at a service. Task cards can be compiled to indicate how inspection and servicing are to be done and to define limits and procedures. Each task card is listed and signed for on the job card. Task cards are reusable and may contain illustrations and maintenance manual extracts. They should be sealed in plastic and used on the job.

Lastly, optimum service and inspection intervals are developed with operating experience. Tasks must be scheduled frequently to minimise failures, with the overall aim of finding a reasonable balance between low maintenance costs and low failure rates.

Examples

RCM decision-making logic is

Oil analysis is appropriate for detecting wear, deterioration and contamination in large gearboxes.

applied to two common industrial components as examples of how scheduled maintenance can extend equipment life.

EXAMPLE 1: Industrial gearbox

Safety consequences? No
Operational consequences? Yes, loss of production
Economic consequences? Yes, cost of repair/replacement
Hidden consequences? Yes, contamination causing high wear rates

Function failure mode: bearing, gear, shaft or thrust washer failure.
Potential failure indications: abnormal wear and overheating, seal failure.

Is an on condition task applicable and effective? Yes
Is an overhaul task applicable and effective? No
Is a discard task effective? No
Is a combination of tasks effective? No

Initial scheduled maintenance programme for gearbox :

1. Visually inspect oil level (weekly)
2. Visually inspect for leaks and seal damage (weekly)
3. Test for overheating and high electric motor current (weekly)
4. Perform oil analysis to monitor oil and machine condition (every 3 months)

Economic considerations:
In a small gearbox holding 0,5 litres of oil, the oil - and even the gearbox - is inexpensive to replace and oil analysis may not be cost-effective unless the failure consequences are critical or serious. In a large gearbox holding 400 litres of synthetic oil at R45 per litre, the oil itself becomes a significant item and a capital asset. In this case oil analysis is warranted in testing for oil contamination and deterioration, and it has the added benefit of monitoring wear. The oil is changed only if it becomes unfit for further use.

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EXAMPLE 2: Industrial hydraulic system

Hydraulic systems and their controls can be very complex so only the basic power pack is considered here:

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.

Initial scheduled maintenance programme:

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 condition (every 3 months)
7. Perform filter analysis (every 3 months)

Economic considerations:
In large systems holding a few thousand litres 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.

Reference :

FS Nowlan, HF Heap - Reliability-Centered Maintenance.