COLLEGE OF ENVIRONMENTAL DESIGN

ARE 524
Facilities Maintenance Management
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Selecting Maintenance Tactics Section 4

Uptime
Strategies for Excellence in Maintenance Management
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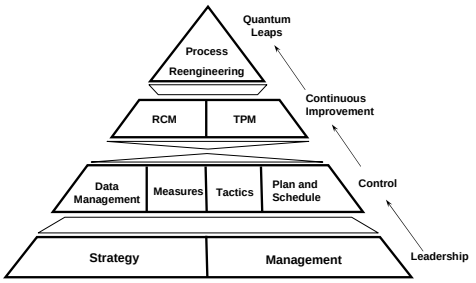

World Class Maintenance

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OUTLINE

- **TACTICAL OPTIONS**
  - **CONDITIONED-BASED MAINTENANCE**
  - **PREVENTIVE MAINTENANCE**
- **THE COST OF TACTICS**

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INTRODUCTION - 1/1

- **Armed with the maintenance strategic plan, it is set to do battle against the evils of breakdown**
- **Having mandate, the strategic objectives, guidelines principles or policies, and a plan of improvement**
- **But when get right down to the equipment, what is the most right to carry out?**
- **Actions and their timing are the tactics needed to carry out the strategic maintenance plan and to make the difference**

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1. TACTICAL OPTIONS – 1/5

- **For a personal car, do you:**
  - **Replace head lights at regular intervals?**
  - **Wait to replace tires until they wear through?**
  - **Check car's engine before replacing it?**
- **Each system or component in the car has a function, a failure mechanism, a consequences, and some economic implications**
- **Some times, a failure left to occur then the replacement carried out. This whenever the consequences aren't sever, easy, and cheap to replace**

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TATICAL OPTIONS – 2/5

- **All available maintenance option for a plant equipment and machinery should be known, and then decide which ones are the most appropriate**
- **The choices tend to be a blend of both actions and timing**
  1. ***Run-to-failure*– Maintenance is performed only after the equipment fails. (Electronic circuit board and lights bulbs)**
  2. ***Redundancy* - Redundancy is built into an equipment system. If the primary unit fails, the secondary unit is available. (Hydraulic pumps used in aircraft)**

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TACTICAL OPTIONS – cont. - 3/5

3. *Scheduled components replacement* – At a predetermined point, based on either elapsed time or use and regardless of its condition. Because the repair expense skyrockets if they run to fail. (Electric wheel motors)
4. *Scheduled overhaul* - Like the scheduled replacement, the plant or equipment is stripped and overhauled, based on a predetermined plan. (Annual shutdown)
5. *Ad hoc maintenance* – Is done on-the -fly or when there is a production window. Many manufacturers revert to this option when there is a sudden increase in required throughput

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TACTICAL OPTIONS – cont. – 4/5

6. *Preventive maintenance* – This is based typically on either time or use factors (kilometers, cycles, fuel consumption). It is carried out by conducting inspections, cleaning and other failure prevention actions. Often records kept for trend analysis. This is typical in process sectors where there are visual signs of wear and corrosion
7. *Condition-base Maintenance*- Maintaining plant and equipment is based on its measured condition such as vibration, stress, contamination, electrical measure and visual inspection
8. *Redesign* – Designing out maintenance is done particularly for critical equipment where it is difficult to measure the condition or detect imminent failure. (Car of 1940s vs. today car)

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TACTICAL OPTIONS – 5/5

- The difficulty comes in selecting the correct maintenance tactic. Which action and schedule is most appropriate when considering cost, plant down time and risks?
- It is essential to understand how the failure happened and if there was any it could be prevented it
- Maintenance is usually time-based but it is hard to assure that a part is more likely to fail due to its age (car parts and body)
- Recent research into equipment failure probability and advanced age has shown some results surprising. The most significant finding is that isn't a strong link at all

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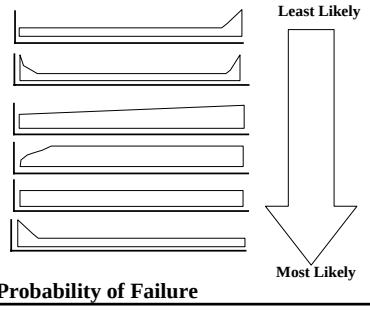
FAILURE AND AGE RELATIONSHIP 1/5

- There are six broad relationships between failure probability and advanced age, not just one or two
  - Worst old
  - Bathtub
  - Slow aging
  - Best new
  - Constant
  - Worst new



Conditional Probability of Failure

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FAILURE PROBABILITY 2/5

- Worst old
  - Age related
  - Rapid increase in failures at a particular point of use
  - The least common failure mechanism of all
  - Routine maintenance based on time is effective
  - Examples: crusher jaws, impellers tracks and liners
- Bathtub
  - High probability of failure at beginning and end of its life
  - Two tactics, at least, are necessary to deal with early and end-of life problems
  - It is a combination of a "worst new" and "worst old"
  - Example: Electromechanical system, HVAC

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FAILURE PROBABILITY 3/5

- Slow aging
  - Steadily increasing probability of failure with age
  - Associated with corrosion or creep
  - Usually when equipment is in contact with a product
  - Use rebuild or component replacement tactics
  - Example: Pipes, tiers, clutches
- Best new
  - Not age-related, except at beginning of life
  - Age-based routine maintenance generally ineffective
  - As with all random mechanisms, on condition is the best tactics
  - Example: hydraulics, penumatics

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FAILURE PROBABILITY 4/5

- Constant
  - Random failure, not age-related
  - Complex equipment system: electrical
  - Routine age-related maintenance is ineffective
  - Example: Ball bearings
- Worst new
  - Most common failure mechanism for complex equipment
  - Probability decline with age, perhaps because of design, manufacture, construction, or management
  - Once the infant mortality problem is solved, routine maintenance plays a minor role
  - Example: Electronics, avoinics

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EQUIPMENT MAINTAINANCE - 5/5

- This study, therefore, gives some important tips about how equipment should be maintained
  - Failure is not usually related directly to age or use
  - Failure is not easily predicted, so restorative or replacement maintenance based on time or use won't normally help to improve the failure odds
  - Major overhauls can be a bad idea because it ends up at a higher failure probability in the most dominant patterns
  - Age-related component replacement may be too costly for the same reason
- Finally, knowing failure pattern only doesn't tell what maintenance tactics to use. But, in addition, an economic study, a careful scrutiny data, and sampling studies will assist the decision

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CONDITIONED – BASED MAINTENANCE - 1/5

- Conditioned-based maintenance is usually most effective because it almost always can warn a failure before it occurs
- The warning may be subtle and give little time to react. However, it's obvious of opportunity to intervene without affecting equipment greatly
- Key equipment with components that fail in a progressive manner, rather than without warning, are good candidates for condition monitoring
- In the other hand, components with electronic circuits do not help as they fail suddenly

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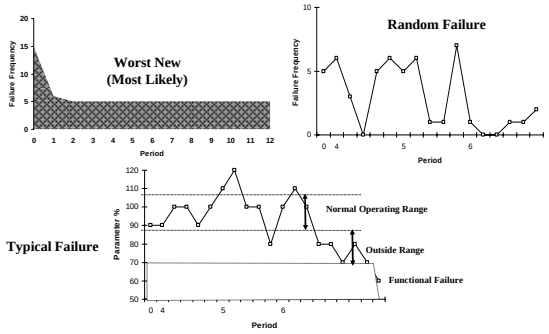
CONDITIONED – BASED MAINTENANCE - 2/5



Condition Monitoring

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CONDITIONED MAINTENANCE - 3/5

- Selecting the most appropriate method or measurement depends on several factors:
  - The failure mechanism it self
  - The reliability of the method chosen
  - The warning time it gives
  - The cost, both initial and ongoing
  - The skill level required to monitor and interpret the measure
- To have an easy time managing cost and skill level whenever two or three methods are used to monitor critical component of important equipment
- Most small to medium-sized business concentrate on fluid and wear particle monitoring method.

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CONDITION – BASED MAINTENANCE - 4/5

- Some of practical monitoring methods are:
  - Vibration
  - Lubricants
  - Temperature
- Condition monitoring is cost-effective. Depending on the method, it can be done by a semiskilled operator and often indicates both equipment condition and product quality. The equipment operator using the five senses is, therefore, the most versatile and valuable condition monitor
- There are more than 50 condition-monitoring and none destructive testing techniques

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MONITORING METHODS - 5/5

- Vibration
  - Vibration analysis monitors the mechanical movement of a machine. The vibration signal is also used to diagnose the location of the problem
  - The most common vibration sources are misalignment and imbalance. Problems defining involve the amplitude (how much movement), frequency (how fast), and phase (how much movement)
- Lubricants
  - Lubricants analysis (tribology) involves lubrication oil condition and wear particle count
  - Physical and chemical analysis of the oil are periodically compared to a baseline to check for deterioration
  - The shape and size of the wear particle as well as chemical analysis can indicate the suitability of the oil

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MONITORING METHODS - 5/5

- Temperature
  - Thermography is useful when it can be related to the condition of the equipment
  - Problems such as loose connections, deteriorated splices or cracked insulators are detected by temperature rises of between 10 and 100 C

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PREVENTIVE MAINTENANCE - 1/2

- PM can reduce failures and emergency repairs. It promotes equipment awareness and disciplined inspection
- It also works well for simple components that become less reliable as they age . In these cases, failures can be reduced by a logical overhaul or replacement schedule
- The first step in developing PM is to classify equipment and key component by failure pattern. They are either age-related or they'r not

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PREVENTIVE MAINTENANCE – 2/2

- For those that are not, condition monitoring should be carried out. For those that are age-related:
  - Set a standard condition, range of function
  - Prepare inspection, overhaul, change out, and adjustment routine and schedules
  - Establish recordkeeping, histories, and trading statistics
  - Organize for analysis and periodic updating, based on the results of the routines and schedules

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COST OF TACTICS - 1/5

- It almost irrelevant to discuss the cost of maintenance without considering what are buying
- The job of maintenance is to keep equipment running and to enhance its speed, reliability, and precision, If it is done on reactive way, after breakdown occur, downtime and subsequences repair bills will be high
- Using PM, unexpected failure declines, as do the production losses it causes
- A PM approach means more and more shutdown to inspect, adjust, overhaul, replace, and test. These delays can cost in lost production time, At same time, emergency repairs will taper off dramatically

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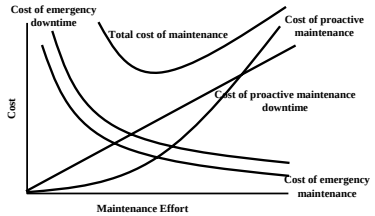
COST OF TACTICS - 2/5

- At some point, there is a balance between the cost of emergency and PM
- The figure assumes that proactive maintenance is indeed appropriate and effective at reducing unexpected failures



Maintenance Total Cost

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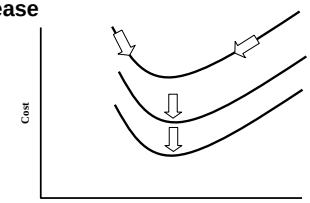
COST OF TACTICS - 3/5

- To truly be prepared; experience, proper data collection and analysis, and combination of good engineering and teamwork
- With all of that the maintenance curve could be decrease



Maintenance Total Cost

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Thank You

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