CORE Principles of Reliability-Centered Maintenance

Rich Overman, CMRP
(904) 655-0787 Cell
Rich@coreprinciplesllc.com
Introduction

• Late 1970’s ushered in a new era of asset maintenance
• United States Department of Defense published the seminal book entitled Reliability-Centered Maintenance (RCM)
• Entire industries have grown from this one book
• Growth brings variability
Definition of RCM

• “a logical discipline for the development of scheduled maintenance programs.” – Nolan and Heap

• “Reliability-centered Maintenance: a process used to determine what must be done to ensure that any physical asset continues to do what its users wanted it to do in its present operating context.” – John Moubray
Definitions of RCM

• RCM is “the best way to develop a maintenance improvement program.” – A.M. Smith
• “RCM uses a cross-functional team to develop a complete maintenance strategy designed to ensure inherent design reliability for a process or piece of equipment.” – Doug Plucknett
• RCM “is to identify components whose functional failures can cause unwanted consequences to ones plant or facility.” – Neil Bloom
Process Variants

• Jack Nicholas categorized various RCM processes:
  – Classical
  – Variants
  – Derivatives

• Result is RCM has come to mean different things to different people
CORE Principles of RCM

• Not presenting:
  – RCM process
  – RCM philosophy
• Primary or CORE Principles of RCM
• Underlying principles upon which all RCM processes are based.
Core Principles of RCM

- Components Fail
- Operational Impact
- Reliability Engineering Solutions
Components Fail

- Without intervention everything will eventually fail
- Each component has failure characteristic
- Nolan and Heap identified six failure characteristics
Components Fail

• Failure characteristic curves basis for all of the RCM processes
• One fundamental principle of RCM is identification of component failure characteristic
• The goal is to attempt to understand failure characteristic to identify appropriate intervention
Failure Characteristics

Wear Out Curves

Conditional Probability Of Failure
But There is More

• It is intuitively obvious that components will fail
• It is possible to intervene in some way to try to prevent all failures
• It is equally intuitively obvious that no company can afford to try to prevent all failures
• The primary purpose of RCM is to identify the appropriate intervention
• Simply recognizing that components fail is not sufficient
Core Principles of RCM

- Components Fail
- **Operational Impact**
- Reliability Engineering Solutions
Operational Impact

• Every component failure has some degree of operational impact
• Direct operational impact ranges from shutting down to none
• Indirect operational impact is to drain resources
• Every failure requires resources that could be more efficiently and effectively used to increase company value
Operational Impact

• Goal of RCM
  – evaluate
  – categorize
  – Prioritize
  – understand the operational impact of failure

• Identify the appropriate intervention.
But There is More

- Components fail
- They impact operations
- That knowledge, by itself, is not sufficient to identify appropriate intervention
- Need a logical way of organizing and evaluating information to make sound intervention decisions
Core Principles of RCM

- Components Fail
- Operational Impact
- Reliability Engineering Solutions
Reliability Engineering Solutions

- Reliability Engineers used analytical techniques for years
  - Failure Modes, Effects, and Criticality Analysis (FMECA)
  - Stochastic analyses

- Only logical to apply these techniques to the issue of failure intervention.
FMECA

• FMECA provides logical method for identifying failures and evaluating operational impact
• Every component failure leads to loss of a function
• Loss of function has process effect
• FMECA process identifies and documents
  – Functions
  – Functional failures
  – Failure modes
  – Effects of failure at various levels
  – Criticality analysis categorizes/prioritizing failure modes
FMECA

• Importance of FMECA to RCM process cannot be overstated
• Understanding operational impact of failure is crucial to developing appropriate intervention
• “a good FMECA will not guarantee a good RCM analysis but a bad FMECA will guarantee a bad RCM analysis.”
Stochastic Analysis

• FMECA is great existing Reliability Engineering tool for understanding operational impact of failures
• Not sufficient for developing intervention schemes
• FMECA is foundation but not end of RCM process
• Stochastic analysis is other Reliability Engineering tool that needs to be employed
• Most common stochastic analysis used in RCM is Weibul analysis
• Weibul analysis can identify failure characteristic curve applicable to failure mode
Relating Failure to Intervention

• Failure characteristic defines intervention
• Scheduled overhaul/replacement would not work for infant mortality characteristic
• A random failure characteristic is more appropriate for applying a predictive maintenance
• A wear out characteristic would benefit from either a predictive maintenance or overhaul/replacement intervention
• Stochastic techniques provide information to determine intervention interval
Function Preservation

Classical RCM asks:
How do I keep fluid flowing out of tank?

Traditional analysis asks:
How do I keep the pump operating?
How do I keep fluid flowing out of tank? 

What are ways to keep fluid flowing out of Tank B other than keeping the pump running?

- Bypass valve
- Standby pump
- Keep tank B full enough to give time to change a failed pump
- With a functional approach, many alternatives are available
7 Steps in the RCM Process

1. System Selection
2. Systems Boundary Definitions
3. System Description
4. Identify System Functions & Functional Failures
5. Failure Modes and Effects Analysis (FMEA)
6. Task Selection
7. Program Implementation
SAE Standard

1. What are the functions, performance standards in the present operating context? (Function)
2. In what ways does it fail to fulfill its functions? (Functional failure)
3. What causes each functional failure? (Failure mode)
4. What happens when each failure occurs? (Failure effects)
5. Why does the failure matter (Failure consequences)
6. What can be done to predict or prevent each failure?
7. What should be done if a suitable task cannot be found?
Example Analysis – Water Jet Machine

- Nagging Failures – Worn and failed tips
- Lots of down time
- Cause – “Dirty” Water
- Source – Versatile Reliability-Centered Maintenance
System and Boundaries
Water Jet Reclamation System

Figure 66 - Water Jet Machine Deionizer Units
Figure 65 - Water Jet Machine Control Side
Water Jet RCM Analysis

- 7 Functions
- 14 Functional Failures
- 47 Failure Modes
- 8 Inspections
- 4 Overhaul/discard
- 1 Failure finding
- 25 Run-to-failure
- Estimated annual savings $334K
Conclusion

• All RCM processes apply CORE Principles of RCM
• Must be applied to identify appropriate failure intervention
• Component failure must be understood
• Operational impact assessed
• Reliability Engineering tools applied
Conclusion

• Each RCM process available today applies the CORE Principles of RCM to varying degree
• Degree applied is indicative of overall benefit
• If CORE Principles of RCM applied superficially - some but limited benefit
• More rigorous application of the CORE Principles of RCM - enhanced benefits
• Degree to which CORE Principles of RCM are applied affects cost of analysis
• The more a company is willing to invest in RCM the more benefit they can expect