Reliability Centered Maintenance (RCM)

What is RCM?

- Reliability Centered Maintenance is a process which establishes the proper proactive tasks for manufacturing assets

  By...

  - *Carefully defining the intended function of the assets*
  - *Applying the science of failure modes (age vs random)*
  - *Ensuring tasks selected are optimal in light of the consequences of failure*

Background

- In the 60's, United Airlines commissioned a study to improve the reliability of the first generation of jet aircraft
- An early call for increased preventive maintenance actually *increased* crashes!
- Stanley Nowlan and Howard Heap developed the process and science of "RCM" as a result (paper issued Dec. 1978) to aid the airline industry
- John Moubray took Nowlan & Heap's work and generalized it into RCM2 (book published 1991) to facilitate application to broader industries
- SAE created standard JA1011 for the transportation industry to standardize on RCM requirements

Objective of RCM

Primary objective of RCM is -

to preserve system functionality at a tolerable level of risk.

By…

- Selecting the right predictive (Pd) or preventive (PM) tasks
- Recommending redesigns when no such Pd or PM tasks are viable
- Asserting “no scheduled maintenance” when the above steps are exhausted and the risk is tolerable

Benefits of RCM

- Produces Preventive & Predictive Maintenance that
  - *Identifies optimum tasks needed to ensure equipment meets the intended function(s).*
  - *mitigates the risk of failure*

Heart of the Process

- Provides an Engineering method to drive technical competence in
  - *Solving root causes in lieu of treating symptoms*
  - *Matching the right type task to the failure mode (problem)*

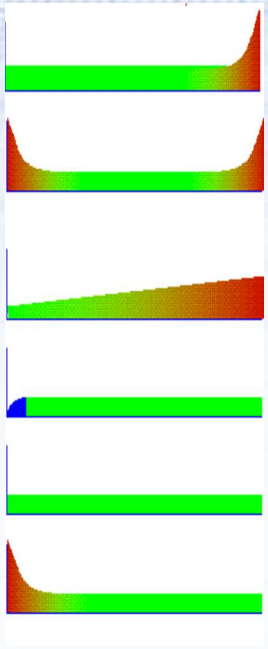
Heart of the Science

What Does it Take?

The team must include members knowledgeable in:

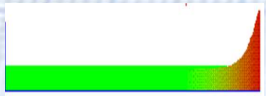
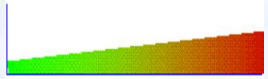
- Operations - failure scenarios, process requirements
- Maintenance – repair times, historical failures
- Process Technical – process service conditions, operating boundaries, process related degradations (fouling, plugging, etc)
- Equipment Technical – equipment design, design limits, component based failure modes, probabilities of failure modes

RCM Failure Patterns

Failure Pattern		% Process Industry Equipment	*The right tasks for the right failure mode:*
A		2	Reciprocating Compressor Rider Bands – replace at end of life
B		2	Machine lube oil with poor lube oil handling practices
C		20	Heat Exchanger fouling - monitor temps
D		6	Resistor - No Scheduled Maintenance
E		10	Sleeve Bearing - monitoring only
F		60	Instrumentation - failure finding

time

Failure Patterns and Tasks

Failure Pattern		% Process Industry Equipment	*The right tasks for the right failure mode:*
A		2	Time Based Tasks
B		2	Time Based Tasks – with procedures or redesigns to mitigate infant mortality
C		20	Potentially Condition Monitoring Tasks
D		6	Potentially Condition Monitoring Tasks
E		10	Potentially Condition Monitoring Tasks
F		60	Potentially Condition Monitoring Tasks (definitely NOT time based)

time

Protective Equipment

- Equipment providing a “protective function” will typically have ***hidden failures***

- A hidden failure in and of itself is not evident under normal operations

Hidden Failures

Hidden (covert) failures require a separate & distinct “abnormality” before their failure is known

- *Vibration probe* — *requires a machine failure*
- *High level switch* — *requires a high level*
- *Safety Valve failing to relieve* — *requires an overpressure*

<u>Evident (overt) failures will eventually (on their own) become evident to operations – regardless of time</u>

- ✓ *Corrosion under insulation (CUI) will eventually become evident*
- ✓ *Safety Valve relieving too soon will eventually be noticed*

How to Treat Hidden Failures

- Hidden Failures are mitigated by “failure finding tasks”

Concept: “Find the hidden failure before you need the protection”… (most of the time)

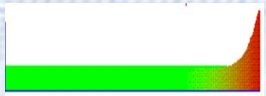
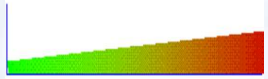
<u>Availability Approach:</u>

Set a required “Availability” for the protective function

Extremely critical	99.9%
Highly critical	99%
Barely critical	90%

CAUTION: method only valid for random failure patterns (D, E, &F)

Failure Patterns and Tasks

Failure Pattern		% Process Industry Equipment	*The right tasks for the right failure mode:*
A		2	Time Based Tasks
B		2	Time Based Tasks – with procedures or redesigns to mitigate infant mortality
C		20	Potentially Condition Monitoring Tasks
D		6	Potentially Condition Monitoring Tasks
E		10	Use Failure Finding tasks for hidden failures
F		60	

time

Priority of Mitigation Tasks

1. Preventative Tasks
   - *Condition monitoring (if monitoring is practical given PF interval)*
   - *Time based restoration/replacement (if life is predictable)*

2. If Failure is hidden, perform failure finding tasks

3. If risk is tolerable - no scheduled maintenance

   else...

   If risk is not tolerable > redesign

Application of RCM

- Select preventive & predictive (monitoring) maintenance tasks
- Define operator monitoring tasks
- Screen turnaround work
- Evaluate PM's
- Improve bad actor performance
- Evaluate equipment improvement opportunities

Keys to Success

- Skilled RCM facilitation resource
- Knowledgable team members
- Buy-in and support from Technical leadership
- Ownership (of the output) by Operations leadership
- Stewardship system to allow all branches of leadership to monitor implementation