DECODING THE PM PUZZLE
(PM – FACT or FICTION?)

Presented to the
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Yet another whack at the PM windmills

NEW THINKING ON OUR PM OBLIGATIONS
(NEBS 11 01 #1)

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Reality Check (NEBS 11 01 #2)

- Maintenance (particularly PM) is an issue of declining importance - relative to several other equipment issues
- But we are still allocating an estimated 3000 FTEs or $300M /year to this area
- We could be doing something more productive with these resources !

The Issues (NEBS 11 01 #3)

1. We still do not have a good consensus on what we mean by the term **"PM"**, or even why we do it !
2. Although the JCAHO has allowed us to exclude **non-critical devices** from our monitored PM programs since 1989, we still don't have a rational process for defining a **non-critical device.**
3. We don't have any good methods for justifying the **PM intervals** that we use.
4. The **PM procedures** that most of us use could be improved.

ASHE Maintenance Practices Initiative 2005 GOALS

1. Research the RCM literature….
2. Metrics for maintenance effectiveness
3. Rationale for maintenance intervals
4. Central depository for reliability data
5. Disseminate information and encourage widespread adoption of ….

The ASHE Maintenance Manuals:

Last updated in 1996 and 1984 respectively

Table of Contents
(2008 edition)

Appendices

A. An introductory primer on RCM
B. Determining the most efficient PM intervals
C. Cause coding: The basic categories of equipment repair calls
D. Automatic protection mechanisms

Etc. etc.

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PM – Why do we do it?

- PM cannot and does not prevent all types of equipment failures.
- It addresses only failures that result from the degradation of a device's non-durable parts and hidden failures.
- There are several other, more common, causes of "device failure".
- What about hidden failures of automatic protection mechanisms?

Better PM terminology

- True preventive maintenance (TPM). inspecting, cleaning, lubricating, adjusting or replacing the device's non-durable parts… scheduled restoration or scheduled discard tasks
- Performance verification and/or safety testing (PVST)……. functional testing to detect hidden failures … failure-finding tasks
- Predictive maintenance

TPM= True Preventive Maintenance

…is the inspection, cleaning, lubricating, adjustment or replacement of a device's **non-durable parts**.

Non-durable parts are those components of the device that have been identified either by the device manufacturer or by general industry experience as needing periodic attention, or being subject to functional deterioration and having a useful lifetime less than that of the complete device.

Examples include filters, batteries, cables, bearings, gaskets, and flexible tubing.

Repair Call Cause Coding

Category 1	Use error. The device and its accessories are still working properly and safely
Category 2	Problem is due to use of a wrong or defective accessory or something in a connected network …
Category 3	Problem due to physical stress (its broken)
Category 4	Problem due to poor installation, initial set-up an incomplete previous repair
Category 5	Problem due to an out-of-tolerance ambient environmental condition

Repair Call Cause Coding

Category 6	Battery problem
Category 7	Deterioration of part normally restored during PM …
Category 8	Problem caused by human interference
Category 9	Uncontrollable, random failure of a component or part
Category 0	Unable to diagnose cause of failure

Other strategies for reducing equipment downtime

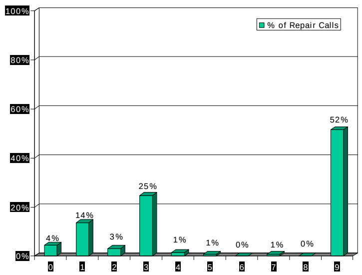
1. Better training the users to operate the equipment properly
2. Having the proper accessories available and encouraging the operators to use them
3. Encouraging the users to treat the equipment more carefully
4. Ensuring the equipment is installed and set-up properly
5. Maintaining the proper ambient/ environmental conditions

Other strategies for reducing equipment downtime

6. Having a well-managed battery care program
7. Having a well-designed PM program
8. Avoiding unnecessary intrusive preventive maintenance
9. Selecting higher quality (more reliable) equipment

Thorburn Repair Call Cause Data

(for 6 month period)



PM Effectiveness Metrics

1. The fraction (percentage) of repair calls that are caused by Category 7 failures
2. The fraction (percentage) of the PMs conducted where a (serious) hidden failure is detected by the PVST testing (aka the PM "yield")

Retroactive analysis (Dec '07)

Code	**Cause of repair call**	Call Count	%age	Aust.
1	User-related	54	**10.2**	**14%**
2	Accessory or connectivity	7	1.3	3%
3	Physical stress-related	120	**22.8**	**25%**
4	Run-on related	11	2.1	1%
5	Environmental stress-related	13	2.5	1%
6	Battery-related	32	6.1	-
7	Inadequate PM-related	17	3.2	1%
8	Human interference-related	0	0	0
9	Random, unpredictable failures	273	**51.8**	**52%**
0	Uncategorized repair calls			
		527	100	100%

Category 1 - User-related
54 calls (10.2%)

- Broad mix of devices involved ; patient monitors, infusion pumps, blood warmers, sequential compression devices, cart washers, etc.
- Relatively few calls on the Ascom units (6/54) (speakers not plugged in, etc)
- Most unusual call - "scale weighing 60 lbs off" (It was set to display in kilograms not pounds)
- Experiment with more formal training(?)

Category 2 – Accessory or connectivity - related
7 calls (1.3%)

- Mix of accessories involved; NIBP cuff leaking error code, missing power cords, ultrasound probe cable, busted hyperthermia hose, etc.
- No connectivity-related calls reported

Category 3 – Physical stress-related
120 calls (22.8%)

- Most frequently damaged devices - pumps (37/120) - closely followed by Ascom units (16/120)
- Other devices damaged - SCAs with broken cases (!) and 4 calls involving portables, beds with bent side rails; connectors with bent pins; etc.
- Most unusual call – replace seat and lid on broken commode

Category 4 – Run-on calls
11 calls (2.1%)

- Relatively few calls relating to poor quality prior repairs and poor initial set up (loose wires, etc.)
- Most unusual call – catching a technician from an outside vendor taking an inappropriate technical short cut.

Category 5 – Environmental stress
13 calls (2.5%)

- Most of the calls (8/13) were for problems with out of spec. electrical power; 5 of these were attributed to routine testing the emergency power transfer switch.
- Other problems related to insufficient steam pressure for the sterilizers.
- Most interesting call – telemetry unit that was inadvertently sent to the laundry.
- Investigate possible benefit of more small UPSs

Category 6 – Battery-related
32 calls (6.1%)

- Most calls (8/32) were for Alaris pumps, next were feeding pumps (5/32), then UPS batteries (3/32), and Ascom units(2/32)
- Other calls were for a variety of devices including an NIBP monitor, an intra-aortic blood pump, and a plethysmograph.
- Most noteworthy call – a transport incubator (where it might be prudent to carry a spare battery.)
- Battery replacement program?

Category 7 – Inadequate PM
17 calls (3.2%)

- Nothing particularly notable. Bearing on a bed blower motor, brushes on a centrifuge, hyperthermia pump needing lubrication, electrical contacts on footswitch, frayed line cords, etc.
- Consider a line cord replacement program?

Category 8 – Human interference
0 calls (0.0%)

- Nothing reported this month.

Category 9 – Random failures
273 calls (51.8%)

- Devices accounting for the largest number of repairs – infusion pumps (45/273 =16%), followed by the Ascom units (32/273 = 12%).
- Other notable items repaired; gamma camera with ring artifact, several calls on the linear accelerators, portables, sterilizers, cart washers, and large lab analyzers
- Will be interesting to see whether or not this is a typical month

Selecting the most cost-effective PM strategies

1. Identify the principal PM – related failure modes (FMEA)
2. Rank them according to their relative seriousness/ criticality (Level of Severity and Likelihood of Occurrence)
3. Use special RCM Decision tree to determine what type of remedial task is required or whether a Run-to-Failure strategy is acceptable.

Proposed scheme for classifying the severity of any PM "findings"

Severity Level	
4	A hidden PM-preventable problem that is potentially life-threatening
3	A hidden PM-preventable problem that could have a major impact on patient care
2	A hidden PM-preventable problem that requires attention but is unlikely to …..
1	An obvious, but apparently unreported defect

Risk Scores: Compounding Severity and Likelihood of Occurrence (LoO)

Severity Level 4 "Catastrophic"	4	8	12	16
Severity Level 3 "Major"	3	6	9	12
Severity Level 2 "Minor"	2	4	6	8
Severity Level 1 "Marginal/ Slight"	1	2	3	4
	LoO = 1 "Remote"	LoO = 2 "Uncommon"	LoO = 3 "Occasional"	LoO = 4 "Frequent"

Infusion Pump Analysis

1. Thorburn team identified 145 potential failure modes.
2. Only six were judged to be addressable by some kind of PM task
3. One had a risk score of 8 (moderate) and the team deemed this not critical but "worth doing"

Documenting the Risk Analysis

1. What is the cause of this type of failure?
2. Will this be a hidden failure?
3. Can the failure be addressed by either functional testing or true PM?
4. Are there serious (Level 3 or 4) adverse safety consequences?
5. Are there serious (Level 3 or 4) adverse operational consequences?
6. Are there serious non-operational (repair) consequences?

Documenting the Risk Analysis

7. What is the estimated likelihood of occurrence?
8. What is the Risk Score?
9. Is there a technically feasible proactive maintenance task that is worth doing?
10. If there is an appropriate PM task, at what interval should it be performed?
11. If there is an appropriate PM task, is there a corresponding task statement in the generic PM procedure?

Indirect benefits of PM programs

1. Finding unreported failed or damaged devices
2. Confirming that the devices are still present in the facility
3. **Providing some level of comfort and security that everything possible is being done to maximize the level of equipment safety.**

How to determine PM intervals ?

Here's how we do it now

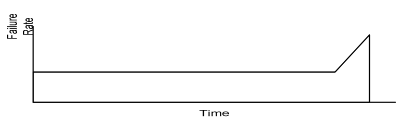
- Based on the EM number
- Whatever the manufacturer recommends (?)
- JCAHO's July 1, 2001 revision to EC.1.6. (f) and EC.2.10.3. permitting maintenance "strategies" other than the traditional time-based inspection intervals. Change from "apply professional judgment" to **"data-driven decisions"** !!

Determining the most efficient PM intervals

For true preventive maintenance (TPM)

- Requires knowledge of the device's age-related failure pattern
- The period between being put into service and the "knee" is called the economic life limit.
- Most efficient interval is just less than 100% of the economic life limit.

Age-related failure pattern



- The period between being put into service and the "knee" is called the **economic life limit**.
- Most efficient interval is **just less than 100%** of the economic life limit.

Determining the most efficient PM intervals

For functional (PVST) testing

- Requires knowledge of the failure mode's mean time between failures (MTBF)
- What level of confidence is required that the device is in a "**safe operating condition**"?
- These two factors set the maximum testing interval.

100 devices checked **annually** for 4 years
High leakage current found 16 times
MTBF = 400 (device years)/ 16 = **25 years**

16 devices in failed state (on average) for 6 months
Total **hidden downtime** = 8 device years
Probability that device in failed state = 8/ 400 = 2%
Probability that device in **safe operating condition** = **98%**

Probability of failed state = 0.5 X test interval / MTBF

For 1% HD (99% SOC) - max interval = 0.02 X MTBF (= 6m)
For 2% HD (98% SOC) - max interval = 0.04 X MTBF (= 12m)
For 5% HD (95% SOC) - max interval = 0.1 X MTBF (= 30m)

Questions ?