



Audit it. Improve it!

Processes and KPIs for a successful CM program

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ZENCO
VIBRATION EXPERTS

Speaker BIO

- Founder / CEO of Zenco – Vibration Experts
 - CMRP, CRL, Cat IV Vibe
- 9 yrs Senior Instructor for Mobius Institute
- 15 yrs Senior Engineer AzimaDLI
- Author of the best selling:
- ***Audit it. Improve it! Getting the most from your vibration monitoring program***



10 Components



1. Right goals

- Having clearly defined and achievable goals that may evolve over time

2. Right People

- Having the right people in the right roles with the right training.

3. Right leadership

- Inspiring continuous improvement.

4. Right tools

- Having the right tools and technology to help reach the goal.

5. Right understanding

- Equipment audits, reliability and criticality audits, FMEA, maintenance strategies, etc.


10 Components

6. Right data collection

- Collecting the right data at the right time to detect anomalies, defects or impending failures.

7. Right analysis

- Turning data into defect or fault diagnoses.



8. Right reporting

- Turning data into actionable information and getting that information to those who need it at the right time and in the right format.



9. Right follow up and review

- Acting on reports, reviewing and verifying results, benchmarking, auditing and improving, etc.

10. Right processes and procedures

- Tying together: people, technology, information, decision making and review.

Having clear goals

- What are the goals of your vibration monitoring or CM program?



Goals must be SMART:

- Specific
- Measurable
- Achievable
- Realistic
- Time-bound

Goals of your CM program(s)

The goals of my CM program...

1. Are well defined and well communicated
2. Are well defined but need to be reviewed
3. Are not well defined
4. I do not have a CM program

Some common goals

- Avoid catastrophic failures
 - Reduce secondary damage
 - Avoid injuries, environmental damage, lawsuits
- Better plan repairs
 - Save on overtime
 - Get spare parts just in time
- Gain control over production
- Compliance
- Insurance

The Reactive Trap

- What is the difference between reactive maintenance and condition based maintenance?
- Many people use CM technologies in a reactive mode



Standards and Compliance

- Is your program compliant?
- Does your program follow industry best practices?



Standards and Compliance

- Best practices and guidelines
 - Make use of industry knowledge
 - Don't reinvent the wheel
- Compliance
 - Liability
 - Industry standards
 - Regulatory



Compliance and liability

- What happens if a machine fails and causes environmental damage, injury or death, loss of production, lawsuits etc?
 - Do you have a CM program in place to prevent this?
 - Does it follow the standards?
 - Was the person who took the readings certified?
 - Was the person who set up the program certified?
 - Were the alarms based on a standard or standard best practice?

Standards and Compliance

- Standards exist for:
 - Condition monitoring program design
 - Training and certification
 - Vibration testing and alarms
 - Balancing and balance standards
 - Acceptance testing
 - Reliability and management



Standards and Compliance

- Some standards organizations:
 - International Standards Organization (ISO): www.ISO.org
 - American Petroleum Institute (API): www.API.org
 - Hydraulic Institute (HI): www.pumps.org
 - International Electrotechnical Commission (IEC): www.iec.ch



Analysis – Alarms and compliance

- Alarms and compliance
 - ISO 10816-7 Pumps

Zone	Description (see 5.2 for details of zone definitions)	Vibration velocity limit r.m.s. value mm/s			
		Category ^a I		Category ^a II	
		≤ 200 kW	> 200 kW	≤ 200 kW	> 200 kW
A	Newly commissioned machines in preferred operating range	2,5	3,5	3,2	4,2
B	Unrestricted long-term operation in allowable operating range	4,0	5,0	5,1	6,1
C	Limited operation	6,6	7,6	8,5	9,5
D	Risk of damage	> 6,6	> 7,6	> 8,5	> 9,5

Business objectives

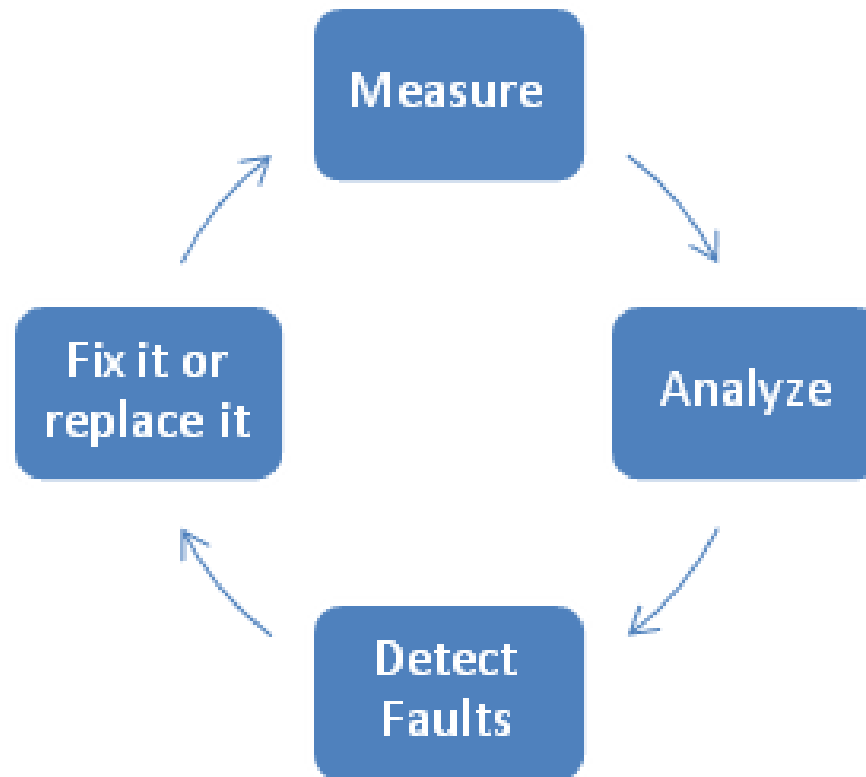
- Are your goals in alignment with your broader business objectives?

Key Performance Indicators (KPI's)

- Not only do you need goals, you need to know if you are achieving them or not
- Think about your goals and how you will measure your progress
 - More on this later



What is Condition Monitoring?



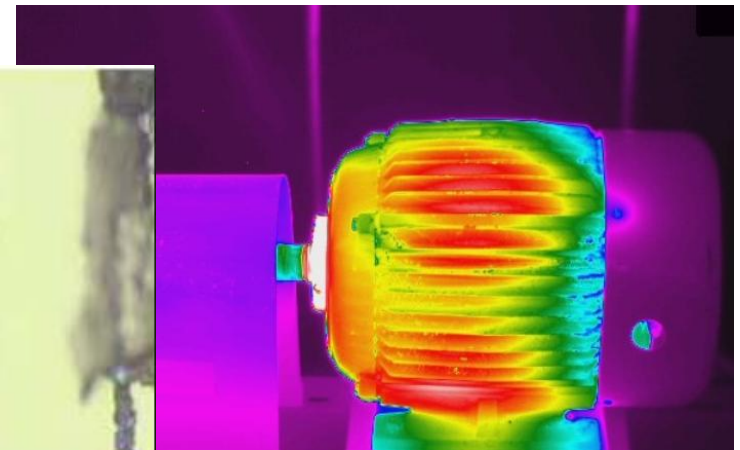
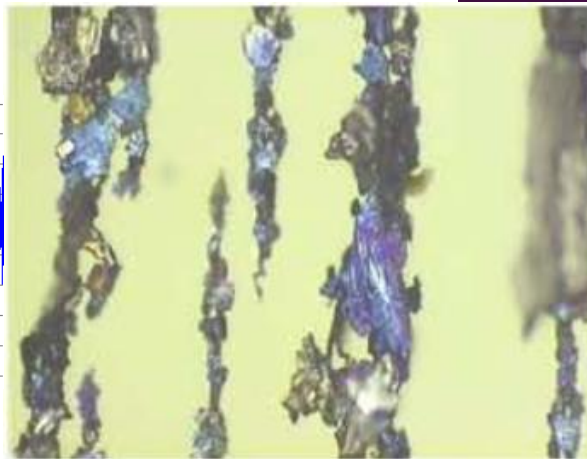
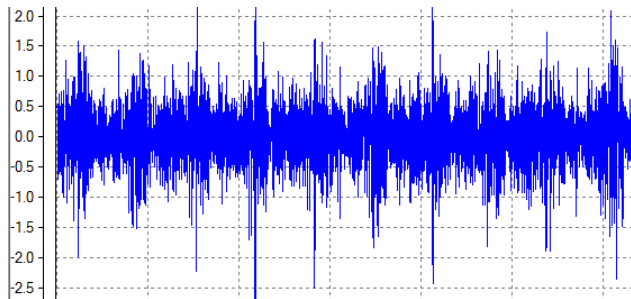
CM and reliability

Does condition monitoring, on its own, improve equipment reliability as defined by Mean Time Between Failures (MTBF)?

1. Yes
2. No

Right Data

- Machines give “indicators” when they begin to fail
 - You must monitor these indicators



Right data => Right Analysis

4. Right tools

- Having the right tools and technology to help reach the goal.

5. Right understanding

- Equipment audits, reliability and criticality audits, FMEA, maintenance strategies, etc.

6. Right data collection

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Right reporting

- Turning data into actionable information and getting that information to those who need it at the right time and in the right format.

Wrong reporting

- When not aligned with your goals...
 - Reports are ignored
 - Reports are inaccurate
 - Reports are not valued
 - Reports are not timely
 - Reports are not understood

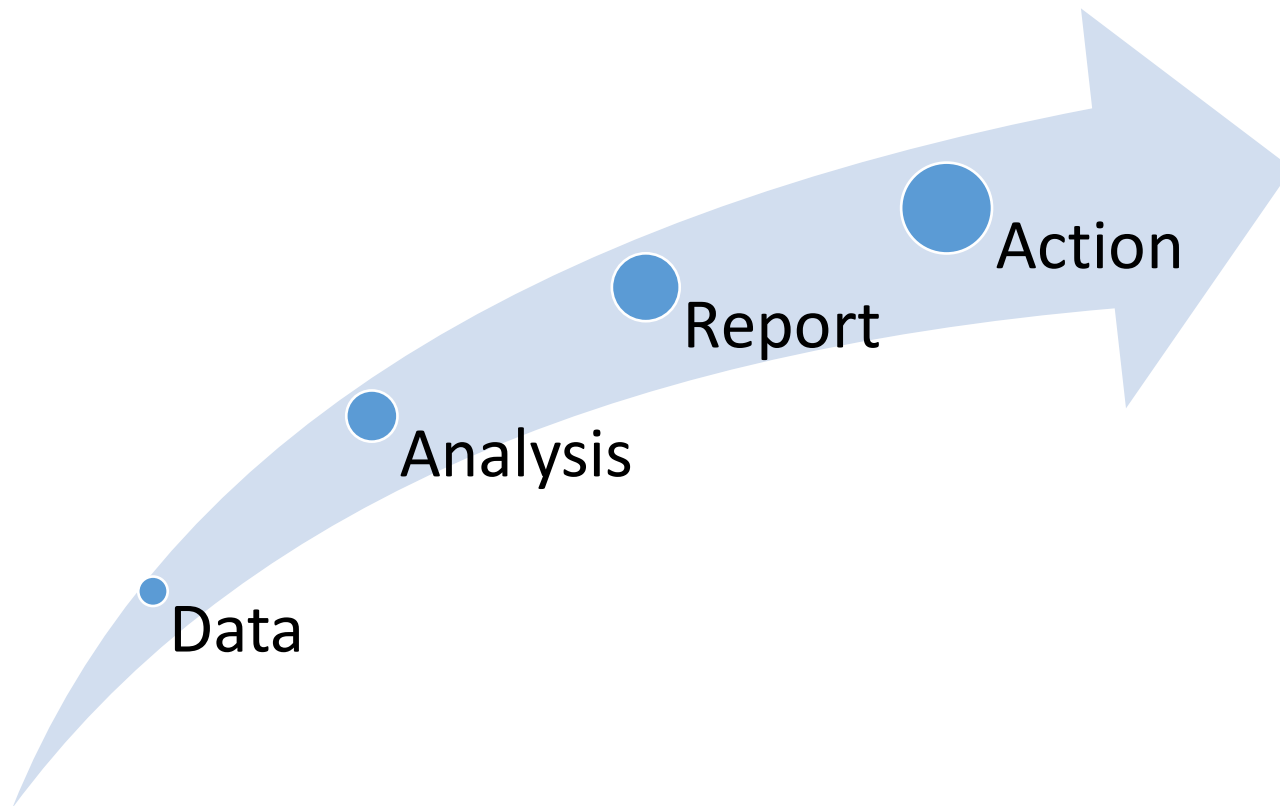
Wrong Reporting

- Sometimes it seems that people take readings and write reports because it is their job
- Reports need to be linked to program goals



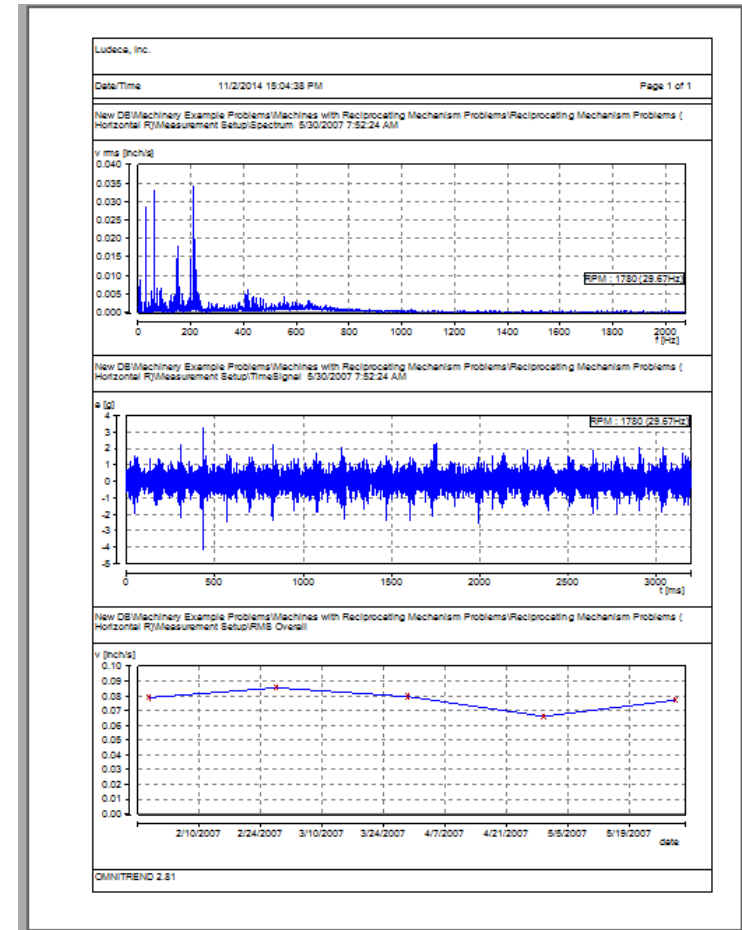
Right Reporting

- The report must contain “Actionable Information”



Right Reporting

- Who?
- What?
 - Format, severity levels, what information
- How?
 - How is it transmitted, passive or active
- When?
 - Severity levels
- What do they do with it?
- Do they value it?



Right Reporting

- Who gets the reports?
 - How will they use the information?



Right Reporting

- What information is in the report?
 - “Machine is in alarm”?
 - Specific repair recommendation?
 - Severity levels?
 - Raw data?
 - Historical data?

Right Reporting

- How are severity levels defined?
 - **Level 1:** No Action necessary
 - **Level 2:** Monitor for changes
 - **Level 3:** Schedule repair
 - **Level 4:** Shut down machine

Right Reporting

- When are reports generated, received, reviewed?
 - How does this relate to the risk of catastrophic failure?
 - How does this relate to planned shut downs?

Right Reporting

Our CM reports are valued and are acted on in a timely fashion.

1. Yes, 90% of the time or more
2. Mostly but not always (60%)
3. Only when a really serious problem is detected
4. Not usually

Right follow up and review

- Acting on reports, reviewing and verifying results, benchmarking, auditing and improving, etc.

Follow up and review

- “As-found” condition reports
- Root Cause Failure Analysis
- Case Histories
- Feedback to engineering / purchasing



Right follow up and review

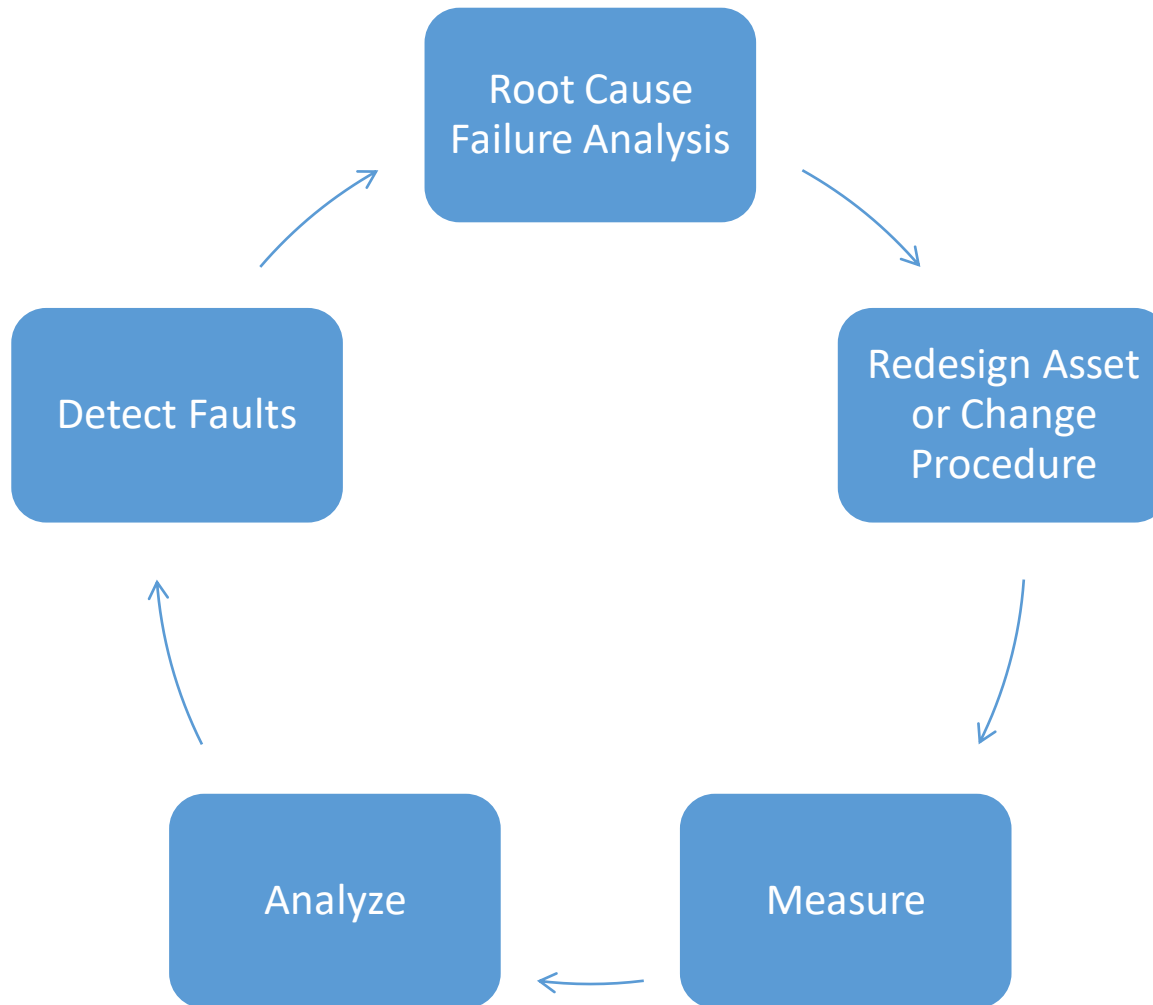
We have a formal process of verifying CM results and documenting “as-found” conditions.

1. Yes
2. No
3. Yes: Not on every asset, but in statistically meaningful way;
4. Yes: but only on the most critical assets

No follow up or review

- Many programs do not have clear goals
- They do not measure:
 - Progress towards goals
 - Financial benefits of program
 - Accuracy of diagnoses
 - What problems are being detected

Right follow up and review



No follow up or review

- Many plants make the same mistakes over and over again
 - There is no culture of continuous improvement



Right Follow up and review

We have formal RCA procedures and a continuous improvement culture

1. Yes, most of the time
2. Only on very critical equipment
3. Only after a major failure
4. We are in a reactive mode

Right follow up and review

The results of our RCA are fed back into engineering and purchasing and improvements are made.

1. 90% of the time
2. 70% of the time
3. 40% of the time
4. Rarely if ever

Measuring your results

- Key Performance Indicators (KPI's)
- Something you can measure
 - Lets you know if you are reaching your goals



Measuring your results

- Key Performance Indicators (KPI's)
 - Financial
 - Technical
 - Solving specific problems
 - Processes and procedures
 - Return on investment (ROI)
 - Etc.



KPI's for CM

- Only measure it if the outcome will change your behavior



KPI's for CM

- Only measure it if the outcome will change your behavior



KPI's for CM

- Leading and lagging indicators
 - Rain forecasts => Umbrella sales
 - Forecasts are a leading indicator
 - # of Accidents => Safety training
 - Reduction in accidents is a lagging indicator



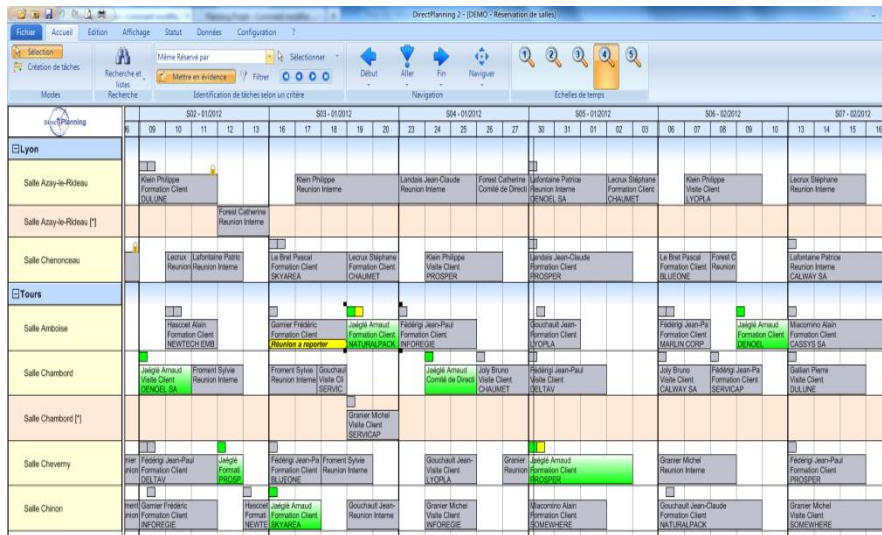
KPI's for CM

- Causal and casual relationships
 - Rain forecasts => Umbrella sales
 - Rain forecasts => Increase in # of purple umbrellas
- # of Accidents => Plant is shut down!



KPI's for CM

- A CM program provides early warning of machine failure
 - Helps planners plan better
 - Helps avoid catastrophic failures



KPI's for CM

- Helps planners plan better
 - Parts
 - Labor
 - Production



KPI's for CM

- How can you measure if you are planning better?
 - Time from fault diagnosis to repair
 - Planned / Unplanned work



Planning repairs

(In your plant) What is the average amount of time between receiving a CM defect report and repairing the asset?

1. 0 – 7 days
2. 7 – 14 days
3. 14 – 21 days
4. 21+ days

KPI's for CM

- How can you measure if you are planning better?
- Parts
 - Lead time cost savings on spare parts
 - Ability to shop around
 - Lower shipping costs
 - Reduced spare parts inventory (just in time)
 - Lead time to repair (LTTR)

KPI's for CM

- How can you measure if you are planning better?
- Labor
 - Overtime
 - Labor utilization (wrench time)



Planning repairs

Our CM program has saved us money on stores / parts and labor utilization.

1. Yes, and it is well documented
2. Probably, but it is not documented
3. We have not used CM results to optimize parts inventories and labor usage

KPI's for CM

- How can you measure if you are planning better?
- Production
 - More uptime / Less unplanned downtime
 - Overall Equipment Effectiveness (OEE)
 - Less planned downtime

KPI's for CM

- CM helps avoid catastrophic failure
 - Accidents
 - Spills
 - Secondary damage
 - Insurance
 - Compliance / Regulators

KPI's for CM

- How can you quantify reductions in catastrophic failures?
 - Accidents / injuries / deaths due to machine failures
 - Cost to repair machine (secondary damage)
 - Number of non compliance events
 - Cost of non compliance (fines)
 - Cost avoidance



KPI's for CM

- Cost avoidance
 - What would have happened if you did not catch the failure and the machine actually failed?
 - Worst case scenario
 - Moderate scenario
 - Actual historical scenario
- You might get some ideas of this from RCM

KPI's for CM

- Cost avoidance
 - Hard for people to digest because the event did not actually happen
 - If I hadn't gotten new tires, this might have happened!



KPI's and metrics for CM

- CM Program KPI's
 - Number of machines tested
 - Cost per machine per quarter
 - Schedule compliance
 - % machines in alarm
 - Level 1
 - Level 2
 - Level 3
 - No faults
 - If more than 30% of your machines are in alarm, your alarms are not set up right!



Wrong Analysis - Alarms

- Alarms for efficiency
 - Alarms tell you which assets to focus on
- The 80-20 rule:
 - 80% of assets are OK
 - Of the 20% that are not OK, 80% of them do not require immediate attention



Vibration alarms

What % of the machines in your database have good baselines / alarms that you are confident are set up well?

1. 0%
2. 20%
3. 40%
4. 90%
5. Don't know

Right Analysis - Alarms

- 1,000 machines per month x 6 test points per machine x 5 tests per point = 30,000 graphs per month
 - Who will analyze all of this data?
- Per the 80-20 rule, only 40 machines require your immediate attention
 - Good software and alarms streamline this process

KPI's and metrics for CM

- CM Program KPI's
 - Defects detected by type
 - Bearing wear
 - Bearing lubrication
 - Misalignment
 - Unbalance
 - Looseness
 - By machine type, area of responsibility etc.



KPI's and metrics for CM

- Its one thing to detect defects, it is another thing to correct them.
 - Defects corrected by type
 - Bearing wear
 - Bearing lubrication
 - Misalignment
 - Unbalance
 - Looseness
 - By machine type or model #, area of responsibility etc.
 - Lead time to repair



KPI's and metrics for CM

- Labor usage (%):
 - Time spent taking measurements
 - Time spent doing PM's
 - Corrective maintenance based on PM's
 - Corrective maintenance based on CM results
 - Unplanned corrective maintenance
 - Wrench time

KPI's and metrics for CM

- CM Program KPI's
 - Defects detected (number or %)
 - Defects verified (number or %)
 - Diagnosis accuracy %
 - Note these can be broken down by CM technology
 - Root case failure analysis carried out (%)
 - Results fed back to purchasing and engineering
 - Average RMS vibration level plant wide

Big data analytics

- Data mining
 - Finding meaning in the data
- What format is your information in?
 - Is it standardized?
 - Is it searchable?
- What else might we discover???

KPI's and metrics for CM

- Any other ideas?



KPI's for CM

- Cautions
 - Don't use too many KPI's
 - Don't measure it if you aren't going to act on the results
 - Don't use KPI's just to make yourself look good
 - Make sure there is a clear cause and effect relationship between the actions you take and the KPI's you measure

Summary

- Condition based maintenance requires a combination of:
 - People / Leadership / Goals / Commitment
 - Technology / Tools / Training / Expertise
 - Processes / Procedures / Follow up
 - Audits and Reviews
 - Continuous improvement

Program audits

I think our program would benefit from an audit.

1. Yes definitely
2. Probably but its not going to happen
3. No

If you don't measure...

- How do you know?



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