Rocket Science, Wild Guess or Somewhere In-Between

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Reliability Centered (Based) Maintenance in any industry is an approach to plant operations and functions that enable the best profit return and result in bonus, trickle-down effects—improving safety, equipment life, employee comfort, reduced operating costs and greater efficiency—just to name a few. It is a new way of doing business and the returns are great. With a two to five year start-up plan for implementation, and the understanding and cooperation of management and accounting, the success profile will be obvious. Both large and small companies have recognized and acknowledged the value of return to investment.

Traditionally maintenance is done using one of the following approaches:

REACTIVE – Fix it when it breaks
PREVENTATIVE – Fix it even if it does not need it, but "just in case"
PROACTIVE – Fix and maintain in an orderly, planned and efficient manner with a measurable return to expenditure

A reasonable goal is to move from 80/20 reactive to 80/20 proactive. This article shows how to move toward proactive maintenance. First, think about this question: Why are we always fixing the same things? Even more critical to achievement: when we build, maintain or repair, what are the expectations for success? Is the outlook for more of the same in terms of mean time between failures (MTBF) –-or can the bar of performance and longevity be raised?

Infrared Thermography and Vibration Analysis are large players in Predictive Maintenance when done correctly, but are only a part of raising the standard. Ultrasonic, root cause analysis, and oil analysis are just a portion of the remainder.

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In business, I have encountered the following situations:

- Bearing failures that have led to catastrophic failure
- A reducer that jumped four inches from the floor on start-up
- A 125 HP leg motor mounted on ½ inch washers
- A new reducer (right-angle drive) 150 horse motor, mounted on a factory-designed bent beam
- A reducer that hangs on a head shaft and changes vertical position by at least ¼ inch every revolution; factory estimate of weight is at least 4000 pounds
- A fifty-foot concrete tank roof that deflects nearly ½ inch as a 3000-4000 bph conveyor runs empty and is the only machinery on the roof
- Electrical connections and switchgear that has not failed for some miraculous reason
- Wonderful improvements in many facilities as we all work to improve
- Twenty-three year-old bearings on grinders that have run as smooth as silk all those years
- Electric motors built in 1924 running today as they did in the first year of production
- Roller mill with over-hung motor mounting issues (altered mountings by customer)
- Grinders that have cracked concrete tanks and support structure
- Steel framework and towers that move and flex as equipment runs
- Units loosening on the anchors/mountings over time: have they always run that way?
- Utility high voltage feeds too small for the plant load – yes, they failed
- Utility connections and disconnects with issues identified and blown off by the utility – yes they did "blow off"

There are many laws of physics and thermodynamics that could be discussed and explored, but due to time constraints, we will look at the basics of heat flow analysis.

- Heat flow is critical, not necessarily heat measurement. Normal is normal if not destructive.
- Ambient environmental operating heat is far different than bearing-generated heat flow.
- While some bearings are designed to "weep" excess grease, manufacturers now recommend wiping all bearings free of excess grease to stop contaminant infiltration as the unit expands and contracts. Engineering handbooks caution against over-lubrication because overheating and premature failure may result. Excess grease can cause balls and rollers to slide rather than roll. Dirt and water puddles collect.

- Billions of dollars are wasted annually in unnecessary repairs from improperly installed and maintained equipment across the industry. Much is a result of a lack ofknowledge and understanding rather than a lack of caring. How do we change this culture?
- I have inspected elevators that were built in the 1920's, still in excellent operating condition even with motors built in 1924. Lack of measured heat was incredible. Absence of vibration and bearing conditions shows true machinist skill. There is an increasing shortage of skilled personnel, and even more critical, a shrinking pool of those who are aware of the payback these skills can return. Accounting says that a $10/hour employee is more cost effective than a skilled $20/hour, long-term employee. How wrong they are! I once worked with a customer who had to cut maintenance costs and eliminated a weekend shift while meal processing continued. The busy operator did not catch an oil line break in a twin barrel extruder and all the oil in the gear case was lost. The new gearbox cost $250,000.
- Laws of thermodynamics have proven the hotter something is, the more efficiently it cools. That is the reason fans are installed on breakers and starters and they continue to function, but this could lead to real trouble later. Some reducers come with cooling fans on the input shaft and while it seems like a good idea, it is actually masking a potential problem. Thermal cooling effects can be calculated, as can effects of loading on electrical components. Do we ever really study the manual and give personnel the time to do so?

Some findings:

- Reducing operating temperatures in control panels prolongs component life.
- Most electrical connections are waiting to fail—especially the modern ones. The typical connection in a breaker has three metals: copper, (hopefully not aluminum) alloy and steel—all expanding and contracting at different rates. The fudge factors have changed: mass and surface contacts are greatly reduced.
- Many utilities do not care if your transformer has poor connections.
- Moisture and dirt are a challenge.
- Looping of incoming conductors into any panel main should be required when across the line starting is used. This is the reason so many dryer main and large machines fail. This problem happens five-ten years after installation.
- A motor's windings expand and contract when started—especially when started under any load.
- Manuals and instructions are rarely read.

The Practical Guide to What We Need to Know (What makes this thing shake?)

<u>Unbalance – usually the most common cause</u>

- Vibration is caused by a heavy spot, from various sources and conditions – but this is rarely the primary reason for vibration
- Misalignment – couplings/bearings and bent shafts – What does ½ of one degree mean 48 inches out? (This is why motor bearings fail, but which is first?)
- Bad bearings – You cannot balance a unit with a worn bearing—it just doesn't work.
- Greases are not always compatible?
- Eccentric journals – think of it as off-center
- Bad gears or shafts – bent, chipped teeth, normal wear, etc.
- Mechanical looseness – for every action, there is an equal and opposite reaction
- Bad drive belts – not usually a factor in our applications. When you replace one gear or chain drive, always replace both.

<u>Electrical – let's define</u>

- Rotor not round
- Eccentric armature journals
- Rotor and stator misaligned – unequal air gap
- Elliptical stator bore – egg-shaped barrel – hit it with a hammer and move the darn thing
- Open or shorted windings (one of the reasons we do infrared)

<u>Other causes</u>

- Aerodynamic or hydraulic forces – blade pass – water or air
- Why fan housings vibrate opposite the rotating blades
- Reciprocating forces – pistons/engines
- Back and forth, stop and go the other way
- Resonance – the one that seems really hard to find. Everything runs smoothly until I start the second dryer! A machine's "natural" beat—this could bring down the Golden Gate Bridge!

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- These are all sources of vibration and must be understood for true vibration analysis. Experience and observation have led to some recommendations I would like to leave with you.
- Pepper Maintenance Guidelines for Bearings, Motors, Reducers and Electrical Systems

Bearings

- If kept clean, most need lubrication only twice a year
- On a monthly basis, wipe clean and keep trash/dirt from backside
- Use rag, towel, or flat wooden stick-no screwdrivers (causes seal damage)
- Carry grease gun two times a year
- After cleaning, run equipment—if grease appears moist on seal, no grease needed
- Grease when equipment is off to prevent over-greasing
- Never drive a bearing on the shaft…use a warming plate if necessary
- Shrink shaft with cold CO2 (upside down canned air works)
- Check bearing alignment—2% max (still too much); seals take <.5%
- Identify the kind of grease packed in the original bearing and make sure it is compatible with what you are using
- Read the manual

  STUDY AND KNOW THE GREASE COMPATIBILITY LISTINGS…
  WHAT MIXES WITH WHAT?

MOTORS

- Remove grease plug and inject grease slowly after using wire to push through to race to ensure new grease will exit overflow
- "Randy's Rule of Thumb"—1 pump to 10 hp and quit if you must (I prefer 1 pump to 20 hp) –With plug in or out, motor should never be too full of grease when done once a year; grease does evaporate
- Alignment is critical—for both couplings and sheaves—USE LASERS
- Set tensions with gauge
- Understand soft-foot and tightening pattern
- Read the manual

REDUCERS

- Follow company policy on type of fluid
- Do not overfill
- Use tension gauge to set belt tensions ($20 from your belt supplier—or ask for a free one); many bearings and seals have been ruined from belt tensions too tight.
- Always use alignment tools—dials or laser (cheap in the long run); insist on it from the millwrights.
- Consider synthetics—they may reduce heat
- Read the manual

ELECTRICAL

- Cycle disconnects and breakers six times, twice a year when de-energized (cleans contacts internally)
- Keep power rooms clean and dust-free as much as possible (air-conditioning pays in the long run)
- Never slam a panel door or bucket door
- Use heaters in panels for removing moisture—plc's included
- Conduits are not usually water-tight—notch elbow cover gaskets to allow moisture to escape
- Place drip caps over doors
- Make small weep holes in panels that hold moisture in bottom
- Seal moisture sources where possible
- Please—no renewable link fuses
- Use same fuse sizes in all three phases (same thermal sizes are best)
- Always clean terminals and conductors—tightening fixes less than 30%; over-torque makes things worse (distorts flat surfaces)
- Pressurize for dust control if not air-conditioned, filtered air
- Follow all safety rules
- Insist utility companies respond to what is needed on their part
- Read the manual

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Send the crew around every month or on your schedule…but keep the grease gun at home. Have them clean and inspect…make notes, etc. Follow the manufacturer's specifications and engineering data. A 25-year life should give you 25 years, or find out why.

We haven't even touched on root cause analysis. Do we ever meet to discuss what went wrong or why? The process does not have to be rocket science. How do we arrive at the best solution to the problem?

Keep in mind that these are suggestions. There are always exceptions, but ask questions… let's raise the standard of installation and operation.

This report couldn't possibly cover everything there is to know, but hopefully, there has been some interest sparked as to where we can head as an industry and lead each of our facilities into the future as a leader in maintenance and operations practices worldwide.