The Nuts and Bolts of Monitor or...How Do I Look at a Rotating Machine?

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In the ever-expanding field of predictive maintenance, there are technologies and equipment used for non-destructive testing. Within that field, there is a certification available which recognizes the visual skills needed for observing, analyzing and responding to the conditions found within any machine or system and its components. It is these skills that we use in the inspections we conduct. At Pepper Maintenance, we use infrared technologies and/or vibration analysis for predictive maintenance purposes. Quite often, you will see the word "monitor" or "monitor closely" in the recommendations given in the report following an inspection. Just what does this mean? The purpose of this report is to explain the role of the facility operations personnel when these phrases appear on a follow-up report.

During an inspection by Pepper Maintenance personnel, if things appear to be running normally, few notations are made. If the operation of the unit deviates from what we consider normal but is still in a satisfactory range, we may have a slight concern and will make a note to "monitor" the operation. If the operation moves further away from the norm, our concerns heighten and we will make the notation to "monitor closely." Equipment is imaged and/or data collected with reports to follow that include the findings. "Monitor" or "monitor closely" means we are concerned that conditions may be moving toward a stressed or failing mode, but in reality we cannot be sure. It is a waste of investment dollars to repair or replace a problem that may not actually exist. We do not conduct surveys of plants often enough to watch conditions on the basis of intercepting all equipment at the exact point of replacement and/or action. The cost for inspections of this frequency would be prohibitive and do not yield a high rate of return on investment. It is our

opinion that this is where the skills of plant personnel must come into play as time unfolds. During a Pepper Maintenance inspection, all equipment is monitored in the visual and audible mode, notations are made of changes in operation, and communications are made with those in charge. The skill to "monitor" or "monitor closely" should be employed in all routine walk-through inspections done by plant personnel on a regular basis. We use these phrases to mark items that need to be carefully watched, and to be aware that conditions may be changing. As long as conditions remain the same, no actions beyond routine maintenance practices are required. It is the combination of these visual and audible skills combined with the routine 90, 120, 180 or 360-day inspections by Pepper Maintenance personnel that bring about the most return on investment dollars.
What are we looking for when approaching a machine used in plant operations? And, is the machine running? While some conditions are more obvious when the machine is operating, there are other conditions that may be better detected when it is not in motion. For instance, leaking seals, oil pooling under bearings or oil from grease seeping at the bottom of bearings on motors, reducers or other bearings may be more striking if the machine is not running. If oil or grease runs down the pillow block, it may indicate incompatible grease. If oil seeps around seals and bearing covers on reducers, it may indicate a bad seal or misalignment, or it may just need a proper breather plug mounted on the reducer.

Every item needs to be inspected periodically for looseness, which may be identified by broken or loosened bolts, welds, struts or any other structural member that shows stress or breakage. Cracks in cement foundations, especially around anchor bolts, are common and should be noted. Foundational vertical members that are not securely fixed to the concrete and above the plane of the foundation are not properly mounted. Proper shimming must be done to carry the vertical load, with shims covering enough area of that load and transferring that load to the foundation. All bolts used have torque ratings, and torque wrenches should be used. This may appear to sound demanding, but it is a fact that torque wrenches serve an important function. All of the above can be accomplished with the machine sitting absolutely still whether it is 0 or 100 degrees F. Run out (how close to perfection the head shaft was made) can be determined on all machine locations. How accurately was the drive mounted (torque wrench used in sequential order)? Dial indicators, a great tool used by old-time machinists, are used for this. Movement from rotation in the radial and axial positions can be determined and measured within one thousandth of an inch or less.

What is the next step? It is critical to occasionally watch each machine on start-up from a cold start. How much movement, how much noise, how long until it reaches a normal running mode, and what vibrations are present all need to be observed and conditions noted. Start-up motion is often a precursor of problems ahead - especially on beveled gear components where axial forces are created in amounts that may cause premature wear patterns on gear teeth. NOTE: If there is a unit with audible backlash under no load, it is important to watch these units under start-up conditions VERY CAREFULLY and note any excessive vibration. Many machines on start-up will go through a vibration that seems excessive but levels out to what seems to be normal as it reaches operating speed. If this is occurring, please convey to Pepper Maintenance personnel for close inspection. We may need to take start-up vibration readings as well. The frequencies (rpm's) at which these vibrations occur are known as critical frequencies and are found in most rotating machinery to some degree. They are normal and as long as the machine does not run at those speeds, there is little danger and no damage being done. If a variable frequency drive is in the system there may be potential for problems if run at that frequency (speed/cycle per minute/rpm). If the vibration continues at running speed, Pepper Maintenance needs to come and investigate the cause.

Now that we are up and running, what are the next steps that need to be taken if you are told to "monitor" or "monitor closely"? You will need to observe the unit as it rotates. Are the bearings running true—in the center of the race? Yes, sometimes the wear is quite obvious and yet there is no noise and no abnormal heating. Do the seals rotate with the shaft and at the same speed? Some seals are designed to rotate with the shaft. Is grease being expelled? If so, the bearing is being over-lubricated. Is there water or moisture? This brings up a point on bearing lubrication. There are bearings that have a seal designed to allow the excess to be purged to the atmosphere. We feel there are potential problems that could result from such bearings and precautions must be taken. New bearings are to be pre-lubricated by the OEM to specs for maximum performance. Lubrication before start-up use should not be necessary. There is the occasional exception, so be observant. If using bearings with this type of seal, you must wipe bearing of excess grease and prevent buildup of purged grease. If grease can purge out as the bearing warms and cools, what is to prevent water and contaminants from re-entering the housing as the unit expands and contracts? If it moves one direction, can you be assured that it does not move in the other direction as well? In some instances, it appears to do so. Wipe the bearings off and clean up the excess grease.

This brings up an important point. If a bearing fails in spite of having adequate amounts of grease and there are no additional combustibles surrounding it, it is likely to be labeled as a "squeaker" or "rough running." It may or may not be "hot." It is possible that such a bearing could suddenly fail for no apparent reason or over-heat in a manner undetected by sensors. If there is no "fuel for the fire." the fire does not occur. We add a significant safety factor by removing all excess lubricant.
Note the amount of run out as the head shaft rotates. Does the reducer, motor, or entire unit "wobble"? If you have a shaft-mounted drive unit, is it free to move and not be restrained in the lateral direction? Such a movement can be a result of an imperfect shaft—either bent or loose. Or, it could mean improper torque sequence tightening of the reducer collar(s). Perfect head shafts are available and much preferred for maximum equipment life. If turned, ground and polished shafts were required in all conveyors, it is my opinion that the cost of these would go down. The market would demand them and they would be readily available. When the motor is mounted solidly to the body of the conveyor or bucket elevator, precision alignment of sheave-to-sheave is difficult, to say the least. The reducer will move with the head shaft and the motor remains fixed. This is the common design of most head sections on conveying equipment we purchase and install in the grain industry.

Observe the torque arm if it is part of the system. Is it loose on rotation—whether empty or full—and does it stay aligned in the same plane? It should be centered in the radial running plane of the reducer. It is not necessary to be centered in the middle of the reducer housing as it is in alignment. Personally, I prefer that the arm be mounted in the center line of the unit for less side loading potential. This can be measured by vibration in the axial direction. If the arm is used to tension the belts, it is my opinion that the preferred location is parallel to the belts at 180 degrees. Many system designs make it difficult to achieve that configuration, but it is beneficial to the life of the unit. The motor mount is conveniently attached to the head of the fixed unit. If the torque arm loosens on occasion, the belts start to become the torque arm and have been known to wear the bearings, belts and even to snap input shafts on some units. Be sure the torque arm is not binding at or in the clevis mounting points. Solid bolting at one end of the arm is not acceptable, in my opinion, for maximum equipment life. Does the torque arm allow freedom of movement of the unit? The longer the torque arm, the more forgiving it is. It should be mounted as far from the final drive as possible for maximum lever and fulcrum function.

Are vibrations present and if so, what might be the source? Is the tower moving and in what rhythm? Is there a smell of belts or the sound of steel on steel with no lubrication? Feel along the bearing bases, motor bases and reducers when mounted to foundations for movement—especially in the vertical—being careful not to place your fingers in dangerous situations. The tip of the finger is very sensitive to this movement. Rotating equipment that is experiencing an elevation of vibration levels should be approached cautiously, particularly if vibrating violently. Failures can occur and dangerous situations may arise. If that condition of increased vibration is found, contact the proper people. Feet and attachment points to steel or concrete foundations can be felt the same way for vibration, in all directions. Proper shimming is required when filling in under a support member that is found to be above the plane of the foundation top. Be sure to use proper shim material—stainless steel is usually preferred. Instead of pulling the unit to the base, shim the base to the unit and torque properly. ALL anchors must be in the restraint system with no exceptions. Looseness will destroy machines over time.

Look for cracks in steel structure, welds, concrete and any other components. Fresh cracks, old cracks and paint stress all point to potential problems. Note whether horizontal or vertical in nature. Keep all equipment as clean as possible. Rust and moisture destroy the integrity of many of the foundations that support our assets. Examine the strength of the base support system. The fans in use, whether for aeration, ventilation or dust collection, were not designed to be on the support structure less than 100 % of unit to base contact. At least be sure to contact OEM and check for minimum support design. Most group material is not designed for compression and should not be used as such. There may be an exception here, but an engineer should be consulted when using grout for this purpose. Grout is not intended to be shimming material in most cases.

Gears and sprockets can be checked for wear patterns; metal flow on the sides of teeth and chain indicate misalignment. Hook formation from wear on teeth usually indicates chain looseness. They can actually end up grabbing the chain and pulling underneath, creating havoc in the system. Alignment of chain and sprockets is important. Manufacturers assemble units and they are sent out ready for installation. However, all require field precision alignment with no exceptions. Be sure the installer follows through with this important step. During inspections, I have seen many installations with no check of alignment—both inside the head section and outside, including all drive components. The same applies to the tail section.

When dealing with fans and aeration equipment, one must always examine the blades and housings for dirt, cracks, breaks and loose rust. Carefully remove material that has collected and use a strong light for examination. Cracks will allow a blade wheel to move back and forth across different planes. This movement will cause vibration at the balance frequencies. Balancing cannot be done until the wheel is repaired or replaced. Base looseness combined with dirt has often been the destroyer of fan units when conditions are not corrected. Be sure all structures—whether conveyor, elevator or fan—are solid to the base on which they are mounted. Washing of fans with high-pressure air or water is not recommended. Whenever any repairs are made to units that move air, fan blade examination is critical and must be done each time the work is serviced.

I trust this will get you started on the road to visual non-destructive testing and monitoring of all equipment. It is my hope that we can work together within all aspects of plant maintenance and operations to create the best and most efficient working conditions and environment possible—enabling both person and machine to reach their fullest potential. With safety as our number one goal, followed by efficiency, profitability and total cost of ownership, we will all achieve our ultimate goal of success.