DEVELOPING YOUR PREVENTIVE MAINTENANCE PROGRAM

By Owe Forsberg, Senior Consultant

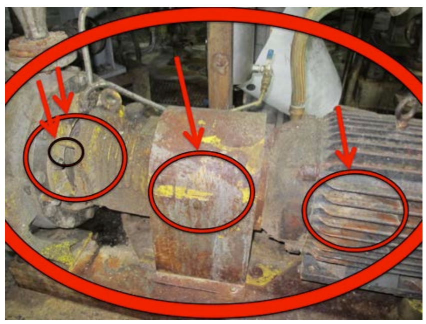
You are the new Reliability Engineer in a plant that currently lacks documented procedures to maintain the plant. You have been asked to develop preventive maintenance procedures (PM's) for the plant and a target of 6 months to complete the project. The plant has around 5,000 pieces of equipment. A corporate initiative to increase output and reliability of product deliveries is the reason for developing and documenting the PM procedures. The plant runs from 5/24 to 7/24 depending on the market demand.

Beside the issue with how to manage this as a project and using a CMMS to manage and maintain the procedures and history this article will focus on how to select your PM procedures in a practical way. Note that most PM procedures should focus on equipment at the component level like bearings, packing, impeller etc.

The following steps are required to develop your PM procedures:

1. Divide equipment into components.
2. How does the component work?
3. How does it fail?
4. What essential care does it need?
5. Is the life of the component predictable or unpredictable?
6. Does it have a Failure Developing Period (FDP)?
7. Select the most cost effective maintenance method.
8. Do maintenance on the run (OTR) or during shutdown (SD) of the equipment?
9. Select objective or subjective (senses) method to check the condition?
10. Develop your PM task.
11. Select the frequency based on FDP
12. Decide who is going to do the task on a regular basis.
13. Transfer all the PM's into your CMMS.

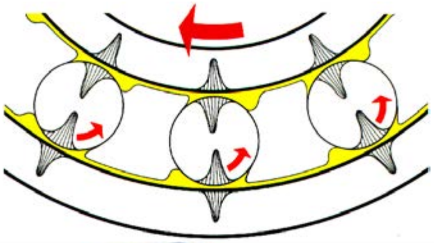
STEP 1: DIVIDE EQUIPMENT INTO COMPONENTS



To divide equipment into components we take a pump as an example. The pump is divided into motor, coupling, pump and mechanical seal. Always go out in the plant and look at the equipment and write down everything that you think pertain to the equipment maintenance procedures.

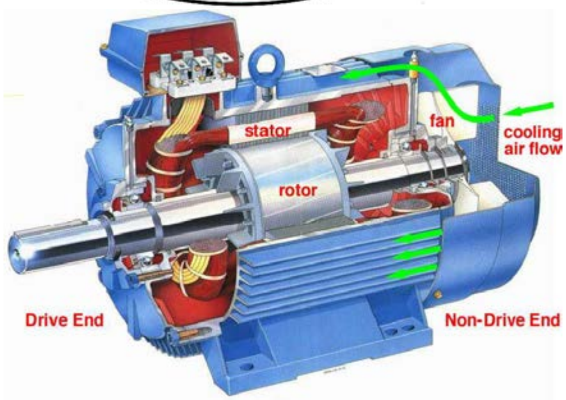
Step 2: How does the component work?

For example, let's say the component is the motor the most important sub-components are stator and bearings. These sub-components are the most common to fail according to the statistics.



Bearings:

The bearings work by eliminating friction between roller and the inner and outer rings.



Stator:

The stator or the windings develop the rotating magnetic field that put torque on the rotor that turns the shaft. The stator windings are insulated to prevent short circuit to ground and between the phases. The number of turns in the stator impact the magnetic field the amp draw and the efficiency.

Step 3: How does it fail?

Bearings can fail due to:

- Lack of lubrication causing friction and overheating
- Dirt in the lubricants causing damage
- Misalignment and vibration will cause damage
- Unbalance of the rotor or the magnetic field not centered
- Overheating
- Water and chemicals can corrode the bearings and remove the lubricant
- Bearing seals can be damaged

Stator can fail due to:

- Over heating that cause the varnish to break down
- Lack of cooling
- Over-greasing going into the stator
- Too many starts within a short period of time
- Process overloading the motor

Step 4: What essential care does it need?

Bearings:

- Re-greasing but in this case they are fully sealed bearings.
- Motor and pump shaft need to be properly aligned according to precision standards
  - Below 2000 RPM: <2/1000 of an inch
  - Above 2000 RPM: <1/1000 of an inch
- Check that foundation bolts and motor mounting bolts are tight and according to the right torque specs.
- Prevent water or chemicals to get on bearing

Stator:

- Keep the fins and fan intake/fan cover clean.
- Eliminate any dirt, water or chemicals to get on the motor and wiring.
- Avoid stopping and starting frequently that can overheat the windings.
- Make sure that the motor is not covered with material/dirt restricting airflow.

STEP 5: IS THE LIFE OF THE COMPONENT PREDICTABLE OR UNPREDICTABLE?

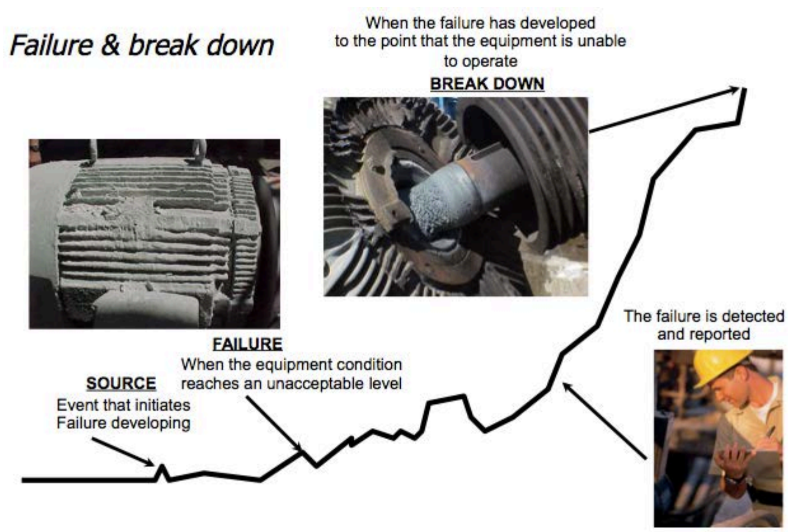
Bearings:

The life of a bearing is a complex question due to the many parameters that affect the bearing condition. Factors that determine life of a roller bearing: temperature, vibration, alignment, dirt and water in lubricant, mounting procedure, storage of the bearings and motor etc. It has shown in laboratory setting that most roller bearings have a random life of 1-25 years. Therefor the bearings are considered un-predictable regarding its life. This indicates that the bearing life factors are impacted based on how well we can do Essential Care.

Stator:

The same approach applies to the windings; we don't have any solid data on this motor on how long the life is of a stator winding. We have to assume that stator life is random.

STEP 6: DOES IT HAVE A FAILURE DEVELOPING PERIOD (FDP)?



The purpose of knowing the failure developing period (FDP) is to determine if there is way to do condition monitoring or predictive maintenance on the component. The idea of the failure developing period is that the failure of the component can be detected, planned and scheduled and replaced before it shuts down or impact the production process. See example in the picture (right) the motor get covered in a raw material from the process, the motor temperature increase and causes the lubricant to liquefy and drain out of the bearing, the bearing failure start developing (failure), and last the bearing seize to work and stop the process (breakdown). The time period from where it is possible to detect the failure until breakdown is defined as the Failure Developing Period (FDP).

In case of the bearing it can be detected at different times before the breakdown based on the condition monitoring method used. The earliest bearing failure can be detected with vibration and SPM measurements. Measure temperature or listen to the bearings will not detect the failure as early as the other methods. Listening to the bearings may only give a lead-time of a few days or hours before you have a breakdown.

Conclusion: Bearings have a FDP.

Stator: Our experience tells us that stator degradation can be detected with methods like temperature measurements, motor analysis, and Megger testing. The Megger testing should only be used if the motor analyzer is not available as a tool.

Conclusion: Stator has a FDP

STEP 7: SELECT MOST COST EFFECTIVE MAINTENANCE METHOD

The basic methods are:

- CBM = condition based maintenance (usually the most cost effective, component is only changed or reconditioned when it fails)
- FTM = fixed time maintenance (normally we don't know the life of components and therefore does not know when to do schedule a replacement)
- OTB = operate to breakdown (not cost effective to do CBM or FTM so run to breakdown, cost and impact of OTB less than FTM and CBM)
- MP = maintenance prevention (always cost effective to preserve and extend life)

Bearings: select CBM and MP

Stator: select CBM and MP

STEP 8: DO MAINTENANCE OTR OR DURING SD

In the case of this motor the bearings and the stator can be checked OTR if the proper tools are used.

STEP 9: SELECT OBJECTIVE OR SUBJECTIVE METHODS TO CHECK THE CONDITION?

An objective tool would be to use vibration analysis, SPM, and IR-gun.

A subjective condition monitoring inspection would be to see, listen, touch and smell. It is recommended to do a subjective check of the motor.

Bearings: Use objective methods to check vibration, SPM and temperature.

Stator: Use objective tool like motor analyzer and temperature readings, and amp readings.

STEP 10: DEVELOP YOUR PM TASK

OTR refer to the IDCON Condition Monitoring Standards

CMS-100R: AC Motor see example to the right

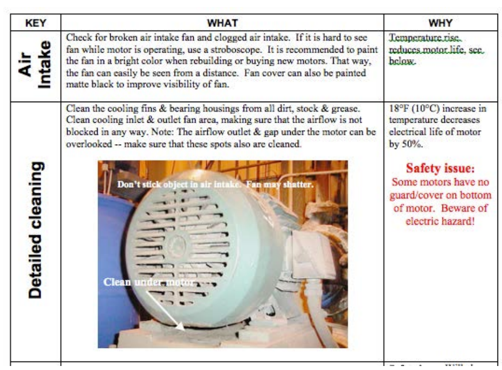
PM Task on route based on the key words in the CMS:

<u>Task #1:</u>

Check: Air intake, detailed cleaning, water and humidity, temperature below 160F, noise and vibration, motor base, and electrical. (Temperature based on current operating condition and ambient 75F motor insulation class H)

<u>Task #2:</u>

Tools for the route: SPM Bearing Checker and vibration pen.



KEY	WHAT	WHY
Air Intake	Check for broken air intake fan and clogged air intake. If it is hard to see fan while motor is operating, use a stroboscope. It is recommended to paint the fan in a bright color when rebuilding or buying new motors. That way, the fan can easily be seen from a distance. Fan cover can also be painted matte black to improve visibility of fan.	Temperature rise reduces motor life, see below.
Detailed cleaning	Clean the cooling fins & bearing housings from all dirt, stock & grease. Clean cooling inlet & outlet fan area, making sure that the airflow is not blocked in any way. Note: The airflow outlet & gap under the motor can be overlooked -- make sure that these spots also are cleaned.	18°F (10°C) increase in temperature decreases electrical life of motor by 50%. Safety issue: Some motors have no guard/cover on bottom of motor. Beware of electric hazard!

Inboard bearing:
Horizontally (one reading should give some idea of the condition) using the Bearing Checker (SPM) and the vibration pen.

Vibration > 0.11 inch/sec report to vibration analyst.

SPM = red, generate work request to replace bearing.

(Reader note: ISO standard 10816 say that overall readings of more than 0.11 inch/sec for Class II medium machines are unsatisfactory).

Outboard bearing:
Horizontally (one reading should give some idea of the condition) using the Bearing Checker (SPM) and the vibration pen

Vibration > 0.11 inch/sec report to vibration analyst.

SPM = red, generate work request to replace bearing.

Task #3:

Using a vibration analyzer collect and analyze the spectrum for both bearings.
Measuring points:
Inboard bearing, horizontally, vertically and axial
Outboard bearing, horizontally, vertically and axial

Task #4:

Use the OTR Motor analyzer and record data.

Step 11: Select the frequency based on the FDP

The frequency for each inspection should be determined based on the FDP. Since we in this case and in most plants don't have a lot of data we have to use our experience. Inspection interval is = FDP/2.

Task #1:

FDP is estimated to be 2 months. Inspection frequency is determined to be 1 month.

Task #2:

FDP is estimated to be 4 months. Inspection frequency is determined to be 2 months.

Task #3:

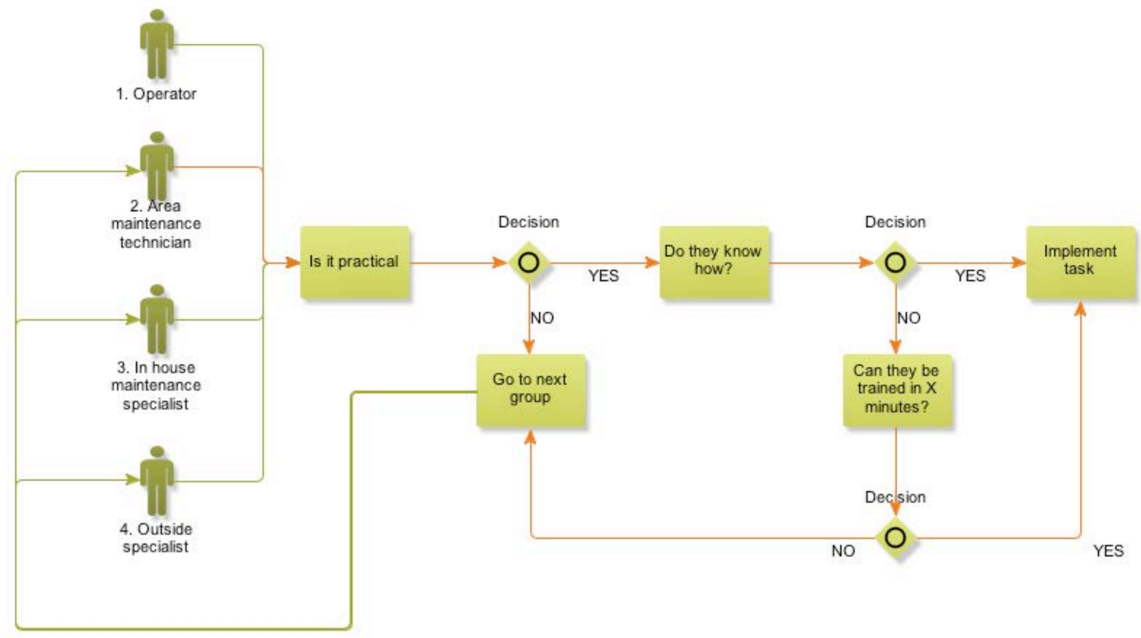
FDP is estimated to be 4-6 months. Vibration data collection and analysis frequency is determined to be 2 months.

Task #4:

FDP is estimated to be 12 months. Motor Analyzer will be used every 6 months.

Step 12: Who is going to do the task?

Follow the flowchart below



Summary of PM's developed for a centrifugal pump motor:

<u>Task #1:</u>

Monthly Check by the Operator

Check: Air intake, detailed cleaning, water and humidity, temperature below 160F, noise and vibration, motor base, and electrical.

<u>Task #2:</u>

2 Months check by a Mechanic.

The tools needed for the route, SPM Bearing Checker and vibration pen.

Inboard bearing:

Horizontally (one reading should give some idea of the condition) using the Bearing Checker (SPM) and the vibration pen.

Overall vibration > 0.11 inch/sec report to vibration analyst.

SPM = red, generate work request to replace bearing.

Outboard bearing:

Horizontal (one reading should give some idea of the condition) using the Bearing Checker (SPM) and the vibration pen.

Overall Vibration > 0.11 inch/sec report to vibration analyst.

SPM = red, generate work request to replace bearing.

Task #3:

2 Months collect and analyze vibration spectrum by Vibration Analyst (could be outside specialist if not available in house).

Using a vibration analyzer collect and analyze the spectrum for both bearings.

Measuring points:
Inboard bearing, horizontal, vertical and axial

Outboard bearing, horizontal, vertical and axial

Task #4:

6 months PM by an Electrician

Use the OTR Motor analyzer and record data.

LEARNING POINTS:

Many of the PM procedures can be copied to similar equipment. Determining frequency and procedures become more obvious as you gain experience of the equipment and the concepts used above. IDCON's Condition Monitoring Standards (CMS) will be helpful to develop the PM procedures and use as training materials for Operators and Crafts people.

This may seem overwhelming at first but as you get started and understand the concept will be simplified to:

1. Divide equipment into components.
2. What essential care does it need?
3. Is it a route with several inspections or a shutdown PM (OTR or SD)
4. Develop condition monitoring task, use IDCON's Condition Monitoring Standards, for reference
5. Select frequency.
6. Who is going to do it?
7. Let's get the routes started and scheduled in the CMMS