Motor Master Series: Mastering Motor Autopsies

TITLE:

Mastering the Motor Autopsy

Motor failure and repair data hold the secret to future reliability and performance.

By Robert Koehler, Derek Norfield, John Thompson, Mike Wilcox, and Forrest Pardue

INTRO:

It is well known that motors are the most important class of assets in a plant, yet all too often they get ignored until they fail. In order to make motors live longer, we must understand why they fail, or degrade prematurely, during service. An “autopsy” by the motor repair vendor or an in-house shop is a great way to capture this information.

This best practice enables determination of the root cause of failure, cost of failure, and mean time between failure (MTBF) – three fundamental industrial reliability metrics. Moreover, it allows impending failures to be predicted and avoided, and lessons learned to be applied to future design, manufacturing, operations, and maintenance decisions.

Unfortunately, motor repair tracking is not always a reliability priority. Root cause failure analyses (RCFAs) are selectively conducted, if at all, and the results are rarely documented in a plant database. The autopsy practice needs to be brought back into the mainstream. Automation and smart systems are no substitute for comprehensive motor repair tracking combined with hands-on dissection and analysis upon failure.

In this article, five reliability leaders with extensive motor management expertise explain why motor autopsies matter, and how a web-based repair tracking system simplifies the process and promotes plant/shop teamwork.

What is a motor autopsy?

Motor autopsies provide a more-robust RCFA. They involve taking apart and inspecting the motor, assessing the application and process trends, reviewing the maintenance and repair history from installation to failure, looking for threads and trends versus similar motors and applications, and documenting the entire process.

It allows plants to view and report on what failures happened, the best estimates of why, and take the necessary remedial or preventive actions. For example, should you adjust your PM program to watch the motors more carefully? Pull the motor proactively rather than reactively? Work with the engineers or repair shop to prevent recurrence? Its purpose is not to lay blame but to take practical steps forward to prevent future failures.

For repairable motors, much of the autopsy process is already occurring during tear-down and inspection. However, the documentation step is missed when the sole focus is on prompt repairs, or on quickly finding a replacement if the motor is not repairable. Detecting and logging the root cause of failure must be a primary goal for both the plant and repair vendor in order to develop the knowledge base needed to improve reliability.

Ideally, a motor reliability program will require the plant shop or motor repair vendor to conduct a teardown autopsy and RCFA whenever a motor fails, capture the data using a standard autopsy form and centralized repair tracking software, and to have a plan for scrap equipment. When outside vendors are used, the autopsy service is specified in the repair purchase order. If a motor is not repairable, some vendors may perform the autopsy in exchange for the copper scrap value.

While full lifecycle tracking of motors is the gold standard, tracking and managing repair data alone will still yield a significant payback – particularly for motors that are critical, repairable, and warrantied.

Why is it needed?
Most plants can't name their top root causes of motor failure, nor their MTBF or cost of failure. Yet, they'll implement modern industrial sensors in hopes the machines will generate adequate analytics. The reality is that repair tracking and failure analysis are not processes that can be automated.

This is because root causes of failure can be found at any point throughout a motor's life cycle, including incorrect specification, design, manufacture, receipt/QA, storage, installation, commissioning, O&M, or repair/rebuild.

Motor repair tracking and autopsies zero in on the sources of failure and enable corrective actions that improve reliability, performance, and profitability. Following are some real-world examples:

- **Motor design and manufacture failure**: A brand new grinding system purchased by a cement manufacturer had a very early motor failure in the pilot implementation. During an autopsy at the motor shop, about a half dozen factors were detected in the design and manufacture of the motor causing it to not perform as intended.

  Solution: The findings were presented to the motor manufacturer, who not only upgraded that particular motor for the customer at no charge, but also manufactured subsequent motors a little differently, resulting in much more reliable motors and applications.

- **Motor design failure**: Four locations with 200 hp vertical motors were consistently failing in less than a year. Similar motors in other locations had a normal life span. An autopsy showed that leaking pump seals resulted in grease being washed out of the DE bearings.

  Solution: A design change including use of a different grease, alternate bearing construction, and adding a seal quadrupled the motor life.

- **Motor selection failure**: A small, low-cost motor used in various equipment throughout a plant was determined to have a common failure mode in autopsy. The associated downtime costs included huge EPA fines and lost production during unscheduled changeouts.

  Solution: Improved motor specification to better suit the application resulted in procurement changes and significant increases in the motor life. Application matching inspired more proactive maintenance cost management practices at the plant.

- **Motor component storage failure**: Investigation into premature bearing failures led a mill to focus on how its motor repair shops managed their bearings when issues there were uncovered.

  Solution: Now this plant's repair shops are certified by a major bearing manufacturer, meaning in part that the bearings are stored in climate- and dust-controlled areas; insulated from vibration via a rubber lining on the shelves; and stored by date so that the oldest stock can purged instead of used in motors. Also, grease in the motor shops is kept in separate containers and a requirement was added to use grease tubes instead of scooping from buckets. In addition, an ultrasonic greasing program was begun at the mill.

- **Motor installation failure**: A 1,000 hp DC motor weighing more than 10,000 lbs ran for only a month or two before the NDE bearing failed. Evidence from analysis of the NDE bearing indicated that the shaft received a heavy impact during installation when the fitters allowed the end of the shaft to bump a concrete column.

  Solution: An autopsy meeting was called to share the findings with the responsible parties and to review procedures.

- **Motor repair specification failure**: Root cause analysis of an unusual motor vibration identified weaknesses in a company's motor repair specifications and repair shop requirements.

  Solution: Air gap standards and checks are now required to be recorded on the motor report form. Core loss and rotor bar testing specs and procedures were added in the repair specs and are also required to be recorded on the repair report.

- **Motor repair procedure failure**: A motor type with rotor bar issues underwent failure analysis, and the problem was something the vendor could solve with a repair procedure change.

  Solution: The company and its vendor worked together to define and implement a solution. Consequently, knowing they were working toward the same goals, both sides became more confident in sharing problems.

Where to capture and manage the information
Collecting motor management information from plants and repair shops – starting from the first touch – is necessary to facilitate motor autopsies. For example, each of the above real-world failure scenarios were supported by web-based Tango Repair Tracker software. It fills voids left by traditional tracking options.

Asset management (EAM/CMMS) software is typically inadequate because it primarily tracks asset maintenance and costs – not the equipment identity, repair information, motor history, location history, or associate failures in similar equipment. Valuable history is lost when a motor's tracking number is lost at overhaul or when it is rebuilt and reinstalled.

Spreadsheets and other homegrown electronic files lack the essential structure and continuity, can be difficult to access, and could become lost or inaccessible due to hardware failures, software updates, or changes in the author's responsibilities.

Paper records are assessable only by those who know of their existence, and who are willing to make the trek to the file cabinet. They are also easily lost or damaged and tend to be borrowed and not returned, therefore limiting the success of motor failure analysis.

Motor repair shop records are also risky. It can be difficult for shops to locate reports a few years after repairs are completed, and the record storage locations may be offsite.

In contrast, successful motor autopsy and RCFA programs thrive when a plant and its repair shops share a cloud-based tool capable of simplifying and consolidating the tracking and failure analysis of hundreds or even thousands of motors – in a plant, across plants, or corporate wide.

Pertinent motor details such as nameplate data (manufacturer, type, frame size, horsepower, etc.), ID/tracking number, storage and service location history, and failure dates are typically controlled by plant personnel, whereas failure modes, repair history, teardown and inspection photographs, and corrective actions are usually entered by the repair shop. Making such information available securely, around the clock, from any location with a repair tracking system, is pivotal to effectively monitoring, resolving, and preventing failure conditions.

How to convert the information to action
Advanced repair tracking systems support motor autopsies by providing:
- Centralized data capture for the full life cycle of equipment and components
- A vendor interface designed to allow motor shops to handle the complete repair tracking, autopsy, and analysis process
- Improved repair vendor interactions, relationships, and reports
- Always-available failure trending data and repair statuses, including from mobile devices
- The structure and system for a broader equipment reliability program

Consolidating motor information in such a system can reveal crucial root-cause insights, such as a specific motor “carrying” its repetitive failure mode from service location to service location, or a location experiencing the same failure mode on several different motors. The data can be sorted and mined at will, illuminating which types of failures occur most frequently or cost the most, or which repair shops (and motor vendors) deliver the best mean time to repair (MTTR) and MTBF.

The readily available RCFA data can be used to improve a motor design, an application, a whole spectrum of applications, or maintenance best practices. In most cases, a simple application or maintenance practice change can solve seemingly unassociated failure problems.

Some users of Tango Repair Tracker delegate the complete motor tracking and autopsy process to authorized repair vendors who are given access to the web-based system. These vendors are doing the same amount of work to document the repair as they used to do with e-mailed reports, and now plant personnel receive repair information (including repair job status) at any time from a mobile device with an Internet connection. There is no need to run back to the office for information needed on the plant floor.

For the autopsy itself, best practices have the responsible technician complete a standardized form associated with the specific motor ID as the failed components are dismantled and examined. The checklist is designed to avoid missing fine details or rushing to judgment. Every aspect must be examined and documented, even those that appear unimportant or irrelevant, in order to get to the true root cause of failure and take the appropriate actions.

Conclusion

Improvement comes from knowing which specific motors failed and why, which requires collaboration between the plant and repair shops. If nothing else, tag and track your critical, repairable, and warrantied motors through every repair in a purpose-built repair tracker solution, and conduct autopsies on failure. It won’t be long until you can name your top root causes of motor failure and see improvements in your MTBF, MTTR, and cost of failure.

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