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Managing the Forgotten Asset

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The Forgotten Asset

Electric Motors and Their Management

by Krzysztof (Kris) Goly

Electric motors are an important part of every production facility's physical assets and should be managed accordingly to achieve high reliability levels at the lowest possible cost. Total cost is the sum of maintenance/repair, production downtime, safety and environmental costs. This is true for any physical asset management process. This article describes the current situation in industry and presents a solution – a Motor Management & Reliability Program.

Industry in Need of Change

Electric motors are a unique asset. They are the primary movers in a vast majority of applications and make plants "run." The impact of motor reliability and availability is felt throughout the entire business. They have the potential to severely affect production output, but often are the forgotten asset, unappreciated and left out in many planned maintenance programs.

Recently, the situation has become exaggerated due to various factors including disappearing motor knowledge from the plant maintenance workforce. During my frequent visits to production plants and motor repair facilities, I often hear complaints about the lack of a trained workforce. While recently observing a simple motor winding insulation test, I was surprised that the technician did not know about temperature normalizing while trending the results. He was even more surprised to learn how much temperature can affect the trending. And this was just the beginning – the plant's maintenance electrical technicians did not understand the difference between induction squirrel cage and wound rotor motors, and had no understanding of synchronous motors. The plant has a large number of motors ranging from fractional to 2,500HP. Most of them are critical to production. The question that came to mind was how the motors were maintained given the relative lack of knowledge by the maintenance department. The answer came through the MTBF (mean time between failures), which was approximately three years. What was more disturbing was that many critical motors were repaired more than once a year. The motor histories were not tracked, so there was no means of assessing the quality of repairs, performing root cause analysis or even checking who repaired the failed motors. This led to less than adequate motor performance and a negative impact on the bottom line. The situation was exaggerated by the fact that the majority of the workforce and management did not see a need for change. They were convinced that given their "unique" applications, if a motor lasted six to 12 months, everything was OK.

Motor Management & Reliability Program – What is it?

In an effort to address the problems just described, a comprehensive Motor Management & Reliability Program (MMRP) has been designed that addresses all aspects of managing motors as a critical physical plant asset. Some of the targeted areas include:

- Preventive and predictive maintenance programs
- Corrective maintenance actions, breakdown and recovery programs
- Motor procurement
- Reliability program
- Motor repairs
- Spares management
- Continuous improvement
- Root cause analysis
- Data management

A detailed description of all MMRP elements and case studies showing real-life results including economic benefits (ROI) are provided. The result is a sustainable process in place that drives motor reliability and plant performance.

Program Description

As mentioned, motors are part of the critical plant asset and should be treated accordingly. What is unique about motors is that they are part of an asset class called "rotable" or "reparable" items, meaning they often are moved out of their loca-

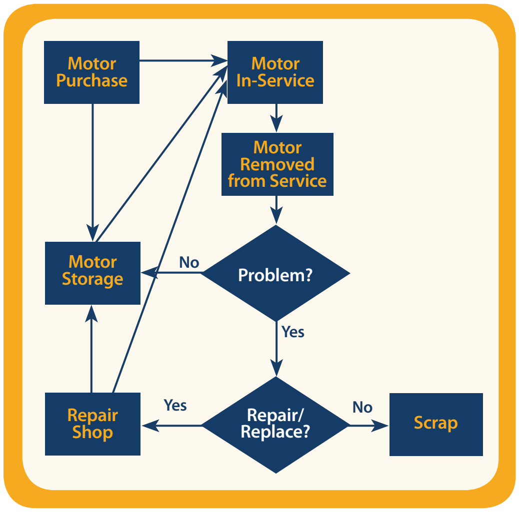

Figure 1 - Motor Management Process

tions and sent to repair shops, warehouses etc. Figure 1 depicts a simplified motor management process.

As shown in Figure 1, the motor life cycle can be complex, and there are many stages that need to be addressed by a Motor Management & Reliability Program. Before going into the detail of the program, it's necessary to define its goals. A well-defined and implemented Motor Management & Reliability Program should:

- Increase motor reliability
- Reduce motor inventory
- Improve equipment uptime
- Optimize return on maintenance cost
- Address motor safety aspects

Having defined the goals of the Motor Management & Reliability Program, the program criteria can be determined.

Figure 2 shows the required elements of a successful Motor Management & Reliability Program.

On-Site (Plant) Services

This is the basic, fundamental function of any maintenance organization and can either be performed in-house or contracted out. What is important, however, is that the work is performed to the right standards. This includes Condition Monitoring – traditional services such as vibration monitoring of bearings, oil analysis for sleeve bearing, infrared thermography and electrical tests – insulation resistance to ground measurement (RTG), motor circuit analysis, power quality, etc. The important aspect of a well-designed condition monitoring program is the use of the right technologies for the application. Selection of PdM techniques and frequency of data collection is beyond the scope of this paper, but suffice it to say that RCM principles should apply when developing a good PdM/CM Program. Similarly, a good Preventive Maintenance Program should be developed and, more importantly, executed. As with PdM, the RCM principle should be utilized when developing a PM program.

Support Services

Motors, like any equipment that ages and wears, require repairs and overhauls. It is important that the plant Motor Management & Reliability Program addresses these issues:

Motor Management Program				
On-Site Motor Service	**Support Services**	**Inventory Management Services**	**Consulting & Engineering**	**Information Management**
Condition Monitoring	Overhaul, Repair & Rewind	Inventory Optimization & Reduction	Motor Management Review	System Design & Interface
24-Hour Emergency Response	Motor Upgrade	Inventory Reliability Verification	Motor Condition Assessment	Motor Information Management
Preventive & Corrective Maintenance	Replacement Motor Supply	Storage & Maintenance	Application Engineering	
		Shared Inventory	Reliability Improvement	
Program Management				

Figure 2 - Motor Management & Reliability Program Elements

- Selection of repair facilities (motor shops) – The price should be only one of the parameters. The shop should follow the repair specification and provide quality, timely repairs; warranties; and information about repairs and causes of failure.

- Development of motor repair specifications and their implementation so that all repairs are performed to the same standards to ensure consistency

- Repair/replacement policy

- Selection of new motor suppliers

From the motor reliability standpoint, it does not matter if the repairs are completed in-house or by outside shops. What is important is that the above criteria are followed and implemented.

Inventory Management

Inventory ties up capital and affects business performance. Too many spares equals too many wasted resources. Not enough spares means uptime and production output are negatively affected. So, from the business point of view, it is extremely important to:

- Optimize inventory. Make sure factors such as motor criticality, cost, lead time, repair possibilities, environment and safety are taken into account. Equipment distributors may prove invaluable in keeping the right motors in stock, freeing up capital. If this is a corporation, consider a shared inventory.

- Make sure motors are stored in the right conditions. Factors to consider – temperature, humidity, floor vibration, access and maintenance. As with in-service motors, spares need to be regularly maintained. The maintenance tasks may include RTG mea surement, visual inspection, shaft rotation and space heater operation.

- Perform inventory reliability verification. When starting a Motor Management & Reliability Program, it may be necessary to test the spares motors. In many cases, the spares are not maintained and the storage environment adversely affects the motors' condition. Motors that do not pass the test should be sent for reconditioning before being placed back in inventory.

Consulting and Engineering Services

A Motor Management & Reliability Program is not only about maintenance and spare parts. To provide real benefits to the bottom line of the business, there are a few additional aspects of modern asset management that should be included, such as the ability to objectively and systematically review and assess motor management processes, as well as motor conditions. These aspects form part of a toolbox for continuous improvement and should be performed on a regular basis to ensure the program is on track and delivering the necessary benefits. Additionally, they identify the areas for improvement by taking guesswork out of the decision process. These values are delivered through Motor Management Review and Motor Condition Assessment modules.

It could be safely assumed that during plant constructions, the proper motors are selected for each application. However, over time, processes change. There are improvements in manufacturing, and usually plant output changes. Often, variable speed drives are added without analyzing the installed motors for a proper application fit. These changes lead to the need for consulting services, specifically application engineering. This service ensures the motors are right for the application and will provide long and reliable service.

One of the goals of a Motor Management & Reliability Program is to increase motor reliability and decrease total cost of ownership. This is accomplished through a module called Reliability Improvement. The main activities include:

- Root cause analysis – motor failures and performance are analyzed and improvement actions developed and implemented.
- Maintenance preventive and predictive plans are continuously reviewed for effectiveness. New and improved predictive technologies are analyzed and implemented.
- Operating practices review – experience shows that even if motors are properly selected for the application, correctly installed and maintained as per the maintenance plan, failures still occur. In many cases, these failures can be traced to the operations. An example is frequent starts and stops of large synchronous motors.
- Application review.

The underlying principle of a Reliability Improvement module is improvement. The above activities, and others mentioned in this article, form integral parts of the Continuous Improvement Process, which is the backbone of the motor management program.

Information Management

Information is power, especially in a Motor Management & Reliability Program. It is extremely important that the right software is used. A properly implemented and utilized CMMS would seem to be the

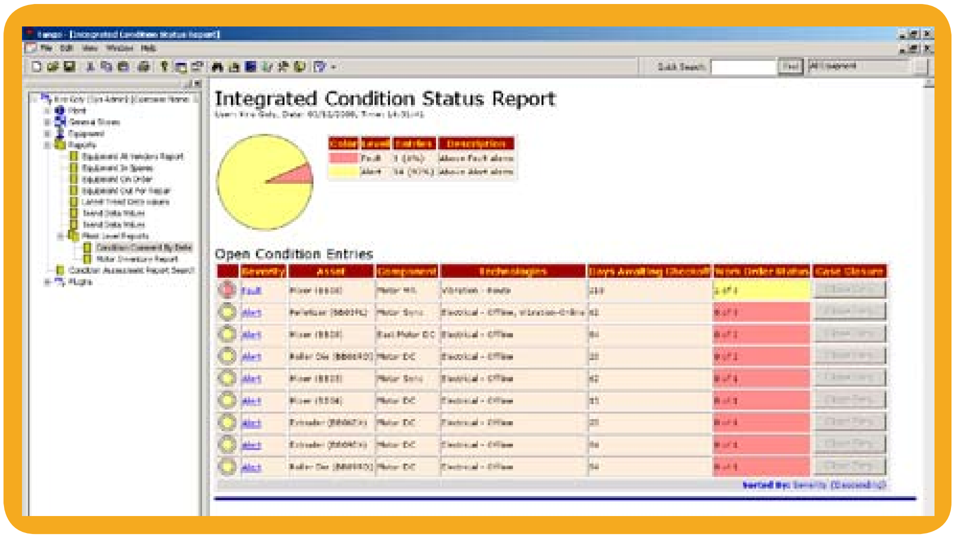

Figure 3 - Integrated Condition Report in Tango Software

right solution. However, in many cases, this is not true. Quite often motors are left out of the CMMS or the information is not tracked properly. For that reason, many companies elect to have separate software installed for managing motors. So what criteria should be considered when choosing motor tracking software? There are many, and they will vary based on a company's requirements, but there are some that are standard. Here are the critical requirements that need to be considered:

- Ease of use – The software will be used by personnel with computer skills at various levels. For the program to be successful, the users cannot feel intimidated by the software and need to see value in it.
- Motor history kept and categorized by location and equipment – This is extremely important, as motors frequently travel from one location to an other such as to and from repair shops and storage areas.
- Integration of predictive maintenance technologies results – User should be able to see "motor health" at the click of a button.
- Comprehensive reporting functions, enabling the rapid analysis of motor condition, history, etc.
- Access to vital information via the Internet for repair shops.
- Ability to track progress of motors sent for repair.
- Spare motors inventory.
- Ability to store or link documents related to motors such as documentation, failure reports, repair quotes and photos.

The selection of the right information tracking system will have an impact on the entire Motor Management & Reliability Program. In fact, it is a critical factor for performing statistical and root cause analysis, determining reliability trends and cost tracking. Equally important is its implementation. Figure 3 shows a screen shot from the software called Tango utilized in some of Siemens' programs. The screen shot, an "Integrated Condition Entry" report, shows equipment requiring corrective maintenance actions sorted by severity of conditions.

Reports like this provide invaluable information that can be accessed easily by relevant plant personnel. They form the basis for decision making about maintenance corrective actions.

Case Study

The following case study of a tire manufacturing plant illustrates the effectiveness of a well-planned and implemented Motor Management & Reliability Program. The plant has a diverse fleet of electric motors ranging from fractional horsepower to 2,500 HP. There are many low-voltage motors, as well as medium-voltage, DC and AC induction and synchronous motors.

Plant management selected 135 motors for the motor management program, which were all deemed to be the most critical to the plant operation. These motors had a history of low reliability and high cost of repairs, ranged in size from 400 HP to 2,500 HP, and were a mix of medium-voltage and DC motors. The following outlines the step-by-step procedure that was followed under the Motor Management & Reliability Program:

- Secured management commitment – This step is critical be cause often during the initial stages of a program such as this, there is resistance from plant personnel. They view it as a negative change and will not support the activities or the end results of the program.
- Developed a motor master list and set up a database in the software for motor management activities tracking.
- Reviewed, optimized and implemented a Preventive Maintenance Program based on the OEM's recommendations, experience and operating conditions. The most change introduced involved proper inspection procedures and cleaning.
- Developed and implemented a predictive maintenance program – The program included vibration analysis, oil analysis, thermography, RTG testing and trending and PdMA testing. All data was temperature corrected, stored and trended in a database.
- Developed and implemented a continuous improvement program and put in place a compressive reporting structure to monitor program performance and equipment performance. The results are provided later in the article.
- Introduced precision maintenance – Workers were trained in precision laser alignment and balancing. Installations of new and repaired

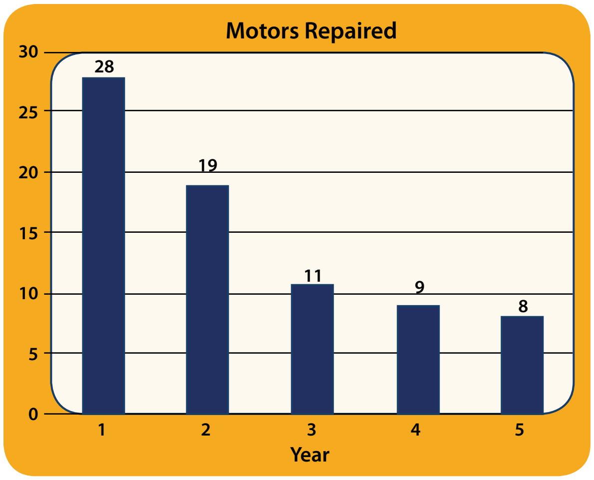

Figure 4 - Number of motors repaired

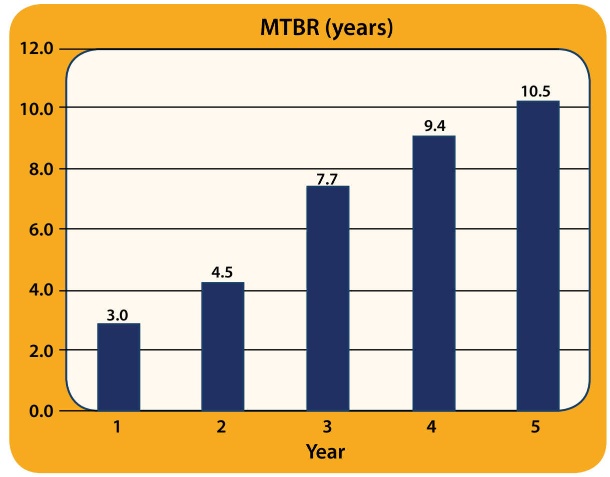

Figure 5 - MTBF - Mean time between failures

motors required following a strict, step-by-step procedure.

- Developed and implemented motor repair specifications based on the plant and repair shop experience and manufacturer specifications. This, together with closer incoming motor quality inspections and repair shop audits, resulted in consistent and high repairs.

There were challenges in the implementation of the program, most of which resulted from the fact that change was required. It wasn't a technical challenge, it was more of a cultural challenge – the tradition of reactive maintenance was being changed. The program was accepted over time as people began seeing the results, and their proactive actions were rewarded. A short summary of the results:

- The number of motors repaired dropped from 28 in the year prior to the program's introduction to eight in the fourth year. Most significantly, the repairs were proactive and there were no motor failures.

- Mean time between failures increased from three years to 10.6 years. Again, there were no catastrophic failures later in the program. Motors were pulled out of service proactively and the repair cost was limited.

- Motor repair cost decreased significantly and more than offset additional costs associated with a predictive and preventive maintenance program.

- Plant cost avoidance (increased uptime) was several millions of dollar per year.

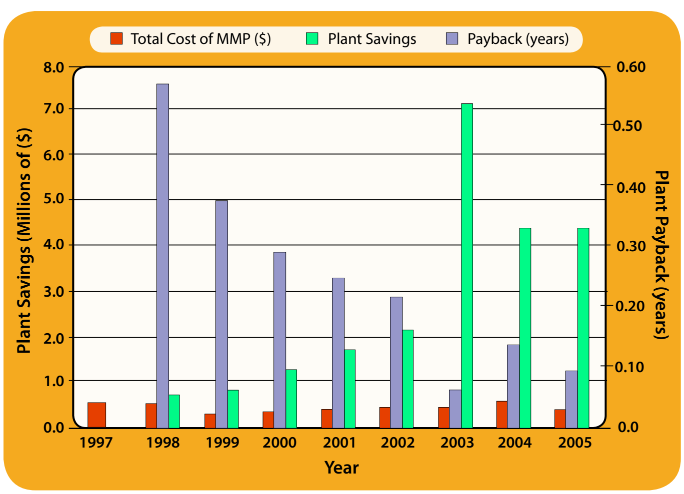

Figure 6 - Program Cost Versus Savings

	1997	1998	1999	2000	2001	2002	2003	2004	2005
MMP Total Cost ($)	540,959	425,826	319,750	377,383	429,432	469,971	458,048	609,265	416,988
Plant Savings ($)	--	751,015	854,602			2,171,987	7,120,656	4,414,656	4,414,806
Payback (years)	--	0.57	0.37	0.29	0.25	0.22	0.06	0.14	0.09

Chart 1 - Program Cost Versus Savings

Conclusion

Electric motors have long been the forgotten asset in the industry, but this does not have to be the case. With a new, structured approach to managing motors (introducing a Motor Management & Reliability Program), the benefits can be garnered relatively quickly. The key to success is to have a detailed implementation roadmap, secure support of senior plant management and persistence. Experience has shown that positive results are the best ambassador for the program.

Krzysztof (Kris) Goly has more than 25 years of experience in the field of maintenance and reliability. His experience includes positions as maintenance and engineering manager, reliability manager and, most recently, principal consultant for Siemens Industrial Services based in Alpharetta, Ga. Goly is a Certified Maintenance and Reliability Professional. He can be contacted at kris.goly@siemens.com

Siemens Energy & Automation, Inc.
3333 Old Milton Parkway
Alpharetta, GA 30005

1-800-964-4114
info.sea@siemens.com

www.sea.siemens.com