



Motor Management Help from Repair Shops through the Internet

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A large continuous process manufacturing plant typically has between 1,000 and 20,000 critical installed motors, and the facility may purchase or repair between 10 and 100 critical motors each month. Motor repair or replacement, along with the related labor and production downtime costs, often takes up a lion's share of plant annual maintenance budget. It's no surprise that most plants want to start or improve a motor management program in order to control costs and increase productivity. More surprising is the large number of plants who have tried and failed to sustain a motor management program. Causes of failure include separate information systems for equipment life cycle and condition monitoring data, along with insufficient plant manpower and lack of information about repair shop findings. Several plants in power generation, pulp and paper, mining, and tire production have implemented effective motor management by partnering with their motor repair vendor, using the Internet as enabling technology.

From a plant perspective motor management has two primary objectives:

- Eliminating unexpected motor failures
- Extending the life of motors between repairs or overhauls

I. Eliminating Unexpected Failures

The plant's first requirement for motor management is the elimination of in-service motor failures. Predictive Maintenance (PdM) technologies provide information about the current status of motor health so developing problems can be detected and planned for. These technologies include:

Vibration Analysis
Infrared Thermography
Motor Circuit Evaluation

Current Signature
Bearing/Winding Temperature
Ultrasonic Inspection

Often multiple condition technologies are applied for monitoring a motor's condition, often using different vendor's software. This segregation makes it difficult at best to evaluate all the current pieces of information about a motor's condition. Also, the traditional deliverable from PdM service suppliers or in-house practitioners has been

hardcopy or e-mailed reports to a few individuals; other employees or managers who could benefit from the ‘warning’ information may never receive it. To fully realize the potential of multiple condition monitoring technologies toward eliminating unexpected failures, several issues should be addressed:

- Reporting should place severe problems on motors critical to plant operations at top of the list, with downward sorting according to motor criticality and problem severity;
- Condition results from all technologies used on a motor should be integrated so all available information can be considered in deciding maintenance action;
- Distribution of integrated and sorted condition results should be easily accessible for potential plant users, including production and operations personnel in addition to maintenance;
- Condition findings and recommendations should be presented only for assets in a viewer’s area of responsibility.

II. Extending Motor Life

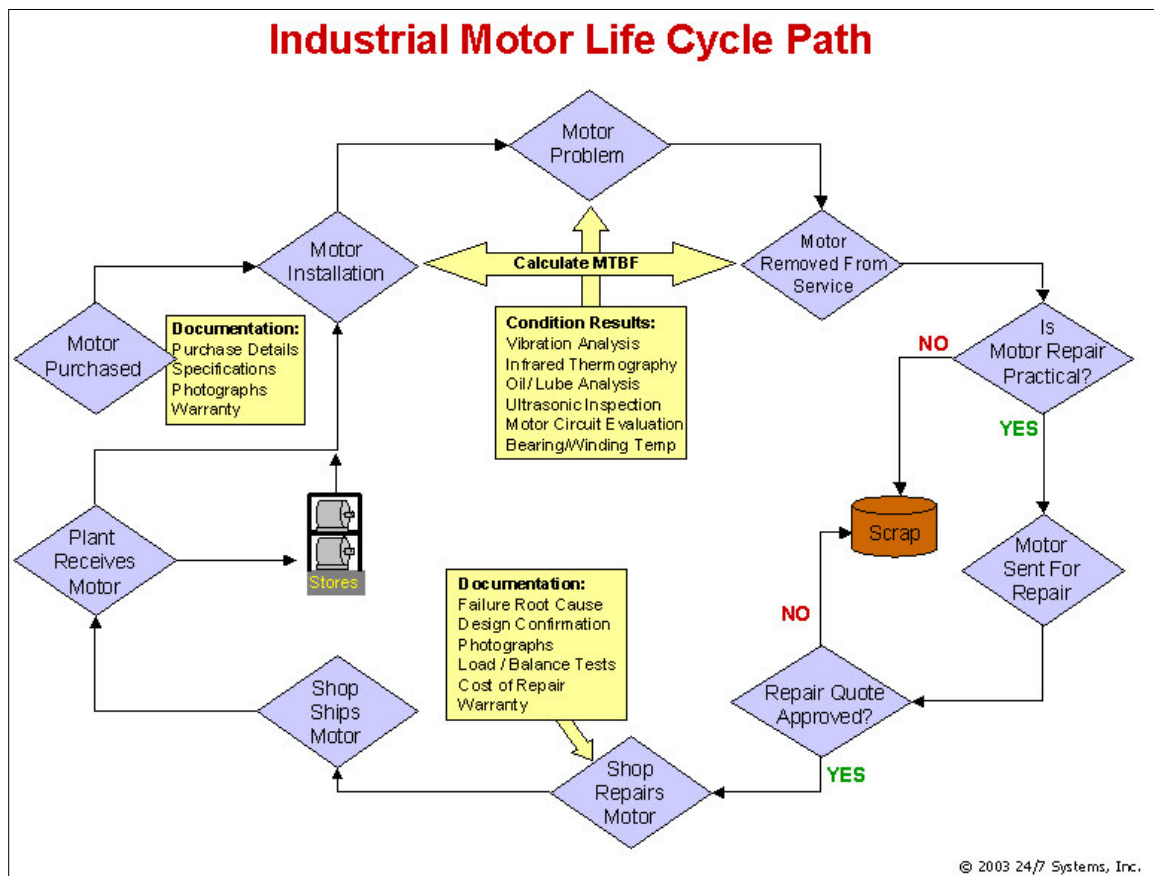
The second focus of a motor management program is extending service life between repairs and overhauls, often calculated as Mean Time Between Failure (MTBF). By tracking life cycle details from initial purchase and design, through service and repair stages, information is available to determine opportunities for improving MTBF. Comparisons can be made among motors in similar applications to spot low MTBF, and analysis can determine if specific design or manufacturer issues are the common characteristic. However, one of the most difficult types of information for plant personnel to resolve is the true root cause of motor failure. Even with experienced Predictive Maintenance coverage the reported failure mode is often a symptom rather than a root cause; for example a bearing failure may be reported when the actual root cause is lubricant contamination.

A motor repair facility is usually in the best position to capture design details and failure root cause. When a failed motor is sent to the repair shop, the first step is disassembly and inspection. At this point the shop knows basic design and failure information about the motor. Once a repair has been approved and performed by the shop, the shop also knows the cost of repair and warranty period. The types of information a repair shop can document include:

- Design Information: Design information on motors needed by the plant goes beyond just the nameplate data. Information such as a bearing currently installed, number of bars and slots, insulation class, and full load current is helpful by plant condition monitoring, maintenance, and purchasing personnel.

- **Root Cause of Failure:** Typically the plant will see the motor's failure as why it stopped functioning, which is either "winding failure" or "bearing failure". This level of information is not helpful for the plant in understanding how to make the motor live longer, because these symptoms are usually the result of some other root cause. A shop can determine the root causes of failure, and the plant can take action can be taken to eliminate the root cause and obtain longer motor life.
- **Date Received and Shipped:** These dates will allow the calculation of Mean Time to Repair and Mean Time Between Repairs.
- **Cost of Repair:** Upon disassembly and inspection, the plant may decide to overhaul the motor or to scrap it and purchase a new motor. In either case, the failure root cause needs to be stored with the failure information.
- **Warranty:** Overhauled motors often have 1 or 2 year warranties and new motors 1 to 5 year warranties. Many plants miss warranty coverage simply because no one knows to file a claim. Often the savings obtained from warranty tracking will more than pay for the complete motor management package.

Figure 1: Major stages in motor life cycle that need to be managed.



Often a plant's first attempt at motor management uses the existing computerized maintenance management system (CMMS). Often it becomes obvious that typical CMMS implementations are not well suited for managing information on repairable assets that migrate from location to location. A motor management "champion" may then create a tool with Microsoft Access™ or Excel™, only to be overwhelmed maintaining updates and distributing information to other users in the plant. These efforts run headfirst into many disparate sources for data. Condition monitoring reports come from electrical and mechanical in-plant sources, or from one or more service vendors. Motor repair shops send hardcopy or e-mailed documentation, but these reports can be irretrievable within a few weeks of receipt. They may be in someone's file cabinet, but no one is sure where; sometimes they're placed in a computer file folder along with hundreds like it, making it very difficult to retrieve and impossible to analyze.

Integrating motor life cycle history and condition information is critical to the above objectives, but how can a plant implement sustainable motor management with its limited manpower and resources?

Solution: Internet-based Motor Management:

The answer can be a partnership with preferred motor repair vendors, using an Internet-based data transfer system. With a web-based system, a motor vendor can deliver purchase, repair, and condition status documentation without accessing the internal plant network. Production, operations, and maintenance personnel go to a secure Internet site to retrieve information from the database, through a web browser. They can search for history on individual motors, see which motors have condition status they should be concerned about, or see a list of motors currently on order or out for repair – all without having to install any desktop software on their computers. Access is protected by user name and password security controlled by a system administrator.

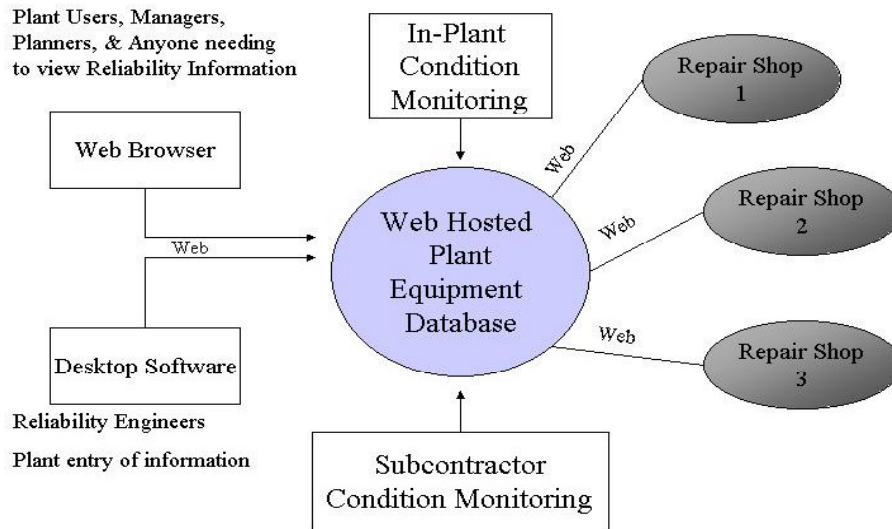


Figure 2: The Web-hosted Equipment Life Cycle Management Database is the key to the communications architecture between plant users and motor repair vendors.

The advantages to the plant of having their motor vendor assist them with managing motors in a web-based application include:

- **Reduced data entry** - The vendor handles the data entry of purchase and repair documentation into the web-hosted database in their normal course of business, so the plant doesn't have to re-enter data or track down hardcopies scattered among various file cabinets.
- **Consistency and Availability of Information** - Often the plant's different functional areas, units or stations create tracking applications using Access or Excel. These independent sources rarely use the same nomenclature that allows other plant users to integrate the information, and the files may not be accessible by all interested parties. With a single web-hosted database a common nomenclature can be enforced, and information is available to any authorized manager or employee with Internet access.
- **Supplements the plant's CMMS limitations** - Often the plants CMMS system does not have the capability or user interface needed for storing and retrieving life cycle steps as a specific motor moves from a service location in the plant, to a repair vendor for service, then back to plant stores or service location. Also, CMMS systems have not proven to be easy to integrate with condition information from PDM vendor's software.

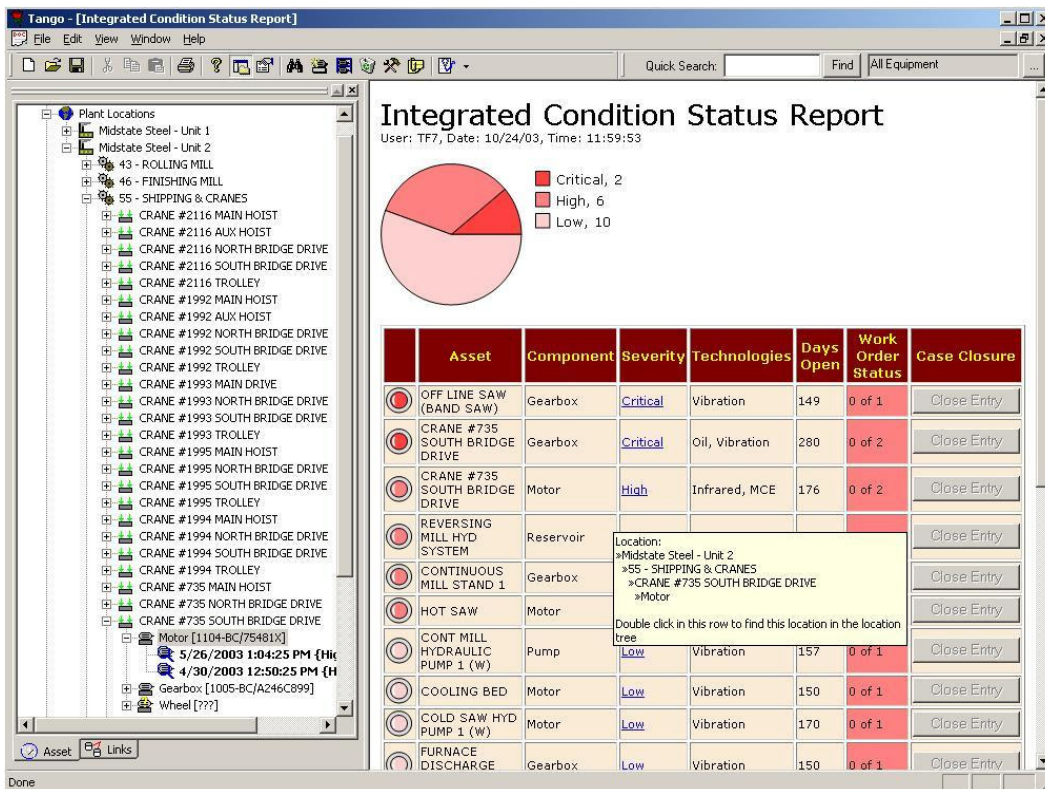


Figure 3: Web-based integrated condition report detailing condition and severity that can be accessed by all authorized plant users.

Using a web based motor management approach; the repair shop enters the motor ID, design information, failure analysis, repair, and cost information into a web form. Repair documents and photos can be linked for retrieval through the Internet. This information is then automatically entered into the web database and creates a life cycle repair history for the specific machine. In addition to the history for each machine, the database can produce information on Mean Time Between Repairs, root causes of failure, and cost of repair. This information can be further sorted or analyzed by frame size, manufacturer, repair vendor, voltage, type of motor, cost by year, etc...

From the motor repair shop perspective, the biggest change in their operation is producing good root cause of failure information. Joe Longo, President of Longo Electrical Mechanical in Wharton, NJ, leads a large progressive apparatus repair facility. Joe states that root cause of failure information is not being analyzed well across the repair industry. He further states that to tell a customer they had a winding failure is not sufficient. Instead, they need to know if it is caused by mechanical, environmental, or electrical sources. "Finally, we have a tool to consistently and easily allow our customers to measure motor reliability. Before Tango everyone talked about reliability but no one knew how to produce the information."

Equipment History Report

Report Date: 9/23/2003

Plant Tag	Serial Number	Frame Size	Model Number	Motor Mfg	Power	Speed	Voltage - Stator
1450	5282414002	509UPD	????	Louis Allis	350 HP	1200 RPM	460 V

Start	End	Days	Type	Remarks
2/1/1983	2/8/1983	7	Repair	
5/12/1986	5/15/1986	3	Repair	RECONDITION * BRGS * NEW OIL SEALS * LEAD WORK
11/1/1988	11/11/1988	10	Repair	RECONDITION

1/5/1990	1/11/1990	6	Repair	
5/19/1993	5/24/1993	5	Repair	
5/24/1995	5/24/1995	0	Repair	

Work Order

Vendor: SANDERS ELECTRIC

Cost: 5,699.00

Order Number: 500895

Shipping Number:

Vendor Order Number:

Repair Type: Repair

Warrenty Date:

Attachments: [Shop balance report](#)
[Shop card](#)

Work/Repair Findings				
Fault Type	Fault Group	Status	Level	Comment
Drive end bearing failure	Mechanical	Fixed	Resulting Effect	
Lubricant contains water	Mechanical	Fixed	Root Cause	
Vibration/Bearings by NDT	Mechanical	Fixed	Secondary Cause	
Worn shaft	Mechanical	Fixed	Secondary Cause	
Moisture/wet	Other	Found, Not Fixed	Contributing Factor	

Figure 4: Web report showing motor repair history. This report is interactive; clicking on any line opens a page with more details on that specific period. All rows colored Red indicate a Repair stage of the life cycle history; the exploded window shows how failure root cause is documented.

Once the motor shop information is entered, the plant has some very useful reliability information and the plant has not had to do any work. At this point, we can achieve some basic measurement of motor reliability for specific motors such as Mean Time Between Repair (MTBR), Root Cause, and Cost of Failure. We are lacking the plant location reliability measurement of location specific Mean Time Between Failures (MTBF), causes of failure, and cost. To achieve plant location reliability information the plant will be required to track which motor was installed into a functional location and when it was removed. This sounds like a lot of work by plant staffs that do not have time for any additional work but let us look at what is involved. A very large facility will install less than 50 critical motors a month. If the ID number for the motor removed and the ID number for the motor installed is entered on a tag or a work order, the re-entry of this information will require less than 5 minutes per motor. If the motor location information is maintained, the web based motor management package can calculate the Mean Time Between Failures, cost of failure, and root cause of failure for an area of the plant or specific functional locations.

Location History Report

Report Date: 9/23/2003

Plant Unit	801 Cooling Tower
Plant Function	TWR
Plant Asset	CLDWELL
Asset Component	PUMP6
Target MTBF	Not Specified

	Plant Tag	Install Date	Removal Date	Days Installed	Remarks
	3591	2/1/1983	1/23/1984	356	BEARINGS BAD
	1452	1/23/1984	1/27/1984	4	
	3591	1/27/1984	4/9/1987	1168	
	1452	4/9/1987	5/10/1987	31	TOP BEARING FAILED
	1452	5/14/1987	12/14/1987	214	REMOVED FOR PUMP WORK
	1452	12/28/1987	6/7/1989	527	BEARINGS??
	1449	7/3/1989	10/12/1994	1927	LOW MEGGER READINGS
	3485	10/12/1994	5/23/1995	223	ONE PHASE OF WINDING HOT & 120 HZ VIBRATION
	55	12/13/1995	9/10/1997	637	COPPER ROTOR BARS - WINDING PROBLEM PDMA
	55	10/2/1997	1/11/1999		
	1450	9/11/2003			

Equipment Type: Motor - AC Induction

Plant Tag*	55
Serial Number*	1-5117-64930-1-1
Frame Size*	507UP
Model Number*	????
Motor Mfg*	Siemens Allis
Power*	350 HP
Speed*	1200 RPM
Voltage - Stator*	460 V
Bars - Rotor (cnt)	57
Comments	COOLING TOWER COLDWELL
Connection Config (Stator)	WYE
Current - Full Load (Stator)	411 A
Duty	CONTINUOUS
Formed Coil	Yes
Insulation Class	F
Key Value For MCE	031034000122:021496095445
Motor Enclosure	WPI, Weather Protected type I
Nema Design Code	B
Nema Power Code (AC)	G
Poles	6
Power Factor	0
Service Factor	1

Figure 5: Web report showing location installation history. This report is interactive; clicking on any line opens a page with more details on that specific period. Rows colored Green indicate an Installed in Plant Service stage.

Figure 6: Web report showing motor repair and installation location history. This report is interactive; clicking on any line opens a page with more details on that specific period. Rows colored Red indicate a Repair stage of the life cycle history; Green indicates an Installed in Plant Service stage. Interactive design details include linked documents.

Equipment History Report

Report Date: 10/24/2003

Plant Tag	Serial Number	Frame Size	Model Number	Motor Mfg	Power	Speed	Voltage
1450	5282414002	509UPD	????	Louis Allis	350 HP	1200 RPM	460 V
Specific Equipment Linked Documents Dimension Drawing Wiring Diagram AC Induction							
Plant Tag*	1450						
Serial Number*	5282414002						
Frame Size*	509UPD						
Model Number*	????						
Motor Mfg*	Louis Allis						
Power*	350 HP						
Speed*	1200 RPM						
Voltage - Stator*	460 V						
Bars - Rotor (cnt)	58						
Comments	COOLING TOWER COLD WELL PUMP MOTOR						
Connection Config (Stator)	Unknown						
Current - Full Load (Stator)	421 A						
Duty	CONTINUOUS						

Equipment History Report

Report Date: 9/23/2003

Plant Tag	Serial Number	Frame Size	Model Number	Motor Mfg	Power	Speed	Voltage - Stator
1450	5282414002	509UPD	????	Louis Allis	350 HP	1200 RPM	460 V

Start	End	Days	Type	Remarks
2/1/1983	2/8/1983	7	Repair	
3/1/1983	5/12/1986	1168	Installation	ROUTINE CHANGE
5/12/1986	5/15/1986	3	Repair	RECONDITION * BRGS * NEW OIL SEALS * LEAD WORK
5/16/1986	10/28/1988	896	Installation	LOWER BEARING FAILURE - NDT
11/1/1988	11/11/1988	10	Repair	RECONDITION
1/13/1989	1/3/1990	355	Installation	ICE PROBLEMS ON TOWER - WINDING GROUNDED
1/5/1990	1/19/1990	14	Repair	REWIND
1/23/1990	5/14/1993	1207	Installation	BEARINGS
5/19/1993	5/28/1993	9	Repair	RECONDITION
6/7/1993	5/23/1995	715	Installation	BEARING PROBLEMS
5/24/1995	5/30/1995	6	Repair	REPAIR UPPER HUB AND SHAFT
6/1/1995	9/11/2003	3024	Installation	

The amount of data keyed in to the database is small; drop down lists provide standardized manufacturer names and fault descriptions for simple selection. The numerous documents that accompany purchase, service, and repair stages are a richer information source:

- Motor photographs
- Design drawings
- Warranties
- Installation drawings
- Maintenance procedures
- Condition monitoring reports
- Shop job tracking documents
- Tear down photographs
- In-shop balance tests
- In-shop load tests

These documents can be stored on the web server and linked to many Tango reports; the result is a virtual library of easily retrievable documents available to any authorized user.

Searching and Data Mining the Database:

Once an inventory of plant equipment has been developed, the database may be searched for replacements, the population of a similar design, low MTBF locations or equipment, high cost of failure equipment or locations, or data mined for common features. Figure 7 shows a typical data mining display of motor MTBF by type of motor. This could be further broken down by motor designs or locations. This analysis could be an additional service deliverable from the motor vendor.

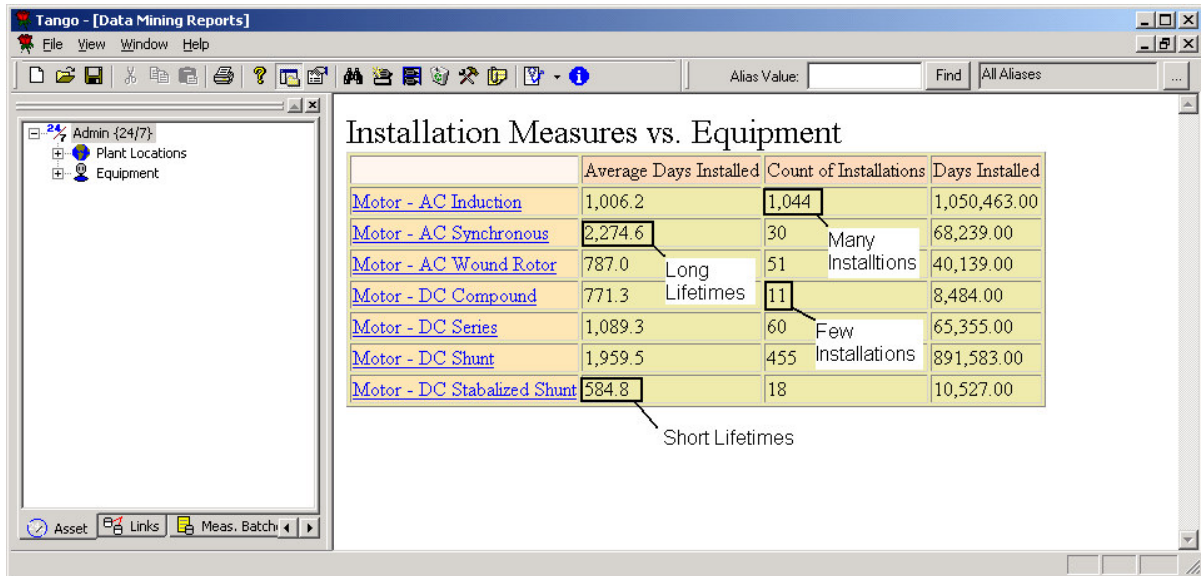


Figure 7: Data Mining interactive drill down into details, pinpointing best opportunities for motor reliability improvement.

Conclusion:

Motor life cycle management at industrial plants is an important part of eliminating unexpected motor failures and extending the life of motors between repairs or overhauls. Such programs have proven difficult to sustain however, due to the large number of data sources involved with condition status, design, failure mode, and repair information; plants also face more challenges that ever in dedicating manpower to long-term payoff programs. A web-based motor management system makes it possible for motor repair partners to enter this information into a single web-hosted database without having to bypass plant network firewalls, and it also allows a wide base of authorized plant users to retrieve the information over the Internet. Communications about daily motor reliability issues in improved between production, operations, and maintenance in the plant, and pertinent information for long-term motor life improvement is readily available for reliability engineers.

For information about Tango Equipment Lifecycle Management Web Service from 24/7 Systems, Inc, e-mail sales@tf7.com, or call 865-681-0282.