White Paper
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CSI 2130
Machinery Health Analyzer

Predictive Maintenance in a Mission Critical Environment

This paper discusses the need to proactively protect mechanical and electrical support systems in data processing centers and data storage facilities against unexpected failure that could cause an interruption in essential operations. By implementing predictive maintenance programs based on the use of advanced information gathering technologies, these facilities can maintain critical equipment at high performance levels and prevent failures that could cause unplanned downtime with catastrophic results.

Protecting mechanical and electrical support systems against unexpected failure

Preventive maintenance is a misnomer! Periodic lubrication of mechanical equipment and other checks may not actually “prevent” a breakdown, because serious internal faults and electrical overloads can go unnoticed for a long time. A more effective maintenance program is necessary for support equipment that is critical to the uninterrupted operation of a data processing center or data storage facility.

Motors, pumps, HVAC units, chillers, electrical control cabinets, and power distribution panels seldom fail without providing some kind of warning! More often than not, the signs of impending failure, such as elevated vibration levels or high internal temperatures, go unnoticed during routine tasks. Yet, the results can be catastrophic.

Information about the health of rotating machinery and electrical equipment is often concealed in physical signals, which can be recognized using well proven techniques for vibration monitoring and analysis as well as infrared thermography. If properly interpreted, these hidden signs can pinpoint the nature, location, and even the severity of developing problems, so steps can be taken in time to avoid losses of data and money.

While every data center backs up current information and maintains redundant systems to prevent the loss of irreplaceable data, the possibility of a faulty piece of support equipment shutting down your round-the-clock operation may never have been considered. Yet, the timely identification of a potentially bad bearing in a motor, pump, fan, or other mechanical equipment could avoid a catastrophic failure and save your operation thousands of dollars.

Predictive Maintenance

Sometimes called reliability centered maintenance, predictive maintenance goes considerably beyond the generally accepted rules for preventive maintenance, performing service only when necessary as dictated by the condition of the equipment. If a failure is imminent, that unit may need to be repaired or replaced immediately. If performance is not significantly degraded, it may be possible to delay repairs until a backup can be arranged to avoid lost time.

Machinery health management carries this approach a step further by prioritizing each machine according to its significance to the operation. Then, greater care is given to the most important machines to be sure they keep running. For example, vibration monitoring is much more frequent, and in some cases continuous online monitoring may be installed, on essential equipment that must continue to operate reliably. On support equipment deemed to be less important, collection of vibration data can be done less often.

Information generated by the monitors is collected and used by analysts and maintenance managers to predict when a problem is likely to occur. With that insight, maintenance can be scheduled when needed − before the problem becomes severe enough to adversely affect the performance of the asset.

Predictive maintenance has been proved in the process industries as a great way to improve maintenance effectiveness while reducing costs for repairs and unexpected downtime. Reactive and preventive strategies are generally reserved for equipment that’s not process-critical and will cause little or no collateral damage if allowed to run to failure.

As shown in Figure 1, implementing a predictive maintenance program based on monitoring the health of machines similar to those found in data centers and storage facilities dramatically reduced the risk of downtime by making timely repairs. In this graph, Priority 1 calls for immediate repair action, Priority 2 requires repair at the earliest opportunity, and Priority 3 allows maintenance to be scheduled when convenient. Reactive and preventive strategies (Priorities 4 and 5) are generally reserved for equipment that’s not process-critical and will cause little or no collateral damage if allowed to run to failure. In all cases, identifying potential problems early resulted in better maintenance at a lower overall cost.

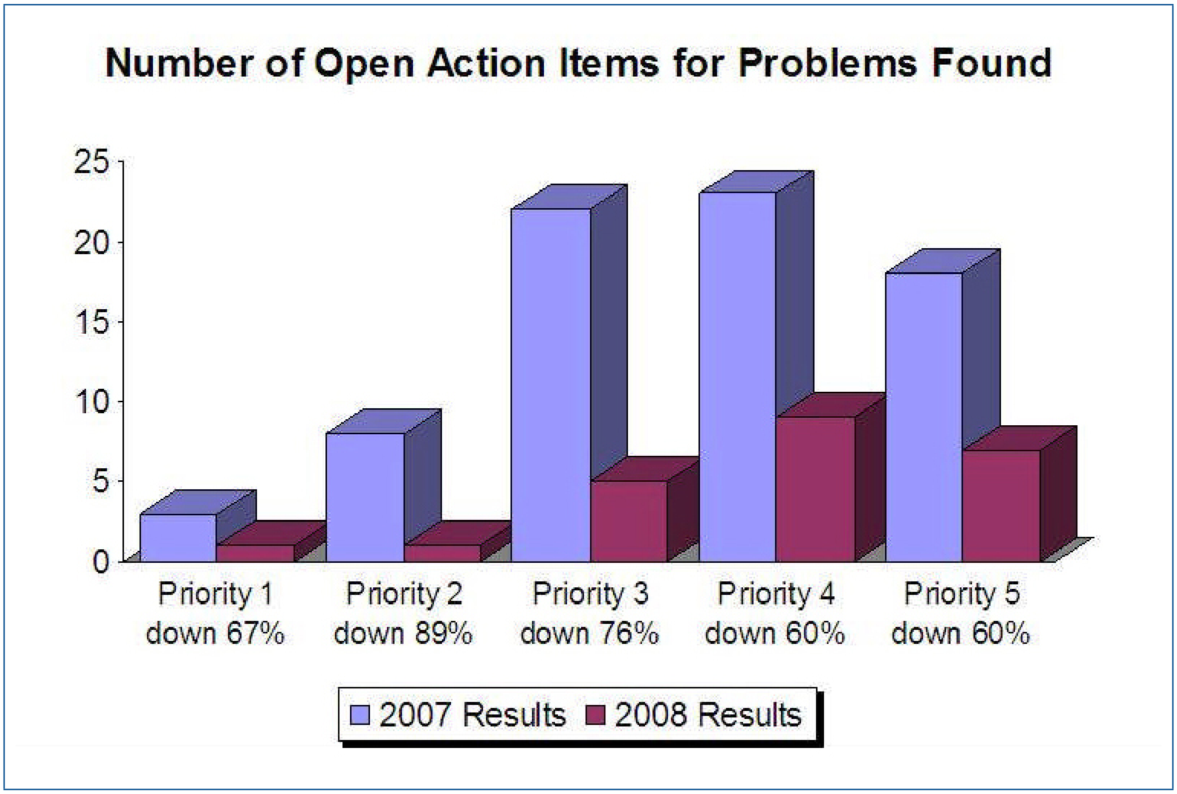

Figure 1 – Measuring Problems Found with Vibration Analysis

The Reliability Challenge

In order to handle the core business and operational data of an organization in the information technology age, data centers must reliably process the transactions and store important electronic information that allow a modern business and government to operate efficiently. Critical mechanical and electrical support assets in server rooms, data centers, and their UPS systems include:

- **HVAC** units for temperature and humidity control
- **Chillers** for cooling or dehumidification
- **Cooling Towers** to reject heat from chillers or HVAC units
- **Pumps** that support the cooling equipment
- **Engine-Generator sets** as source of backup power
- **Electrical** control cabinets, motor control centers and switch gear
- **Uninterruptible power supplies (UPS)**, automatic transfer switches
- **Power** distribution panels

Preventing Equipment Failures

Vibration Analysis is a non-intrusive technology by which users attach a spectrum analyzer to machinery and record waveform signatures. Analysis of this data makes it possible to diagnose:

- Mechanical wear in bearings, belts, couplings, gears, and support structures
- Imbalances and misalignments
- Other defects such as lubrication failure, bent shafts, broken motor rotor bars, resonances, and many more.

Emerson was contracted by a major financial institution to perform vibration analysis on critical rotating machinery at their data center and trading floor. Maintenance technicians in the facility were trained to collect vibration data using a portable CSI 2130 Machinery Health Analyzer to record waveform measurements along a predetermined route of selected machinery. The data is dumped periodically via a secured Internet connection or e-mailed to an Emerson machinery health analyst who performs vibration analysis using the AMS Machinery Health Manager software. A monthly machinery condition report to the facility manager includes recommendations for repairs.

The trend analysis chart (Figure 2) illustrates periodic measurements recorded on an HVAC unit at this facility over a five-month period. In March 2008, the initial data collection and analysis showed that the motor had a severe bearing defect, which was reported to the facility manager as “critical”, along with a recommendation to replace the motor at the earliest opportunity.

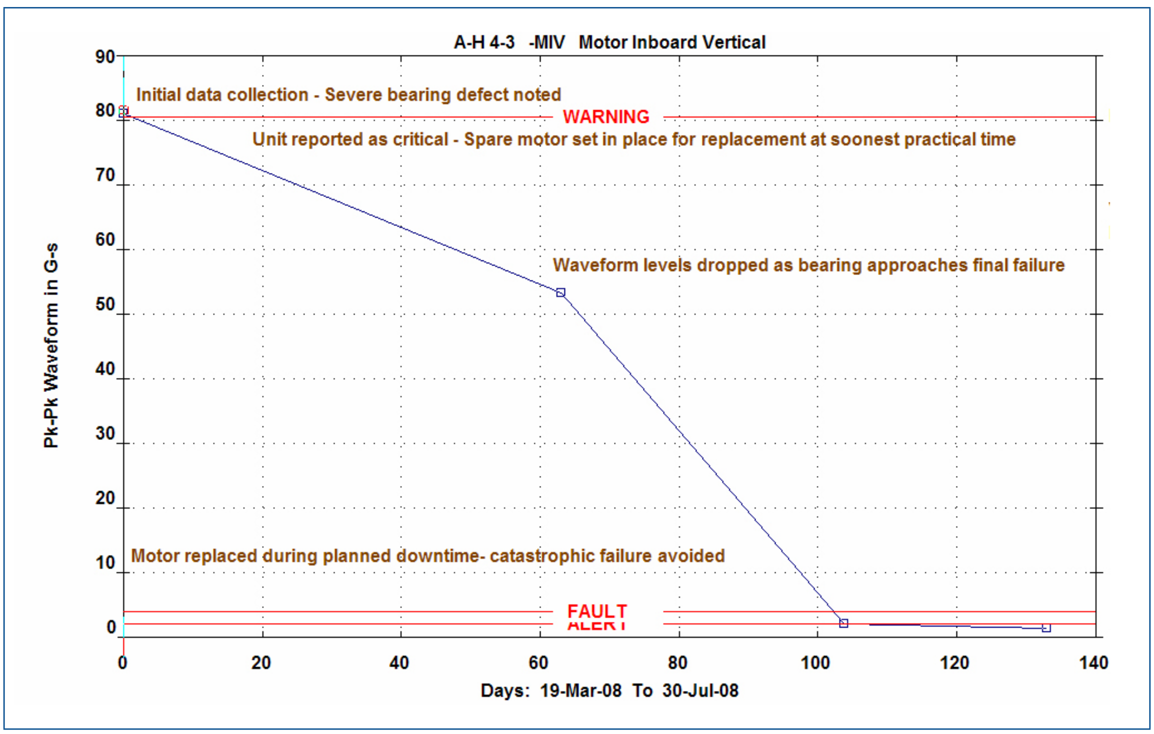

Figure 2 – Vibration Analysis Reveals Failing Bearing

That unit continued to deteriorate until the repair actually took place during a regularly scheduled outage in June 2008. A catastrophic failure might well have occurred if the warning signs had not been recognized in time. As a result, unexpected downtime in this mission critical operation was averted.

Infrared Thermography is an effective means of identifying potential problems before an incident or failure occurs. Applying this technology in a data center environment can be extremely beneficial when trying to maintain system availability 24 hours a day, 7 days a week. This non-intrusive technology can identify abnormal thermal rises in electrical, mechanical, or structural components. A successful infrared thermography program will identify:

- Loose and or poor connections
- Unbalanced electrical loads
- Defective components
- Irregular surface temperatures

The benefit of performing infrared thermography is its ability to identify problems before they impact the facility. A tripped circuit breaker may protect equipment, but the subsequent downtime could have disastrous consequences within a data center.

A Meta Group study identified the hourly impact on different organizations to system outages. (Figure 3) It's clear that any downtime in the data center of a retail brokerage comes with a very expensive price tag. With this amount of money at stake, infrared thermography should be a key component in the maintenance routine of any data center, especially those serving retail brokerage firms.

Type of Business	Average Hourly Impact
Retail brokerage	$6,450,000
Credit card sales authorization	$2,600,000
Home shopping channel	$113,750
Catalog sales centers	$90,000
Airline reservations centers	$89,500
Cellular service activation	$41,000
Package shipping services	$28,250
Online network connect fees	$25,250
ATM service fees	$14,500

Source Meta Practice, 25 February 2004

Figure 3 – Financial Impact of Data Center Downtime

Emerson Network Power was contracted by a major financial institution to perform an infrared thermographic survey on all electrical connections within their facility. The survey included electrical and mechanical equipment from the building's utility entrance through the branch circuit breakers within the data center and trading floor. Qualified maintenance technicians performed the survey using an infrared camera in accordance with the procedure set forth in the Standard for Maintenance *Testing Specifications for Electrical Power Distribution Equipment and Systems* by the International Electrical Testing Association.

Scanning the electrical distribution panels that feed the IT equipment on the data center floor revealed a problem (Figure 4) where the camera indicated a temperature 140.2°F. Furthermore, current readings of the individual conductors revealed that Phase A of the circuit was carrying 120Amps, or 96 percent of the rated line capacity of 125Amps. The National Electrical Code 102-22(c) states "a continuous load shall not exceed 80 percent of the branch circuit rating."

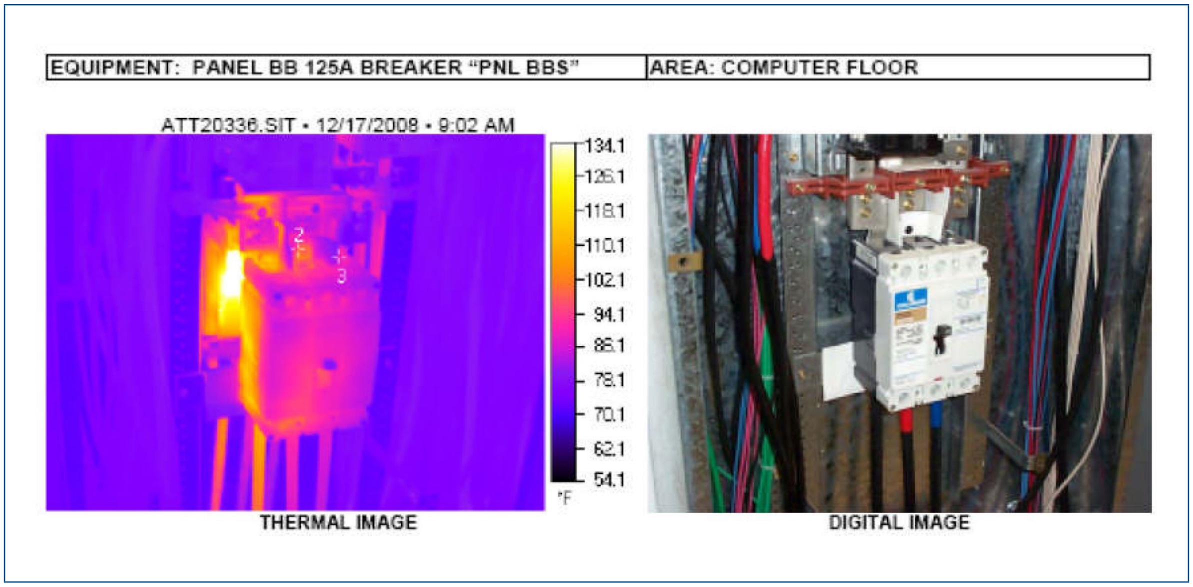

Figure 4 – Infrared Camera Readings on a Data Center Floor

The Emerson technician recommended the loads in the panel be distributed immediately to other circuits. If the load should exceed 125Amps, the circuit breaker will likely overheat and trip open, causing the panel fed from this device to lose power, as well as all the IT equipment fed from that panel. Depending on circuits fed from that panel, part or all of the data center's electronic equipment could be shut down due to that overheating situation. That disaster was averted by the timely infrared scan.

Conclusion

With no room for downtime, data centers need a strategy to ensure that supporting assets are reliable. Deteriorating machinery may cause severe problems, which can be avoided by utilizing advanced predictive technologies in a mission critical environment.

A best-practices facility uses predictive maintenance for essential equipment where condition-monitoring is practical, limiting reactive and preventive strategies to equipment that's not mission-critical and will cause little or no collateral damage if allowed to run to failure. By applying infrared thermography and vibration monitoring, you can observe the health of critical support systems in order to detect impending failures and minimize the risk of a catastrophe.

About the Authors

Frank Vitucci is a District Manager in New England & New York Metro regions for Emerson which helps process industries to better manage plants through automation systems, intelligent control systems and software, measurement devices, consulting and industry expertise. He has a B.S. from the University of Connecticut, Level 1 Certification in Infrared Thermography and Vibration Analysis and 20 years experience working with diverse industries to help implement Plant Asset Management Programs, Reliability Based Maintenance and Machinery Health Management Technologies.

Brian Olsen is a Business Development Manager for Emerson Network Power, Liebert Service Division. He has a B.S. from the United States Merchant Marine Academy and a M.S. in Management from Stevens Institute of Technology. Brian has 8 years of experience in maintenance of critical data center equipment.

Brandon Schaner is a Senior Machinery Health Analyst at Emerson. He has over 13 years experience in heavy and commercial industrial applications providing predictive & preventive maintenance implementation service, along with PdM mentoring services. In addition, he also provides troubleshooting, corrective and re-engineering expertise for problematic in-place machinery. Brandon is certified ISO Category II in Vibration Analysis and ASNT Level I in Thermography, Ultrasound and Visual Inspection.

Emerson
Reliability Solutions
835 Innovation Drive
Knoxville, TN 37932 USA
+1 865 675 2400

www.emerson.com/ams