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Condition-based Maintenance Maximizes Efficiency of BSL Facilities

National Institutes of Health Implements Advanced Predictive Maintenance Strategies

The National Institutes of Health (NIH) recently established a condition-based maintenance (CBM) program for the organization's BSL-3 and BSL-4 facilities on its Bethesda, Md., campus. The CBM approach, utilized by the U.S. Navy and other asset-intensive commercial organizations, is a process that analyzes equipment condition data to make timely decisions regarding maintenance of critical facility components. The system has proven to significantly minimize facility operating costs by increasing reliability and research output while minimizing downtime.

"Condition-based maintenance is a proactive way to get in front of potential failures. When you understand the actual health of your equipment, you can accurately determine what maintenance is required and when," says Jeff Evans, vice president of technology at Blue-Cardinal, an asset management and consulting firm that helped NIH establish the CBM program.

CBM shifts the maintenance emphasis from a reactive approach to a proactive one that utilizes a blend of available building data and advanced diagnostic technologies to predict problem areas before they become liabilities. Equipment condition information is derived from a range of sources including routine inspections, building automation systems, and predictive technologies.

"It is a process of collecting data, determining what the data means, and then making optimal decisions regarding what to do about it from a maintenance standpoint," says Evans.

The comprehensive CBM program implemented by NIH includes scheduled diagnostic testing, problem response with root-cause analysis, collection of operational data with handheld barcode scanners, and integration of information pulled from building automation systems.

Blend of Strategies

A common approach to maintenance, known as reactive maintenance, is where equipment is fixed or replaced only when it fails. Preventive maintenance is another maintenance strategy which can be used, and generally involves periodic equipment shutdowns to perform OEM recommended maintenance activities. A preventive maintenance program can help improve reliability, but the tasks being targeted are not necessarily proactive and can be expensive. CBM programs make extensive use of what is known as proactive and predictive maintenance—a process of using advanced diagnostic tools and existing facility data to understand the true health of equipment.

"Reactive maintenance is a common strategy, but this is a very high-cost approach. What we are striving to do with condition-based maintenance is change the mix of strategies to incorporate streamlined predictive maintenance and proactive techniques," says Evans.

Acceptance Testing and Commissioning

Whether it is being implemented in a new building or, as in the case with NIH, in an existing facility, the first step in developing a CBM program is establishing an acceptance testing plan to set the baseline for equipment performance.

"The first step is to identify any underlying deficiencies that exist within the equipment and bring critical facility assets up to a reliable state. It is hard to implement an advanced program like CBM until existing equipment design, installation, and maintenance deficiencies are resolved," says Evans.

Typical commissioning activities focus on establishing operational performance. CBM acceptance testing takes this a step further by identifying reliability and maintainability issues before the equipment is turned over to the occupants.

"We have had great success applying these techniques to new facilities. Predictive diagnostics not only serve to accurately baseline equipment, but also to identify inherent design or installation deficiencies," says Evans.

Once the equipment baseline has been established the next step is to define the optimal balance of preventive, predictive, and proactive activities that need to be performed regularly.

Because most of the BSL labs at the NIH campus are located inside buildings with other functions, facility equipment was divided into three categories of criticality. The first category includes all system components that would have an impact on containment or safety in the event of a failure. The second category consists of equipment that supports general lab operations. The third category covers general building operations. Using these categories, NIH developed a task matrix to define the optimal mix of preventive, predictive, and proactive activities.

"Ranking equipment on a scale of criticality helps define how aggressive the proactive maintenance strategy should be," says Evans.

Data Collection

The CBM approach creates an accurate depiction of equipment health by compiling data from a range of sources including maintenance work order systems, HVAC systems, and building automation systems (BAS). At NIH, a dedicated data management system integrates and manages this information.

"If you look at the components of a condition-based maintenance program, the most elemental feature is the real-time BAS system. It has an inordinate amount of valuable data in regard to how the equipment is operating. You need to be able to integrate BAS data together with other preventive and predictive data in one place to be able to really understand what is going on," says Evans.

Integration with other facility systems also allows NIH to define specific goals and metrics in order to track the effectiveness of the maintenance program.

Defining Procedure

One of the biggest challenges to implementing an advanced CBM strategy is ensuring that the people conducting the operations and maintenance have the proper skills and understanding of best maintenance practices. Clearly established procedures and work processes are critical.

"Technology is great, but the real challenge is implementing procedures and processes that people will follow. Training is of utmost importance in the whole process. We try to keep the focus on maintaining reliability and working smarter, not harder," says Evans.

Advanced Diagnostics

Predictive technologies are a significant component of the CBM strategy. The primary diagnostic technologies utilized to assess equipment health at the Bethesda campus include vibration analysis, infrared thermography, airborne ultrasound, oil analysis, and motor circuit evaluation.

Vibration analysis uses sensors placed on equipment to provide a detailed spectrum of vibration frequencies. This technology can identify equipment imbalance, misalignment, bearing faults, and abnormal installation conditions like soft foot. Ultrasonic equipment is used to measure sound frequencies outside human capacity and can be used to identify bearing problems, air system leaks, steam trap leaks, and valve leaks.

Infrared thermography is a technology that utilizes a thermal imaging system to provide a thermal profile of temperatures on operating equipment. It is useful for diagnosing electrical equipment and can identify loose or improper terminations, load imbalances, overload conditions, and other typical electrical problems. Thermography is also used to analyze mechanical equipment to assess steam trap performance and motor/belt temperature profiles.

"Infrared imaging is, without a doubt, the most cost effective technique for assessing the health of electrical equipment. Anyone still going around tightening electrical connections as part of a preventive maintenance program should stop and take a look at the advantages of an infrared inspection program," says Evans.

Routine checkups are established for the testing of mission critical equipment. Diagnostics are also used to troubleshoot problems as they occur in order to determine the root-cause of identified problems and institute long term corrective measures to prevent their reoccurrence. The NIH predictive maintenance program has already demonstrated a significant increase in equipment reliability, as evidenced through fewer maintenance order calls and a drastic reduction of common mechanical failures.

Maximum Benefits

The CBM program implemented by NIH helped identify numerous opportunities for cost reduction in the organization's installations by identifying potential problems and initiating proactive changes to improve equipment performance.

"If equipment reliability is maintained at a high level over the entire lifecycle of a building—so equipment is lasting 20 to 30 years instead of 10 to 15 years—this can generate a considerable amount of operational savings," says Evans.

Energy consumption is one of the biggest costs associated with operating BSL facilities. Ensuring that building components are operating as efficiently as possible also has a notable impact on the bottom line, and CBM can help to optimize energy efficiency.

"There are significant financial benefits in terms of overall reduction in maintenance expenses by implementing a CBM approach. Improved reliability can enhance revenues because your customers can perform their mission with minimal service interruptions," says Evans.

Biography: As vice president of technology at Blue-Cardinal, **Jeff Evans** provides consulting and technical services in the development and implementation of Condition Monitoring and Asset Management programs. He has more than 18 years of experience in the operation and maintenance arena and has worked in a variety of industries including utilities, chemical, waste water, manufacturing, and facilities management. He has experience in all facets of Preventive and Predictive Maintenance Program implementation including data acquisition and analysis, RCM, Maintenance Optimization, Root-Cause Failure Analysis, and Systems Integration. He has been Program Manager for the NIH project for the last five years. He is certified in vibration analysis, infrared thermography, and oil analysis. Evans has authored dozens of articles and presentations at industry events.

This report is based upon a presentation by Jeff Evans and Daniel Smith at the Tradeline *2007 International Conference on Biocontainment Facilities* in March.

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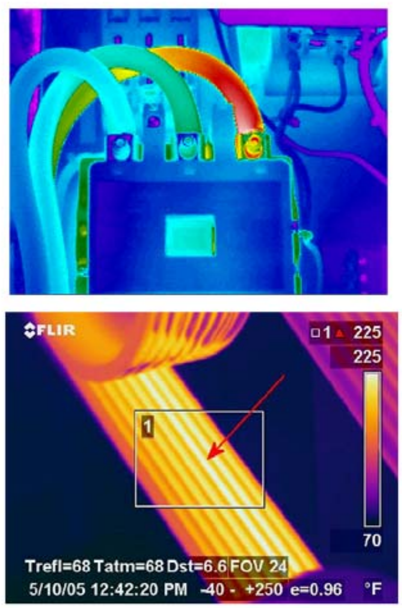

Infrared thermography is a thermal imaging technology that analyzes equipment heat signatures and can identify typical electrical problems, mechanical malfunctions, and potential belt failures. *(Image courtesy of Blue-Cardinal.)*

Operations and Maintenance Impact on Design of Biocontainment Buildings

Due to the high costs related to operating BSL-rated facilities, instituting a comprehensive, data-driven facility operations and maintenance program is one of the biggest factors in the long-term success of biocontainment research programs. The cost of operating a biocontainment facility will exceed the facility design and construction cost within the first five years of operation, according to data presented by Daniel Smith of Atlanta-based Smith Carter Architects.

The average construction cost for a biocontainment facility in North America is currently between $600/sf and $800/sf ($70 million for 100,000 sf), but the cost of operating the facility will eclipse that capital investment by year six and continue climbing for the next 25 to 50 years. As a result, having operations and maintenance personnel involved in the design and construction process of a biocontainment facility and incorporating “best practice" procedures is an important part of reducing ongoing costs over the lifecycle of the facility.

Smith Carter Architects, which has developed some of the world's most leading-edge, high-containment research facilities for the Canadian Science Centre, the CDC, the NIH, and the U.S. Army, requires all contractors to produce a set of highly detailed construction coordination drawings.

"We want to make sure that this contractor is doing all his due diligence to make sure that he understands what his means and methods are," says Smith.

There are numerous protocols established for lab decontamination that are impacted by decisions made during the design and construction process. There may be carts that run down aisles that have both width and height considerations and equipment clearance parameters that are necessary for regular maintenance.

"Operations and maintenance begins the moment a piece of equipment hits the site. It's important that we know how it is stored, how it is installed, and how it is maintained. The commissioning process is an important part that operations and maintenance staff absolutely needs to be involved in," says Smith.

Biography: Daniel Smith is a project manager with Smith Carter Architects and Engineering in Atlanta.

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Smith Carter Architects requires contractors to produce detailed construction coordination drawings for all high containment facilities. The drawings are considerably more detailed than normally required and indicate where piping conduit and duct work will run to accommodate things like light fixtures, air distribution systems, sprinkler systems and electrical systems. *(Image courtesy of Smith Carter Architects.)*