

COMMUNICATION AND ACCOUNTABILITY ARE THE KEYS TO SUCCESS IN CONDITION-BASED MAINTENANCE

by

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ABSTRACT

By the mid-1990s, a large chemical company, in Kingsport, Tennessee, had over 10 years' experience with several condition monitoring technologies, and were recognized as being technically proficient in predicting equipment problems before they caused production interruptions. These results were produced from a central predictive maintenance (PDM) group with seven core predictive technologies serving a plant containing over

20,000 rotating equipment trains. However, management could see room for improvement in communicating condition status information and holding both operations and maintenance personnel accountable for acting on it. They modified the maintenance organization for each operating area, and in 1999 implemented a web-based system to integrate and communicate predictive maintenance results. This paper describes the chemical company's organization and web-based system for integrating and communicating predictive maintenance information, and discusses the improvement in holding operations and maintenance personnel accountable for condition-based maintenance results.

INTRODUCTION

Over the past 20 years, many US plants have invested heavily in condition monitoring technologies such as vibration, oil analysis, thermography, and motor circuit evaluation to provide an accurate prediction of plant equipment problems. These predictive maintenance programs use best of breed technical equipment along with trained and certified analysts, and they often produce solid technical results. Each month valid condition monitoring results are produced and distributed to plant maintenance and operations personnel. So why do critical machines that have been identified as degraded in advance continue to fail in service? Why do many predictive maintenance programs have their funding and staff cut at the first sign of a sales decline?

The problem is actually that plant management implemented condition monitoring without laying the groundwork for condition-based maintenance. What is the difference? Condition monitoring is largely a technology and training issue while condition-based maintenance requires the existence of a reliability culture involving both operations and maintenance. Innovative plants such as Eastman Chemicals, in Kingsport, Tennessee, have found that a consistent program of communication and accountability have helped them to instill and sustain that type of condition-based maintenance culture.

CREATING A CONDITION-BASED MAINTENANCE PLANT CULTURE

Typically, top management sets a condition-based maintenance vision:

“Our plant will. . .

- Eliminate in service failures on critical equipment,
- Eliminate costly preventive (scheduled) maintenance work when condition analysis shows no need for the work,
- Eliminate basic machinery problems so that less total maintenance is required,
- Extend the life (reliability) of plant equipment while achieving the lowest total lifecycle cost, and
- Measure program results and adjust resources and focus as needed.

The plant then proceeds to either buy monitoring equipment and train personnel, or hire predictive maintenance contractors. So the plant must be doing condition-based maintenance...right?

Not really—condition-based maintenance is far more than conducting condition monitoring activities and developing technical proficiency with the tools. Those steps are necessary, but so is the need for upper management to instill a mindset that equipment reliability is the shared responsibility of operations and maintenance. Until that shared attitude is made an integral part of plant culture, the reliability improvement initiative is fragile and prone to cutbacks, inattention, and failure. Therefore, top management’s responsibility must go beyond “setting the vision” and “acquiring monitoring technology” to include:

- Creating an effective system for communicating machinery health status
- Holding plant employees accountable for follow-up actions and results

COMMUNICATING MACHINERY HEALTH STATUS EFFECTIVELY

In too many plants poor communication leads to wasted effort by the condition monitoring teams. Condition monitoring results are produced by multiple monitoring technologies, each using a different database and analysis software. This is inevitable as the plant strives to match the best system for a specific technology with the plant’s needs, or to select the best PDM contractor for certain technologies. Unfortunately, different technicians using dissimilar systems create reports with different formats and terminologies. These are usually dispersed among various people in different departments based on the technology, and quickly secluded in report binders and long e-mail lists. This piecemeal communication makes it difficult for a broad audience of maintenance and operations personnel to be aware of all known information about a specific asset’s health.

For example, the Kingsport plant is a large, multiproduct chemical facility with over 20,000 rotating machinery trains. The Kingsport plant began performing predictive maintenance in the mid-1980s and developed a predictive maintenance group using multiple technologies such as:

- Vibration monitoring (route and online)
- Infrared thermography
- Lubrication analysis
- Ultrasonic monitoring
- Motor analysis

By the mid-1990s, this predictive maintenance group was well respected for its technical proficiency, and was credited with preventing a significant number of production interruptions by catching equipment problems prior to failure. However, several people within the company’s management felt there was room to improve.

First, they realized that the organization was handling condition information as shown in Figure 1. Individual condition reports from different technologies were going to different maintenance contacts for an operation’s area. These contacts would usually have to negotiate with their operations counterpart over the need for and scheduling of repair activity, before being able to forward a request to the maintenance planner. This resulted in delays and “dropped balls” in handling equipment problems in a condition-based maintenance manner. The key issues leading to this result were:

- Few people, if anyone, had a complete picture of all known condition issues on a piece of equipment,
- Operations had very little “buy-in” to the concept of condition-based maintenance,
- The first notice maintenance managers had about “dropped balls” was usually a call from operations, after the fact.

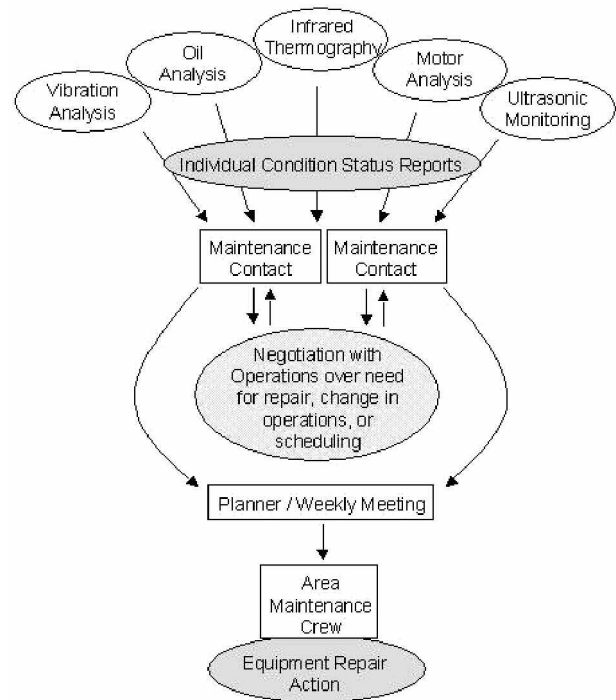


Figure 1. Old Flow of Condition-Based Work.

In the late 1990s the decision was made to modify organizational structure and information flow to improve use of equipment condition information and better support a condition-based Maintenance mindset.

The organization structure was modified as shown in Figure 2. The key change was assigning a single maintenance contact to each operating area; this contact is the liaison between the predictive maintenance group and operations. They work with operations to evaluate potential equipment problems and scheduling options for maintenance action, and are ultimately responsible for ensuring that timely maintenance action takes place.

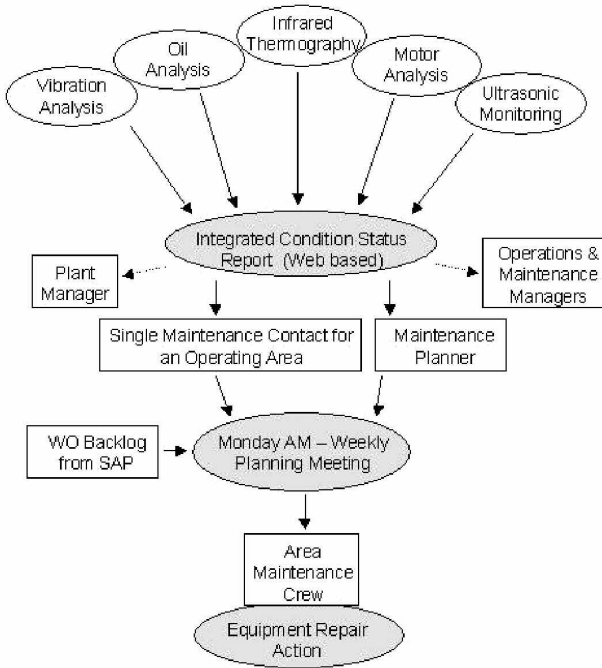


Figure 2. Modified Flow of Condition-Based Work.

Following the organization change it was also decided that an integrated condition status report was needed to merge findings and recommendations from each of the technologies being used to monitor a problem machine. High priority was put on making the integrated condition results easily available to a wide audience of operations, maintenance, and executive managers. The report had to be asset-based rather than monitoring technology-based, and it also needed to be accessible without requiring installation of special software by users. That led to creation of a web-based integrated condition status report system.

With the new organization and integrated condition status report in place, the weekly planning meeting became the focal point for joint responsibility of equipment reliability. Everyone involved, including predictive maintenance analysts, planner, and area operations and maintenance managers, now have access to the same equipment health status information before and while in the meeting. Issues cannot be swept under the table or ignored, and the group is able to spend their time focusing on operations scheduling and work order priorities for maintenance action.

There were several communications issues that had to be tackled in the evolution from technology focused reporting to asset-centered communication of condition monitoring results:

- Integration of health status information from multiple technologies
- Standardization of reporting format and terminology
- Distribution of findings, recommendations, and work status to a broad base of plant personnel

Integrating Condition Status in a Web-Hosted Database

The piecemeal communication described in the company's old organization is technology-centered, both in report generation and in who receives the reports. Integrating condition results from all technologies under each specific machine location is the first step toward asset-centered communication of health status. Web-hosted database technology offers a solution for asset centered integration. Condition results can be collected in a single web-hosted database, independent from the proprietary databases housing the technical data. In-plant technicians and outside PDM contractors enter plain language findings and recommendations into this web-hosted database via the Internet,

bypassing any issues about outside vendors having to cross security firewalls in the plant network. Authorized plant users login via a web browser to retrieve a health report for their area of the plant, without having to install and maintain any special software. Machines with severe health problems are marked with a red light at the top of the list. The Kingsport plant uses an asset-centered health status report as seen in Figure 3 to graphically communicate which machines have significant health issues based on all the monitoring technologies being applied to that machine.

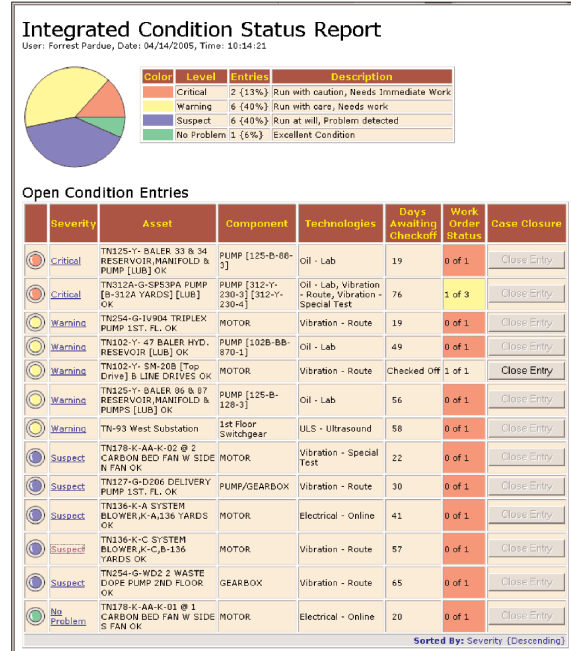


Figure 3. Multiple Technology Results Integrated for Each Asset Location.

Planners, supervisors, and plant managers can see what may affect operations, then drill down for more detail to support their daily decisions (Figure 4). If they are interested in the technical data behind the analyst's recommendations, they can open linked documents to view the supporting information.

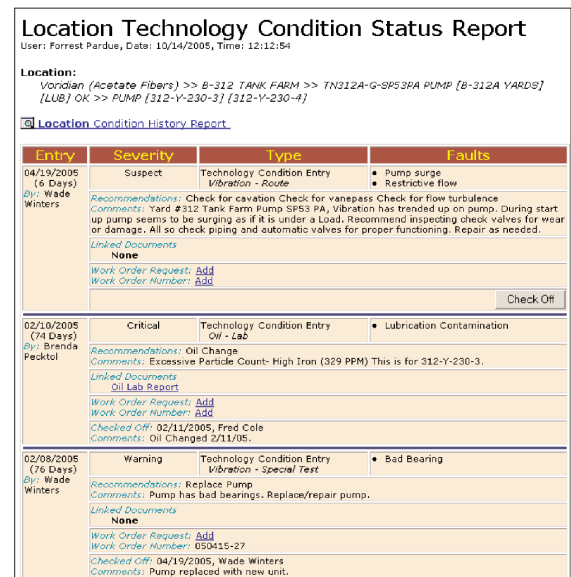


Figure 4. Drilling Down to Detailed Recommendations and Supporting Documents.

Once planners have generated a work order they can enter a reference number to the condition entry, so anyone who wants to check into work order progress knows where to look it up in the plant's database system. Once a work order reference has been entered, the integrated condition status report also shows how many days the oldest work order for an asset has been open. When the work is complete, the planner can also notify others by "checking off" the condition entry. When that is done, then the integrated status report also shows a "close entry" button for that condition case, as seen in Figure 3. The predictive maintenance technician responsible for that entry can then close the case and remove it from the report, in many cases after a follow-up monitoring session to confirm that the problem has been resolved.

Therefore, participants in the weekly planning meeting not only see condition status for problem machines, but they also get a snapshot of response and work status for those health issues. That keeps all departments informed on progress; such broad exposure of condition-based maintenance status also makes it a lot harder to hide shortcomings.

Standardization to Improve Understanding of Information

Just as in human medicine, it is very important that all parties use common terminology when describing machinery health issues. Standardization of condition results means that everyone inputting findings and recommendations use common equipment location names, faults, and severity levels, and that the output information has a standard look and content regardless of technology, analyst, or whether they are plant employees or an outside contractor.

Once again a single web-hosted database can provide a results entry form (Figure 5) that uses pull down lists to enforce standardized terminology. This screen utilizes a standard pull down list for the selection of faults, recommendations, and severity. The pull down lists also enforce brevity to make the information easier to understand; an analyst can also write a more comprehensive problem description if needed. Such standardization allows a common look and language between condition technologies, and it also facilitates future mining of the information for common patterns. This simple mechanism for standardizing basic findings and recommendation content does not exclude technical reporting, as supporting data images and documents can be linked to the condition entry, for retrieval by interested users.

Figure 5. Standard Condition Results Form.

Distribution to a Broad Plant Audience Via a Web Browser

Something amazing happens in human organizations when people know that information about their area of responsibility is widely available to others. They care more about what is happening and tend to focus their energy on doing a better job. This applies to executives as well as managers, engineers, and craftsmen.

Web-browser technology is well suited for allowing a broad base of users to access equipment health information with minimum effort, while still providing some control over what each individual

user can view or interact with. Practically all computers have an Internet browser installed, so there is no need to install and maintain specialized software. They only need the correct URL for their web-hosted database, along with an authorized user name and password, to see the current health status of equipment in their area of concern.

One of the reliability engineers at the Kingsport facility credits the wide and persistent visibility of condition results as one of the keys in making operations and maintenance joint owners of equipment reliability. He says that "prompt response to resolve condition-based maintenance issues" has become the way of life because everyone knows that "the bosses care."

Accountability for Results

Good communication of condition status may be essential for guiding work prioritization, but that alone does not mean that the best condition-based maintenance results are being delivered to the plant business.

Personnel must be held accountable for using the information to produce increased reliability results. Two important execution measurements for condition-based maintenance are:

- If equipment does show health issues, are timely maintenance responses happening?
- Is condition history being kept and analyzed to spot and address chronic reliability issues?

As has been said many times—"What gets measured gets done!"

In addition to the work response measures available in the integrated condition status report, the company has taken advantage of a single database with integrated condition results and work follow-up status to generate several custom reports. One of these trends the timeframe in which condition-based work orders are resolved; the report can be set to cover all condition-based activity or a single technology in a specific operations area. Figure 6 shows that over 90 percent of work requests generated by vibration monitoring during the first nine months of 2004 had been addressed and resolved.

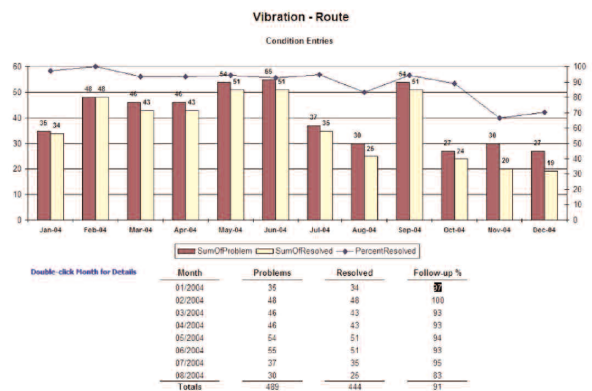


Figure 6. Customized Maintenance Followup Report for Condition-Based Work Orders.

A reliability technology report (RTP) for vibration monitoring is shown in Figure 7. It tracks resolution of condition-based work requests and is available to area managers for more detail on how well their crews are utilizing information from a specific predictive technology. It shows area operations and maintenance managers how condition generated work orders were handled during the month, and how their area compared to others. Area managers typically focus on the year to date (YTD) "percent corrected" table at the bottom and ask "what do we have to do to get better?" Predictive maintenance technicians also review these reports to understand which areas may need additional help in using their information.

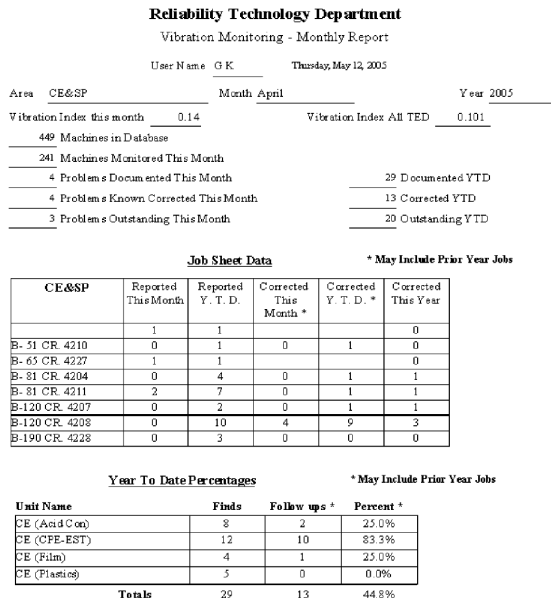


Figure 7. Customized Maintenance Followup Report by Individual Monitoring Technology.

USE OF HISTORICAL CONDITION INFORMATION

The company's condition monitoring analysts and reliability engineers are also able to receive custom reports that help them identify chronic failure issues. In their "Faults by Component" report, the user selects plant areas, timeframe, and monitoring technologies; the example shown in Figure 8 covers all technologies being used across several operating areas for 2005 YTD (through June 2005). Reduction gearboxes quickly stand out with the highest number of faults. Drilling into the report would uncover filter design and lubrication issues that are the greatest common denominators behind the gearbox faults; providing important information for targeting reliability improvement initiatives. For example, over the last several years this company has significantly reduced chronic equipment problems such as imbalance, misalignment, lubrication, and installation issues by using historical failure mode information to change procedures and justify special training and tools.

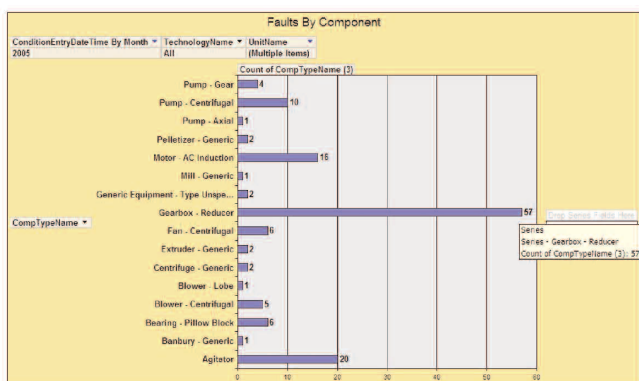


Figure 8. Customized Report for Number of Faults by Equipment Type, 2005 YTD.

The company has also been able to use historical condition information to fine-tune its condition monitoring activities. When a condition monitoring "find" is defined as leading to a maintenance or repair action, it is generally accepted that condition monitoring programs at industrial plants typically progress according to the trend shown in Figure 9.

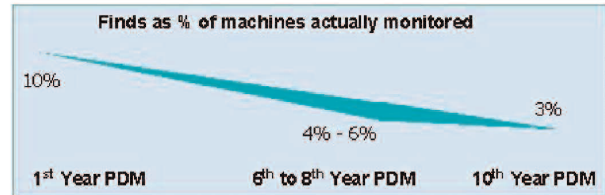


Figure 9. Typical "Find Percent" as PDM Program Matures.

A reliability engineer there used the historical information to calculate their "find percent" and found that they were at the 4 percent level in the mid-90s and reached 2½ percent around 2003. It is probably not a coincidence that the improvement in reliability culture was occurring at the same time. Management's confidence in condition-based maintenance execution helped decide to reduce vibration monitoring frequency for less critical equipment from monthly to every other month or even quarterly. They were then able to shift some manpower from routine monitoring to higher value added root cause analysis activities. It is also probably not a coincidence that over the same time period the wrench-turning maintenance force has decreased from approximately 1200 employees to around 800, while production capacity has slightly increased.

CONCLUSION

At the Kingsport, Tennessee, chemical company, the management vision for condition based-maintenance and equipment reliability has really been embedded in most of the plant's culture:

- Operating area "bosses" know and care about what is happening with equipment reliability because they can view current integrated condition status and work response via their web-browsers.
- A weekly planning meeting is the focal point where operations and maintenance work together to prioritize work based on condition status—to the point that condition surveys conducted on Friday are expected to be entered and responded to in time for the Monday morning planning session! That is culture change!
- Accountability is consistently based on condition status and work execution rather than informal complaints from operations.
- Condition history is being used to spot chronic equipment problems and focus reliability improvement resources, as well as fine-tune the monitoring activity.

One of the significant contributors to the company's condition-based maintenance success is their single database for housing all equipment condition status and web-based distribution of information from that database (Figure 10).

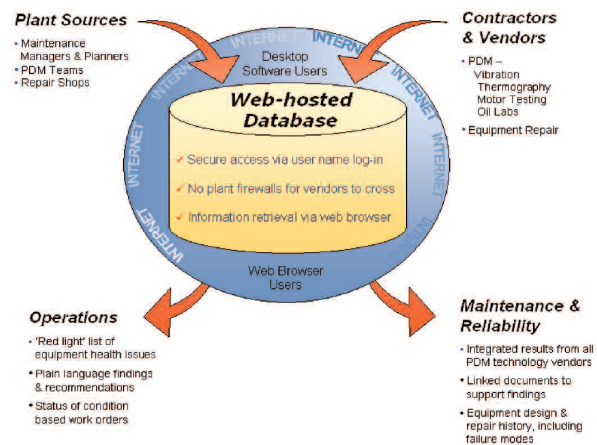


Figure 10. Web-Hosted Database Model for Containing All Condition Results in a Single Database and Communicating Integrated Condition Status to a Large Plant Audience.

