COMMUNICATION and ACCOUNTABILITY are the KEYS to SUCCESS in CONDITION-BASED MAINTENANCE

Steve Quillen
Eastman Chemical Company
Kingsport, TN
squill@eastman.com

Forrest Pardue
24/7 Systems, Inc.
Louisville, TN
parduef@tf7.com

Dick Hancock
24/7 Systems, Inc.
Louisville, TN
hancockd@tf7.com

Abstract: The goal of equipment condition monitoring is to increase equipment availability, increase product yield and quality, and reduce maintenance cost by:

1. Eliminating in service failures on critical equipment
2. Extending the life (reliability) of plant equipment
3. Eliminating costly prevention (scheduled) maintenance work when condition analysis shows no need for the work

Over the past 20 years, 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. Most plants put significant time and resources into measuring equipment condition, and then much of the information is never acted upon – What's up?

Often the problem is that condition-based maintenance programs are begun by corporate or plant managers and never get "buy-in" from plant maintenance. When plant maintenance supervisors are asked why they do not act on condition-based results you can hear many excuses like:

- Do not believe the results
- Not enough time
- Lost or did not look at the report
- No money – costs too much
- Operations will not allow repair
- When a machine fails they are the hero and receive overtime

Many plants have noted that it often takes a catastrophe to get buy in for condition-based maintenance. Some innovative plants have found that a consistent program of communication and accountability have made the shift to condition-based maintenance easier and faster.

Text:

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 of 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?

Pick an excuse:

- It just doesn't work here
- We're too reactive to be proactive
- Lack of management support
- Lack of production support
- Cultural barriers
- Lack of training
- Operators will not allow repairs
- No money – cost to much to do the repairs
- Maintenance will lose its overtime

The problem is actually that plant management implemented condition monitoring without laying the groundwork for condition-based maintenance. What's the difference? Condition monitoring is largely a technology and training issue while condition-based maintenance requires the creation of a reliability culture. Innovative plants such as Eastman Chemicals in Kingsport, Tennessee have found that a consistent program of communication and accountability have made the shift to a condition-based maintenance culture easier and faster.

Creating a Condition-based Maintenance Plant Culture

Top management sets the Condition-based Maintenance vision:

"Our plant will…

- Eliminate in service failures on critical equipment
- Extend the life (reliability) of plant equipment
- Eliminate costly preventive (scheduled) maintenance work when condition analysis shows no need for the work

So the plant must be doing Condition-based Maintenance… Right?

Actually, until Condition-based maintenance is made an integral part of plant culture, the reliability improvement initiative is fragile and prone to cutbacks, inattention, and failure. Top management's responsibility for establishing plant culture must go beyond 'setting the vision' to include:

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

Communicating Machinery Health Status Effectively

In too many plants poor communications lead to wasted effort by the condition monitoring teams. Condition monitoring results are produced by multiple monitoring technologies, each using 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 multiple systems create separate reports with different formats and terminologies. These are usually dispersed among a few 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. In an effective condition-based maintenance culture, all known condition results for a troubled asset should be easily available to operations and maintenance decision makers for scheduling and work order decisions. Several communications issues have to be tackled in the evolution from technology focused reporting and communications to asset-centered communication of condition monitoring results:

1) Integration of health status information from multiple technologies

2) Standardization of reporting format and terminology

3) Distribution of findings, recommendations, and work status to a broad base of plant personnel

1) Integrating Condition Status in a Web-hosted database

The piecemeal communication described above is technology-centered, both in report generation and 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. Eastman Chemicals in Kingsport, Tennessee uses an asset-centered health status report, as seen in Figure 1, to graphically communicate which machines have significant health issues based on all the monitoring technologies being applied to that machine.

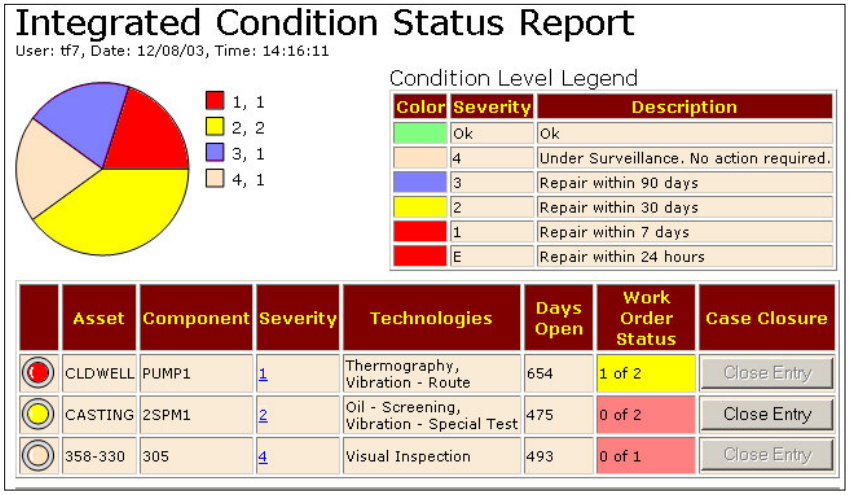


Figure 1: Multiple technology results integrated for each asset location

Maintenance planners, production supervisors, and plant managers can see what may affect operations, then drill down for more detail to support their daily decisions (Figure 2). If they are interested in the technical data behind the analyst's recommendations, they can open linked documents to view the supporting information.

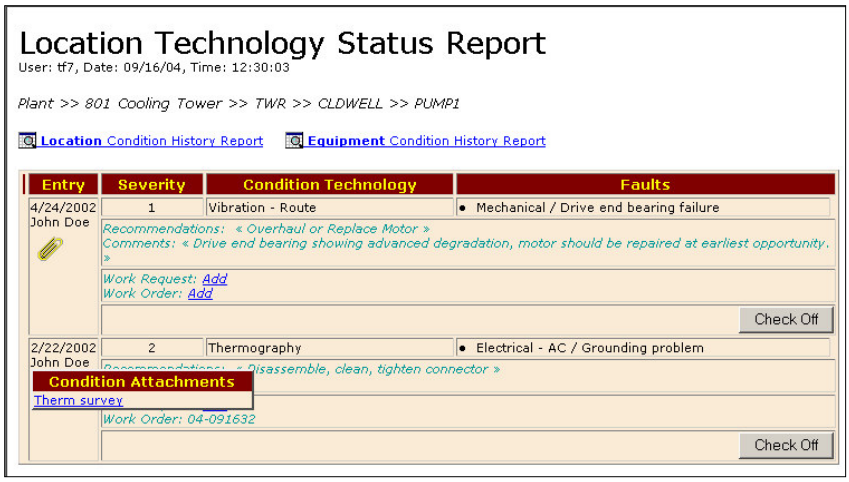


Figure 2: Drilling down to detailed recommendations & supporting documents

2) 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 mean 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're plant employees or an outside contractor.

Once again a single web-hosted database can provide a results entry form (Figure 3) 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.

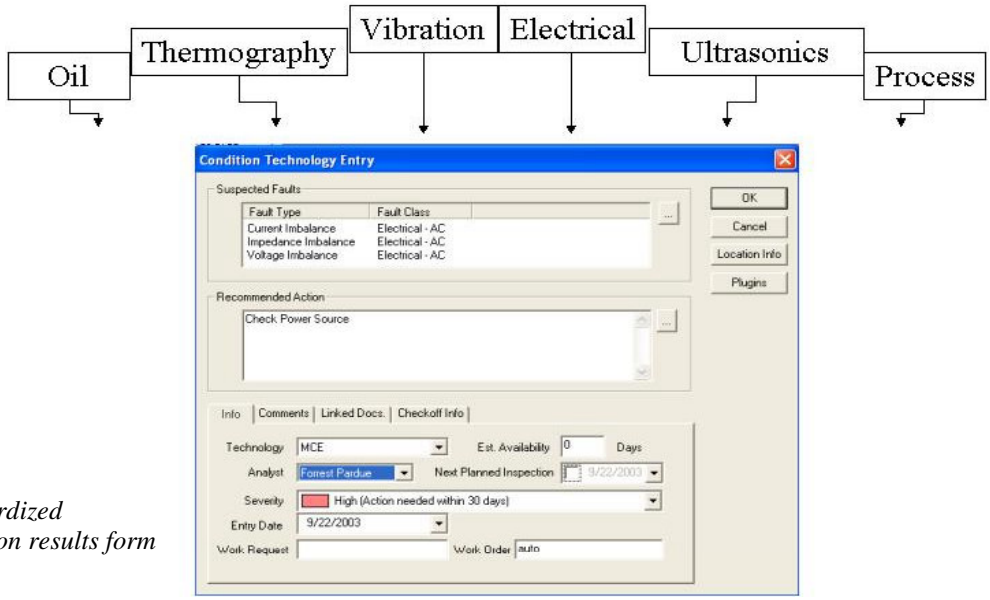


Figure 3: Standardized condition results form

3) Distribution to a Broad Plant Audience via 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's 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. Most users already have an Internet browser installed on their computer so there's 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.

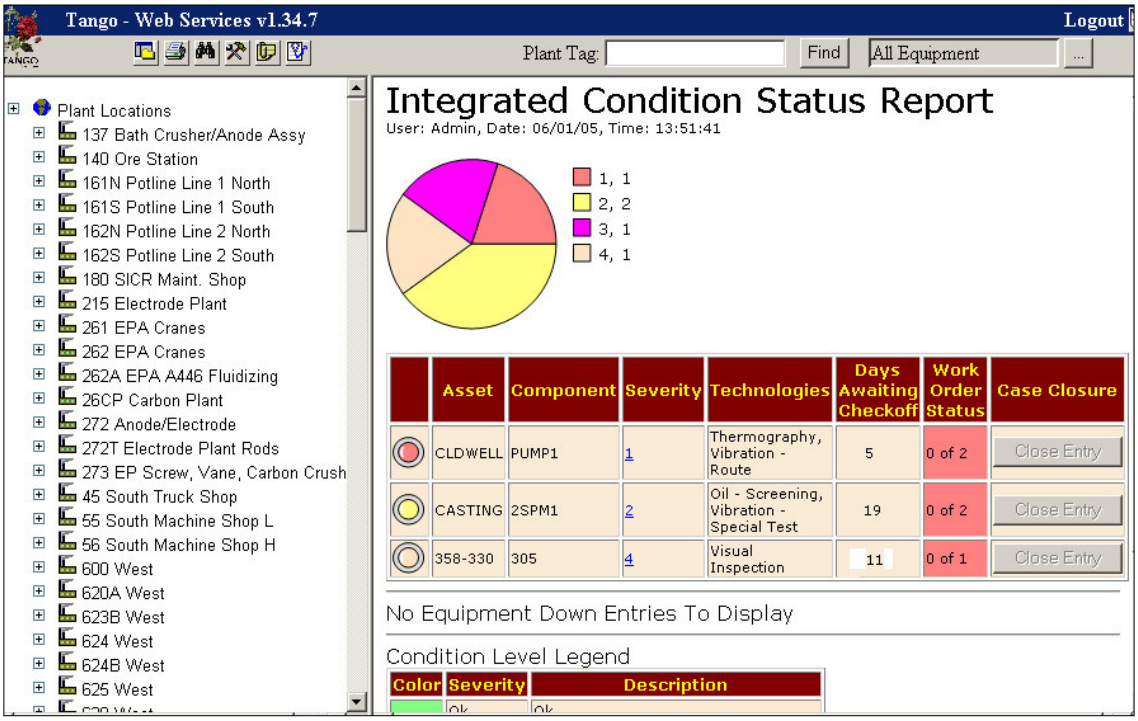


Figure 4: Web-browser report on current equipment health status for user's specific area of interest

When the simplicity of a graphic equipment health status report as seen in Figure 4 is combined with the convenience of web-browser distribution, it's much easier for operations and maintenance personnel to work together toward condition based maintenance. In the four years since the web-browser condition status report has been available Eastman Chemicals in Kingsport, Tennessee participation in the maintenance scheduling process by operations personnel has increased dramatically according to one reliability engineer at the plant. Area managers use the integrated information to prepare for weekly maintenance planning meetings; they now show up ready to discuss critical problems and to assure themselves that reasonable action is in place to prevent in-service failures, one of the plant's key initiatives.

Since the web-browser report also shows the status of work generated in response to the condition information, so managers, supervisors, and technicians can easily keep abreast of how well they're achieving condition based maintenance goals. Everyone can see if a work order has been generated in response to the condition entry, and how many days the work order has been open. That keeps all departments informed on progress; on the flip side, such broad exposure of condition based maintenance status also makes it a lot harder to hide shortcomings.

Accountability for Results

If a plant really wants to execute condition-based maintenance rather than just run a condition monitoring program, then plant personnel must be held accountable for results after effective communications are in place. Three of the most important execution measurements for condition-based maintenance are:

1) Has all the equipment set up for monitoring actually been measured on a timely basis?

2) If equipment does show health issues, are timely maintenance responses happening?

3) Is condition history being kept and analyzed to spot long term reliability issues?

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

Performance of Monitoring Tasks

Accountability is also needed in the management of work and validation that the monitoring tasks are being performed on time and that missed critical machines have been flagged for follow-up. Reports that make it easy to know when the PDM program is getting behind and needs to adjust priorities or add resources are critical.

One approach plants have taken is to create the monitoring routes as task in the plant CMMS. This produces a record that a route was performed but no record of which machines were monitored and their status. This leaves the plant with very little validation of monitoring activity and survey results history at the equipment level. This issue is even more complex when an outside contractor is used to collect data.

Once again, a single web-hosted database makes it very practical to monitor the scheduling of "condition assessment tasks" down to each equipment location level. These tasks can be assigned to a specific individual on an ongoing basis, or can be re-assigned to different technicians as needed. Automatic e-mail notifications can be sent prior to due dates to aid work planning. Web-hosting also allows tasks assigned to outside contractors to be scheduled and managed just as if they were inside the plant, since they can post results without having to cross plant firewalls. Figure 5 shows how graphically the status of monitoring for each piece of equipment can be presented once all the technology results have been housed in a single web-hosted database, making it easy to manage timely condition measurements.

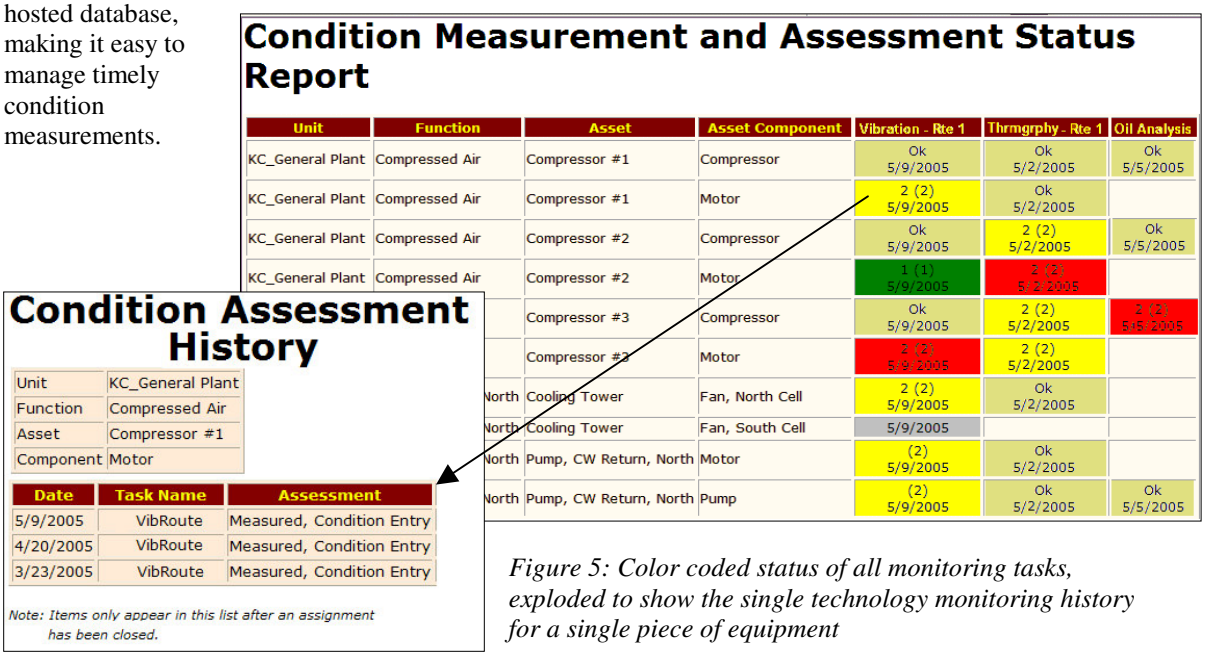


Figure 5: Color coded status of all monitoring tasks, exploded to show the single technology monitoring history for a single piece of equipment

Timely Maintenance Response

Even when condition monitoring tasks are well timed far too many plants allow machinery problems to "fall through the cracks" until emergency maintenance is required. Wide distribution of the integrated condition status report discussed earlier is the first line of defense at Eastman Chemicals. Their Rotating Equipment Group engineer reports that in 4 years since the dynamic web-report has been available, awareness of condition-based work requests is significantly higher among production managers and plant management. He says that "prompt response to see that maintenance issues are resolved" has become the way of life because everyone knows that "the bosses care".

Eastman Chemicals has also taken advantage of a single database with integrated condition results and work follow-up status to produce several custom reports. One report tracks resolution of condition-based work requests and is e-mailed to area managers for monitoring how well their crews are utilizing information from different predictive technologies. Figure 6 shows an example for one operating division:

Reliability Technology Department

Vibration Monitoring - Monthly Report

User Name GK Thursday, May 12, 2005

Area CE&SP Month April Year 2005

Vibration Index this month 0.14 Vibration Index All TED 0.101

449 Machines in Database

241 Machines Monitored This Month

4 Problems Documented This Month 29 Documented YTD

4 Problems Known Corrected This Month 13 Corrected YTD

3 Problems Outstanding This Month 20 Outstanding YTD

Job Sheet Data * May Include Prior Year Jobs

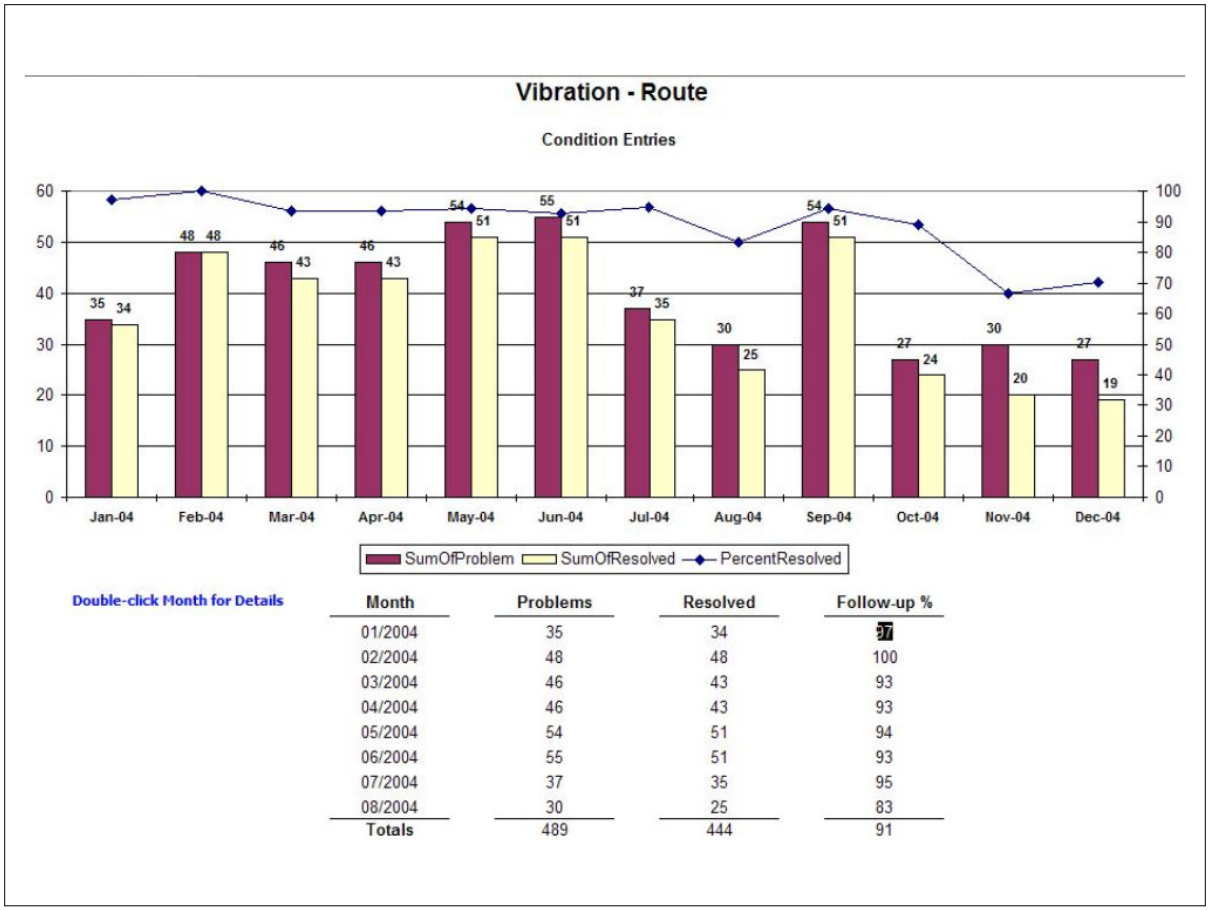
CE&SP	Reported This Month	Reported Y. T. D.	Corrected This Month *	Corrected Y. T. D. *	Corrected This Year
	1	1			0
B- 51 CR. 4210	0	1	0	1	0
B- 65 CR. 4227	1	1			0
B- 81 CR. 4204	0	4	0	1	1
B- 81 CR. 4211	2	7	0	1	1
B-120 CR. 4207	0	2	0	1	1
B-120 CR. 4208	0	10	4	9	3
B-190 CR. 4228	0	3	0	0	0

Year To Date Percentages * May Include Prior Year Jobs

Unit Name	Finds	Follow ups *	Percent *
CE (Acid Con)	8	2	25.0%
CE (CPE-EST)	12	10	83.3%
CE (Film)	4	1	25.0%
CE (Plastics)	5	0	0.0%
Totals	29	13	44.8%

Figure 6: Customized maintenance follow-up report by individual monitoring technology – monthly basis

Eastman Chemical also generates a custom report to trend the timeframe in which condition-based work orders are resolved. Figure 7 shows that over 90% of work requests generated by vibration monitoring in over the first 8 months of 2004. That's one key indicator that Eastman Chemicals is effectively implementing a condition-based maintenance culture.



Month	Problems	Resolved	Follow-up %
01/2004	35	34	97
02/2004	48	48	100
03/2004	46	43	93
04/2004	46	43	93
05/2004	54	51	94
06/2004	55	51	93
07/2004	37	35	95
08/2004	30	25	83
Totals	489	444	91

Figure 7: Customized annual maintenance follow-up report by individual monitoring technology

Use of Integrated Condition History Information

With multiple technology condition information integrated into a single database, Eastman's condition monitoring analysts are also able to receive custom reports that help them identify problem areas such as what components are failing the most and what fault types are showing up most often. In the 'Faults by Component' report, the user selects plant area, time frame, and technology to include. The example shown in Figure 8 on the following page covers all technologies being used across several production units, for 2005 YTD. Reduction gearboxes quickly stand out as the most offending equipment type. The 'Top Ten' fault type report shown in Figure 9 was set to include problems uncovered through vibration analysis only, and shows that bearing problems were the most discovered fault with that technology. Both reports invite more detailed analysis with tools such as OLAP based data mining, to detect any common denominators such as service location or equipment design that could be targeted for reliability improvement initiatives. The information is also very helpful in helping to justify training and maintenance expenditures.

Figure 8: Customized report for number of faults by equipment type, 2005 YTD

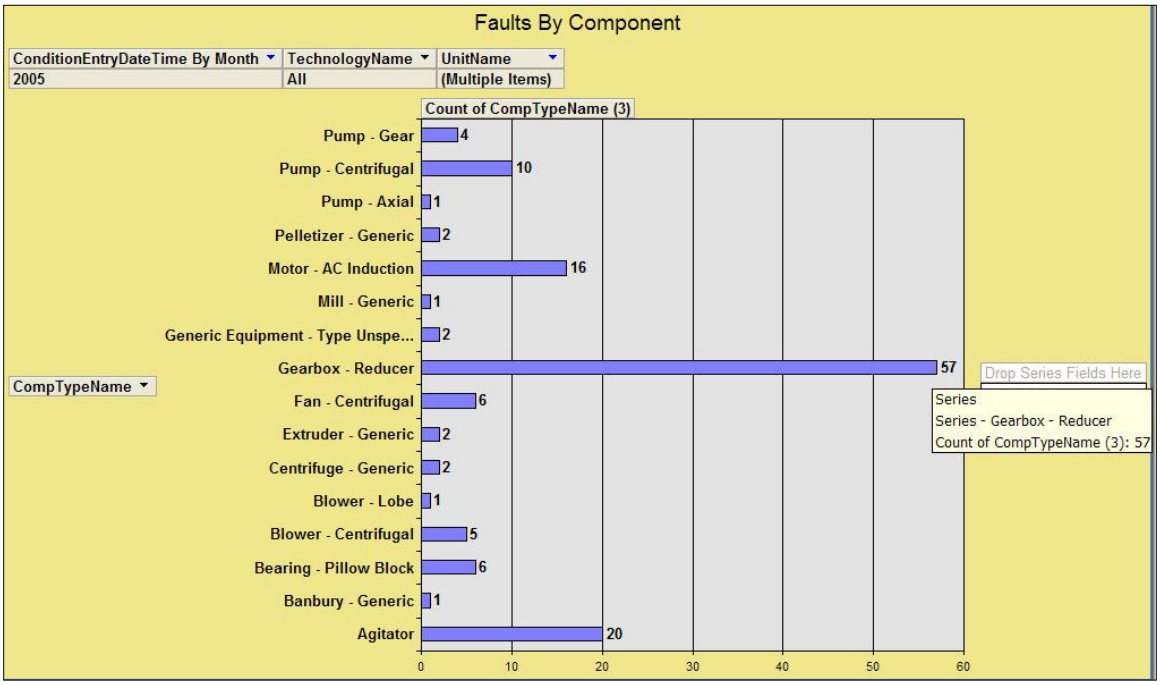
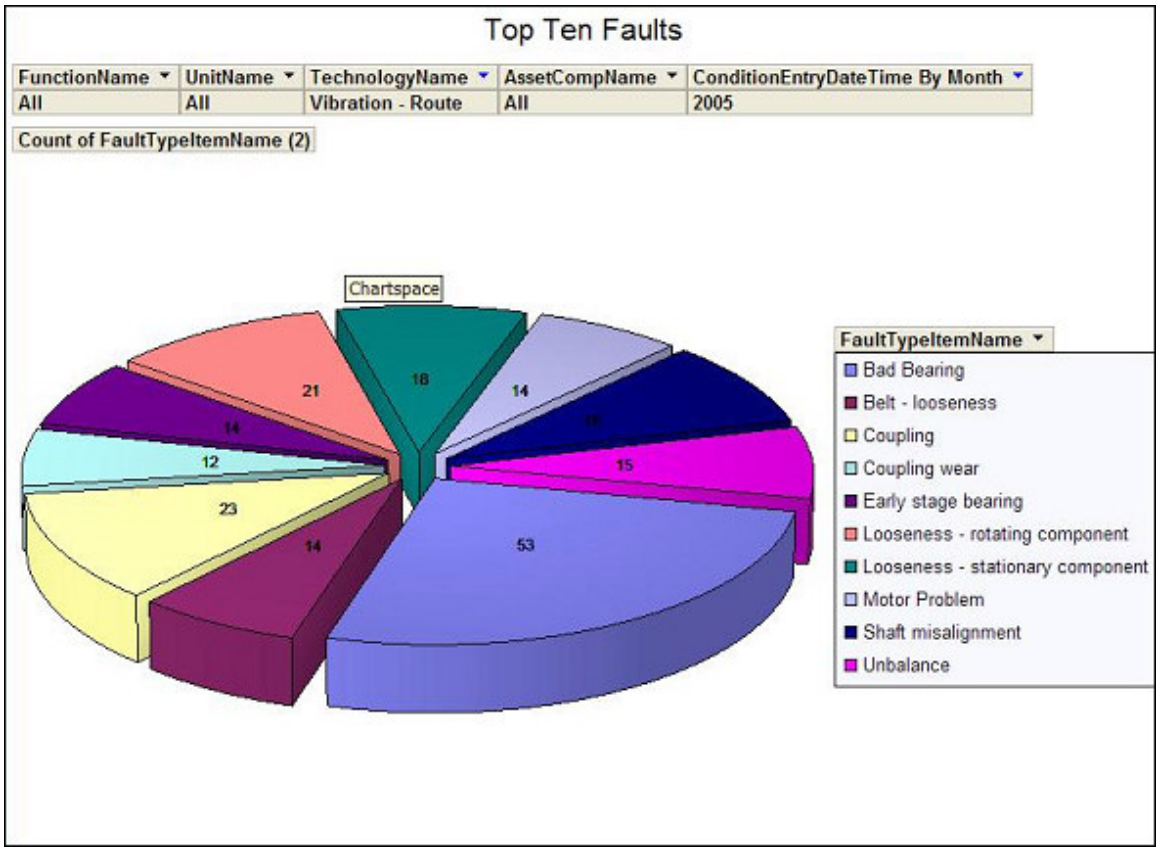


Figure 9: Customized report showing top ten fault types, 2005 YTD



In Summary:

Innovative industrial plants such as Eastman Chemicals, Kingsport, TN have found that effective communications of condition monitoring results is key component in turning predictive maintenance program into a condition-based maintenance culture. They have identified three major activities for achieving that communication:

1) integration of equipment health status from different monitoring technologies

2) standardization of reporting format and terminology

3) widespread delivery & convenient retrieval of asset-centered health status

As shown in Figure 10, today's web-hosted database technology can provide these requirements.

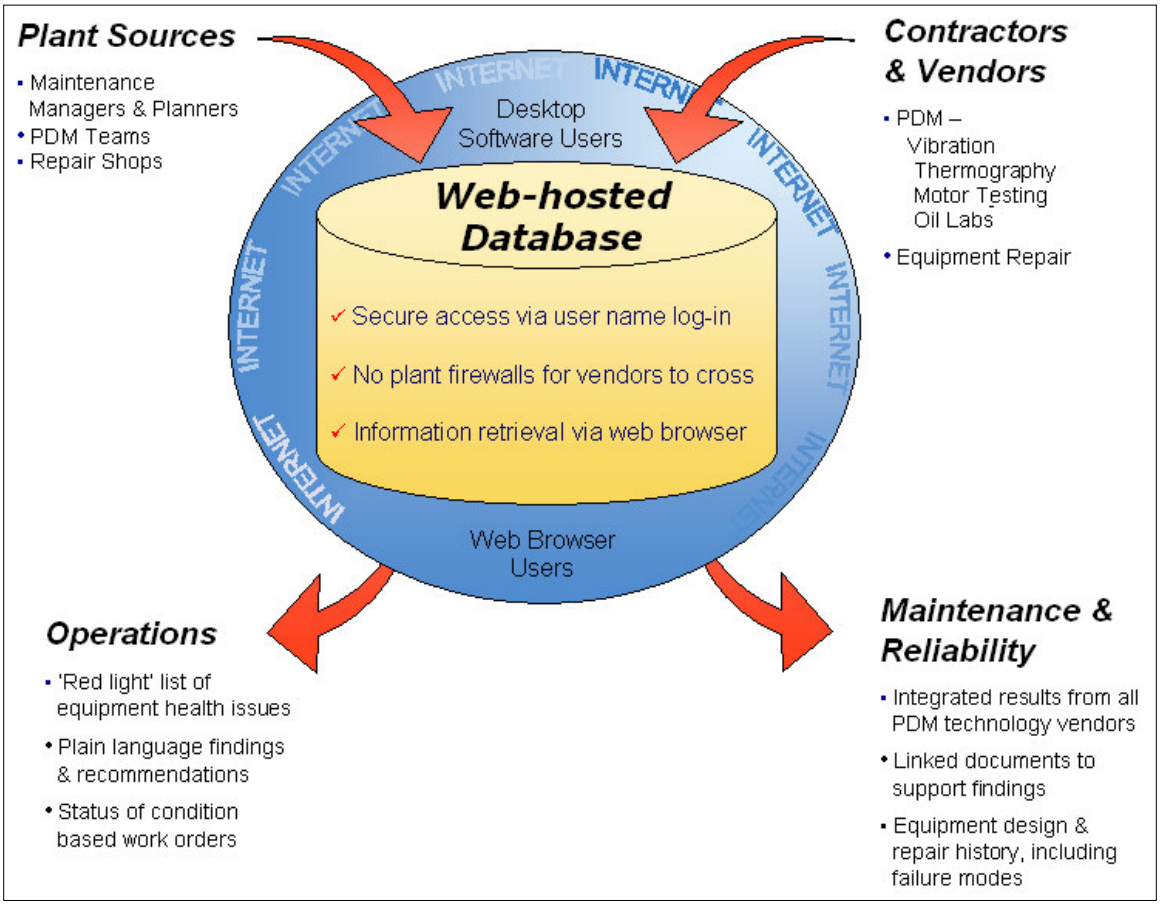


Figure 10: Web-hosted database model for communicating machinery health status to a large plant audience

Eastman Chemicals also recognizes that effective communication goes hand in hand with the ability to hold plant personnel accountable for results. Key components in that regard are:

1) Assurance that equipment monitoring schedules are being met,

2) Visibility on timely maintenance response to condition-based work requests, and

3) Effective use of condition history in a single database to spot repetitive reliability issues.