Many maintenance professionals agree that there are two basic reasons for the focus on reliability in industrial plants:

- Eliminating unexpected equipment failures that can interrupt production and cause high repair costs;
- Extending the life of equipment between repairs to lower total lifecycle costs.

To accomplish these goals a plant must implement and manage many condition monitoring, lifecycle tracking, and failure analysis activities. This involves many plant employees and contractors who generate and use hundreds of pieces of information for each asset. Unfortunately, many industrial organizations concentrate on the generation of condition, failure mode, and repair information. Only later does the realization come that reliability information needs to be standardized and integrated into a process that facilitates communication, accountability for action, and analysis. We believe that Reliability Information Management is the key to having accurate information available and accessible for the mitigation of unexpected failures and equipment lifecycle extension.

Why isn’t the need for a Reliability Information Management process apparent for any industrial organization as they begin a reliability improvement initiative? Most who have been down that road agree that ‘cultural change’ is one roadblock. It is a major task to get plant stakeholders refocused from decades of reactive and interval-based maintenance strategies to predictive and proactive ones.

There’s also the challenge of adopting and using condition monitoring technologies, even when they might be provided by service contractors. For example, look at the experience of Eastman Chemical Company in Kingsport, TN that was documented in a paper presented at the 2005 SMRP Conference (1). That paper describes how Eastman Chemical Company began implementing several condition monitoring techniques in the mid 1980’s. By the mid-90’s their 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. Yet co-presenter Mark Mitchell of Eastman Chemical Company noted that “several people within management felt there was room to improve as we still haven’t achieved a condition-based maintenance culture”.

Finally, good documentation takes planning, and let’s face it, many organizations are ready to ‘ready, shoot, aim’ when making investments in new programs.

So, what kinds of reliability information are we talking about? During the ‘cradle to grave’ life of a piece of industrial equipment there are many ‘life stages’ generating information (Fig 1):

- Initial purchase documentation, including design specifications, purchase documentation, installation instructions, warranty details;
- Location at the plant – does the equipment initially go into a stores location, or into a functional service location?
- If in stores, periodic tests, inspections, or maintenance procedures may be performed; is there an auditable history of those procedures?
- If installed in a functional location, are there condition monitoring and physical inspection tasks checking the health status of the equipment?
- When repairs are needed, is information about the failure modes and root cause of failure being documented?
- Where are the documents (photographs, specifications, drawings, & reports) associated with each life cycle stage being kept?
How does this equipment life cycle information fit the two basic reliability improvement objectives?

Extending life between repairs, and in fact extending the overall length of service, requires a wider range of information to feed failure analysis and root cause identification (Fig 3). It starts with knowing equipment design details, and the history for both service locations and individual pieces of equipment. Even with excellent condition monitoring technique, identification of developing failure modes is still an inexact science that should be confirmed during the repair to understand whether root causes of failure are linked to equipment design, location environment, or operational problems.

Many organizations look first to their plant’s CMMS to be the master program holding all the reliability information. CMMS systems are usually strong in managing maintenance work transactions related to equipment locations, but often weak in handling condition monitoring information related to functional locations or any detail about specific pieces of equipment. This leads some plants to pursue a ‘bits and bytes’ transfer of data by contracting an integrator to program links between various data sources. In many cases they focus on trying to link inspections also produce valuable information about the condition of operating equipment – this comes from the ‘installed in service’ stage. Periodic tests and maintenance during the ‘stores’ phase also contribute. What is important is the ability to access and utilize any and all information for clues (Fig 2).
multiple plant sources with years of historical equipment data, where non-standardized definitions for equipment and fault modes make it difficult to ensure data quality. This integration effort can certainly produce information flowing between programs, but can be costly to initiate, take significant time to implement, and be costly to maintain.

What is often overlooked is that much of the reliability information is generated outside the plant by equipment suppliers, service contractors, and repair vendors. These outside sources traditionally deliver the information via e-mail because they are not allowed direct access to a plant’s IT system – yet how many plants have personnel with the time and patience to transfer e-mailed documentation into a plant database?

Eastman Chemical Company and North American Stainless are two large industrial plants who have focused on their Reliability Information Management process.

For Eastman Chemical Company, their mid-90’s conclusion that they needed to create a condition-based maintenance culture resulted in the communication of equipment condition issues to a wider audience and increased accountability for appropriate response. They realized that individual condition reports from different technologies were going to different maintenance contacts for an operations 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. The key issues behind 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.

In the late 1990’s Eastman Chemical Company – Kingsport decided to improve their use of equipment condition information and drive a Condition-Based Maintenance mindset. High priority was put on making integrated condition results easily available to a wide audience of operations, maintenance, and executive managers. The communication had to be asset based rather than monitoring technology based, and it also needed to be accessible without installation of special software by users. That lead to the specification of a web browser based Integrated Condition Status Report system.

North American Stainless in Ghent, Kentucky started focusing on Reliability Information Management in late 2005. Up until that time the central reliability group e-mailed a variety of equipment condition reports to area engineers. They received feedback on planned actions and status by reply e-mails or by searching for work order history in the CMMS. With over 20 area engineers involved along with input from maintenance technicians, operations, and vendors, the high volume of e-mail and report documents could be very difficult to manage and track. Often the e-mail trail for specific issues would eventually be lost. In those cases any attempt to track maintenance response or pinpoint root causes of failure at times depended more on tribal knowledge than documented facts.

North American Stainless used a web service offered by a lubricant vendor that allowed the reliability group to store PDF reports for retrieval. While each PDF document could be searched for specific machines or mill areas, simply
having a collection of PDF reports did not always provide a useable overview of critical equipment problems and status. Along with the individual PDF reports, the group was still maintaining Excel spreadsheets to help summarize information. They desired a more automated approach to reporting that allowed more interaction by all individuals involved with maintenance and reliability of assets. That experience led North American Stainless to develop its own wish-list for a web-based Reliability Information Management system early in 2008, and to consider building the system in-house.

It turned out that many of the key items on their wish-list were similar to those specified by Eastman Chemical Company years earlier:

- Show current machine health status for plant assets, based on all known results from all condition monitoring activities, including those being provided by service contractors

- Provide e-mail notification to the appropriate plant personnel when a new health problem is posted to the system

- Enforce the use of standardized fault definitions and severity descriptions across all the condition monitoring activities to improve day-to-day communications and allow meaningful reliability analysis

- Deliver a web-page dashboard display customized for each user, showing only the information for the assets in that user’s area of responsibility

- Show the status of planned actions or corrective work on the dashboard display, including any status comments made by involved personnel, up to the time problems are corrected and the problem is closed

- Capture the failure mode information on each asset, including probable root causes, from repairs being done both in-house and by outside vendors

- Allow authorized users to review and report entire lifecycle history for each service location or for specific pieces of equipment

As the North American Stainless reliability team was investigating the development of a more interactive and possibly in-house website, they came across an existing Reliability Information Management web-service that had been created in response to the earlier Eastman Chemical Company specifications. They evaluated the existing system and began using it in the second half of 2008.

North American Stainless utilizes vibration analysis, ultrasonics, IR thermography, oil analysis, and gear inspections. Most of these predictive technology inspections are complete in-house, and a portion are assisted by outside vendors. They also run some monthly equipment inspections by technicians, with expectations to use handheld PDA’s to automate that process. Their scheduled monitoring and inspection activities are tracked with the web-based system (Fig 4). Web browser access is controlled by authorized user names and passwords, and allows plant stakeholders to confirm that the reliability group is ‘doing what we said we’d do’.

Fig. 4 – Web browser view of monitoring tasks & schedules
The in-house and service contractor technicians use various brands of monitoring hardware and software for data collection and analysis; once they have collected and analyzed the data for a specific task they use the web-based system to document their results. This is where standards for asset location names, problem severity descriptions, and fault codes are enforced. Regardless of monitoring technology or inspection, every analyst enters his results in a common web-hosted database via the Internet. For each asset covered in the monitoring task, he documents whether the asset was in good condition, has a problem, or was skipped (Fig 5).

For an asset with a detected problem, the analyst creates a condition entry and picks both the problem severity and failure mode from pull-down lists (Fig 6). He adds his recommended actions and can link multiple documents supporting the analysis, such as a vibration spectrum or infrared image.

As soon as this information has been entered, authorized users can then view the condition status for assets in their area of responsibility, via their web browser. The status dashboard shows the total number of condition issues in each category, prioritizes the display by problem severity, and shows all condition sources reporting problems on a specific asset (Fig 7). The web report is produced dynamically each time a user opens it, so the latest posted information is always shown.

To see the analyst’s detailed findings, recommendations, and supporting documents the user can drill down into the condition entry; if the condition case has had more than one entry for the same problem the user can view the entire thread (Fig 8). At North American Stainless, the area engineers provide feedback to the plant stakeholders through status comments.

Since the Reliability Information Management system is web based, authorized users can interact with the information. For example, North American Stainless area engineers and maintenance planners can use the integrated information on the dashboard to make decisions about opening work orders on condition-based calls, and then reference the work order numbers from their CMMS. This information can be reviewed in planning meetings with operations to fine-tune scheduling.

Fig 5 – Documenting asset condition states

Fig 6 – Adding condition entry details
Fig. 7 – Condition status dashboard display

**Integrated Condition Status Report**

<table>
<thead>
<tr>
<th>Color Level</th>
<th>Entries</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>Critical</td>
<td>12 (67%)</td>
<td>Examine - Repair ASAP</td>
</tr>
<tr>
<td>Fault</td>
<td>7 (38%)</td>
<td>Above Fault alarm</td>
</tr>
<tr>
<td>Alert</td>
<td>102 (58%)</td>
<td>Above Alert alarm</td>
</tr>
</tbody>
</table>

**Open Condition Entries**

<table>
<thead>
<tr>
<th>Severity</th>
<th>Unit</th>
<th>Function</th>
<th>Asset</th>
<th>Component</th>
<th>Technologies</th>
</tr>
</thead>
<tbody>
<tr>
<td>Critical</td>
<td>Cold Mill</td>
<td>332 - AP #2 Hot</td>
<td>332-405-110 - #2 Brush Scrubber Pump #1</td>
<td>Motor</td>
<td>Vibration - Route</td>
</tr>
<tr>
<td>Critical</td>
<td>Melt Shop</td>
<td>131 - Slab Caster</td>
<td>131-233 - Steam Exhaust Fan #4</td>
<td>Motor</td>
<td>Vibration - Route</td>
</tr>
<tr>
<td>Critical</td>
<td>Hot Mill</td>
<td>272 - Leveler</td>
<td>372-020 - Leveler Hydraulic System</td>
<td>Oil Analysis</td>
<td>Oil - Lab</td>
</tr>
<tr>
<td>Critical</td>
<td>Hot Mill</td>
<td>275 - Dividing Shear</td>
<td>275-010 - Dividing Shear Hydraulics Aux</td>
<td>Oil Analysis</td>
<td>Oil - Lab</td>
</tr>
<tr>
<td>Fault</td>
<td>Cold Mill</td>
<td>332 - AP #2 Hot</td>
<td>332-410-120 - Cascade Rinse Pump #3</td>
<td>Pump</td>
<td>Vibration - Route</td>
</tr>
<tr>
<td>Fault</td>
<td>Long Products</td>
<td>870 - Coil Pickling</td>
<td>870-040-100 - High Pressure Rinse Pump #2</td>
<td>Pump</td>
<td>Vibration - Route</td>
</tr>
<tr>
<td>Fault</td>
<td>Cold Mill</td>
<td>331 - AP #1 Cold</td>
<td>331-380-010 - #3 Strip Dryer (Pickling)</td>
<td>Motor</td>
<td>Vibration - Route</td>
</tr>
<tr>
<td>Fault</td>
<td>Hot Mill</td>
<td>271 - Plate Furnace</td>
<td>271-013 - Plate Pickling Furnace Exhaust Fan</td>
<td>Fan</td>
<td>Vibration - Route</td>
</tr>
<tr>
<td>Fault</td>
<td>Cold Mill</td>
<td>332 - AP #2 Hot</td>
<td>332-925-100 - #2 Sconecon Desludge Pump</td>
<td>Pump</td>
<td>Vibration - Route</td>
</tr>
<tr>
<td>Alert</td>
<td>Cold Mill</td>
<td>332 - AP #2 Hot</td>
<td>332-174-007 - 5-1 Bride (east)</td>
<td>Gearbox</td>
<td>Visual Inspection</td>
</tr>
<tr>
<td>Alert</td>
<td>Cold Mill</td>
<td>332 - AP #2 Hot</td>
<td>332-250 - Exit Loop (245 Stirling)</td>
<td>Gearbox</td>
<td>Visual Inspection</td>
</tr>
<tr>
<td>Alert</td>
<td>Melt Shop</td>
<td>911 - MS Compressors</td>
<td>911-013 - LP Air Compressor #31-R</td>
<td>Compressor</td>
<td>Oil - Lab</td>
</tr>
</tbody>
</table>

Fig. 8 – Findings & recommendations, along with status comments

**Entry**

| Location: | Cold Mill > 362 - ZH #2 > 362-380-500 - Cooling Tower Fan #2 (9) > Gearbox (Located In Tree) |

<table>
<thead>
<tr>
<th>Entry</th>
<th>Severity</th>
<th>Technology</th>
<th>Faults</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mar 18, 2009 by Bob III</td>
<td>Fault</td>
<td>Vibration - Route</td>
<td>Bearing fault, Coupling - loose, Drive shaft problem</td>
</tr>
</tbody>
</table>

**Recommendations:** First, inspect the coupling and drive shaft for issues. Hopefully an issue here is exciting or creating the possible bearing fault at the input to appear-and not the opposite. Vibration should be re-checked to verify. Plan for possible gearbox replacement.

**Comments:** Vibration at 2x drive shaft nearly doubled in the axial direction on the motor this month. This might suggest a developing coupling or drive shaft problem. The measurement from the output of the gearbox also shows an increase in vibration at input shaft speed (1760 rpm). Of more concern, there is a noticeable modulation in the waveform data at the input of the gearbox. It occurs at about 0.42 orders of shaft speed, which is an indicator of a bearing cage fault. The waveform amplitudes on this #2 fan input is noticeably higher than on the #1 fan.

**Work Order Request Number:** CMGS 000

**Status:**
- 5/8/09 - Found rubber bushings in coupling hubs had failed and worn out the holes in the hub on the gearbox shaft. Will need new coupling hubs and inserts; will check condition of drive shaft. This fan is down until repairs can be made.
- 7/8/09 - DRIVE SHAFT WAS FOUND TO BE BENT. IT WAS REPAIRED AND INSTALLED. NEW COUPLING HUBS WITH INSERTS INSTALLED. NEED TO COMPLETE SHAFT ALIGNMENT BEFORE PUTTING THE FAN BACK IN SERVICE. NGB (Mike Brine, Jul 08 2005)

**Add Status Comment**

**Checked Off:** May 13, 2009

**Checked Off By:** Bob III

**Comment:**

**Additional Case Data:**
The right hand side of the condition status dashboard shows ‘Days Awaiting Checkoff’, so participants in the planning meeting get a snapshot of response and work status for critical equipment issues (Fig 9). In the 2005 SMRP paper(1) Mark Mitchell at Eastman Chemical Company credited the wide and persistent visibility of condition results as one of the keys in making operations and maintenance joint owners of equipment reliability. He said that “good response to resolve condition-based maintenance issues” has become the way of life because everyone knows that “the bosses care”.

At North American Stainless, Reliability Engineer Broc Sparks says he monitors the ‘Days Awaiting Checkoff’ and uses the information to praise good performers or enlist area maintenance managers’ where response is poor.

As of mid-2009 Broc Sparks says that the web-based Reliability Information Management system has helped North American Stainless make very good progress toward the ‘eliminate unexpected failures’ reliability goal. He notes three contributions by the web-based system toward that success:

- Integration of monitoring results in one place, with entry being done directly by both contractors and in-house technicians
- Standardized report formats makes it easier for centralized reliability engineers & area engineers & supervisors to consume the important information
- Web-browser distribution of condition status and feed-back is building a retrievable long term history of what happened in critical equipment situations.

When a work order is completed, the area engineers can let the central reliability group know by ‘checking off’ the condition entry. The reliability group can then validate the repair work with a follow-up condition survey, and close the case. At that point the condition case information is no longer included in the condition status dashboard, but becomes part of the life-cycle history for that service location and piece of equipment.

Going into the last half of 2009 North American Stainless is now starting to focus on managing the information needed to tackle the second basic reliability goal – extending life of equipment. The retrievable history of faults detected through condition monitoring is helping them pinpoint locations and fault types that need attention (Fig 10). They are now setting up their equipment repair vendors to deliver repair documentation through the same web system, linking that information to all the condition results in the same web-hosted database. That will allow the vendors to directly input design details, repair costs, and their findings on fault modes and root causes, helping confirm or modify the condition monitoring findings. The reliability group at North American Stainless knows this will help them accurately target specific equipment life extension projects, and achieve the plant reliability benefits that management expects.
Summary

Industrial plant organizations such as Eastman Chemical Company in Kingsport, TN and North American Stainless in Ghent, KY have recognized that technical excellence in condition monitoring and maintenance are only part of the means to achieve basic reliability goals of 1) eliminating unexpected failures and 2) extending the life of equipment. They are incorporating a process of Reliability Information Management utilizing web browser and web-hosted database technology to capture essential reliability information from plant sources and from their service contractors and repair vendors, then communicate actionable issues to a broad plant audience, and create accountability for timely maintenance follow-up.

(1) “Communication and Accountability are the Keys to Success in Condition-Based Maintenance” by Mark Mitchell & Steve Quillen of Eastman Chemical Company, Forrest Pardue & Dick Hancock of 24/7 Systems, co-presented at the 2005 SMRP Conference in St. Louis, MO