

Operations & Maintenance 201

Using online monitoring and predictive diagnostics to reduce maintenance costs

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Overview



Online monitoring, diagnostic tools, and intelligent **digital field devices** and **plant equipment** can help boost **maintenance productivity**. They deliver this advantage by enabling you to:

- See what's happening in your process and your equipment
- Detect and identify conditions that could lead to problems
- Deliver the right information to the right people at the right time

As a result, you can take action to keep things running smoothly, efficiently, and profitably.

With the ability to see what's actually happening—and about to happen—in your process and equipment, your operators and maintenance technicians no longer have to spend as much of their time reacting to unexpected events (caused by problems they didn't know about), or trying to find and fix problems that may not even exist.

Instead, they can focus on more productive tasks, like heading off problems they know are on the way, and finding new ways to reduce costs and improve performance. In fact, people who use online monitoring and diagnostic tools consistently report 40%+ reductions in maintenance cost, and 90%+ reductions in troubleshooting time.

This course looks at some examples of how online monitoring, intelligent devices, and predictive diagnostics make this possible for rotating equipment, field instruments, valves, and process equipment.

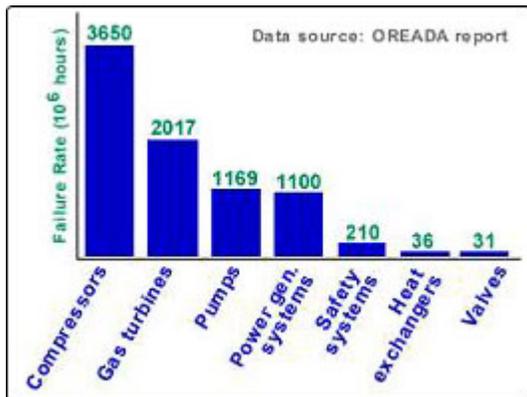
Hint

As you go through the topics in this course, watch for answers to these questions:

- How can you use online monitoring and predictive diagnostics to help reduce maintenance costs?
- What tools are available to improve operator productivity so that they do not spend much of their time and talent reacting to unexpected maintenance situations?

Rotating Equipment

In most process plants, rotating equipment tends to be the least reliable component. Half of equipment failures that cause downtime typically involve mechanical equipment such as pumps, motors, compressors, and turbines.



Rotating equipment maintenance cost can be significantly reduced by monitoring all candidate assets continuously with technologies such as vibration monitoring.

Monitoring them periodically with technologies such as walk-around vibration monitoring, lube oil analysis, and thermography can also help.

Benchmark studies show that companies monitoring 90% of candidate rotating equipment assets have maintenance costs up to two-thirds lower than companies that monitor only 60% of candidate assets.

Rotating Equipment >> Monitoring Technologies

An effective monitoring program for rotating equipment uses multiple technologies. No single monitoring technique gives a comprehensive picture of rotating equipment health. By using multiple, complementary monitoring technologies, a clear picture of rotating equipment health and performance can be obtained.

Vibration monitoring is a commonly used monitoring technology. However, other techniques are complementary to vibration monitoring and they should be implemented as a part of a comprehensive monitoring program.



Lube oil analysis is the key to detecting conditions that cause deterioration before it starts. Key conditions to be monitored are oil contamination and oil chemistry. If contamination and oil chemistry issues are caught at an early stage, deterioration can be avoided. The cost of lube oil analysis and lubrication replacement is very small compared to the cost of failure downstream.



Wear particle analysis can be combined with online vibration monitoring to reduce cost by locating internal damage and estimating the extent of the damage. For example, vibration monitoring that can detect an increase in high frequency noise alerts you to early bearing failure. However, wear particle analysis can show bearing wear at an earlier stage when less damage has occurred. In addition, the size and shape of wear particles can show the cause and severity of the damage, and the composition of the wear particles can isolate the location of the damage to specific components.

Thermography can detect many problems ranging from steam leaking and insulation breakdown to electrical, wiring, and excess friction problems. For example, thermography can detect local hot spots that can indicate potential problems in motor windings.



Motor current analysis can detect power problems that reduce motor life through excess loads or power imbalance that stresses parts of the motor.



Rotating Equipment >> Online and Offline Monitoring

Online monitoring provides the most comprehensive early warning because it is able to provide a continuous flow of real-time information about what's happening in the equipment. It has the potential to detect conditions leading to deterioration before it actually starts. **Assets that are critical to production, or have a high repair cost if failure occurs, should be monitored online.**

Continuous monitoring by permanent sensors, but with walk-around data collection, is the next best choice. This can detect and record transient events that can cause damage even if they are not reported immediately.

Walk-around monitoring with temporary sensors is the third choice. Transients may be missed, and portable sensors such as magnetically coupled vibration sensors do not have the sensitivity or frequency response of permanently mounted sensors. This reduces the sensitivity to initial failure conditions. Walk-around monitoring may be appropriate for less critical assets or assets with lower repair cost.

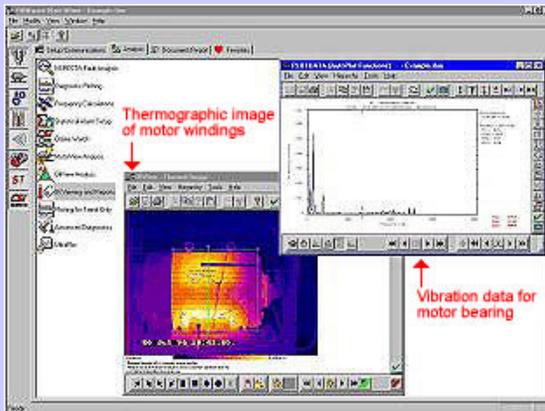
Maintenance scheduling is also an important factor in reducing maintenance cost. Rotating equipment is subject to rapidly escalating collateral damage. It is important that maintenance be performed before damage occurs. The solution is to **increase the frequency of monitoring** as equipment wear accumulates.



Online Monitoring

The PlantWeb Advantage

In the PlantWeb architecture, the **AMS Suite: Machinery Health Manager** combines online monitoring information with a range of analytical tools to identify rotating equipment that needs service urgently.



The AMS Suite: Machinery Health Manager uses vibration monitoring, IR thermography, oil analysis, ultrasonics, and motor diagnostics to give you a better view of actual condition of rotating equipment.

Bearing failure, for example, is a common problem with rotating equipment. **PeakVue software** can detect and identify very high-frequency noise associated with early bearing wear. You get warning of problems before accumulating damage that can significantly increase the cost and time for repairs.

Field Instruments

Field instruments such as transmitters and analyzers are quite reliable, but there are so many of them in the typical plant that total device maintenance costs are high. However, most instrument maintenance is not required.

To reduce device maintenance cost, you can:

- Use online monitoring and predictive intelligence to eliminate unnecessary maintenance
- Monitor devices online to eliminate routine field checks
- Automate scheduled maintenance procedures
- Extend the interval between scheduled maintenance activities such as calibrations
- Automate data capture during maintenance

Field Instruments >> The Smart Instrument Advantage

Smart instruments, when monitored online, help automate maintenance procedures. For example:

- If you suspect a functional or performance problem, you can check instrument health using asset management software before going to the field. If devices check out, unnecessary maintenance is eliminated.
- Many smart devices diagnose their own health and provide alerts if maintenance is needed or performance is deteriorating. On these types of devices, routine checks can be eliminated.
- Scheduled maintenance activities can frequently be automated using a capability called "methods." A method will automatically execute many maintenance activities such as sensor trims, and provide guidance to the maintenance technician where human interaction is needed. Methods are device specific and can both improve the speed of maintenance and reduce or eliminate errors.

You can also use smart calibrators and calibration management software. These tools help you to:

- **Optimize calibration routes**
- **Automate calibration procedures**
- **Review calibration** as-found and as-left information and extend the time between calibration for devices that don't drift over time.
- **Capture maintenance activity results** automatically for upload into the asset management system. These results can include calibration data; documentation of methods executed; and time, date, and personnel information.



Smart calibrators can significantly reduce calibration time.

Using smart calibration techniques reduces typical device calibration time by 50%. In addition, the typical interval between calibrations can be doubled. The result can be a 75% reduction in instrument calibration cost.

These changes can cut device maintenance cost and increase productivity dramatically.

The PlantWeb Advantage

The proven reliability of PlantWeb's **Rosemount**, **Rosemount Analytical**, and **Micro Motion transmitters** reduces maintenance needs right from the beginning. **Built-in performance monitoring and diagnostics** in these devices help you focus your maintenance efforts where they are needed.

For example, transmitters can fail if electronics are exposed to excessive temperatures. But temperature monitoring and alarming in PlantWeb instruments can alert you about the problem in time. This can help you to find the cause and remedy it.

Similarly, the **sensor fouling detection diagnostic** in our **pH transmitters** can trigger a maintenance request before fouling causes process problems—or even automatically initiate cleaning of the sensor.

AMS Suite: Intelligent Device Manager software consolidates all information related to valves and instruments for easy access. It also provides a robust, user-friendly tool for many maintenance tasks, from initial device configuration through troubleshooting and record keeping.

For example, the software's **remote monitoring** and **diagnostic capabilities** dramatically increase the speed of equipment checks. What might have been a 25-minute check in the field becomes a two-minute task. This task can be performed online from the maintenance shop or control room without exposing workers to hazardous environments.

AMS Device Manager software also helps cut instrument calibration time almost in half, from an average of 47 to 25 minutes. And its automatic documentation of maintenance tasks virtually eliminates the manual data entry that eats up so much "wrench time."

Valves

Eliminating unnecessary rebuilds and maintenance can reduce valve maintenance cost. Repeated studies show that between two-thirds and three-fourths of valves are rebuilt when they could be fixed by making some adjustments without removing the valve from the line. Many valves pulled for service need no maintenance at all. The key to reducing valve maintenance cost is to know the valve's actual condition.

One low-cost way to determine valve condition is by using smart valve instruments, such as digital valve controllers.

There are three levels of functionality available:

Level 1. A **valve diagnostic** tool can be connected to the smart valve instrument by the signal wires. The diagnostic sweep is conducted one valve at a time from the maintenance shop. This reduces cost, as the maintenance technician need not be physically present near the valve.

Level 2. A **smarter diagnostic** tool combined with a smart valve instrument can batch valves for testing. With this capability, several valves are selected as a group, and valve diagnostics are run automatically—testing one valve at a time. The technician is free to do other work while a report for each valve is compiled.

Level 3. Using **continuous valve diagnostics** in a running process is least expensive. The smart valve instrument continuously performs self-diagnostics while the process runs. In addition, many on-demand diagnostics can be executed while the process is online—identifying problematic valves and alerting maintenance. This maximizes maintenance resource productivity and minimizes downtime.

If the valve is not equipped with a smart valve instrument, valve condition is typically determined by performing valve diagnostics using PC-based tools. These tools are connected to a valve, and the valve is stroked to determine condition.

Disadvantages of this technique are that the valve must be removed from service, and the tools brought to the field and connected to the valve. In addition, these tools can be used only on one valve at a time. This is expensive, but much less than unnecessary valve rebuilds.



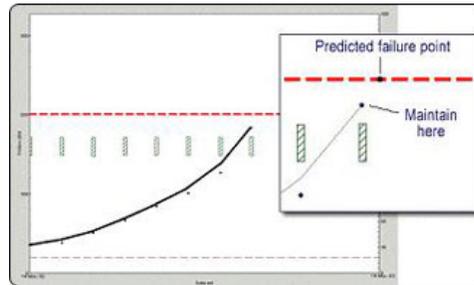
PC tools can speed valve diagnostics in the field.

Valves >> Diagnostics to Minimize Valve Maintenance Cost

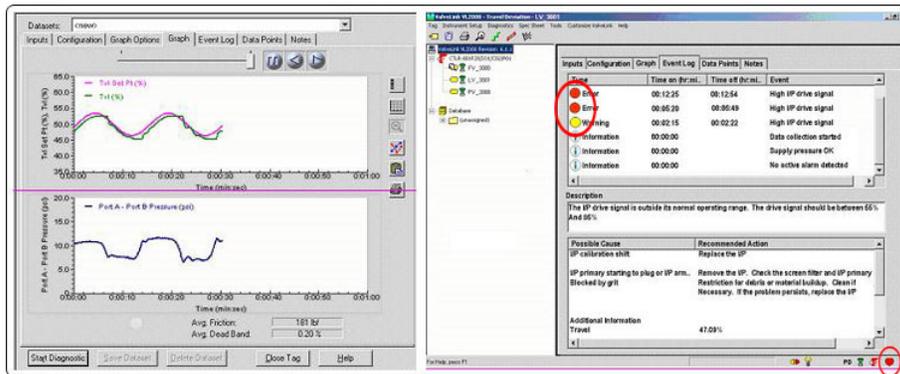
Valve diagnostics can not only alert you to existing problems, but also to conditions that can lead to future wear-related problems.

This plot indicates that friction will exceed the recommended limit in one month. This will enable you to schedule replacement of the valve packing before process quality, availability, or throughput is affected.

A simple green, yellow, and red valve status indicator shows if the valve needs future maintenance, needs maintenance now, or has failed.



Valve Diagnostic Plot



Advanced Diagnostics

On-line diagnostics are continually running in the background during the valve's normal process operation.

Detailed information on the bottom of the Event Log gives plant personnel meaningful and actionable information.

Advanced diagnostics give a valve health summary with a simple "green, yellow, red light" indicator. Green is healthy, yellow is maintain soon, and red is maintain now. Diagnostics also give probable causes and fixes for valve problems. This reduces troubleshooting time, and helps technicians fix problems correctly and quickly.

The PlantWeb Advantage

In the PlantWeb architecture, valve diagnostics can tell you (often while the valve is still in service) if conditions like seat wear, packing friction, or air supply leakage are approaching the point where maintenance is needed.

This capability both minimizes maintenance cost, and helps maintain valve performance at the levels necessary to achieve needed quality and throughput. The net result is higher first pass production levels and lower operations and maintenance cost.

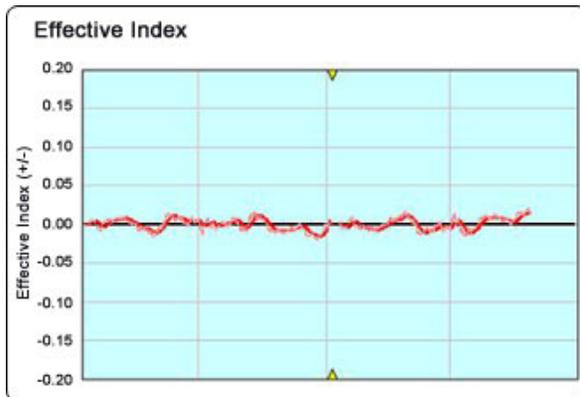
Process Equipment

There are two primary avenues to reduce maintenance cost for process equipment such as turbines, pumps, and compressors.



One avenue is to have **better process control to reduce process extremes**. Temperature and pressure cycling, for example, can stress plant equipment. They can also cause premature degradation in unexpected places such as catalyst beds. Better process control will reduce variability. This minimizes the chance for the process to exceed constraints and place equipment under undue stress.

The second avenue to reduce maintenance cost is to **monitor plant equipment for performance and efficiency**. Performance monitoring is available for equipment as diverse as boilers, heat exchangers, pumps, compressors, turbines, and columns. All these are subject to periodic maintenance to clear scaling, fouling, or plugging. By monitoring actual performance of these assets, and performing maintenance only when performance deteriorates, maintenance cost can be reduced.

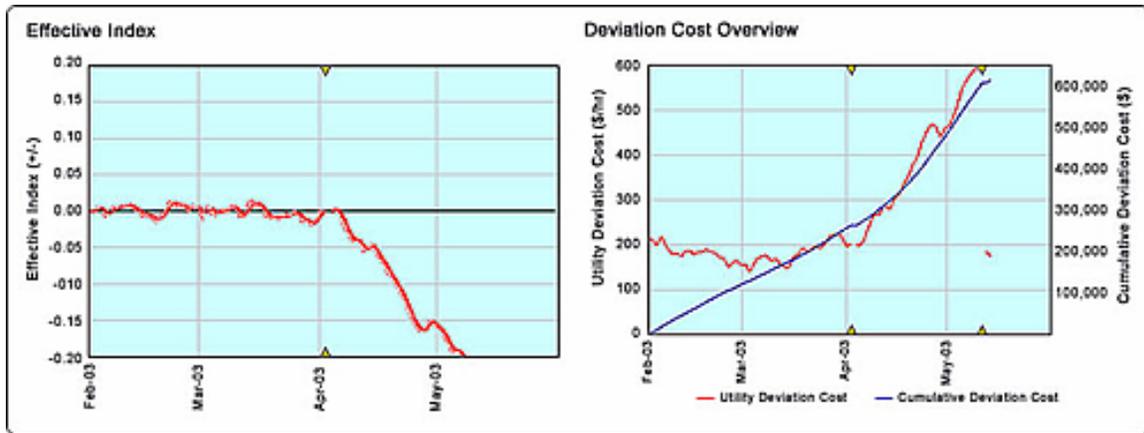


Monitoring actual performance of process equipment can reduce maintenance cost. A heat exchanger was scheduled for maintenance, but based on performance, maintenance was deferred. If heat exchanger efficiency or capacity were deteriorating, the plot would drop over time.

Now or Later

Maintenance cannot always take place as soon as a potential problem is first detected. Production needs often require equipment to remain in operation even if it needs maintenance.

That's possible when predictive diagnostics let you see that the equipment will continue to safely deliver adequate performance until the next scheduled downtime. In that case, you can weigh the value of continued production against the potentially higher repair costs and performance degradation from leaving the equipment in service.



Effective index shows equipment efficiency. Deviation cost shows cost of inefficiency. By using the two, the optimum time for maintenance can be predicted based on production versus cost.

Similarly, if asset health is predicted to deteriorate below acceptable levels before the next scheduled downtime, performing maintenance during a current shutdown—before it is actually needed—may be more profitable.

Operators and Maintenance Costs

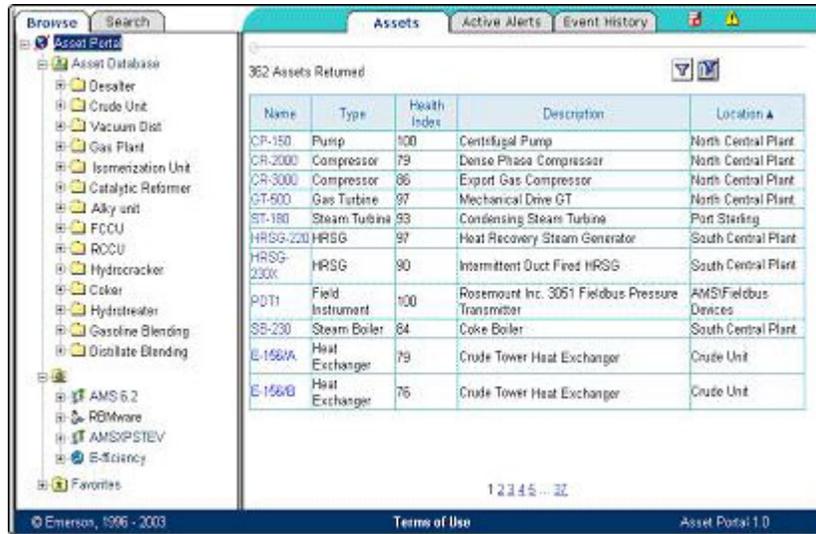
Operators can significantly affect maintenance cost. They can increase cost by operating equipment in ways that cause excess stress and wear, and by initiating maintenance requests when equipment is operating correctly. This is typically caused by a lack of operating tools that determine if equipment is operating within limits and performing correctly.

Without these tools, operators must develop a "feel" for the process. Maintenance requests are frequently based on the operators' impressions. Most of these maintenance checks find no problem. Such "no problem" checks are expensive, as they must be comprehensive to really determine if there is a fault.

If, however, operators have easy access to basic information on the health and performance of both the control and physical assets of the plant such as transmitters, valves, rotating equipment, and process equipment, they can work more effectively with the maintenance team to identify and prioritize actual maintenance needs.

For example, digital communications using protocols such as FOUNDATION fieldbus provide status information with the process variable. This information shows if the variable is good, bad, or uncertain. With this information the operator can verify if a value is good without performing a check at the device. This way, operators know that they are controlling on "known good information."

Although operators can take advantage of easy access to asset health and performance information, it is also important not to overwhelm them with data they don't need—especially when they're busy dealing with abnormal process situations. For that reason, asset-related alerts should be sent to operators only when an equipment problem is known and may affect process operation.



Tools such as the AMS Suite: Asset Portal give operators a quick view of the health of a broad variety of plant assets. When operators can verify equipment health without a check by maintenance, work requests and overall maintenance costs are reduced.

The PlantWeb Advantage

Operators can also easily check equipment condition to anticipate and adjust for potential problems. The **AMS Suite: Asset Portal** provides an integrated, high-level view of information on valves, instruments, rotating equipment, and process equipment in a single browser-based interface. This access to predictive diagnostics and other asset data also enables operators to determine when equipment health is (or, more likely, is not) causing process problems.

When process or equipment problems occur, **PlantWeb Alerts** notify the right people without flooding operators with unnecessary alarms. This capability relies on powerful software in Emerson field devices, AMS Suite software, and DeltaV and Ovation systems to immediately:

- Analyze the incoming information
- Categorize it by who should be informed
- Prioritize it by severity and time-criticality
- Inform the recipients about what is wrong and advise them what to do about it—in clear, everyday language

Monitoring for Control Problems

Identifying and reducing process control problems—especially excess variability—can help reduce maintenance costs.

- **Identifying excess, correctable variability**

All processes have some variability. It is impossible to eliminate it. However, process variability is frequently in excess of what is optimum. Excess process variability contributes to higher maintenance costs in a variety of ways. It ranges from equipment stress leading to failures, to creating an operator demand for more equipment checks.

By monitoring loop performance, automatically calculating actual versus minimum variability, and making that information available to the operator, loops in need of improvement can be identified and fixed. This will reduce variability-induced equipment stress and wear, and maintenance costs associated with that equipment. More importantly, if an operator feels that a loop is not responding properly, but a check on variability shows good control, a maintenance check can often be eliminated.

It is important to understand that although reducing variability can help quality and throughput, it may carry potential maintenance cost. For example, a faster control execution cycle or more aggressive tuning can reduce variability. It may also cause the valve to move much more frequently. This accelerates valve wear. A majority of loops with excess variability can be improved, however, without a significant effect on asset life or maintenance cost. In many cases, a reduction in variability will increase the life of assets.

- **Identifying other control problems**

Loops may not respond as expected due to conditions such as being control limited, or because associated loops are in the incorrect mode. If these causes are not identified, equipment problems may be suspected, and maintenance checks performed. By identifying control problems, corrective action can be taken by changing mode, tuning, or using other options before maintenance is called for.

Monitoring equipment for health and performance can reduce maintenance cost by half, reduce troubleshooting time by 90%, improve first pass quality, and improve throughput. This makes online monitoring and diagnostics one of the most powerful techniques available to improve plant profits.

[End of course]