Remote Machine Monitoring: A Developing Industry

ABSTRACT

Technology is revolutionizing the field of predictive maintenance. With intense competition and a shrinking skilled talent pool, industrial plants are faced with doing more with less. This white paper details how new technologies are helping plants to better monitor their critical industrial equipment, resulting in increased uptime, improved efficiency, and reduced operating costs.

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Background of Predictive Maintenance

For decades, predictive maintenance programs have had a cyclical existence at continuous process plants.

Staff cuts and reorganizations prompt their demise and then unanticipated, costly failures re-ignite management's passion for these early warning programs.

This flow and ebb happens because predictive maintenance has long been considered an important, but non-critical function. In the short-term, not having a predictive maintenance program does not have a major impact. However, as time goes on, machine use and age take their tolls and unanticipated failures rear their expensive heads.

However, something has changed – and it is revolutionizing the predictive maintenance industry.

The Rise of Remote Monitoring

A combination of factors has resulted in a new kind of predictive maintenance: _remote monitoring and analysis_.

New technologies and the Internet now enable automated data collection and remote analysis via the Web.

This method eliminates the expensive, cumbersome manual data collection aspect, leaving maintenance workers to focus on analyzing data, rather than acquiring it. With Web access to the data, maintenance workers can review health metrics anywhere, anytime – nights, weekends, holidays, etc.

Remote monitoring and Web access also enable companies to have equipment data reviewed easily by third-party, off-site analysts. With a true Web-based system, all one needs is a Web browser and an Internet connection to view machine data.

The benefits of remote monitoring become even more attractive when combined with the critical issues facing today's continuous process industries:

- **Increased Competition.** Fierce competition from overseas is forcing U.S. companies to find ways to produce more, while at the same time cut operating costs.

- **Higher Utility Costs.** Skyrocketing fuel costs are drastically impacting profits.

- **Dwindling Workforce.** A large percentage of maintenance workers are nearing retirement age. There is not enough skilled talent to take their places.

A Paradigm Shift

Today's predictive maintenance industry is beginning to embrace a paradigm shift that changes the way machines are monitored. The paradigm is based on the concept that a plant will become more efficient if it is smarter about how equipment is monitored.

Rather than monitor all equipment on the same schedule—typically once a month—it is more efficient to study the equipment and monitor critical machines more often than non-critical ones. For example, critical equipment may be monitored once a day; non-critical once a month.

With manual data collection, such a paradigm shift is both unreasonable and costly. Often critical equipment is in a hard-to-reach location or requires time-consuming safety precautions to access. In addition, many companies have just a few in-house data collectors and must pay travel expenses to get them from plant to plant. Others pay a premium for an outside company to do the manual rounds.

With automated, remote monitoring, health metrics are collected at whatever frequency is needed – without the expense or hazards associated with manual rounds.

Enabled By Wireless Technologies

The key to this new paradigm is wireless technology.

Over the past few years, new wireless devices, combined with the Internet, have enabled plants to wirelessly collect data and make it available via the Web.

A machine analyst can be at an airport, at home, or in a motel with a wireless Internet connection and be able to view machine condition and send correspondence to operations on whether the equipment will make it to the next outage.

Wireless devices have provided many benefits:

- Commercially available and affordable.

- Eliminates costly cables.

- Require little IT involvement.

- Enables anywhere, anytime access to data.

Benefits of Remote Monitoring

As the predictive maintenance industry changes, plant management will embrace the new technologies that can make their facilities more efficient.

The following are 10 reasons to move to wireless, remote monitoring:

- **Spend more time analyzing data and less time collecting it.** Reductions in personnel have put a strain on the predictive maintenance departments of most companies. Remote monitoring enables analysts to be more efficient, and helps departments do more with less staff.

- **Collect data from previously inaccessible machines.** Vital equipment that is difficult to access or located in hazardous or restricted areas can be monitored because collection is automated.

- **Increase safety.** Large cranes, conveyors, drag lines, open drive shafts, and open gear sets all pose dangers to personnel collecting data via traditional walk-around methods.

- **Automated data collection.** Data can be obtained day, night, weekends, and holidays. Sick days, vacation days, and staff turnover will not impact collection.

- **Collect additional metrics.** Perform better analysis by having additional types of data collected, such as speed, pressure, temperature, and flow rate.

- **Consistent data collection.** When manual routes are run, inevitably some machines will not be in operation. Automated collection can be scheduled for when machines are running.

- **Increase collection frequency for problematic machines.** The more data you have about a problematic machine the more accurate the diagnosis. Automated data collection removes the difficulties associated with manual data collection, such as taking multiple readings in a day—especially evenings, weekends, and holidays.

- **View plant-wide data.** A database tracks data from all machines at all plants. Multiple analysts and/or manufacturers can view the same data at the same time.

- **Setting of accurate alarms.** Automated, consistent data collection can provide hundreds of data points, enough to establish statistically accurate alarms. Manual data collection once a month often results in just 10 or 11 points—insufficient for setting accurate alarms.

- **Ability to monitor supervisory panels mounted on vital machines.** There is a higher likelihood that a remote system will catch increased vibration prior to trip than a walk-around program.

Remote Monitoring Philosophies

Remote monitoring methods can vary from the simple to the complex.

Simplest Form of Monitoring
- Convert output from a vibration transducer to a 4-20 mA or DC value - Send value to plant data-logging system - View data via an off-site connection using Remote Desktop or similar application.
Results: Little information is gained other than whether vibration is high, normal, or low. The cause of elevated levels cannot be determined due to lack of spectral information.

Complex Form of Monitoring
- Collect output from a real-time analysis system that interfaces with a site server. - Access information with a VPN connection.
Results: Typically provides spectra, waveform overall trends, DC gaps, and orbits. Some systems can track transient conditions, such as startups and coast downs. Some can also produce Bodé and polar plots that show the location and severity of critical speeds. Some can perform advanced functions, such as run out subtraction.

Whether a company opts for simple or complex monitoring is highly dependent on who is going to review the data. A complex monitoring system with advanced data sampled will provide value only if qualified people are available to interpret the information.

This is where the concept of remote monitoring becomes even more important. With the availability of data over the Internet, it is now feasible to connect the data with those qualified to interpret it. Off-site specialists can make recommendations to maintenance and operations personnel.

The Internet is the perfect means to notify both the specialist and to provide access to the data. It is the enabling technology that allows the machinery expert to view the vibration data and request the monitoring system take more detailed information (for example, to increase temporarily the rate of data collection, increase spectral resolution, or alter the maximum frequency range).

The key features for specialists are automatic notification, the ability to view data from anywhere, and the option to change the analysis parameters remotely.

The Web-Based Approach

When instituting a remote monitoring system there are three ways to access data:

- **#1 Least Flexible:** Remote Desktop or other similar application.

- **#2 More Flexible:** Using an on-site server that can be accessed via a Virtual Private Network (VPN) connection.

- **#3 Most Flexible:** Send data to a remote server and access it via a standard Web browser (for example, Microsoft Internet Explorer or Mozilla Firefox).

There are many benefits to approach #3:

- Anyone with a user name and password can view data without installing client software.

- Plant staff, analysts, and equipment manufacturers can simultaneously look at data at the same time to collaborate on remedial action.

- It requires little training because most people know how to navigate a Web site and use a mouse.

Acquiring Data: Wired vs. Wireless

There are different approaches to transferring data from a machine in the middle of a facility to a computer where it can be viewed by an analyst via a remote connection.

Method #1: Run Cables	Method #2: Single CAT 5	Method #3: Wireless
Run cables from the transducers to a data acquisition unit that transfers data to an on-site computer.	Run sensors to a local hub and connect that hub to the central server with a single CAT 5 Ethernet cable.	Transmit data wirelessly to the on-site server with some systems directly off site.
Impact:	**Impact:**	**Impact:**
Very costly – a large plant with 100 transducers would spend so much on cables it would make remote monitoring cost prohibitive.	Significantly reduces cabling costs.	Wiring is eliminated completely if wireless access points are already installed.
Example: If fans are 500 feet from the control room and there are 10 transducers on a fan, it would require nearly one mile of cable to be run through conduit and cable trays to monitor just one fan.		Becoming an increasingly attractive option.

Many facilities are opting for Method #3, taking advantage of the wireless aspect. There are two ways to have data collected using Method #3, although one poses several issues:

- Install battery-powered, combined sensor/transmitter on a bearing. Collecting and transmitting data this way poses the following issues:

  - Bearing may be hot enough to damage the electronics.

  - Electronics may be damaged due to wear and tear (maintenance staff may step on it when climbing on the machine, etc.).

  - Location of bearing may not be ideal for wireless transmission.

  - If combo device fails, replacement can be costly.

- Standard sensors with short wires connected to a local sensor hub. This is the preferred way to collect and transmit data.

  - Hub samples data and transmits it.

  - Hub can be located near machine, but in place better for wireless transmission (away from heat, above the machine, etc.).

  - Battery-powered hubs are acceptable when data is taken once or twice daily. More frequent acquisition requires line-powered hubs.

Wireless Networking Protocols

There are various wireless networking protocols that enable equipment data to be transmitted within a plant environment. The most common are 802.11b/g, ZigBee, and Bluetooth.

Each has its benefits and drawbacks. For example, ZigBee uses much less power than the others, but is not as fast. The 802.11 protocol uses more power, but makes integrating different applications and commercial devices easy. Bluetooth is reasonably fast, but has a very short range.

The following table compares the protocols.

	802.11 b/g	ZigBee (802.15.4)	Bluetooth (802.15.1)
RF Band	2.4 GHz	915MHz – 2.4GHz	2.4 GHz
Bandwidth (Kbps)	11,000+	20-250	720
Range (Ft.)	1-300	1-200+	1-30+
Benefits	Speed Flexibility Ubiquity	Low Power Cost Effective	Cost Convenience

The following chart plots maximum radio frequency bandwidth against maximum range for each of the protocols.
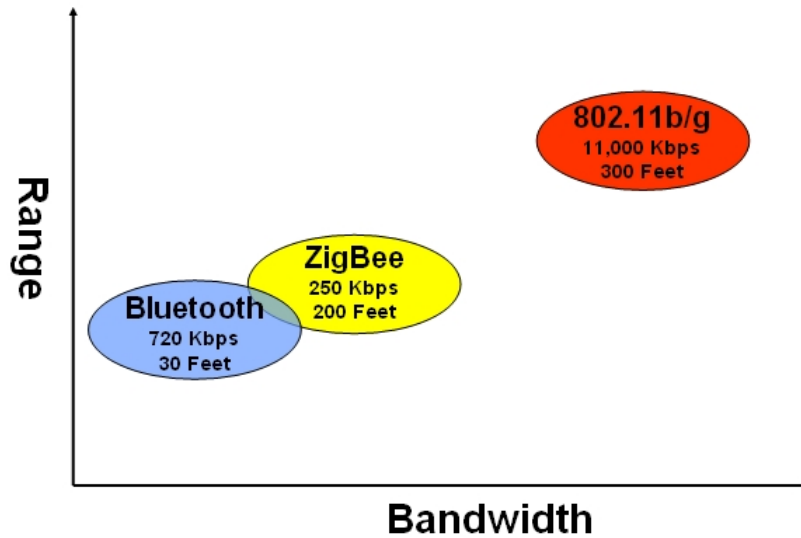
Network Security Issues

When setting up a wireless monitoring system, security is an issue. There are several concerns that typically arise:

- Will outsiders be able to hack into the wireless LAN?

- Is the wirelessly transmitted data encrypted?

- Will there be RF interference with safety equipment?

All three wireless networking protocols (802.11, ZigBee, Bluetooth) have solid security. Each has multiple measures in place for authenticating who can access the wireless LAN and then additional methods for encrypting data.

For example, 802.11 and ZigBee use encryption keys, essentially passwords that allow communication between an access point and a client. Bluetooth uses PIN numbers.

In addition, 802.11 and ZigBee can maintain a list of trusted devices (for example, by their MAC addresses) and only allow those on the list to communicate.

In addition to the security measures mentioned above, a wireless network can be segmented for different types of traffic, regardless of the protocol used. The most common and cost-effective way to do this is with VLAN, a feature available on most sophisticated access points.

As for RF interference, 802.11b has shown no impact in nuclear power plants, where solutions at 900MHz have been observed to interfere with plant equipment.

Summary

As new technologies emerge, the field of predictive maintenance continues to evolve. Cost-effective, easy deployments bring critical information simultaneously to the laptops of maintenance staff and off-site specialists.

Remote monitoring also helps companies face the growing skills shortage—due primarily to the aging workforce and lack of trained replacements. Companies without on-site specialists can have third-party analysts view data over the Web from anywhere, anytime.

There are various methods for remote monitoring, but the most effective so far is wireless monitoring using industry standard sensors wired to a wireless hub.

Regardless of the wireless protocol (802.11, ZigBee, Bluetooth), information can be quickly and securely transmitted and accessed by multiple users via a standard Web browser.

These changes in technology are revolutionizing predictive maintenance and are giving industrial companies the tools they need to increase uptime and improve efficiency – without breaking the bank.

About the Authors

Nelson Baxter has nearly 30 years experience in vibration analysis and advanced testing of industrial equipment in nuclear and fossil power plants, steel mills, and paper mills. Mr. Baxter is one of only 82 people in the country to be certified as a Level IV Vibration Analysts, the highest level possible. In addition, he teaches the Level IV certification course for the Vibration Institute, where he is also a board member. He has written many technical papers, authored many magazine articles, and is a sought-after speaker. Mr. Baxter has a master's degree in nuclear engineering from Purdue University and is a registered professional engineer. He is currently the Vice President of Diagnostic Services for Azima, Inc.

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