New Sensor Technology for Broad Distribution of Vibration Data Collection

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In this overview presentation, we will look at some of the issues in distributing the effort to collect vibration data, and how some new sensor technology may help in overcoming those issues.

- Requirement for Broad Distribution of Data Collection Effort
- Obstacles to Achieving Broad Distribution of Data Collection Effort
- Portable Vibration Data Collection Tools - Benefits and Drawbacks for Broadly Distributed Data Collection.
- Dynamic Data Acquisition Using Handheld Computers (PDAs) – Recent Developments

Requirement for Broad Distribution of Data Collection Effort

Problem – Collecting Timely Vibration Data

Even a well-trained and highly motivated reliability team, armed with the latest model data collectors, can have trouble sticking to their data collection and analysis schedules. Why? Simply put, most reliability teams have insufficient resources to meet their goals of collecting and analyzing data from all rotating assets within the plant.

When faced with insufficient resources (reliability personnel) to collect and analyze the data from all the assets in the plant,

- With limited manpower, the tendency is to target available resources at the most critical assets.
- Focus on the critical assets requires that “balance-of-plant” assets be attended less frequently.

This reality is exacerbated by the reluctance of reliability teams to give up the control of the data collection process. It is widely recognized that having the vibration specialist collect the data that he/she analyzes is the ideal. However,

- Vibration specialists can spend their time either collecting data or analyzing data.
- Having the specialist collect and analyze vibration data often leads to missed plant equipment or longer than optimal intervals between readings

One of the main difficulties in any vibration program is to access the resources needed to collect and analyze the appropriate data.

To expand a data collection and analysis program, plants have several options.

- Technology-Driven Options
- Human-Driven Options

Technology Driven Options (Pros/Cons)

- Install equipment to facilitate data collection – permanently mounted sensors, switchboxes, etc.
- Install online data acquisition systems to collect data from permanently mounted sensors.
- Use diagnostic tools such as condition assessment software to decrease analysis time for spectral data.

Human-Driven Options

- Hire and/or train more vibration specialists.
- Outsource all or part of the data collection / analysis function.
- Use other plant personnel to collect vibration data, and have existing vibration specialists analyze that data.

All of the methods listed to expand data collection coverage merit consideration, and any combination of these strategies can be used effectively. However, in this paper, we are going to take a detailed look at the last of the options – using plant personnel other than reliability staff to collect vibration data. What is needed to even attempt to put make such a program effective?
Collection of Vibration Data by Operations or Lubrication Personnel

What is needed to even attempt to use non-reliability personnel to collect effective vibration data?

- Cooperation and participation from non-reliability staff – operations, lubrication and maintenance.
- Cooperation and participation from the vibration specialists themselves.
- Data collection tools that can and will be used by non-vibration specialists to collect vibration data.
- Data collection tools that have the ability to collect data at a level of detail sufficient for vibration specialist’s analysis time to be used effectively.

Getting Cooperation from Operators

It can be difficult to get non-reliability staff (operators, lubrication techs, PM mechanics) to cooperate with a vibration data collection routine. How do you get them to consider adding this effort to their (already heavy) workload?

- **Keep It Light** – the amount of additional work should be kept to a reasonable amount (< 1 hour per week, if possible)
- **Keep It Simple** – any data collection tool you ask operators to use must be usable with minimal training.
- **What’s In It For Me?** – operators and lube techs have their own data collection / inspection duties – can you offer them a solution that will improve their situation while facilitating collection of vibration data?

Getting Cooperation from Vibration Specialists

It can also be difficult to get vibration specialists to be enthused about non-reliability staff – and they have some valid reasons to object. How to deal with their objections?

- **Ensure Data Richness** – vibration specialists need enough data richness to be able to make a front-line evaluation of the machine. Nothing is more frustrating than to make a special trip out to an asset that an operator has identified as having a problem, take a set of spectra and find that the machine is running perfectly. The vibration specialist needs enough data from the operator to make a “first-pass” evaluation of the asset before making a visit to the equipment.
- **Help Ensure Positional Accuracy** – vibration specialists’ fear that other personnel will not be as diligent in ensuring that they are collecting readings on the specified asset. Reduce this fear by taking advantage of data collection tools for operators that use identification technologies such as bar codes or RFID to make sure they are recording data.
at the right spot.

- What's In It For Me? – vibration specialists prefer to analyze data they've collected themselves, but even the most diligent find it difficult to cover all “run-of-plant” equipment. Proposing a solution that focuses on equipment that all participants agree is not being covered effectively can

Data Collection Tools / Technology

Assuming that we have convinced operators or lube techs to contribute to an overall asset care program by collecting vibration data, what tools do we give to these non-vibration specialists to collect this data?

- Overall Vibration Meters
- Overall Vibration Meters connected to PDA-based devices.
- One, two or four channel multi-purpose data collector / analyzers.
- Or something else?

Overall Vibration Meters

Overall vibration meters (Figure 1) can be used to collect acceleration, velocity and/or displacement overall values. Many can also collect bearing condition using shock pulse or some other high-pass filtered signal.

The main benefits of using overall meters are cost and simplicity.

- It is relatively easy to teach an operator to use an overall meter – if the operator is interested and involved.
- Operators can be equipped with overall meters for a low cost relative to more sophisticated tools.

The main drawback to using overall meters centers on resistance from the non-reliability staff.

- Asking operators to collect and write down vibration levels onto a clipboard is unlikely to create an enthusiastic response.
- You can expect a fairly high number of errors in your data, based on readings taken incorrectly or simple transcription errors.
- Clipboard-collected data is difficult to use for decision support until it is entered into a spreadsheet or database. Many manual inspection programs fail at this critical point.

- What’s in it for me? – Well, for the operators collecting data, there is nothing except extra work.

Overall Vibration Meters + PDAs

Some overall vibration meters can be connected to a PDA (Figure 2).

The main benefits of using overall meters connected to data capture devices ARE:

- It is relatively easy to teach an operator to use an overall meter, even when you add the complexity of the cable connection to the PDA – if the operator is interested and involved.
- Operators can be equipped with serial output overall meters for a lower cost relative to more sophisticated vibration analysis tools - but more expensive than simple overall meters.

- What’s in it for me? – Operators / lube techs will look at the PDAs as tools to manage their own data collection rounds. They may be convinced to use the PDA device to collect vibration data in addition to their own inspections – however, they are generally opposed to collecting vibration data alone.

The use of PDA technology can allow vibration data to be collected by operations personnel during their own inspection rounds. In other words, the collection of vibration data can be presented to the operators as an add-on to using the PDA as a clipboard replacement. The operators and lube technicians will be primarily interested in the use of PDA technology as a tool to make their lives easier.

Figure 2 – Overall Meter with RS232 Output

The main drawback to using overall meters with PDAs in an asset care program centers on resistance from the vibration specialists.

- It is impossible to know if a high overall reading is a problem bearing or a poorly taken reading.
• It is difficult to know if a very low overall reading is a well-running machine or a faulty meter/sensor or a poorly taken reading.

• Doubt over the status of the machine causes vibration specialists to make more trips to verify machine condition using a data collector/analyzer.

• What’s in it for me? – vibration specialists do not see any real reduction in their workload. In fact, if there are a substantial number of "false alarms" coming from the overall meter rounds, they may see their workload increase.

Data Collectors / Analyzers
Multi-purpose, multi-channel data collector / analyzers can be used to collect a wide variety of both static and dynamic data. Why don’t we equip operators with data collector / analyzers? Operators could gather rich (FFT/TWF) data.

There are three reasons why we don’t (typically) do this:

• It is too expensive. The cost to equip operators with these tools is prohibitive.

• High training requirement. The multi-purpose nature of these devices – they can be used for data collection, balancing, bump tests etc., make them complex to learn to use, even for simple operations.

• Poor for inspections. These devices have limited ability to collect inspection data, or have difficult interfaces, so it would be tough to convince operators to use them.

What Would Be A Solution Of Choice?
A solution of choice would be to equip operations and lubrication staff with

• a device capable of collecting inspection data (thus fulfilling an operations staff need);

• with the data acquisition capability to collect dynamic data of sufficient quality for vibration specialists to do a complete “first-pass” analysis;

• that is relatively easy to use, and rugged enough to withstand operators’ mistreatment; and,

• priced so that it can be widely deployed.

A solution of this nature would enable broad distribution of the collection of “balance-of-plant” vibration data, while allowing the vibration specialists enough data to effectively carry out analysis and focus their efforts on critical/troubled equipment.

PDA Technology for Automating Inspection Rounds
Rugged PDA technology has progressed to where there are numerous brands to choose from for deployment of handheld technology in industry.

The use of PDAs for operations, S/H/E (safety / health / environmental) and lubrication rounds is one of the fastest growing areas in reliability best practice. (Figure 3)

Figure 3 - Inspections Using PDA

There is no question that rounds-based inspection procedures can be carried out using paper check-sheets. Automating the program using PDA technology offers several advantages.

• Implementing inspection programs is easier and more efficient.

• Increases the accuracy and consistency of collected data.

• Immediate feedback is available to the operators when assessing the asset.

• Exceptions are indicated immediately to maintenance and reliability staff.

Well-documented and highly compliant data allows an easy comparison of results from one inspection to the next. Machinery and process
parameters when logged can be analyzed to establish trends in equipment performance to provide an early indication of the presence of a developing fault condition.

**Dynamic Data Acquisition Using Handheld Computers**

Recent developments in the world of digital sensing technology has made the above-mentioned “solution of choice” available since late in 2006.

There are multiple organizations working on general-purpose interfaces for accelerometers, allowing them to be used to capture dynamic data both into general purpose PDAs (Windows Mobile and Palm OS units) and into tablet PCs.

Sensor-to-device communication technologies being used (or investigated) include USB, Bluetooth, WiFi and Wireless USB.

**Integrated Digital Sensor**

There are at least two organizations that have created integral dynamic data acquisition units, wherein the accelerometer and signal processing hardware are embedded into a single case, with a digital output.

These devices can be built using either MEMS (micro-electro-mechanical systems) or ICP™ type sensors, the type of sensors traditionally used for predictive maintenance applications.

For example, one such sensing device (built around an ICP accelerometer) has sufficient memory and processing power to collect time waveforms of up to 65kSamples. (Figure 4)

- The device is powered directly by the USB cable, with no A/D cards or separate power supply required between computer and sensor.
- The device can be interfaced to any computer with a USB port, including PCs, Macs, Linux and Pocket PCs.
- Sensor has a built-in 16-bit A/D converter.
- Sensor is capable of sampling rates ranging from 125 Hz to 65KHz.
- Hermetically sealed – resistant to hot/wet environments.
- Sensor has two built-in analog band pass filters/rectifiers for amplitude demodulation/enveloping of signals.
- Communicates to host computer via USB 1.1 or USB 2.0, allowing for very fast transfer of digital data.

The vibration sensor allows operators to collect full waveform data with no more operational complexity than using an overall meter. Digitized time waveform data is retrieved from the sensor.

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**Handheld Computer (PDA)**

Data collected from the sensor is stored in the handheld computer (PDA). This data is then uploaded to the host computer for further analysis.

The PDA is responsible for
- digital filtering of the signal
- generating FFTs
- calculating overalls
- storing results to disk / memory
It is certainly possible to design software for the PDA that is used solely for vibration data collection, and several organizations have gone down this path. However, a PDA system designed specifically for vibration analysis does not offer any distinct advantage to operators who also want to carry out their own inspections. Ideally, the ability to collect spectral vibration data would be an add-on to an existing tool that meets the data collection requirements of operators and lubrication technicians.

InspectCE™ firmware was primarily designed for operators and lubrication techs to carry out inspections. Time waveform (TWF) collection and storage capability was added to InspectCE™ firmware, and TWF Filtering, TWF Integration, FFT/inverse FFT, and a complete signal processing library was added to InspectCE™ firmware. (Figure 5)

The ability to collect vibration points was added to the existing inspection route collection module. Inspection routes were able to be automated using Windows Mobile™ Based PDAs, and take advantage of:

- Integrated Bar Code Scanning / RFID support.
- Pen and Keyboard Entry.
- Wireless networking support.
- Other add-on data acquisition tools i.e. portable thermometers.

InspectCE™ firmware designed to automate operations, lubrication and preventive maintenance routes. Typical types of data collected on these routes include:

- Operator Check Sheets.
- Lubrication Routes.
- Asset Condition Check Routes.
- Safety / Health Protection Inspection Routes.

By adding vibration data collection to an existing tool originally designed for automating inspections, operators and lubrication technicians can still take advantage of automating their PM and TPM inspections, and vibration data can be collected during those inspections using identical handheld technology.

**Conclusion**

In this presentation, we have looked at some of the issues raised by expanding vibration data collection beyond the vibration specialist. There are several methods that can be used to expand data collection – all have merit and should be considered.

If considering using operations or lubrication staff to collect balance-of-plant, all parties (including vibration specialists) must feel that they are gaining (win-win)

Using overall meters (either connected to a PDA or not) have drawbacks to both the operations staff and vibration specialists.

New technology (digital accelerometers that can be used to collect spectral/TWF data during inspection rounds) can help resolve some of those drawbacks.