By Anthony DeMatteo

Since the first analog vibration instruments were introduced to industry, the power generation industry has been a strong proponent of the technology and has used it to keep power plant equipment healthy and well balanced.

I was a mechanic in a power plant in the mid-1970s. During each major turbine generator overhaul, we sent dozens of motors out to the motor shop for cleaning and bearing replacement, regardless of whether the motors needed repair. Rotating components like fans, pumps, coal crushers, conveyors, and other equipment associated with the out-of-service boiler were at least inspected and many were disassembled and reconditioned.

We were practicing Preventative Maintenance – repair and parts replacement on a calendar-based schedule. It was a common practice at the time, when labor cost and manpower didn’t seem to be big issues.

I started doing vibration analysis at the plant in 1977. We had a few analog, tunable filter vibration analyzers that were used for balancing and quarterly vibration checks on critical rotating equipment. Measuring vibration was slow and tedious back then. There were no computers or pre-programmed routes. Operating the instrument was like tuning an old radio looking for stations. It required manually tuning the analyzer through several frequency ranges while watching the amplitude needle. When amplitude fluttered and peaked, we observed the frequency and amplitude and recorded the values on a paper form, as shown in Figure 3.

In the early 1980s, we started doing pre-overhaul vibration checks on all equipment associated with upcoming overhauls. This eliminated the need to send all the motors out to the motor shop.

It also meant that only machines with known faults were repaired. The technique was effective. It saved time and reduced overhaul costs. After the overhaul was completed, we measured the equipment again to be sure that no new or undiscovered problems existed. Pre- and post-overhaul vibration testing was effective, but it was time consuming and expensive using analog instruments.

Microprocessor-based digital signal analyzers were introduced in the mid-1980s and replaced the

**Figure 3: 1980 handwritten vibration data sheet**
tunable filter analog instruments. The new analyzers
significantly decreased vibration data collection times.
Route-based software programs, which came with the
vibration analyzer, insured consistency from collection to
collection and facilitated analysis and storage of vibration
data. The spectral resolution available on the analyzers
allowed more accurate diagnosis and trending of faults.
Predictive route-based vibration testing was becoming
more powerful and economical.

Vibration instruments and sensors have continued
to evolve and improve through the years. The newest
generation of vibration analyzers is smaller, weighs
less than 3 lbs, has lots of internal memory (more than
1 GB standard), faster processing speeds, and higher
spectrum and waveform resolution (more than 100,000
Lines of Resolution). Analyzers are available in single-
and multiple-channel configurations. Multi-channel
analyzers, capable of cross-channel calculations, make
phase analysis possible using two sensors, instead of
depending on a photo-tach and reflective tape.

Some analyzer manufacturers offer optional firmware
that allows the instruments to be used for balancing or
alignment work.

The analyzers operate in pre-programmed route
mode or in standalone mode for troubleshooting
mechanical and electrical faults on rotating equipment.

Most analyzers have special circuits for measuring high
frequency vibration caused by lack of lubrication and
metal-to-metal contact from bearing and gear faults.
Route-based vibration data collection is fast, powerful,
and economical. Analyzer software provides the user with
wizards, calculators, and many other options for trending,
analysis, and reporting. Third party software add-ons for
ODS and modal analysis provide 3-D and photo realistic
animation of machine vibration.

What does it take to keep a predictive vibration
program healthy and successful?

To be successful, a predictive program requires
ongoing funding for instrumentation, software upgrades,
and product support. Some vendors now offer free
lifetime product support, free lifetime firmware upgrades,
and free lifetime software updates. As your technical
knowledge increases, you must make sure that your
instrumentation can be upgraded in an economical way.
Make sure that your equipment vendor offers a clear
upgrade path to support your needs today, and in the
future.

The people involved in the program must have
continuing technical training, product training,
and certification. There are many technical training providers
to choose from. Select a vibration training provider that
gives illustrative, interactive, and entertaining courses.
For predictive vibration training, select a provider
that follows the ISO:18436.2 standard and the ASNT
SNT-TC-1A standard. Certification testing should be a
requirement for all employees involved in the vibration
program. Category I, II, III, and IV certification is available.

Steps to improve your predictive
maintenance program

• Create Quality Standards for components like motors,
pumps, and fans, as well as power transmission
components like couplings and bearings. Buy Quality
Parts. Low cost bearings, couplings, sheaves, and
motors are often poor quality and have substandard
metallurgy.
• Establish Quality Agreements with vendors to provide
quality parts at reasonable prices.

Figure 2: Analog Vibration Meter

Figure 4: Vibration Data Collection with VIBXPERT® (Photo
courtesy of Ludeca Inc.)

Figure 5: Measurement preparation with OMNITREND®
software (Screen courtesy of Ludeca Inc.)
• When failures do occur, perform Route Cause Failure Analysis. Find the source of the problem. Fix it once and fix it right.
• Improve and expand your Route Based Vibration program. Refine the program by improving measurement parameters and fine tuning machine vibration alarm limits.
• Use Advanced Vibration Techniques like resonance testing, orbits, phase analysis, operational deflection shape testing (ODS), and modal analysis to analyze problem machines. Phase is a powerful diagnostic aid that can help the analyst determine the problem and confirm suspected faults on machines and structures. ODS makes phase analysis even more powerful by animating a structure drawing or photo-realistic model of the machine.
• Incorporate other Predictive Technologies into your predictive program. Oil analysis reveals information about lubrication chemistry, quality, and contamination. Acoustic Ultrasound is inexpensive and may save hundreds of dollars per month through identification of compressed air leaks in pipes and tubing. Infrared thermography is used to find wiring problems and overloads in electrical cabinets.

Figure 6: Technical specifications for vibration, noise, and resonance

• Act on corrective recommendations made by the people involved in predictive services.
• Use Efficiency Testing to evaluate the operation of rotating machines like generators, pumps, and fans.
• Create Technical Specifications for vibration, noise, and resonance. Attach the specifications to all purchase orders for new and rebuilt equipment. Technical specifications are a first step to protect against poorly designed and improperly installed equipment. Specifications can be simple or detailed, it’s your choice. These technical specifications list acceptable values, while also detailing the measurement collection technique and documentation method for presenting the results.

A sample natural frequency and resonance specification might state: “… No rotor natural frequencies may exist within the operating speed range
of the machine or within 15 percent of the second order of rotation or within 15 percent of blade pass frequency of a fan or vane pass frequency of a pump.”

The vibration specification might reference a published standard such as ISO:10816-3 or similar. You may wish to design your own specification which satisfies plant guidelines for machine health and product quality. A sample specification might read as follows: “... Acceptable overall vibration, 3-1000 Hertz is not to exceed 0.08”/second Peak at the bearing positions.”

• Use Acceptance Testing to verify that new or rebuilt equipment meets noise, vibration, and resonance specifications after installation and before signing off on purchasing and contracting agreements. For large or expensive new and rebuilt equipment it also is an option to travel to the OEM or service provider location to perform acceptance testing before the machine is delivered to the plant.
• Write Standard Operating Procedures for maintenance and operation tasks.
• Use Precision Alignment and Balancing to reduce operational forces and extend the life of bearings and seals.
• Provide vibration awareness training for plant operators, maintenance personnel, and managers. A little bit of information pays back dividends in program support.

The proper implementation and use of a predictive vibration program will improve your equipment and facility reliability by:
- Providing early identification of equipment defects
- Reducing maintenance cost
- Providing tools that can be used to identify the real causes of equipment failures
- Improving product quality
- Improving facility safety
- And much more …

Anthony DeMatteo is a diagnostic measurement, signal analyst, and technical training instructor with more than 30 years of experience, as well as a technical contributor to Ludeca Inc. DeMatteo owns 4X Diagnostics, a service and training company providing consulting services, mentoring, and training in diagnostic measurement and analysis, modal analysis, and operational deflection shape testing. He can be reached by e-mailing editorial@woodwardbizmedia.com.

Operational Deflection Shape testing (ODS) is a non-intrusive measurement technique used to analyze the motion of rotating equipment and structures during normal operation. An ODS is an extension of phase analysis, where a computer generated model of the machine is animated with phase and magnitude data or simultaneously measured time waveform captures. ODS testing is able to identify a wide variety of mechanical faults and resonance issues such as looseness, soft foot, broken welds, misalignment, unbalance, bending and torsional resonance modes, structural weakness, and foundation problems.

Modal Analysis is an experimental method of determining the natural frequencies, damping values, and mode shapes of a structure. Modal Analysis is needed when machine vibration is amplified by resonance. Modal Analysis is the first step toward correcting resonance problems. In a Modal Analysis, the natural frequencies of a machine or structure are excited into resonance through a series of impact tests or forced excitation from a portable shaker system. Modal Analysis software reveals the natural frequencies and mode shapes, as well as deriving the mass, stiffness, and damping properties of the system under test. Modal analysis is completed on an off-line machine.

The picture below shows the ODS deformation shape of a forced draft fan at motor/fan turning speed. To see a movie of this ODS animation, check out December’s Energy-Tech e-newsletter. You can sign up for the e-newsletter by visiting www.energy-tech.com.