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BENTLY NEVADA SOFTWARE TECHNOLOGY CENTER

orbit

VOL. 33 | NO. 3 | JUL 2013

A Technical Publication for Advancing the Practice of Operating Asset Condition Monitoring, Diagnostics, and Performance Optimization

BENTLY NEVADA SOFTWARE TECHNOLOGY CENTER...

...IN MUMBAI, INDIA

Editor's Notepad

Gary Swift
Editor
Orbit Magazine
gary.swift@ge.com

Greetings, and welcome to *Orbit!*

In the past two issues, we looked back at Bently Nevada history and then caught up with the current state of our Minden, Nevada facility. In this issue, we are expanding our view to look at the India region as a specific example of our global presence.

The Indian articles include an interesting case study on a steam turbine seal rub and a customer success story on the value of training. We also have an update on our Mumbai Technology team, which has played an important role in the evolution of our software over the past 20 years. The Mumbai story includes recognition for employees who received awards for their years of service, and for their outstanding engineering work.

In keeping with Don Bently's strategy to employ factory-trained local Sales & Services personnel in regions around the world, we officially established our presence in India in the early 1990s. Our presence expanded when we became a part of GE, and currently includes four different regions within India. The physical locations for these offices are listed here, along with e-mail addresses for contacting the associated Sales Managers. If you are in India, please feel to reach out to us if you have any questions that we can help to answer!

Note: This information was accurate at the time of printing. But since contact information changes over time, it is a good idea to check our online site for the latest updates.http://www.ge-mcs.com/en/contact-us.html

Namaste!
Gary

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The 3500 ENCORE* System

Designed to provide a cost effective upgrade path for legacy 3300 monitor systems, the 3500 ENCORE Series now offers two convenient upgrade packages. The newest edition – the 3500 ENCORE System – is designed as a standalone direct drop-in to existing 3300 panel cutouts, while the 3500 ENCORE Rack Upgrade, introduced in the JUL 2011 issue of Orbit magazine (V31N2), retains the 3300 chassis, I/O modules and field wiring while upgrading the power supplies, system monitors, and monitor modules. Both packages provide continuous, online monitoring suitable for machinery protection applications.

The system's highly modular design incorporates the following components:

- 3500/07E Instrument Chassis (required)
- 3500/10E Power Supply (required, 120/230 VAC)
- 3500/23E Transient Data Interface (required)
- 3500 Rack Configuration Software (required)
- One or more 3500/42E Vibration Monitor Modules with I/O
- One or more 3500/45E Position Monitor Modules with I/O
- One or more 3500/50E Tachometer Modules with I/O
- One or more 3500/61E 6-Channel Temperature Modules with I/O
- One or more 3500/33E 16-Channel Relay Modules with I/O
- Color front panel displays

For a limited time we are offering incentives for customers who upgrade or replace a 3300 monitor system with the 3500 ENCORE Series. For more information, contact your Bently Nevada sales representative.

The Team

As with all of our new products, the design, development, manufacturing and testing of the 3500 ENCORE System required the collaboration of a cross-functional team of engineers from a variety of disciplines (electrical, firmware, manufacturing, mechanical, quality, software and product management).

We will describe the 3500 ENCORE Series in more detail in future Orbit articles. ■

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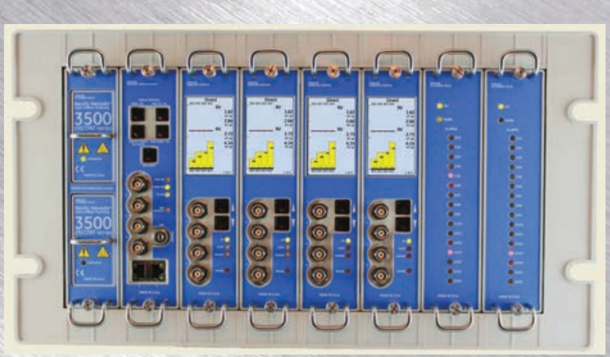
3500 ENCORE TEAM PAUSES FOR A GROUP PHOTO IN FRONT OF THE SYSTEMS BEING TESTED IN THE FACTORY ACCEPTANCE TESTING (FAT) LAB IN MINDEN BEFORE BEING SHIPPED TO THE CUSTOMER. LEFT TO RIGHT: Justin Nickles, Trevor Seyfried, Russ Christianson, Duane Folden, Joe Taylor (front), David Lopez (back), Mark Dieter, Rajesh Kumar (front), Alan Tart (back), Sean Summers, Mitch Cohen, Brian Steinkraus, George Cox (front), Sam Francis (back) and Brian Axness.



THE 3500 ENCORE SYSTEM: Available in an 8 Position rack – as shown here – or as 10, 12 and 14 Position racks that match legacy 3300 rack sizes.

2013 Middle East Turbomachinery Symposium (METS)

Building on the success of the first METS event in early 2011, Texas A&M Turbomachinery Laboratory organized the second METS event for the first quarter of 2013. The event again took place in Doha, Qatar, although it moved to a new convention center as it had outgrown the hotel conference room that was used in 2011. METS2 was attended by more than 1000 participants, who enjoyed more than 50 technical sessions (with optional continuing education credits for delegates) and an international exhibition featuring more than 60 different companies.

The event was supported by Texas A&M University at Qatar and was hosted by Qatar Petroleum, which was well represented by five delegates who attended the ribbon-cutting opening ceremony. GE Oil & Gas again participated, with representatives from the Turbomachinery, Global Services and Measurement & Control businesses (demonstrating examples from the Bently Nevada* product line), as well as GE's Intelligent Platforms business (with demonstration of Proficy** SmartSignal software).

Bently Nevada Presentations

As part of our contribution to the Symposium, Sanker Ganesh (Bently Nevada Lead MDS Engineer) co-presented a case study on "Resolving Intermittent Vibration Spikes on Steam Turbines" along with Ashraf Abdelrahim (Senior Condition Monitoring Engineer – Rasgas Operating Company). A second case study was co-presented by Sherief Mekawey (Bently Nevada Principal MDS Engineer) and Isham Sudardjat (Reliability Engineer, QP Offshore Operation) on "Resolving Vibration Issues of Diesel Engine Driven Fire Water Pumps." ■

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**Trademark of GE Intelligent Platforms, Inc. SmartSignal is a trademark of SmartSignal Corporation, a wholly owned subsidiary of GE Intelligent Platforms, Inc.

TOP: GE display booth as visitors begin to arrive. **MIDDLE:** Middle East Region Services Team Leader, Moukarram Alameddine, and Sales Managers, Fadi Nassif, and Ahmed Ghanem try out the Bently Nevada product demonstration equipment. **BOTTOM:** Jim Flakus prepares the interactive product demonstration for action. Products included an RCK-1 Reciprocating Compressor Kit, 3500 Series monitor system, RK-4 Rotor Kit, AnomAlert* Motor Condition Monitor, wireless system and both System 1* and Proficy SmartSignal software.


Works in
MIDDLE EAST,
NORTH AFRICA
& TURKEY
REDEFINING WHAT'S POSSIBLE
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Bently Nevada* Reciprocating Compressor Monitoring Seminar

Steve Schickling
Bently Nevada Sales Engineer
Steve.Schickling@ge.com

The Seeds of an Idea: Returning to the Bently Nevada team in 2011 after 14 years in a different job, I found that my previous experience (from 1990–1997) had become a bit rusty. It was also outdated, as our products had changed quite a bit while I was away! As I worked with our users, I started to see that many of them were also a bit rusty in terms of understanding proper transducer selection, operation and installation.

While attending a 3500 Operation & Maintenance class, I was impressed with a point that Customer Training Instructor Les Wright made. He explained that an 11-inch (28 cm) diameter machine rotor weighing more than 100,000 pounds (45,000 kg) and spinning at 3600 rpm can safely vibrate at a displacement equal to the thickness one human hair or one sheet of paper; around 3 mils (76 microns). However, if the same rotor starts to vibrate at a displacement of the thickness of two human hairs or two sheets of paper, you may have very serious issues. That is really amazing to consider and it also makes you realize that any noise in the signal can easily drown out the vibration signal. All the money that a customer spends on a 3500 system and System 1* software can be negated by a poor transducer installation.

Back-to-Basics

I started to kick this idea around with Field Application Engineer (FAE) Darell Feldmiller. We had both observed that many of our customers were becoming quite knowledgeable on using accelerometers and interpreting vibration spectrums but that often, only the more seasoned and experienced plant staff knew anything about proximity transducers and orbit plots. To help address this knowledge gap, Darell and I put together a 'back-to-basics' class on vibration monitoring using eddy current proximity transducer systems. Our first session was in Bakersfield, California, with 28 participants. Three months later, we held a similar session in Sacramento, California, and had 50 participants.

Our agenda was simple. Darell started with a discussion of proper transducer selection, operation and installation. FAE Mark Snyder then presented guidance on machine specific applications, with discussion of appropriate probe location for motors, pumps, turbocompressors, reciprocating compressors, hydro turbines, steam turbines, aero-derivative gas turbines, etc. as described in industry-recognized American Petroleum Institute (API) standards and Bently Nevada recommended practices. I then contributed with a discussion on maintenance strategies, including Failure Modes & Effects Analysis (FMEA) and asset criticality ranking.

Finally, FAE Billy Gilkerson discussed different monitoring instruments including continuous, scanning (wired and wireless) and portable monitoring systems. He tied the morning's concepts together with a demonstration before lunch. At the end of the day, he showed the rotor kit monitored with a 3500 rack with System 1 software, demonstrating concepts such as measurement of shaft runout and showing valuable diagnostic data available from proximity probes during a machine start-up or coast down. Many of the end users commented on how illuminating the day was for them. They were able to explore some basic concepts of vibration monitoring using eddy current displacement transducers, and they had the chance to experience some of our monitoring products in action.

Reciprocating Compressor Monitoring

Building on our experience with informal Back-to-Basics seminars, our Western USA Sales team recently hosted a free one-day seminar for our reciprocating compressor monitoring customers. Although this particular event was held in California, similar product demonstration events are occasionally held by members of our Sales team in many different regions around the world.

Participants at the event were end-users who actually apply our sensors, transducers, monitors and software for protection, condition monitoring and diagnostics of their reciprocating compressor assets. Through discussions of actual case histories, the participants learned how better reciprocating compressor condition information translates into enhanced profits through more effective operating and maintenance decisions.

In addition to studying case histories, participants learned how our portfolio of measurement capabilities continues to evolve and grow – with enhanced capability to assess the condition of compressor valves, pressure rings & rider bands, pressure packing cases, crosshead, crosshead shoes & pins, as well as online thermodynamic performance measurements of each compressor cylinder and stage.

FIELD APPLICATION ENGINEER STEPHEN PLAISANCE: facilitates a Reciprocating Compressor Condition Monitoring Best Practices session for a group of end-user customers.

Seminar Topics

- Reciprocating Compressor Measurements Overview
- Best practices from API 618 standard, "Reciprocating Compressors for Petroleum, Chemical, and Gas Industry Services"
- 3500 System and System 1 software for Reciprocating Compressors
- Presentation and live demonstration using reciprocating compressor kit
- Case Histories: Root Cause Analysis, Valve Failure Detection, Predictive Maintenance
- System 1 Reciprocating Compressor RulePaks and Decision Support*
- Proficy** SmartSignal software overview
- Service and Installation Considerations

More Information

For more information on condition monitoring for reciprocating compressors, visit our online Bently Nevada Application Pages at the following link: http://ge-mcsdev.sensing.ge.com/en/bently-nevada-application-solutions/reciprocating-compressor-condition-monitoring.html

The Reciprocating Compressor Condition Monitoring page includes many useful references in the **Overview, Experience, Media Gallery** and **Download** tabs. ■

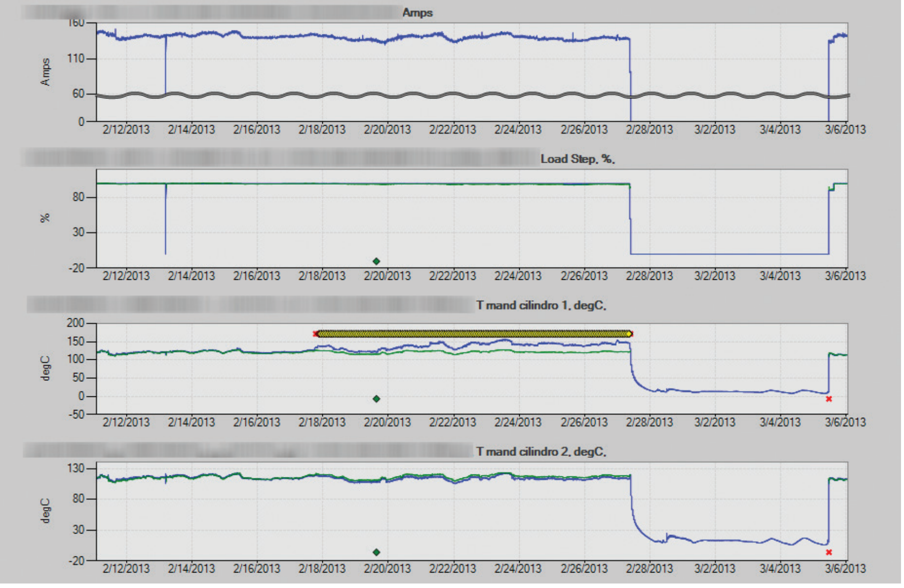
Note: Informal customized events such as the one described in this mini article are separate from our formal training courses, which are described at our online training site: http://ge-energy.turnstilesystems.com

Damaged Valve on a Reciprocating Compressor Detected at an Oil and Gas Facility

[This short customer success story was contributed by our friends at GE Intelligent Platforms' Availability & Performance Center. It is a nice complement to our Reciprocating Compressor Condition Monitoring Seminar article. – Editor]

What Did the Proficy SmartSignal Software Find?

In mid-February, the Proficy* SmartSignal solution detected small increases in the cylinder discharge temperature on a reciprocating compressor at an oil and gas facility. Given loading conditions, discharge temperatures were expected to remain around 125 degrees Celsius. Over the month of February, discharge temperatures rose to values as high as 150 degrees Celsius. The Availability & Performance Center notified the client and helped track this item on the regular weekly calls.



SCREENSHOT: depicting actual values (blue) and expected values (green). Compressor driver amperage shown in top graph (the wavy line just indicates a break in the scale of the y-axis). Percent load shown in second graph with blue and green curves overlaid almost exactly. Discharge temperatures for two of the compressor cylinders are shown in bottom two graphs.

What Was the Underlying Cause?

When the client investigated this issue, they confirmed that there was a damaged valve on this reciprocating compressor.

What Was the Value to the Client?

This notification provided the client more than 10 days of early warning which allowed the client to confirm a damaged valve and then schedule an outage at a time that had the least impact on production revenue. Had this issue not been addressed, this defective valve could have led to mechanical damage of the compressor such as piston ring wear, rider band wear, or mechanical packing wear. This secondary damage would have resulted in higher repair costs and a larger loss of production due to equipment down time.

Who Found It?

- Jenn Khong, Customer Reliability Engineer
- David (Mike) Roe, Customer Reliability Manager

For More Information

GE Intelligent Platforms publishes a "Catch of the Week" e-newsletter that includes success story summaries like this one. If you would like to receive this free newsletter, simply sign up at this link: http://www.ge-ip.com/catch-of-the-week. ■

THE PURPOSE–BUILT GE SKILLS DEVELOPMENT CENTRE: Located at Jandakot is a convenient destination for students from Australia, New Zealand and across the Southeast Asia region.

GE Skills Development Centre Delivering to Our Customers

James Wallace
Measurement & Control
Training Sales Manager
ANZ region

Several important changes have occurred over the past twelve months across the Measurement & Control business, leading to Bently Nevada* training becoming a business in its own right. A continued growth in demand has also meant that in Australia and New Zealand a new position of Training Sales Manager was established to cater for the increasing regional interest.

With the opening of the GE Skills Development Centre at Jandakot in Western Australia, by the Australian Prime Minister late last year, we now have an ideal venue for the delivery of high quality Bently Nevada training courses. In addition to a variety of conference rooms, classrooms, interactive training workshop and an auditorium, the Skills Development Centre features a dedicated Measurement & Control Solutions Centre, which showcases a large portion of our product portfolio.

As the Centre becomes established and the oil & gas footprint continues to expand in the region, the author and the Measurement & Control team are looking to showcase the facility, Bently Nevada products and equipment to customers through an 'open house' environment featuring product demonstrations. An overview of our training courses – including 3500 Operations & Maintenance, System 1* Fundamentals and Machinery Diagnostics – will also be presented by our instructors.

The Bently Nevada training team achieved another milestone during the first quarter by conducting the first Advanced Machinery Dynamics (AMD) course in the Asian Pacific Region. Held at the Skills Development Centre, customers from Asia and across Australia were able to learn from both international and local instructors, as they shared their years of diagnostics experience. Based on the positive feedback from participants and increasing interest in AMD concepts, a second offering of the course will be conducted later in the year.

The influx of Liquefied Natural Gas (LNG) projects in Australia is also keeping our instructors busy presenting a variety of Bently Nevada courses, including Systems & Instrumentation, Condition Monitoring and Machinery Diagnostics. The ANZ team is also looking at the best way to service its customers, included the possibility of taking the training to them. Identified targets include Adelaide, Brisbane, Collie, Darwin, Karratha, Melbourne and Sydney.

Having properly trained technicians on staff can empower our customers to apply condition monitoring techniques more effectively – potentially saving their companies significant costs by avoiding unplanned outages and adopting more proactive maintenance strategies – all by completing a three day or five day training session.

For more information about the Jandokot Skills & Development Centre, the upcoming AMD course or any of the Bently Nevada courses, please visit the website: http://ge-energy.turnstilesystems.com/

Alternatively contact James Wallace, Measurement & Control Training Sales Manager, ANZ region at +61 8 6595 7018 or +61 477 300 833 or email: james1.wallace@ge.com ■

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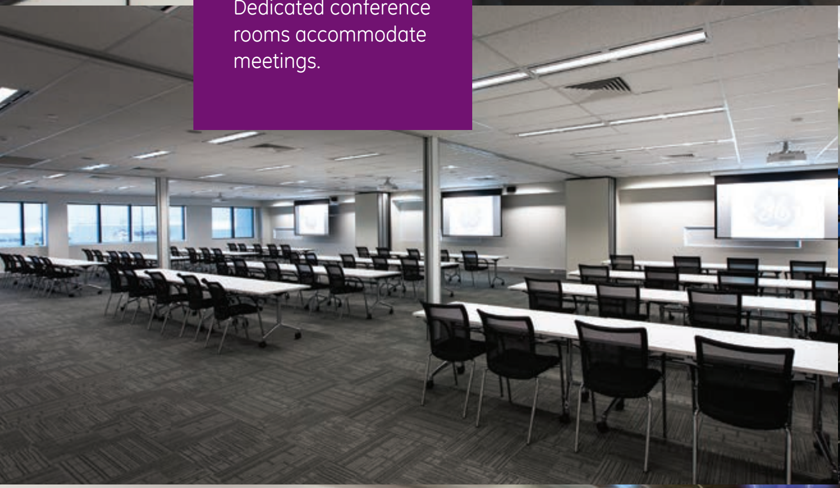

TOP: Australian Prime Minister Julia Gillard inspected the dedicated Measurement & Control facilities during the official opening of the GE Skills Development Centre in November, 2012. GE Graduate Engineer Jo Thompson was at hand to help guide the Prime Minister through the tour. **MIDDLE LEFT:** Large classrooms feature folding walls that allow for flexible configuration. **MIDDLE RIGHT:** With theater-style seating, the auditorium accommodates larger audiences. **BOTTOM:** Dedicated conference rooms accommodate meetings.

Marketing and Voice of the Customer (VOC)

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At GE's Bently Nevada, we pride ourselves on our history of innovative products, but the days of "build it and they will come" are long gone. Our marketing group continues to invest heavily in gathering customer insights – whether directly from our long-standing customer relationships, or through studies that we commission with independent, third-party vendors to understand market trends – to understand your pain points and the problems you are trying to solve. We constantly strive to bring your perspective to our product innovation.

Customer Advisory Board

One example of this investment is the Bently Customer Advisory Board (CAB) that consists of key customers from the Oil & Gas and Power Generation industries. It is a representative group of approximately ten customers who meet with us once a year in the spring. We get together for two days at picturesque Lake Tahoe, near our Minden office in western Nevada. There, we consider a variety of topics including the Bently Nevada vision, and how it guides our products and services.

During the CAB meeting, our customers interact with a cross-functional GE leadership team and help shape and drive our strategy. At the same time, they share their own perspective of industry trends, business outlook, and the challenges they face. On the third day, the CAB visits the Minden office where they spend the day touring the plant, having deep dives with our Product Managers and Technology team on specific topics, and getting a preview of what we are working on. We continue to build on our long-standing tradition as a true learning organization and this close interaction helps us to better understand the problems that our customers experience, and the solutions they want.

What's Next?

One of things we learned from our participants is that we need to be more effective at sharing news of our product line with the broader population of customers beyond just the CAB. In the past, the Bently team's deep rooted engineering culture has caused us to shy away from the marketing-driven culture of self-promotion, and this has hindered our willingness to publicize our new offerings more aggressively.

As we go forward, we will do better job of sharing product update news. To this end, our marketing team has developed a preview of some of our key offerings in 2013, and we are creating a special website to make this information more easily accessible. At the time of this writing, the new website is not quite ready to "go live," but we will publicize the link in Orbit as soon as it is available. We are confident you will find the new site to be both interesting and useful! ■

LEFT: Emerald Bay is one of the most-photographed scenic destinations at Lake Tahoe. **RIGHT:** A participant in our 2012 CAB event visits the Minden Remote Monitoring Center, and chats with RMC Engineer, Corby Cobb (seated).

Printed Circuit Board Assembly (PCBA) Prototyping Center Open for Business

In the previous issue of Orbit, we announced the upcoming opening of our new PCBA Prototyping Center. With the recent ribbon-cutting ceremony, it is now official! The state-of-the-art Surface Mount Technology (SMT) assembly line is located in our Minden, Nevada facility, where it leverages in-house infrastructure and process expertise. — Editor

"Reliable electronics are critical to the product lines and customers of Measurement & Control, and the printed circuit board assembly (PCBA) process is a major element of this reliability," said Julie DeWane. "By building prototypes through one center and being involved early in the design and manufacturing process, we create increased reliability, a faster development cycle and better outcomes for our customers."

"THE TEAM HERE IN MINDEN HAS INCORPORATED THEIR EXPERTISE IN LEAN TECHNIQUES IN THE INFRASTRUCTURE DESIGN, BRINGING THE DEVELOPMENT OF THE PROJECT IN AT SIX MONTHS FROM CONCEPT TO CREATION," ADDED ERNEST CAREY, GLOBAL SUPPLY CHAIN LEADER FOR THE BENTLY NEVADA* AND CONTROL SOLUTIONS PRODUCT LINES. CAREY WENT ON TO THANK THOSE WHO WERE CRITICAL TO THE DEVELOPMENT AND EXECUTION OF THE CENTER INCLUDING REI WAHL, THE CENTER'S LEADER; LEIF LAURIDSEN, SOURCING LEADER; CURT HOOPER, MANUFACTURING ENGINEERING LEADER; MICHAEL ARTHURS, TEST ENGINEERING LEADER; KEN FORBES, MINDEN FACILITY PROJECT MANAGER AND JIM FLEMMING, MINDEN PLANT MANAGER.

Now that the center is up and running, project discussions have begun, and several prototypes have made their way through the process. Engineers in the center not only develop the physical prototypes, but they are also involved in understanding the customer product requirements, application and design restraints, and developing the strategy for testing and sourcing for production of the PCBA. The intent is to have the expertise in the discussions right from the beginning in order to improve quality and speed up the redesign and New Product Introduction (NPI) processes. ■

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TOP: Measurement & Control Global Supply Chain Leader, Julie DeWane, (in red smock) cuts the ceremonial ribbon to officially open the M&C PCBA Prototyping Center. Rei Wahl and Ernest Carey hold the ribbon, while other Minden employees look on. Following the ribbon-cutting, the grand opening continued with tours of the new center for local employees and visiting members of the Global Supply Chain team. **LEFT:** Ken Forbes and Curt Hooper led their teams to complete the installation and commissioning of the new line on schedule. **BOTTOM LEFT:** Curt Hooper inspects prototype PCBs being populated with components by the SMT machines. **ABOVE:** Michael Arthurs explains how Non-Destructive Testing (NDT) is used to detect potential defects. *[Photos by Adrian Cobb]*

OUR MUM

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BAI

TECHNOLOGY TEAM

BENTLY'S TECHNOLOGY TEAM IN INDIA

Our Bently Nevada* software development team in India goes all the way back to 1992 when one of the authors, Soundrapandian Ravichandran ("Ravi"), was hired as the first Bently Nevada employee in India. Since then the team has grown to its current size of nearly 135 software engineers and support staff. Over the years, the team has developed and sustained the entire range of Bently Nevada software products – starting with Trendmaster*, Data Manager* and 3500 and evolving through the current version of System 1* software and 3701 (ADAPT*) monitoring systems. The team became a part of GE back in 2002, and has since expanded to working on broader GE applications in addition to those that are part of the Bently Nevada product line. Being a key product development team for the product line, we are working to continuously improve our software offerings, and are currently developing some exciting new products that future Orbit issues will cover.

LEFT: The Mumbai Technology and Information Management (IM) teams take a moment to pose for an "all-hands" photo at the Mumbai Technology Center.

Mumbai Technology Center (MTC)

Don Bently saw Mumbai as an ideal location in India for a product development team, for its advantages in availability of talent, connections with commercial and services teams and ease of doing business. The team started operations in a well known export zone and as we grew in size, moved into one floor of a larger, brand new facility in 2008 in central Mumbai. This building is also home to the Measurement & Control IM team.

The facility's proximity to the sales and services teams in the region has enabled frequent and close collaboration with them and through them, with customers. This has given us a better understanding of customer needs.

The quality of work, state of the art infrastructure, the collaborative development model and pride in the Bently Nevada brand, have all contributed to the high morale and retention of key talent in the team. Many members of the leadership team have been with GE's Bently Nevada for more than 15 years.

Long Standing Award Winners

As is the tradition in GE, every year we take the opportunity to "celebrate our experience" by recognizing employees with continuous service spanning 10, 15, or more years. This year, we recognized 16 employees at the MTC.

Annual Engineering Recognition Day Winners

We also recognized a group of Engineers for their outstanding work during the previous year. ■

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"As an engineer, it has been a great experience to see the team grow under GE Bently and provide value to our customers. We can take pride in the global collaborative model of product development and world class talent that the US and India teams have successfully demonstrated."

SOUNDRAPANDIAN "RAVI" RAVICHANDRAN
India Engineering Leader, GE Oil & Gas

"Our MTC team has been a longstanding pillar of our technology capability. As you can see, we have many talented engineers with many years of experience developing and supporting solutions for our customers."

ERIC BUTTERFIELD
Bently Nevada Executive Engineering Manager

"Being a new leader in Bently, I quickly realized the vast knowledge base that our team has developed over the past 20 years. It is experienced engineers like these who help us show differentiation to our customers and deliver high quality, state of the art products."

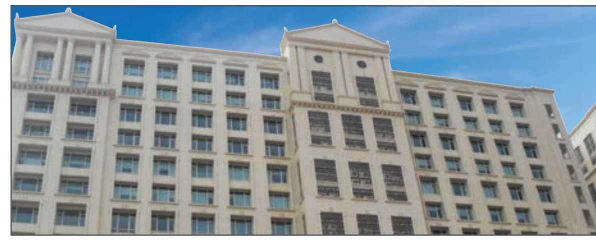
CLAYTON SYNARD
Bently Nevada Software Engineering Manager

15 YEAR MILESTONE


Meera Agrawal


Sunil Desai


Sujata Shetty


The modern MTC facility is home to a variety of industrial businesses.

10 YEAR MILESTONE


Girish Aralikatti


Uday Biradar


Anupama Chandalia


Danni David


Nirav Doshi


Shailesh Hinge


Jessy Kurien


Sunil Kutty


Prabhat Mishra


Navin Pai


Aniket Palkar


Shekhar Sashital


Arif Shaikh

THE 2013 ENGINEERING RECOGNITION DAY WINNERS WITH GE LEADERS (LEFT TO RIGHT): Anikt Goyal, Ravichandran, Omkar Manohar, Eric Gebhardt, Vandana Warty, Praddep Desai, Anand Mokashi, Sajith Nair, Sandeep Patil, Saurabh Gore and Sandeep Marode.

INSTRUMENT GROUNDING

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This article introduces fundamental grounding concepts that are important for electrical safety and for reducing noise in the signals measured by an installed transducer system. It also includes some very basic concepts of safety barriers and galvanic isolators that are used for Intrinsic Safety (I.S.) in Hazardous Area installations.

SAFETY GROUNDING is required by electrical codes and regulations to ensure personnel and equipment safety. If an electrical fault causes an exposed enclosure to become energized, the safety ground provides a low-resistance return path for the fault current to the source.

Note: The ac distribution "mains" that power Bently Nevada* monitors and transducer systems are typically 230 or 120 Vac. These voltages can be lethal if systems are mis-wired, so it is vital to follow appropriate electrical codes and standards when connecting power supply wiring, including earth ground connections.

INSTRUMENT GROUNDING provides a zero reference for the signal measurement. It may be accomplished in conjunction with a power supply safety ground, or it may be done using a separate path to eliminate ground loops, which can introduce unwanted noise to the signal.

Figure 1 shows a simplified single phase ac power distribution system, such as the type that is used to power proximity transducers and monitor systems. Voltage is typically 230 Vac for a 50 Hz system and 120 Vac for a 60 Hz system.

In addition to Line and Neutral conductors, ac distribution systems include a Ground conductor, which is connected to the exposed metal surfaces of the load (frame, housing, chassis, etc.). Typically, the ground conductor does not have any current flowing through it unless a fault energizes parts of the electrical system that are not designed to be current carrying conductors – such as the load enclosure.

If a fault occurs, the ground conductor provides a low-impedance path that shunts the return fault current back to the source. This prevents the load enclosure from being an electrocution hazard. Protective devices continuously monitor the ground conductor, and when a fault current is detected, they automatically open the supply breaker, de-energizing the circuit.

Table 1 shows that color-coding of electrical wiring insulation varies widely from one geographic region to another. It is vitally important to understand and follow the applicable color-coding scheme that is used at each specific installation site. This table is provided for illustration only, and is NOT meant to be used as an official code reference for performing any actual electrical work.

Monitor Rack Power Supply Safety Ground

The safety ground for Bently Nevada monitor racks is normally connected at the rack power supply module. Figure 2 shows the ac power cord connection to a Power Supply Input Module (PIM) on a 3500 rack for a 120 Vac electrical distribution system in the USA.

The three electrical leads in the cord are the black conductor (Line 1) which is connected to the upper terminal, the white conductor (Neutral) which is connected to the center terminal, and the green with yellow stripes conductor (Earth Ground) which is connected to the lower terminal. The ground conductor is electrically bonded to the monitor rack chassis by the aluminum grounding strap.

It is extremely important that the grounding strap is installed to provide the safety ground functions that we have discussed. The electrical caution statement shown in Figure 3 is used throughout Bently Nevada product technical documentation, where applicable.

The photos in Figure 4 show a closer view of the conductive straps that bond chassis ground for the 3500 and 3300 system racks to earth ground through the ground lead of the ac power supply cord. Other monitor

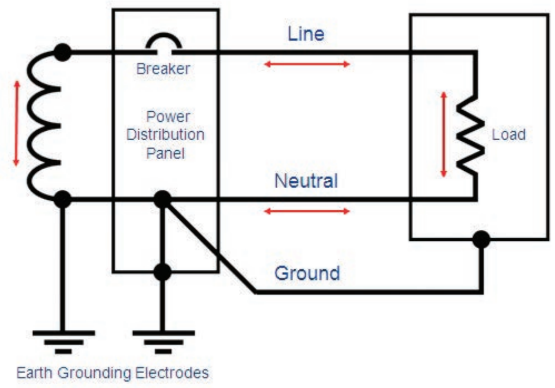


FIGURE 1: Simplified electrical distribution system showing safety ground. Earth grounding electrodes are typically large metal rods or plates that are buried underground per applicable electrical codes and safety regulations.

Country	Line 1	Line 2	Line 3	Neutral	Ground
Canada	black	red	blue	white	green (or bare copper)
China	yellow	green	red	light blue	green & yellow striped
Europe	brown	black	gray	blue	green & yellow striped
India	red	yellow	blue	black	green
USA	black	red	blue	white or gray	green, green & yellow striped (or bare copper)

TABLE 1: AC Wiring Color Examples

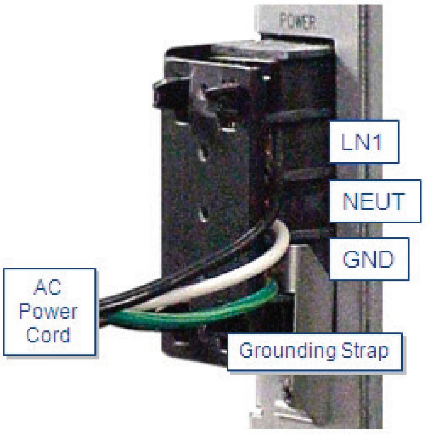


FIGURE 2: Example photo: Monitor rack power supply safety ground connection.

systems, such as the older 7200 series, used similar straps or links to connect chassis ground to earth.

Instrument Grounding

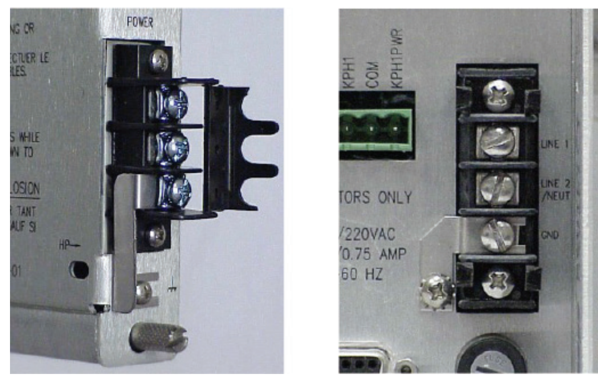
In electronic systems, common portions of circuitry are traditionally connected to "chassis ground" (the casing or enclosure of the circuitry) in each individual system module. This standard technique has been used throughout the electronics manufacturing industry for many decades, and it is not limited to Bently Nevada transducer systems. Unless the metal chassis is double-insulated (completely surrounded with a non-conductive material), it is normally connected to earth ground via the ground conductor in the ac power distribution system.

The simplified diagram in Figure 5 illustrates the signal common path in a typical Bently Nevada proximity transducer system – shown as an alternating dashed and dotted line. This path is electrically connected to the outer barrel of the probe cable connection, the Proximitor* Sensor case and the monitor rack chassis. The internal probe wiring is electrically isolated from the probe case, so the probe case is not at signal common potential.

⚠ CAUTION

Proper rack chassis grounding requires that this metal strap remain connected. Failure to follow this warning could expose personnel to dangerously high voltage levels that could cause shock, burns, or death.

FIGURE 3: Electrical safety caution statement.



3500 Power Input Module (PIM) Grounding Strap

3300 Power Input Module (PIM) Grounding Strap

FIGURE 4: The grounding strap physically connects the rack chassis to the power supply earth ground conductor. The grounding strap was made to be removable for the very specific situation where Safety Barriers are installed in the system. Safety Barriers are introduced near the end of this article.

Ground Loops

Depending on the specifics of regional electrical codes, large industrial facilities may have a buried grid of large-diameter copper cables underneath the entire plant. Individual machines, such as large electric motors, have their safety grounds bonded to this grid using large cables that disappear from view into the concrete pads and foundations where the machines are mounted.

Any imbalance between loading of the phases in the motor windings produces some circulating current in the grounding grid, which can make these grounds noisy for use with monitoring instrumentation. If a grounding grid is not used at a particular site, the problem is usually even worse, as the earth itself has significant electrical resistance (which varies with soil composition and moisture content), and circulating currents can cause significant voltage differences between different locations on the site.

If the cable connectors or Proximitor Sensor are allowed to contact earth ground, (such as the inside of a bare metal conduit or a steel mounting bracket) any voltage difference between these points causes current to circulate through the Signal Common conductor (Figure 6). This introduces noise to the measured signal. Ground loop noise often occurs at the power system distribution frequency (50 or 60 Hz) or an integer multiple harmonic (100 or 120 Hz, etc.).

Single Point Ground

The key to avoiding ground loops is to eliminate all of the earth grounding points in the system except for one. This is often called a single point ground (Figure 7). The following Application Note excerpt summarizes this concept:

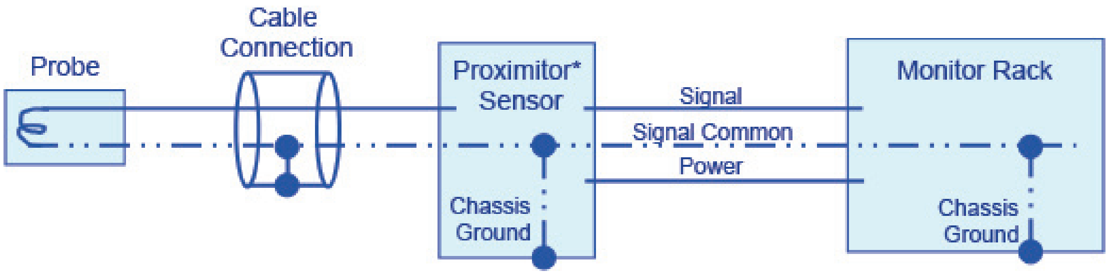


FIGURE 5: Signal Common potential exists at three exposed points: Probe to Extension Cable Connection, Proximitor Sensor Case, and Monitor System Chassis

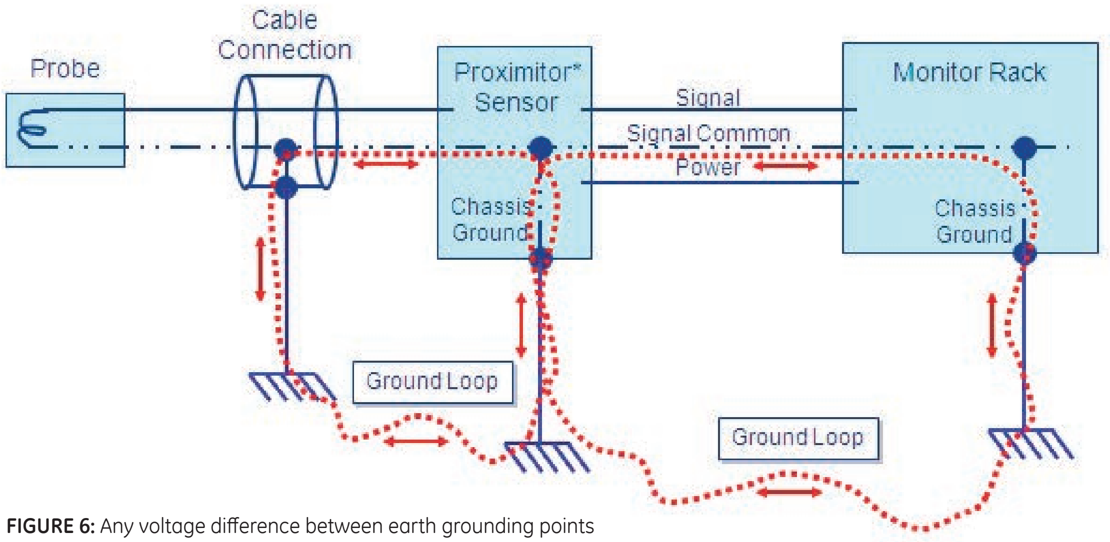


FIGURE 6: Any voltage difference between earth grounding points causes current to circulate through the Signal Common conductor, introducing noise to the system.

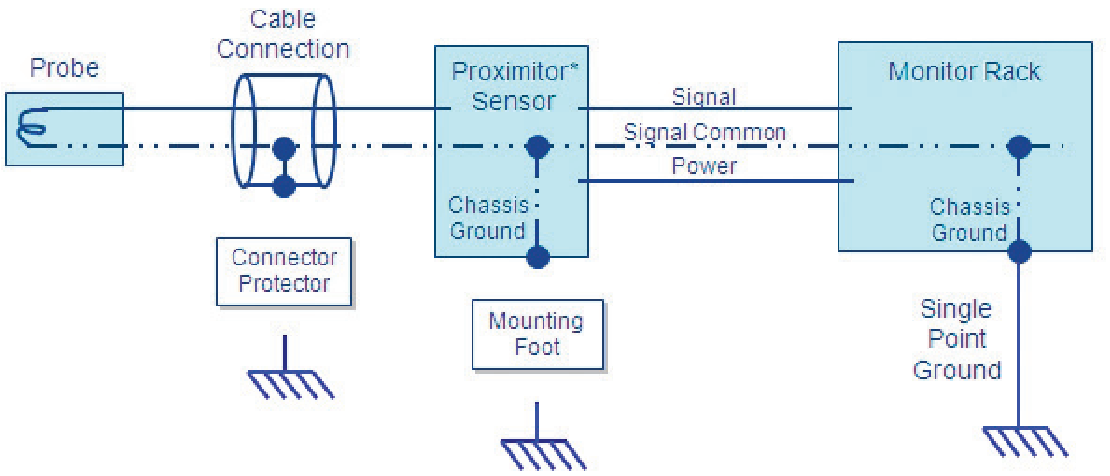


FIGURE 7: Isolating the cable connection and Proximitor Sensor chassis from contact with earth ground eliminates ground loops. The connector protector is an elastomeric boot that provides physical protection against moisture ingress, as well as insulation from ground. The Proximitor Sensor uses a plastic mounting foot that isolates the metal casing from ground.

"Connections between system common and earth ground must occur at earth ground points of equal voltage potential. Usually this is most easily accomplished by connecting system common to earth ground at a single point. That point is usually at the instrument rack or, for Intrinsically-Safe (IS) systems, at the barrier 'earth' ground bus bar." (Reference 1)

Field Wiring Shield Ground

Field wiring cables connect each Proximitor sensor to the Input/Output (I/O) Module of the monitor rack. These cables include a braided screen (shield), that is similar to the outer screen in the triaxial probe and extension cables. In probe cables and extension cables, the outer screen is not electrically connected, and only provides mechanical protection against cable abrasion. However, with field wiring, we intentionally connect the shield to ground, so that any induced electrical noise that it intercepts can be "drained" to ground (Figure 8).

The reason that we only connect the shield at one end is to prevent creating another ground loop. If the shield were connected at both ends, any electrical noise that it intercepted would appear as a voltage difference between chassis ground at the Proximitor Sensor and the monitor. This voltage difference would be superimposed on signal common.

Note: This technique of connecting a cable shield at only one end is very commonly applied across every industry with electronic instrumentation of all kinds – including electric guitars plugged into musical instrument amplifiers or concert sound systems!

Diagnostic Connections

Monitor modules incorporate buffered signal outputs for the convenience of connecting diagnostic instrumentation such as digital multimeters, oscilloscopes and various data acquisition devices and signal analyzers. The buffer amplifiers match the impedance of the connected device with the internal circuitry of the monitor, preventing the connected device from degrading the signal. The buffered outputs are also short-circuit protected. This means that a short circuit in the connected test leads will not damage the monitor circuitry – although it could very likely damage the buffer circuit, requiring the monitor module to be returned to GE for factory-authorized repairs.

It is important to realize that the buffer amplifiers do not provide any electrical isolation (i.e., the outer conductor is connected to signal common.) Signal common in the monitor will still be physically connected to signal common in the diagnostic instrument. If signal common in the diagnostic instrument is connected to chassis ground, this introduces a ground loop by adding a second earth grounding point to the system. (Figure 10)

Unless they are double-insulated, most ac-powered diagnostic instruments are required to have their chassis grounded for safety through the third-prong on the AC power cord to the instrument. Unfortunately, this introduces a ground loop into the transducer and monitor system – even if the probe to extension cable connections and Proximitor Sensor cases are correctly isolated from earth ground.

Note: Many portable diagnostic instruments (such as battery-powered hand-held digital voltmeters or portable vibration analyzers) are not required to be connected to an earth ground at all, so they do not create a ground loop when connected to the monitor system.

Several techniques can be used to interface the buffered transducer outputs to diagnostic instruments, such as ground isolation switch (if present), single conductor adaptors, and various electrical isolation methods.

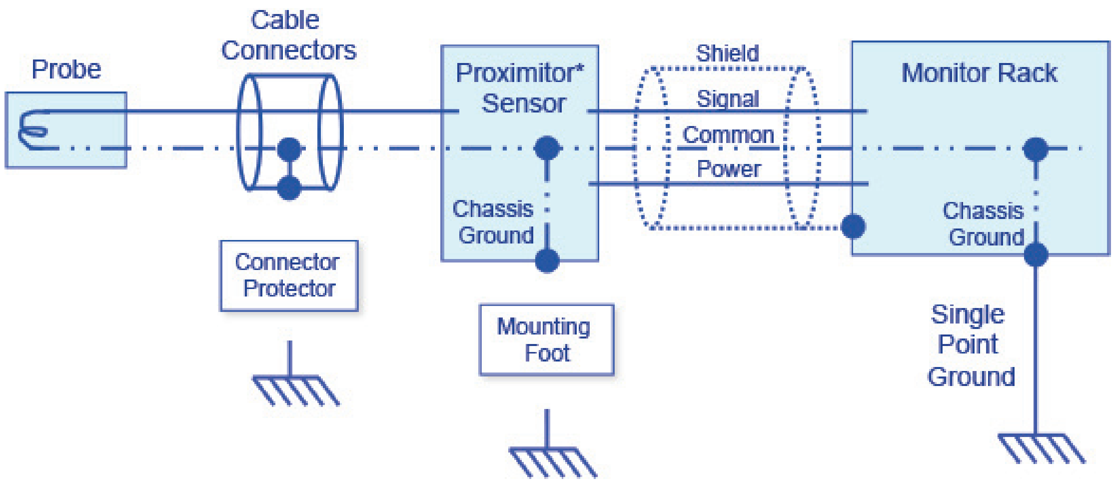


FIGURE 8: The field wiring shield is connected to ground at the monitor chassis.

3300 Buffered Signal Outputs

3500 Buffered Signal Outputs

FIGURE 9: Buffered transducer outputs (BNC connectors) allow the connection of diagnostic instruments without degrading the signals.

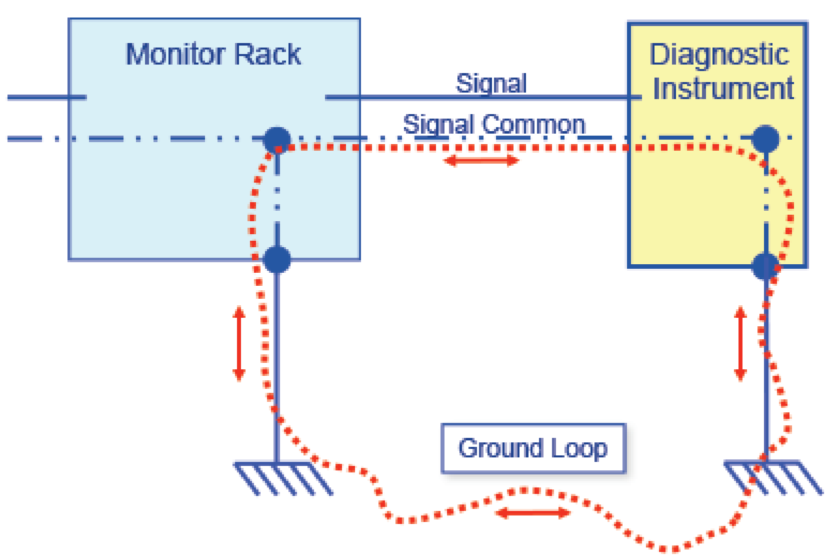


FIGURE 10: Connecting a grounded diagnostic instrument to the monitor rack can introduce a new ground loop.

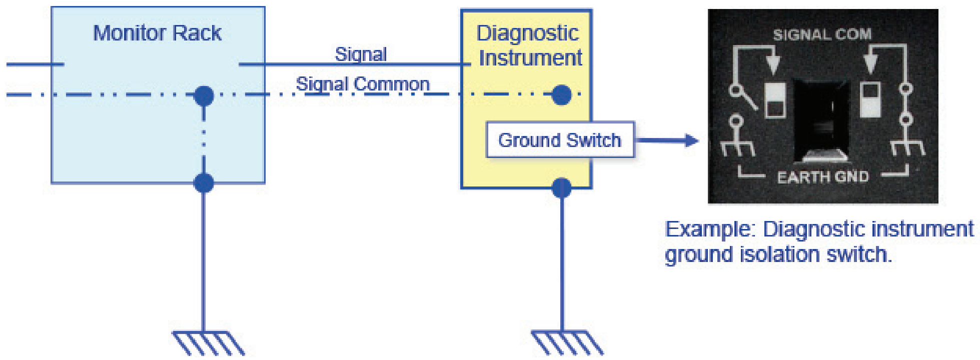


FIGURE 11: Isolating Signal Common from chassis ground in the diagnostic instrument eliminates the ground loop while maintaining the safety ground connection to the chassis.

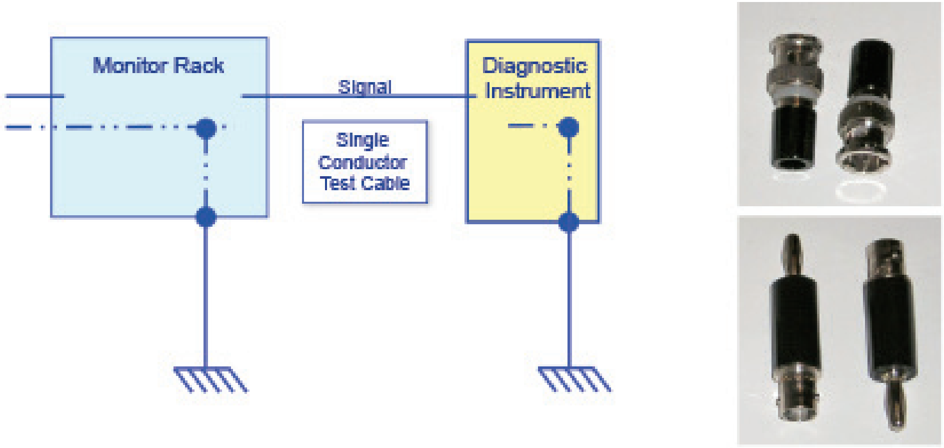


FIGURE 12: Another way to prevent a ground loop with an ac-powered diagnostic instrument is to use single conductor adaptors with the diagnostic instrument test cable. The photo shows examples of BNC to banana connection adaptors.

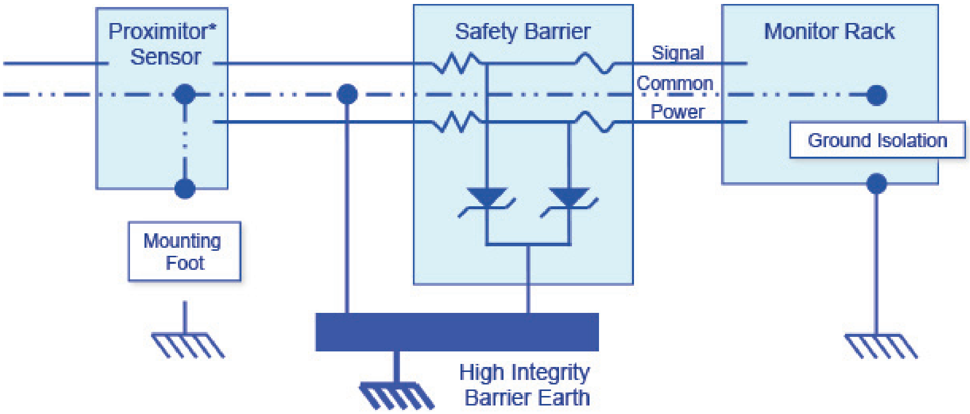


FIGURE 13: Signal Common is grounded at the Safety Barrier, so it must be isolated from chassis ground in the monitor rack.

Ground Isolation Switch

The preferred method to break the ground loop caused by a grounded diagnostic instrument is to open the connection between signal common and chassis ground in the diagnostic instrument. Some test instruments (such as the ADRE* 408 DSPi) include a built in grounding switch (Figure 11) or a link that can be opened to provide this isolation. Observe that we are not removing the connection between the test instrument chassis and earth, which is REQUIRED to be connected for personnel safety.

Single Conductor Adaptors

The ac-powered diagnostic instrument in Figure 12 does not have a switch or removable link to isolate signal common from the chassis. However, we can still avoid a ground loop by connecting the instrument to the signal path only (NOT to signal common). This can be accomplished by using single-conductor adaptors to connect the test cable to the BNC connectors at the monitor buffered outputs.

When a safety barrier is installed, the signal common field wiring leads are connected to earth ground at the safety barrier. Since we cannot remove the safety ground from the monitor rack chassis, we eliminate the creation of a ground loop by disconnecting signal common from chassis ground in the monitor rack itself.

Unfortunately, a drawback of this method is that the diagnostic instrument is now measuring the voltage difference between signal potential and the earth ground at the diagnostic instrument – rather than between the signal and signal common leads. Since this earth ground point may be at a somewhat different potential from the earth ground at the monitor, the diagnostic measurements will likely be noisier than they would be if a ground isolation switch were available in the test instrument.

Additional System Grounding Considerations

For monitoring system installations that involve Hazardous Areas (with potentially combustible atmospheres), special IS interface devices are often used to restrict the available electrical energy in the Hazardous Area wiring for any fault that can occur in the Safe Area instruments. With the IS interfaces, any sparks or heat caused by a fault will then be too weak to ignite a flammable atmosphere. Also, the low voltages that are used enhance personnel safety and facilitate maintenance of energized instruments. A full discussion of these concepts is beyond the scope of this article, but we will briefly mention the two most commonly used IS interfaces, and their particular grounding requirements.

Galvanic Isolators – are active devices that use components such as transformers and optical couplers to physically separate the connection between safe and hazardous areas with a layer of insulation. Unfortunately, these components also introduce some error into the signal. However, galvanic isolators do not require high integrity earth grounds, and they allow most transducers to electrically “float” in the Hazardous Area – completely independent of earth ground potential.

Safety Barriers – are sometimes called Zener barriers or shunt-diode barriers. They are less expensive and more reliable than galvanic isolators due to the simplicity of their passive design. Safety Barriers do not require a power supply, and they do not introduce any distortion into the signal. However, they do require a dedicated low-resistance path to earth ground.

When a safety barrier is installed, the signal common field wiring leads are connected to earth ground at the safety barrier. Since we cannot remove the safety ground from the monitor rack chassis, we eliminate the creation of a ground loop by disconnecting signal common from chassis ground in the monitor rack itself (Figure 13).

Ground loop noise often occurs at the power system distribution frequency (50 or 60 Hz) or an integer multiple harmonic (100 or 120 Hz, etc.).

The 3500 system PIM incorporates a ground isolation switch (Figure 14) that performs the same function as the diagnostic instrument isolation switch described earlier. In the 3300 system (Figure 15), a small jumper must be removed to isolate signal common from the monitor chassis.

We hope that you have enjoyed this article, and that it has served as a useful introduction (or timely refresher) on the basic concepts of instrument system grounding! ■

References

1. Guidelines for Grounding (Earthing) Bently Nevada Rotating Machinery Information Systems, Application Note 013.

*Denotes a trademark of Bently Nevada, Inc., a wholly owned subsidiary of General Electric Company.

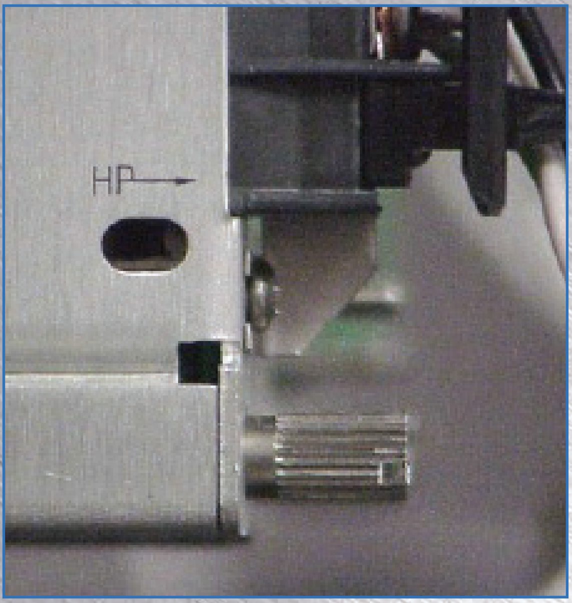


FIGURE 14: 3500 Power Input Module: When the switch is slid to the "HP" position, Signal Common is isolated from Chassis Ground.

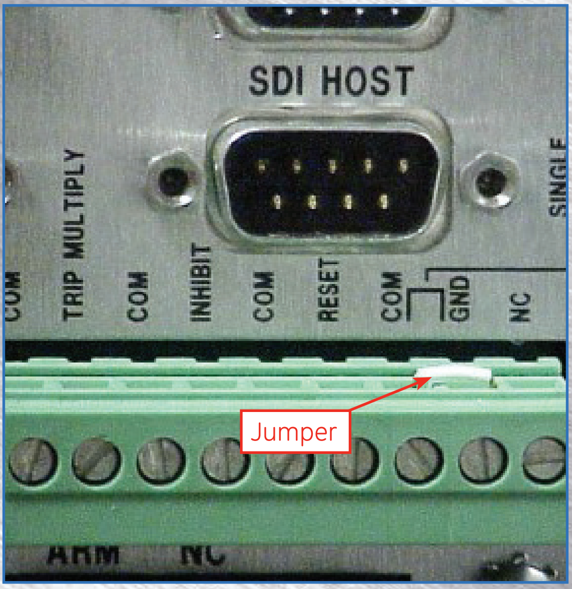


FIGURE 15: 3300 Power Input Module: When the jumper between the "COM" and "GND" terminals is removed, Signal Common is isolated from Chassis Ground.

Vibration Monitoring Identifies Steam Turbine Seal Rub

Bently Nevada Asset Condition Monitoring team helps petrochemical plant to continue operations for 32 months!*

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In 2005, the Bently Nevada team entered into a long term service agreement (sometimes known as Supporting Services Agreement, or SSA) with a petrochemical plant in India. Scope of work included monthly visits for machinery diagnostics and regular optimization of data collected in the machinery management software – which included both Data Manager* 2000 & System 1* installations. The events described in this article took place on a compressor unit in one of the main plants at the facility.

Monitored Assets

The machine of interest is a centrifugal compressor driven through a flexible disc pack coupling by a 14-stage 30 MW steam turbine (Figure 1) with rated running speed of 4068 rpm (maximum 4271 rpm). The turbine and compressor both have fluid-film bearings, and both are instrumented with XY proximity transducers for radial vibration monitoring, axial probes for thrust position monitoring, and a Keyphasor* transducer for phase and speed measurements. The machine train is protected using a Bently Nevada 3300 System, while Data Manager 2000 software facilitates vibration condition monitoring and diagnostics.

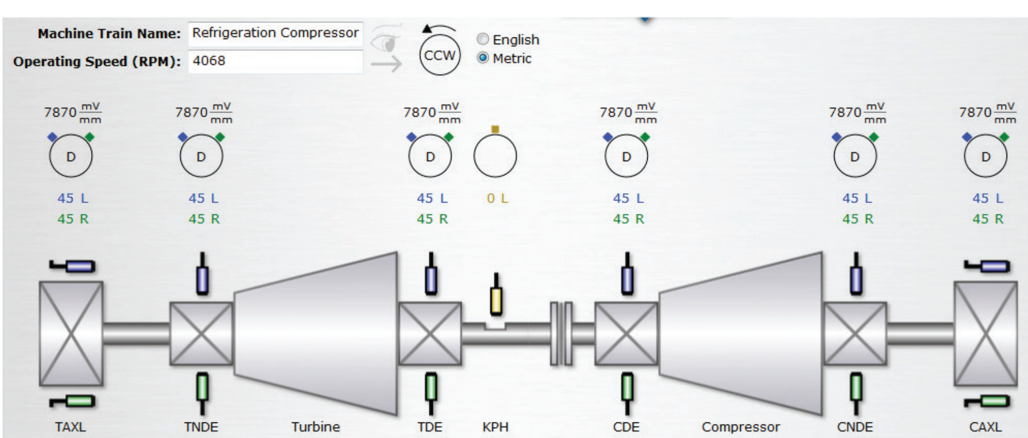

FIGURE 1: Simplified machine train diagram of the refrigeration compressor

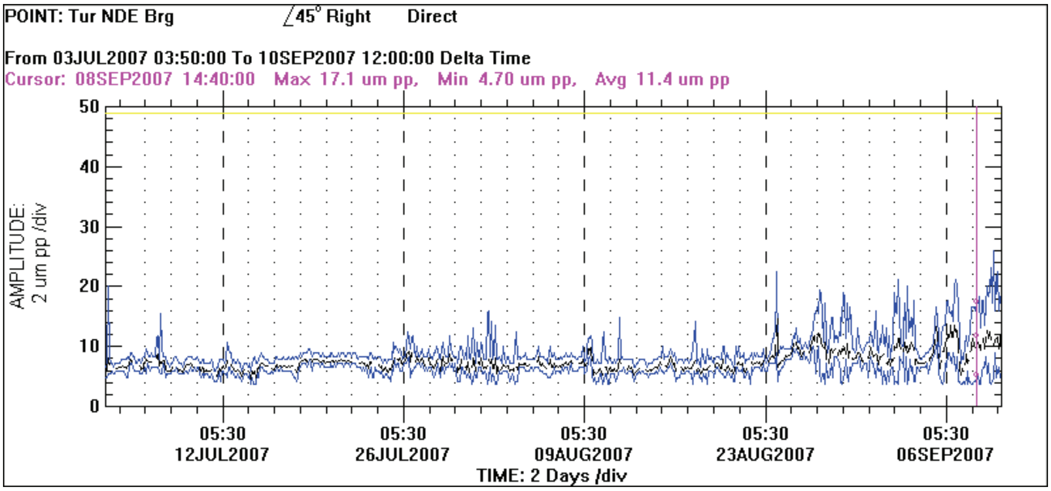

FIGURE 2: July-September 2007 trend of Direct (broadband) vibration amplitudes on steam turbine NDE bearing.

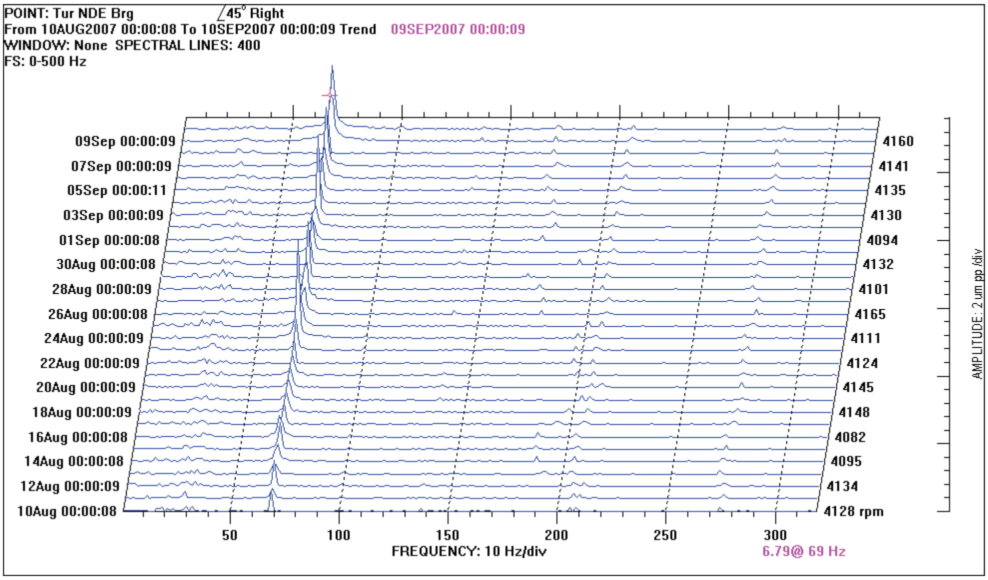

FIGURE 3: August-September 2007 waterfall plot showing spectral components of the vibration excursions on turbine NDE bearing during August and September. Note: The ~69 Hz peak corresponds to the machine running speed, which validates that it is 1X vibration.

Event History

In July and August, 2007, the steam turbine NDE bearing started showing brief high vibration excursions on both probes (Figure 2). Although peak amplitudes were less than the Alert setpoints, these vibration excursions started becoming more frequent in the month of September.

Frequency domain analysis showed that the vibration excursions were mainly due to synchronous (1X) excitation (Figure 3).

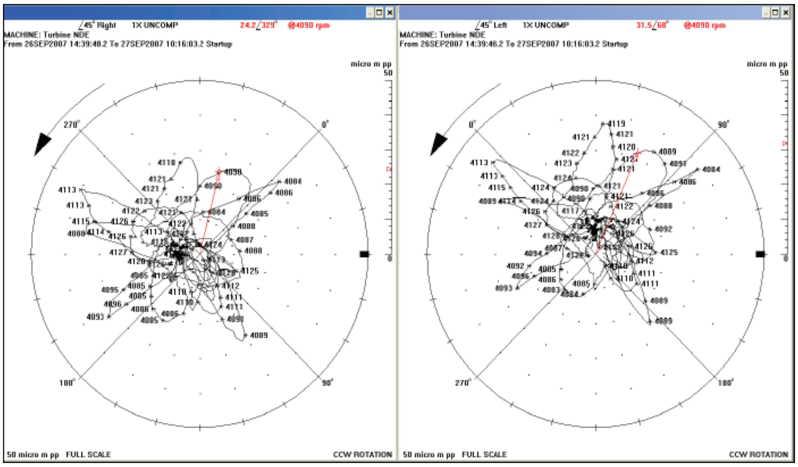

FIGURE 4: September 2007 ADRE polar plots showing widely varying phase angles for different high vibration events.

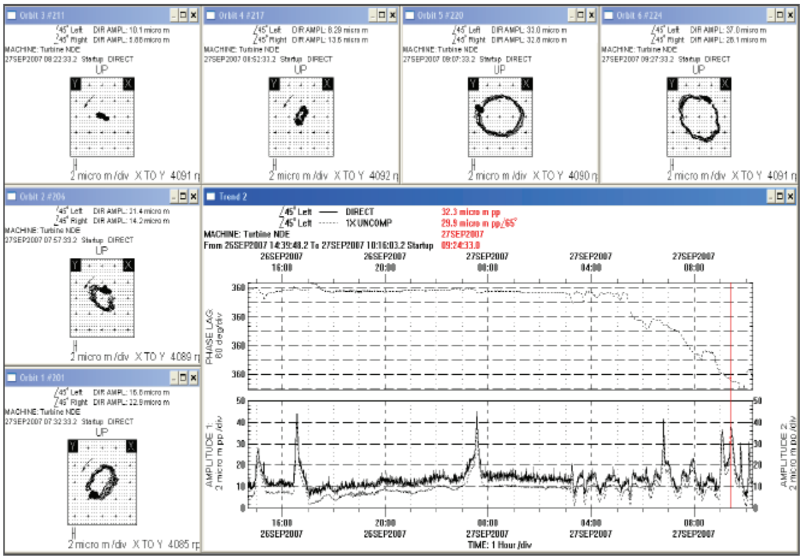

FIGURE 5: September 2007: ADRE plots show changes in orbit size and vibration phase (Keyphasor dot) indicating intermittent rotor bow symptoms.

To study the event in more detail, we used the high resolution trend capabilities of Data Manager 2000 software, and connected an ADRE* unit to collect additional data. Along with 1X vibration amplitude changes, 1X phase changes were negligible during any single event of elevated vibration amplitude. However, the phase changed significantly from one event to the next (Figure 4). These observations indicated the possibility of an intermittent rotor thermal bow, with the added characteristic of a "hot spot" location that did not remain constant. Orbit size and shape (Figure 5) confirmed the rotor bow due to a rub.

Rub-Induced Thermal Bow

Figure 6 shows a local heating mechanism that can cause thermal bow of a rotor. Due to friction & impact forces caused by a rub, localized heating of the rotor creates a hot spot at the point of contact between the rotor and a stationary component of the machine. When combined with the rotor's original heavy spot (residual unbalance), the "high spot" at the heated area produces a new effective unbalance vector and a new heavy spot resulting in a new phase angle for the 1X vibration. If the location of the hot spot doesn't change over a rub cycle, the thermal vector is repeatable and the resultant phase angle is constant. However, the amplitude and phase change due to new effective unbalance vector.

With an intermittent rub, the hot spot – and its associated thermal vector – disappear when the physical contact between the rotor and the stationary component is eliminated. The hot spot cools, the rotor bow subsides, and vibration amplitudes and vectors return to original values based on residual unbalance, without the influence of a thermal bow. However, if the root cause remains and the rub reappears, causing a new hot spot with a different location, the vibration excursion may happen again – with a completely different vector. This appeared to be what was happening during the observed events of 2007.

Annular rub is another variety which can destroy the machine in a matter of hours when the rotor contacts stationary components such as the inner surface of a steam seal or bearing for a full 360 degrees. With this type of rub, the orbit is typically very circular, since the rotor is rolling all the way around the inner surface of the stationary component. If adequate lubrication exists between the rotor and the stationary component, precession of the rotor vibration will continue to be

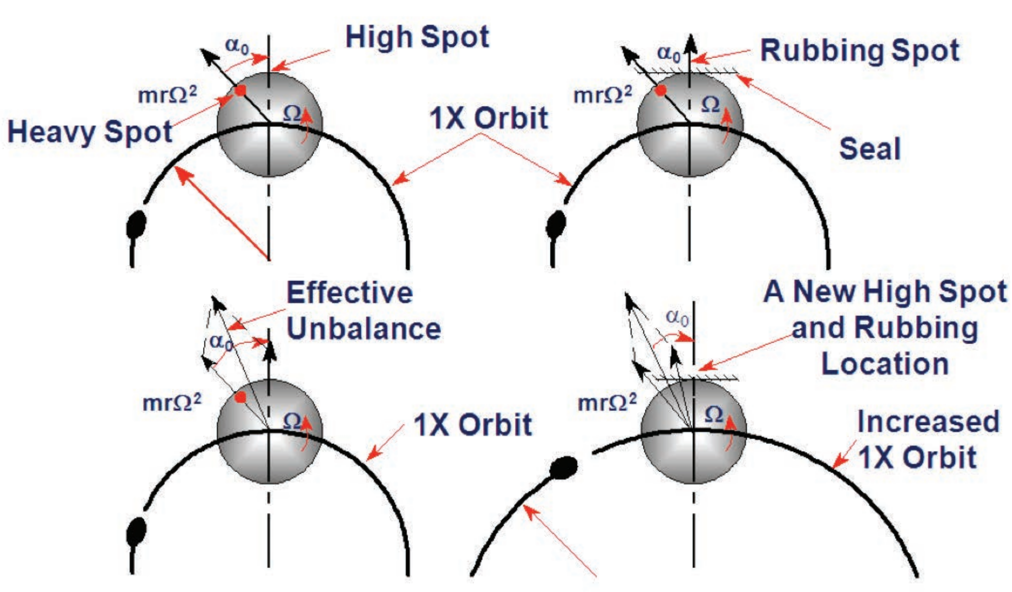

FIGURE 6: Changes in vibration amplitude (orbit size) and phase (Keyphasor dot location) can occur when a rub causes a hot spot that produces a thermal rotor bow.

forward (in the same direction as shaft rotation). But if inadequate lubrication exists, it produces a dry rub, which results in reverse precession, and in its most extreme form, can destroy the machine in a matter of minutes.

Note: A rub is always a secondary effect that is produced when another malfunction causes the average or dynamic shaft centerline to be too close to the limits of available clearance between rotating and stationary components. Excessive radial loads caused by problems such as misalignment can force the average shaft centerline to shift too close to the clearance limits, while high vibration caused by unbalance, instabilities or rotor bows can allow contact to occur even if the average shaft centerline position is normal.

Data Evaluation

As discussed, the observed orbits were not circular, and observed precession was predominately forward. Combined with the fact that the episodes of elevated vibration were not continuous, these symptoms indicated the presence of a light, intermittent rub. The changing phase angles corresponded to a classic shaft rub with a wandering hot spot causing a thermal bow.

Vibration data pointed to a localized rub close to bearing 1 (steam turbine NDE, the governor end of the turbine). The most suspected locations were the bearing 1 oil seal – where accumulation and hardening of lube oil in the labyrinth seal may have had the chance to create hard coke deposits – and the HP packing (front labyrinth seal of the casing itself), which is made of a very hard stainless steel alloy.

Action Plan

Since the high vibration amplitudes were less than the alert setpoint, and the intermittent events were of short duration, plant staff decided to continue running the compressor while closely observing the data available in the Data Manager 2000 software. They controlled operations to minimize changes in process conditions in order to limit the occurrences of high vibration. This allowed them to meet plant production requirements while maintaining a heightened watch on compressor condition.

Additionally, the staff planned ahead for corrective maintenance in case the compressor needed to be shut down before the next scheduled outage. They staged a spare turbine rotor and related spare parts for this contingency, and were standing by to take action at short notice if needed. Operations continued as before, with occasional instances where vibration amplitude briefly exceeded the Alert setpoint (Figure 7).

Eventually, at two different times, vibration amplitude exceeded the Danger setpoint and caused the machine to trip (20JUL2008 & 13AUG2009). One of these instances happened late on a Sunday evening. Immediately following the trip, the Bently Nevada Machinery Diagnostic Services (MDS) Engineer remotely analyzed the data from Data Manager 2000 over a dial-up network.

The MDS Engineer verified that the steam turbine had tripped due to excessive high vibration during another brief episode of rotor thermal bow, which was similar to what had been observed for several months. Plant staff allowed the rotor to cool and the bow to straighten by operating the machine train at slow-roll conditions. After verifying that vectors were within acceptable values, they continued with a very cautious startup. Operation continued under close observation by the plant condition monitoring team and Bently Nevada MDS engineers.

The first occurrence of rub had been witnessed in the month of July, 2007 and the refrigeration unit was successfully run until March, 2010 with heightened monitoring. As 2010 progressed, the observed time between the episodes of high vibration was increasing. It was apparent that there was a definite trend of small peaks appearing in clusters, building up to the highest amplitude peak over a period of about 6 to 8 days. Once past the high amplitude peak, the vibration excursions would cease for a few days and then gradually reappear (Figure 8).

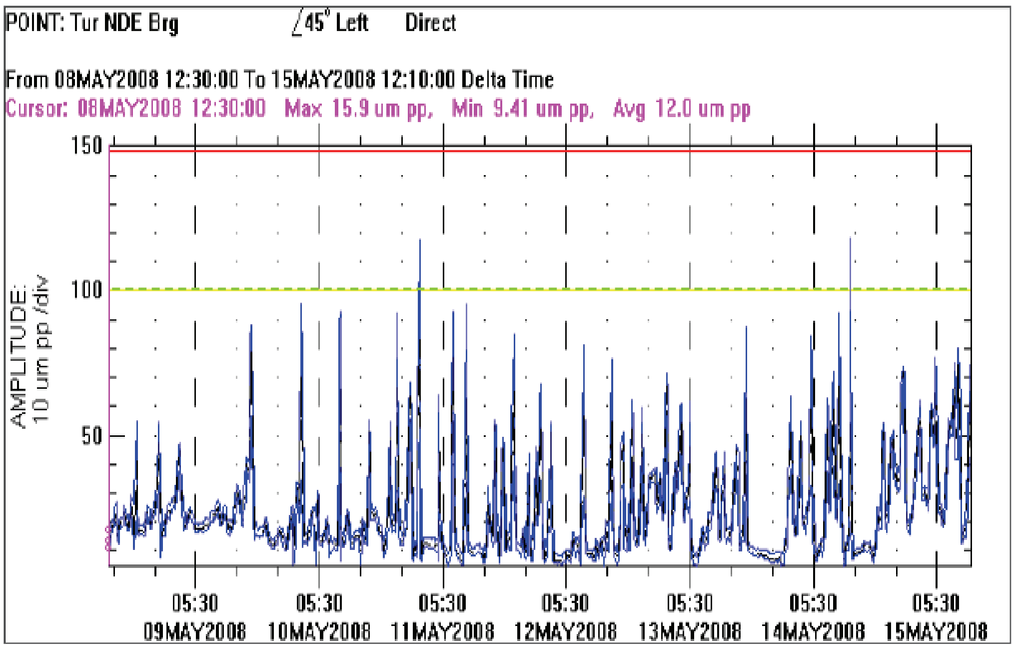

FIGURE 7: May 2008 trend shows persisting vibration excursions, occasionally crossing the Alert set point (yellow line, emphasized by a dashed line overlay at 100 microns pp).

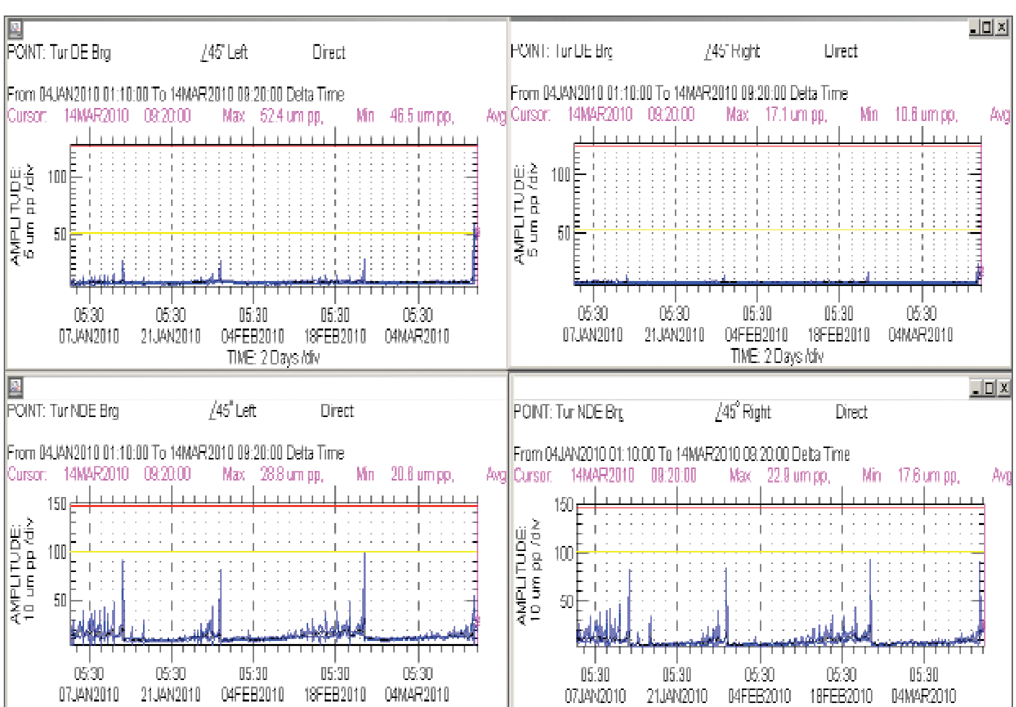

FIGURE 8: January-March 2010 trends show that vibration excursions continued, and that the period between episodes of peak amplitude was increasing.

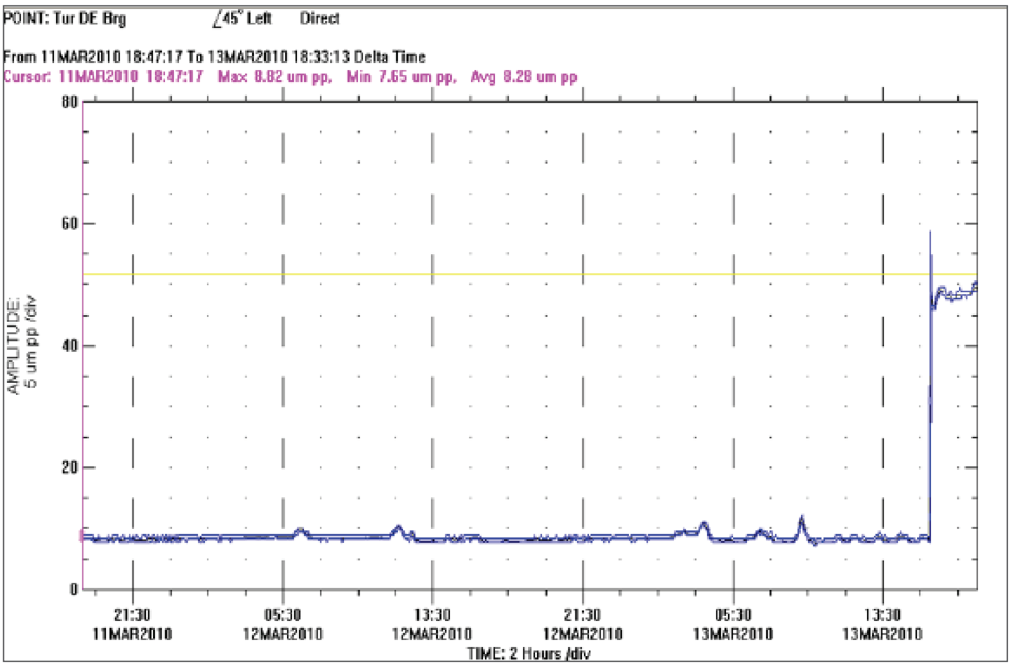

FIGURE 9: 11-13MAR2010 trend shows sudden vibration increase on steam turbine DE bearing.

The Shutdown

Although the plant engineers knew that they needed to perform an internal inspection of the steam turbine – and most likely replace some damaged seal components – they were able to avoid shutting down the refrigeration unit for more than 32 months after the first occurrence of the rub. They mitigated the risk of operation and built their confidence in managing the plant by continuing close observation of vibration condition monitoring data using the continuous data collection of the 3300 System and the diagnostic features of the Data Manager 2000 software.

Everything was fine until 13MAR2010, when there was a sudden increase in vibration on the turbine DE bearing (Figure 9). This vibration spike was very sudden, as observed in 4 second fast trends captured during a high vibration Alert event. Interestingly, no elevated vibration amplitudes were recorded on the steam turbine NDE bearing. Vibration rise was just 15 microns pp on the NDE bearing.

At the same time as the sudden increase in vibration occurred, a sudden small (1 micron) shift in average shaft centerline position was recorded at both the DE and the NDE bearings of the steam turbine. As we will see in the inspection results photos (Figure 12), this small but significant change was caused by an interesting mechanical event...

Also, a significant shift in rotor precession occurred at the time of the elevated vibration. Figures 10 & 11 show that the orbit shapes changed and the forward and reverse vibration components changed – as shown in the full waterfall plots.

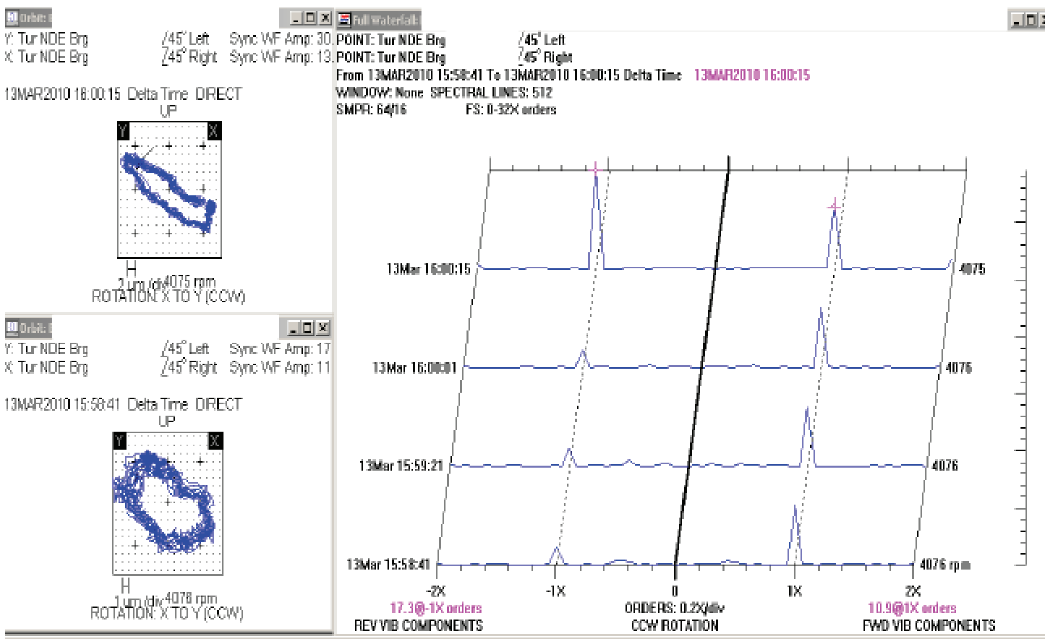

FIGURE 10: Orbits and full waterfall for steam turbine NDE bearing. Reverse 1X frequency components dominated, and change in orbit shape indicated a change in radial loading caused by the increase in rub severity.

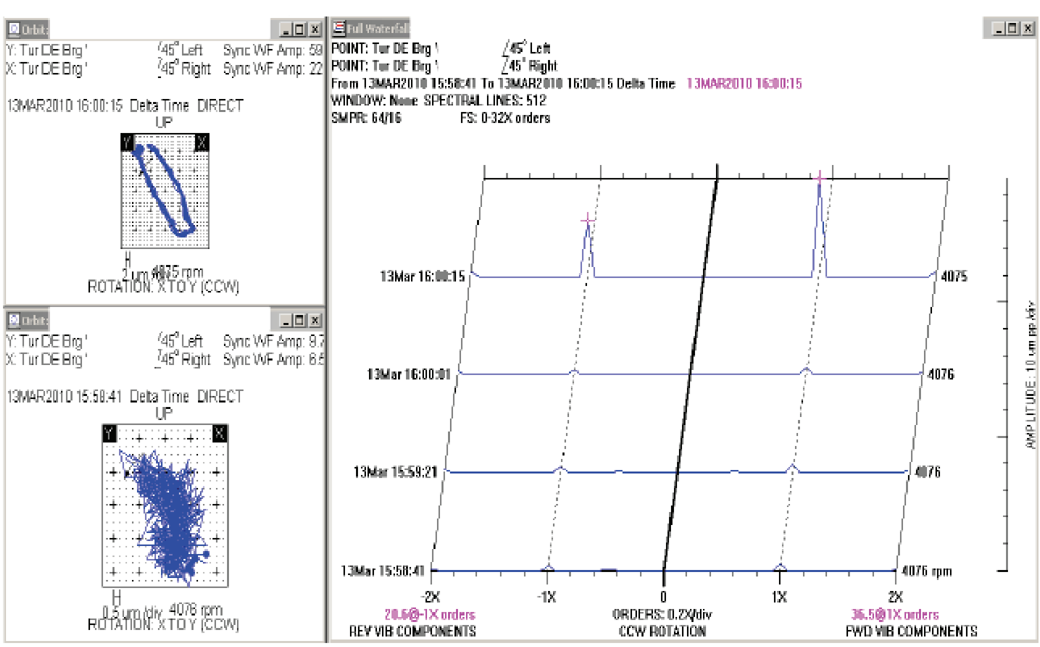

FIGURE 11: Orbits and full waterfall for steam turbine DE bearing. Forward 1X frequency components dominated. As we will see in Figure 12, there was a very good mechanical cause for increased unbalance at the DE bearing end of the turbine rotor.t

The DE bearings at both the compressor and the steam turbine experienced the maximum changes in amplitudes of vibration with corresponding 1X phase changes. These vibration changes at the DE bearings persisted. Changes on the steam turbine NDE bearings were smaller and did not persist. After the initial step changes, 1X vibration amplitudes and phase angles at NDE bearings stabilized.

Synchronous Rotor Response

Synchronous or 1X vibration response is the resultant of both unbalance force and dynamic stiffness of the rotor system. Changes in either one of them (or both) can cause changes in 1X amplitudes and phase.

$$\text{Synchronous response motion (d)} = \frac{\text{Unbalance Force}}{\text{Dynamic Stiffness}}$$

A sudden change in 1X amplitudes, as was observed in this event, can be caused by a sudden change in unbalance force. Such changes can be caused by the addition of mass (anything becoming loose and trapped in the rotor) or removal of mass (typically by a blade failure on LP stages of the steam turbine). Damage to the coupling (such as a bolt that breaks and flies out) can also cause changes in 1X amplitude on DE bearings of both compressor and turbine.

Based on these possibilities, our MDS Engineer recommended shutting down the compressor at the earliest opportunity to inspect the coupling and the steam turbine internals. Over the next few days, increasing vibration trends were noted, along with higher than normal structural vibration in associated piping and supports. At this time, plant staff shut down the refrigeration unit for planned inspection and any required corrective maintenance.

Inspection Results

RUPTURED TURBINE BLADE

Visual inspection revealed that the machine coupling was intact but one of the steam turbine blades had ruptured at about 100 mm from the tip (overall blade is about 325 mm long). The unbalanced force caused by this "liberated" blade (Figure 12) explains the observed sudden step change in vibration.

STEAM SEAL COKING

The cause of the intermittent light rub was identified as formation of coke deposits on the NDE oil labyrinth seal. Rubbing against the hard carbon deposits was observed to cause deeply scored grooves on the corresponding rotor shaft area (Figure 13). The affected area was about 100 mm wide and the grooves were up to 35 mm deep in the rotor shaft!

FIGURE 12: One blade had ruptured at the last row of the 14 stage steam turbine (DE end, lowest pressure stage).

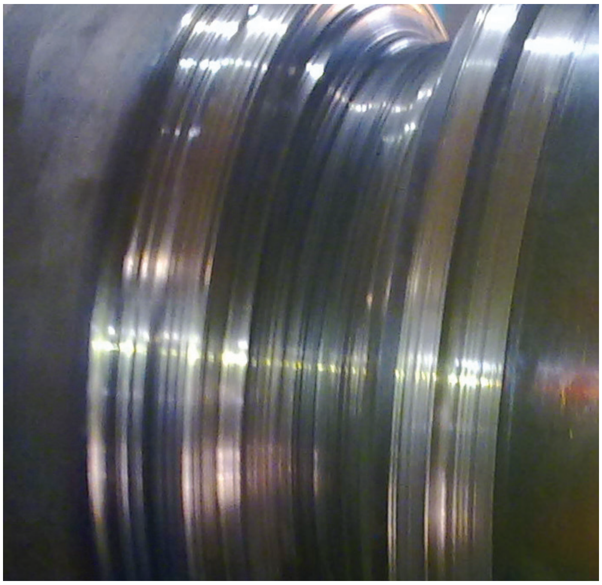

FIGURE 13: Rubbing against hard coke deposits on the high-pressure labyrinth seal has caused deep scoring (shiny bands) on the corresponding shaft area.

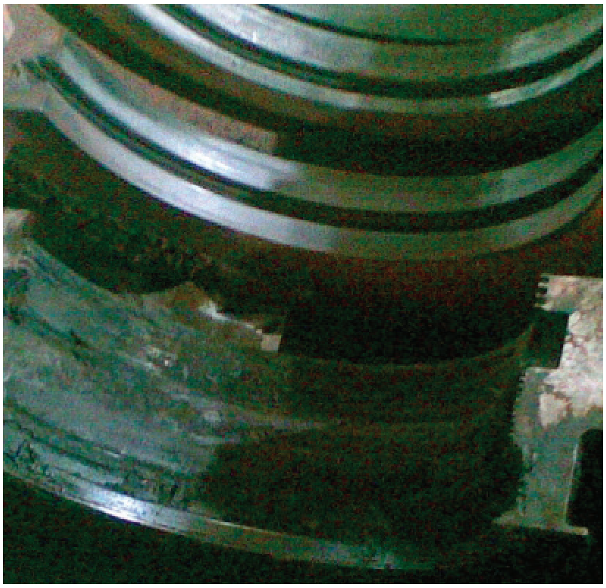

FIGURE 14: Oil catcher labyrinths were filled with coke (including the oil drain ports, which needed to be cleaned).

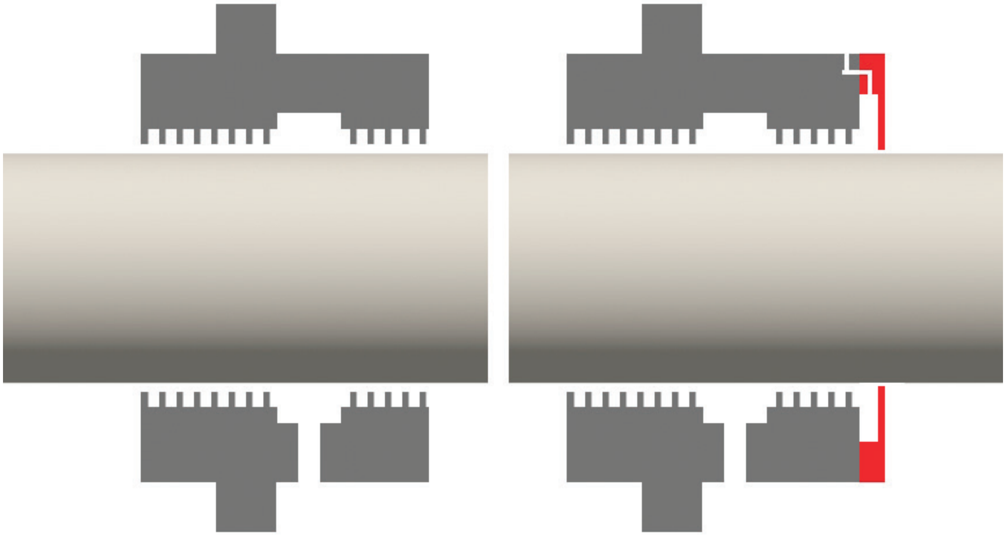

FIGURE 15: Simplified drawing of steam turbine labyrinth seal, before (left) and after (right) the nitrogen purge injection feature (red) was added. In both cases, oil from the bearing flows from left to right through the labyrinth to the drain, while steam flows from right to left.

The observed coking in the labyrinth seals was apparently caused by heating of leaking lubricating oil and vapors by gland sealing steam. Over a period of time, the coke deposits built up in the clearance between the seal and rotor. Eventually, the soft coke started touching the rotor – causing symptoms similar to seal "run-in."

As the soft coke was removed, normal clearance was restored, eliminating the rub and reducing the rub-induced vibration. But after a while, more coke would form and the whole cycle would repeat. The lubricating oil drain ports were also discovered to be plugged with coke, which contributed to further buildup of oil in the NDE labyrinth seals (Figure 14).

Labyrinth Seal Modification

A proven technique to prevent lube oil from being overheated by steam in the labyrinth seals is to provide a "curtain" of cool nitrogen purge gas on the steam side of the seal (Figure 15). In addition to keeping the oil from forming coke deposits, injecting a purge gas can also reduce the need for dewatering in the lube oil system by reducing the ingress of water into the oil in the first place. Plant engineers worked closely with the steam turbine manufacturer to design, manufacture, and install a suitable barrier plate and implement a nitrogen purge system for the affected labyrinth seal. After these modifications and the installation of a new rotor and seal assembly, the compressor was restarted and has run successfully without any problem recurrence.

Conclusions

Machinery management systems such as Data Manager 2000 and System 1 software can be a valuable and integral part of a comprehensive plant condition monitoring program. They provide not only the necessary proactive information on changes in machinery behavior, but also high resolution diagnostic data captured during unanticipated machine trips and other surprise events. These systems can provide added confidence for operating the plant during periods of known machine degradation.

Note: Data Manager 2000 software is obsolete. The plant where this event occurred will be upgrading to the latest version of System 1 software in an upcoming outage.

As described in this article, a petrochemical plant was faced with a high vibration situation on one of its highly critical steam turbine drivers. With our ongoing long term service agreement facilitating the help of the Bently Nevada team, the plant staff received not only pinpoint diagnostics response (often at odd hours) but they were also able to continue vital production by safely extending the required plant outage for almost 32 months. Accessibility of data over a remote connection made it very easy for the Bently Nevada MDS Engineer to promptly review the vibration data for the high vibration turbine trip events and subsequent startup – without the time delays or cost of travelling to the site in person. ■

References

Bently, Donald E. & Hatch, Charles T., "Fundamentals of Rotating Machinery Diagnostics," Bently Pressurized Bearing Press, 2002.

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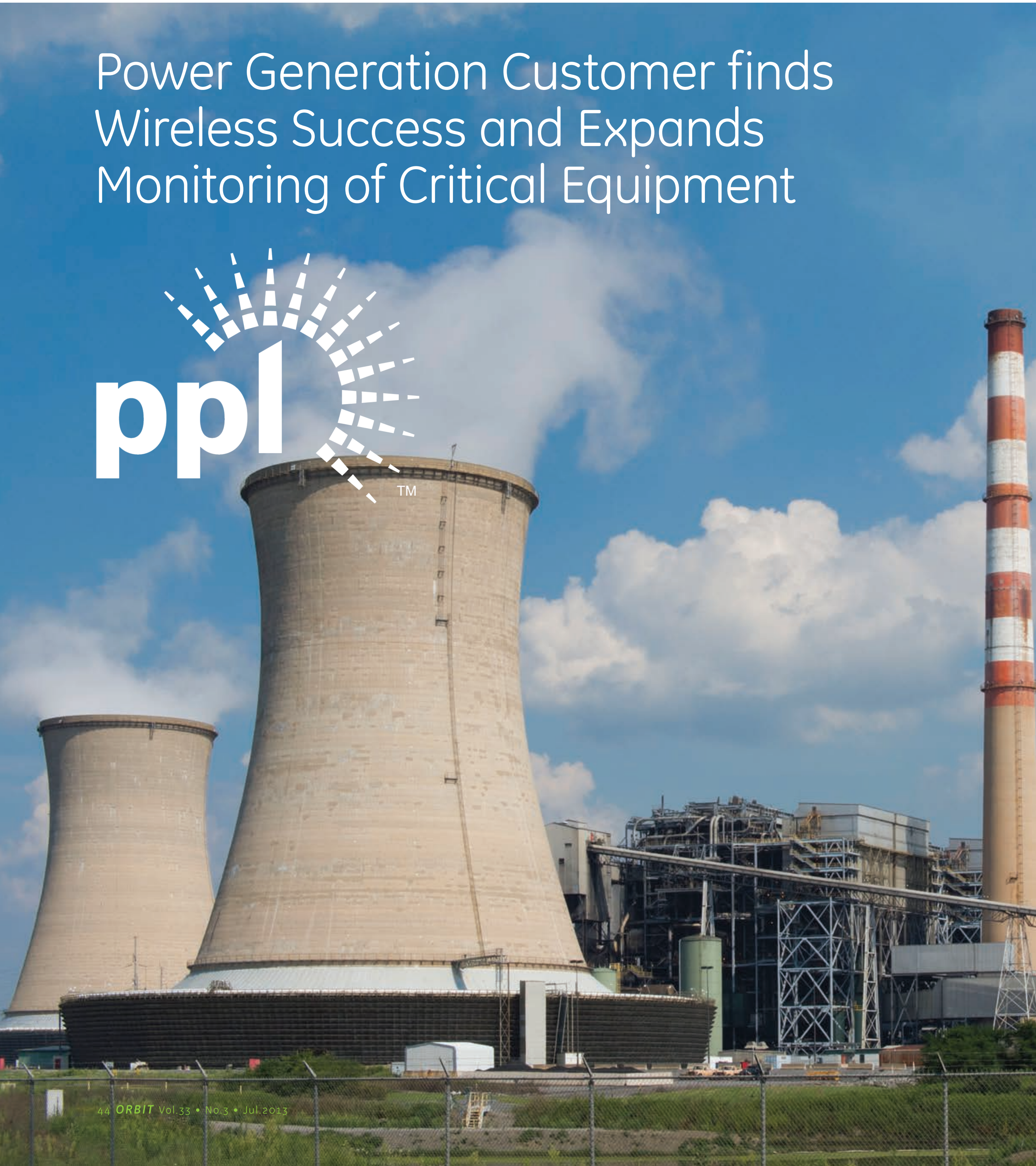
Power Generation Customer finds Wireless Success and Expands Monitoring of Critical Equipment



Montour Power Plant Washingtonville, Pennsylvania, USA

Located about one mile northeast of Washingtonville, Pa., the PPL Generation Montour Station has two coal-fired units with environmental control technologies that minimize emissions of sulfur dioxide, nitrogen oxides, mercury and fine particles. Unit 1 began commercial operation in 1972 and Unit 2 came on line the following year. Each unit has about 768 megawatts of generating capacity.

Since the Montour plant isn't located along a major river or stream, its main source of water is a 12-mile pipeline to the West Branch of the Susquehanna River. As a backup water source, PPL created the Lake Chillisquaque reservoir. Surrounding the reservoir is the Montour Environmental Preserve, a 1,000-acre area that includes a wildlife refuge, hiking trails and a visitor center.

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The Monitored Assets

Montour plant's Forced Draft (FD) Fans are highly critical assets due to the impact on plant operation if they are unavailable for service. Each unit has two, 50% capacity fans, so for full load operation, we need to ensure that these fans are reliable. Part of our reliability strategy is to expand continuous monitoring of our most critical assets to identify equipment issues promptly, enabling us to take proactive action to reduce downtime and where possible, mitigate any potential damage to the equipment.

PART OF OUR RELIABILITY STRATEGY is to expand continuous monitoring of our most critical assets to identify equipment issues promptly, enabling us to take proactive action to reduce downtime and where possible, mitigate any potential damage to the equipment.

To do this effectively we wanted to bring the FD fan sensors into our System 1* condition monitoring and management system. To this end, several years earlier as part of a fan overhaul, the fans were outfitted with XY proximity transducers on both the motor and fan bearings, along with a Keyphasor* phase and speed reference transducer (Figure 1).

The Monitoring System

Connecting the bearing transducer signals to System 1 software using standard techniques requires a substantial investment in conduit and cabling to connect to the electronics room approximately 100 yards away from the fans. Project estimates for a traditional wired solution resulted in delays in the installation schedule as other projects competed for the available funding. With recent advances in wireless technology, we considered the possibility of a wireless solution as a means to achieve a significant reduction in the cost of connecting the FD fans to System 1. Three options were evaluated:

1. Running 19 triad cables 100 yards to a 3500 mini-rack tied into the System 1 data acquisition (DAQ) server.
2. Installing a Trendmaster* Pro DSM local to the fan and running fiber-optic cabling back to the plant network to connect to the System 1 DAQ server.
3. Installing a Trendmaster Pro DSM local to the fan, and using wireless network technology to send the signals to the System 1 DAQ server.

Ultimately, it was determined that option 3 would be by far the most cost effective solution, but only if it would provide reliable data at the required bandwidth. PPL Generation and Bently Nevada personnel met and concluded that Option 3 had merit. We developed a plan to test the feasibility of the approach, and if successful, to implement a wireless system on a unit at PPL Generation's Montour station.

To determine if option 3 was viable, a third party 2.4 GHz wireless access point with a 5 mile radius was tested on-site, and was found to work sufficiently well to transmit the desired data - but only if the antennas were placed very strategically. We followed this up with additional testing utilizing GE's MDS** iNET-II industrial wireless access point.

The lower radio frequency (900 MHz) of the MDS iNET-II product resulted in higher signal strength and greater penetration through objects in the power plant environment. The frequency hopping technology reduced interference caused by the noisy environment and it minimized multi-path issues which ultimately simplified antenna placement.

As an added benefit, we anticipate expanding the Trendmaster system into other areas of the plant. Having a system which allows us to expand via additional wireless nodes and give us greater flexibility was deemed to be an important factor.

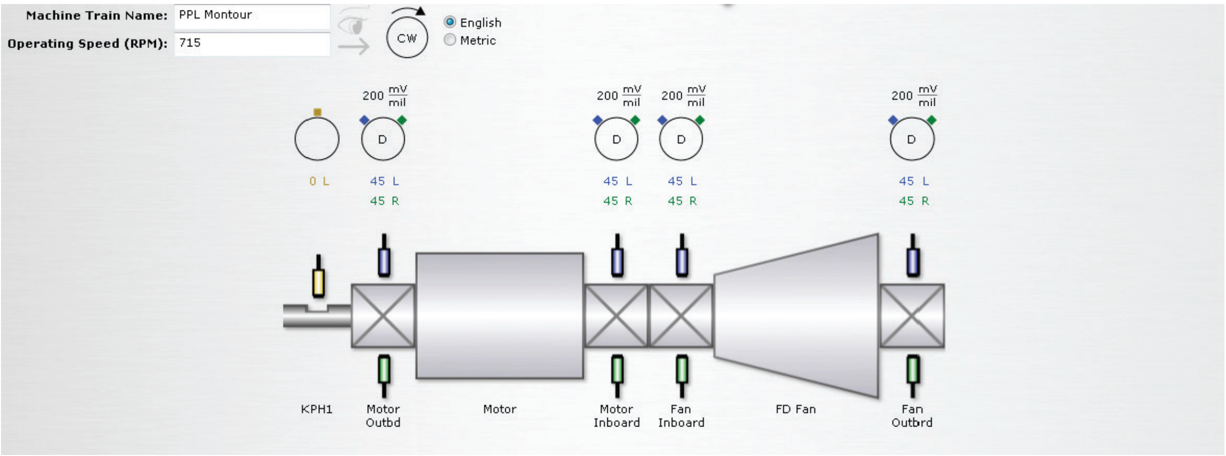

FIGURE 1: Probe installation diagram for FD fan

System Performance

Since installation of the system in the fall of 2011, data collection has been extremely reliable. Kristoffer Bunce, PPL Generation Senior Engineer, notes "Every time I go in, the data is there!"

As a reliability engineer with a heavy workload, Kris appreciates the ability to get "on the fly Orbits and Spectral data within 20 seconds" of requesting it. Ryan Dunlevy, a PPL Services Applications Developer supporting the project, remarks that "data is available whenever we want – and it's quick!"

Option 3 turns out to have been the best choice. It allowed us to expand our System 1 asset coverage throughout the plant and reduced costs compared to a traditional wired installation. The project costs were approximately one third the cost of our original estimate.

Vibration Data

Fortunately, in the time since installation of the system we have not had any upsets that required the in-depth diagnostics that the system is capable of, or that are typically included in case history articles describing machine problems.

However, the normal data that we have collected so far will serve as an excellent baseline for comparison and will allow us to identify any possible changes in fan condition that may occur over time. In addition to basic trends of vibration amplitudes, we also use the dynamic (waveform) formats to evaluate the data in orbit, spectrum and waterfall plots.

Domain Expert Development Program

Realize the full potential of your technology investment

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The Concept

There are three critical factors for the success of any condition monitoring program.

PROCESS AND PRACTICES	TECHNOLOGY INNOVATION	APPLIED DOMAIN EXPERTISE
1 Organizational proactive vision for Condition Monitoring	2 Selection of suitable technology to implement vision	3 Process and technology skill development

Success of Condition Monitoring Programs

Organizational vision for condition monitoring is the main driver for the success of any condition monitoring program. This vision needs to be complemented by proper selection and application of the appropriate technology. However, mere deployment of technology doesn't yield the desired results. This depends on people who will use the technology and actually drive the success of the condition monitoring program. It has been observed that the condition monitoring systems and software (which are often procured during the initial project stage) may never be utilized to their optimum potential during actual implementation of a condition monitoring program.

Dusty Keyboard Syndrome

Typically, plant staff receives a few days of software and technology orientation training by the supplier – which often extends to a few days of OJT (on the job training). However, as time passes, priorities change, employees rotate to different job assignments, and the actual utilization of monitoring systems and software gradually dwindles. The end result is that the condition monitoring vision is never fully implemented and the anticipated Return on Investment (ROI) from the technology is never quite realized. This situation was recognized at an industrial business in India, which has a large installed base of GE's Bently Nevada* protection and condition monitoring products. It was observed that although people were initially trained how to use System 1* software, it eventually fell into disuse due to the factors mentioned above.

The Program

At this point, GE entered into a discussion with the end user to design a detailed 'Skill Development Program' to develop in-house Domain Experts for vibration analysis using their installed System 1 platform. The program focused in three main categories, described here.

1. Video Conferencing Sessions

These conferences allowed employees who are stationed at remote locations to interact with centrally-located staff. The result was some very useful sharing, with discussion and agreement on the solutions of commonly faced issues. In addition to facilitating direct interaction between employees and management, the video conferencing technology allowed the meetings to occur while avoiding the lost work time and expenses associated with unnecessary travel.

2. Onsite Field Workshops

In coordination with the customer, GE deployed Lead Engineers to facilitate on-site workshops at various widely distributed facilities. Onsite field workshops were typically 2 to 3 days long, and were organized to allow maximum participation from operating shift personnel. These workshops were designed with classroom sessions for concept learning and hands-on practice with the installed systems. Best practices were emphasized for operation and maintenance of transducers and 3300 & 3500 monitor systems, as well as for field balancing of machine rotors and operation of System 1 software. While GE engineers were present for the onsite workshops, they also assisted with troubleshooting of any ongoing machinery vibration issues and instrumentation abnormalities. Approximately 15 of these workshops have been conducted over the past 3 years.

3. Domain Expert Development Program

This part of the program featured 29 days of classroom training scheduled over a span of one year in five different levels. This sequencing provided sufficient time for participants to practice their newly-acquired skills by applying them in the field between classroom sessions. Participants analyzed machinery vibration problems with their site's equipment and submitted field reports describing the problems. In some cases, they also performed the corrective actions required to restore the machines to normal operation. Each classroom training session included appropriate assessment to verify acquired skill sets. Instructors continuously provided feedback to help participants improve in identified areas of need. As shown in Figure 1, this part of the program focused on two main areas, Basics & Product Skills (Understanding the Technology) and Analysis Skills (Managing the Processes), described in more detail below.

Understanding the Technology

This part of the program included detailed study of GE's Bently Nevada transducers, the 3500 vibration protection and monitoring system, and System 1 software. Classroom sessions emphasized theoretical understanding of the fundamentals, with hands on workshops for guided practice – helping participants to understand recognized best practices for the operation and maintenance of transducers, monitors and software. This section reinforced the importance of installing and configuring Bently Nevada systems as specified for their defined purpose.

Managing the Processes

This part of the program started from basics in order to effectively train participants with a maintenance background, but no prior experience with vibration analysis. It also served to provide refresher training for more experienced professionals. Participants were exposed to five levels of in-depth understanding of diagnostics methodology, established over decades of Bently Nevada experience. Working in hand with our Machinery Diagnostic Services (MDS) Engineers, they practiced vibration analysis based on raw vibration data from a wide variety of industrial machines. This section focused on using the installed condition monitoring products to make effective maintenance decisions. A proactive approach towards monitoring of the asset health using System 1 alarming & reference data capability was practiced. Participants used Bently Nevada multimedia training products (Data Acquisition CBT and Machine Library) as references throughout the course.

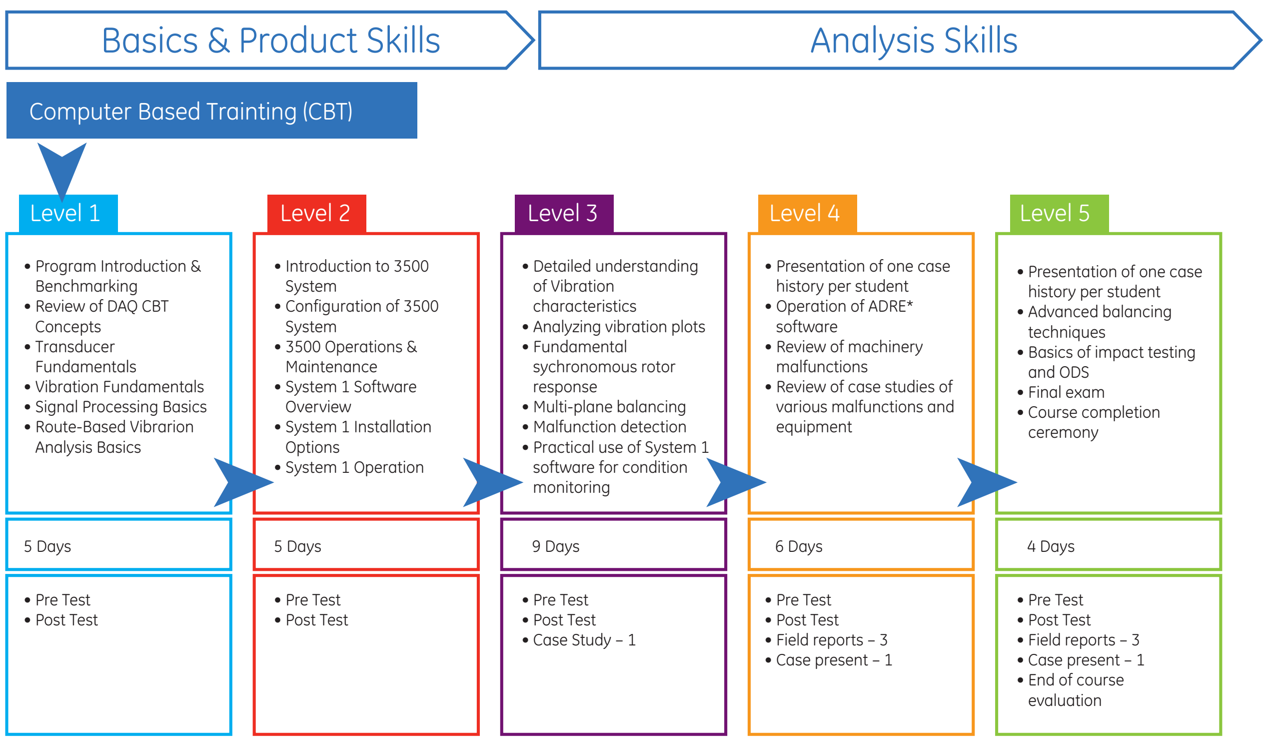

FIGURE 1: The curriculum was designed to progress through five levels of attainment, starting with basic concepts and moving to more advanced techniques.

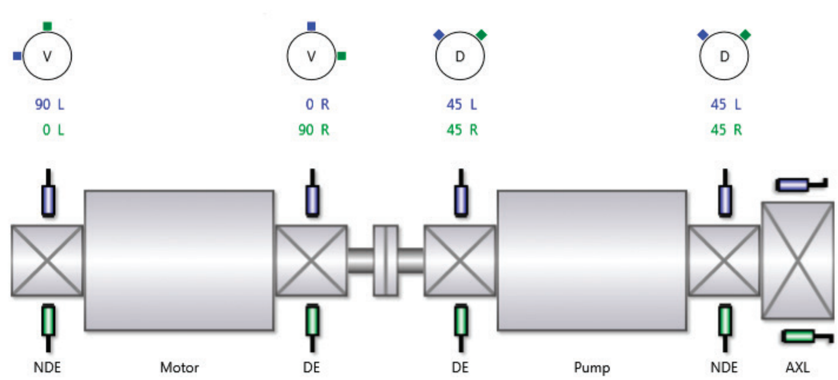

FIGURE 2: Simplified machine train diagram shows the motor, pump, and System 1 measurement points.

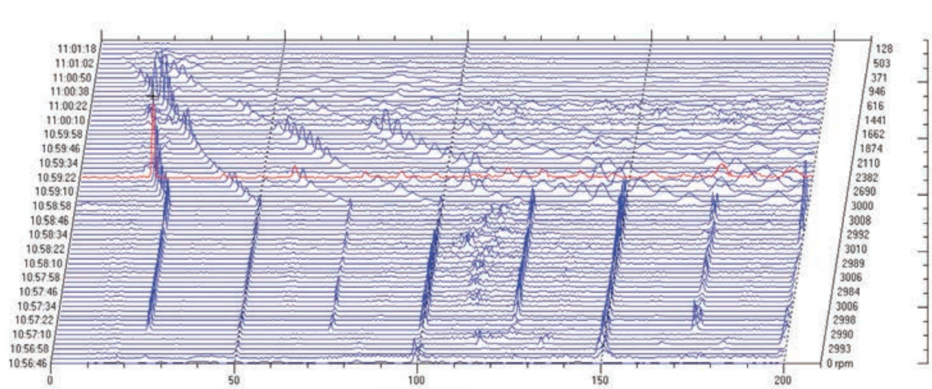

FIGURE 3: Waterfall plot for DE Bearing Y probe with clear signs of strong 0.5X vibration and harmonics. Note: The vibration peak at 50 Hz corresponds to 1X vibration for this 3000 rpm machine, so the strong peak at 25 Hz represents 1/2X vibration.

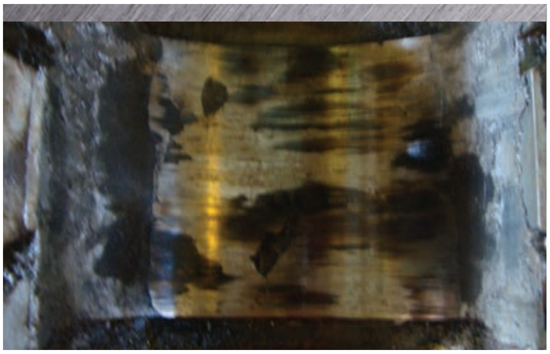

FIGURE 4: Heavy rub damage was observed to the surface of motor DE Bearing.

Key Program Features

- 2 "batches" of students, 21 Engineers total.
- 29 days of classroom training
- OJT including 6 field case studies
- Pre & Post - tests at each of the 5 levels
- 70% proficiency required to pass.
- Field workshop

Return on Investment (ROI)

Within one month of completing the program, one of the participants faced a high vibration situation with a pump drive motor (Figure 2). He applied his newly-gained knowledge to troubleshoot the issue.

History

The motor had a chronic issue with high vibration and had been sent for overhaul two years previous to the event described here. Unfortunately, the motor had recently been lying idle for about one year in a storage yard, and the exact storage conditions were not known.

After reinstallation of the motor, high vibration was observed. Casing absolute vibration was more than 12 mm/s pk. Bearing temperature was observed to increase suddenly after motor start up. System 1 vibration data plots were reviewed (Figure 3), and it was very clear that a strong 0.5X vibration component (with harmonics) was present. Also, the temperature of the DE bearing was seen to increase by about 26 deg C within two minutes of startup, which is an unusually large increase. All of these symptoms pointed to the possibility of a rub, and suggested the need for a visual inspection and verification of proper bearing alignment. The motor was shut down to prevent damage.

Upon disassembly of the motor, inspection revealed that a severe rub had occurred between the rotor and the DE bearing (Figure 4), and the rotor was observed as having excessive bow. The DE bearing was heavily rubbed while the NDE bearing had very little indication of rubbing. Also there were burn marks at the DE casing under the bearing housing and the seal was sheared. While the investigation for the root cause is still under progress, we suspect that poor storage conditions may have been a contributing factor to the observed symptoms.

Training Participant Comments

- "...Earlier, I had this training with Mr. Don Bently. Almost 12 years later, it is a welcome reminder and a highly improved team led by Mr. Pankaj Sharma. The smoothness of sequencing of the training is most attractive..."

- "...This training has imparted machinery diagnosis skills and effective use of 3500 & System 1 at my plant. The training faculty was outstanding. All of the instructors were highly dedicated and interested in sharing their knowledge and experience..."

- "...Besides the knowledge of plot analysis, I have learned how to reduce vibration. Now we have big responsibilities for our machine vibration. I have already taken the baseline data, and whenever there will be a vibration problem, I will work to solve it..."

- "...Knowledge about the vibration techniques was a treasure hidden in ourselves but we did not have the keys to open it. Now GE has given the keys to open that treasure. It is wonderful..."

Piston Rod Vibration Analysis PART 1

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Many examples of successful API-618 reciprocating condition monitoring combine cylinder pressure, rod load curves, and vibration data to identify problems within the sealing systems of the cylinder or mechanical defects, such as looseness. In these examples, a particular feature, frequently an impulse event, in a vibration signal is correlated with changes in the pressure curve or load curve. Most often it is crosshead or cylinder acceleration that expresses these features (Reference 1). Recent case histories have shown that piston rod vibration provides information similar to that expressed in the crosshead accelerometer signal. This paper focuses on analytical techniques to extract machine condition information from piston rod vibration.

Piston Rod Vibration

As a large reciprocating compressor operates, the piston rod not only moves back and forth, but also vibrates. It has become common to measure this vibration with proximity probes mounted at the pressure packing case flange (Figures 1A & 1B). For most reciprocating compressors, the change in the position of the piston rod with respect to the packing case flange during start-up and as the rider rings wear is large enough to exceed the linear range of 8mm probes. For this reason, most applications use 11mm proximity probes to view the piston rod.

The proximity probe produces a signal that is proportional to the distance between the probe tip and the piston rod. Figure 2 shows an example of the piston rod vibration signal. Since proximity probes measure the displacement with respect to the probe tip, and not the average or middle of the signal, they produce DC-coupled signals. This means that the signal has a part that varies continuously riding on top of an average value that is not zero.

The DC-coupled vibration signal provided by the proximity probes can be used to make different kinds of measurements. For example, the average distance, or “gap,” between the probe tip and the piston rod could be stored just after the rider bands have been replaced. As the rider bands wear over time, the difference between the stored gap value and the DC-coupled signal can indicate the rate of wear of the bands. In order to accurately indicate the amount of rider band wear, the measurement needs to be multiplied by a correction factor to account for the fact that the probes are at the packing case and not inside the cylinder. This is the principle behind the rod drop measurement.

The rod drop measurement depends on a set of simplifying assumptions that are not completely valid. This can cause the measurement to be less accurate in reality than it might be in theory.

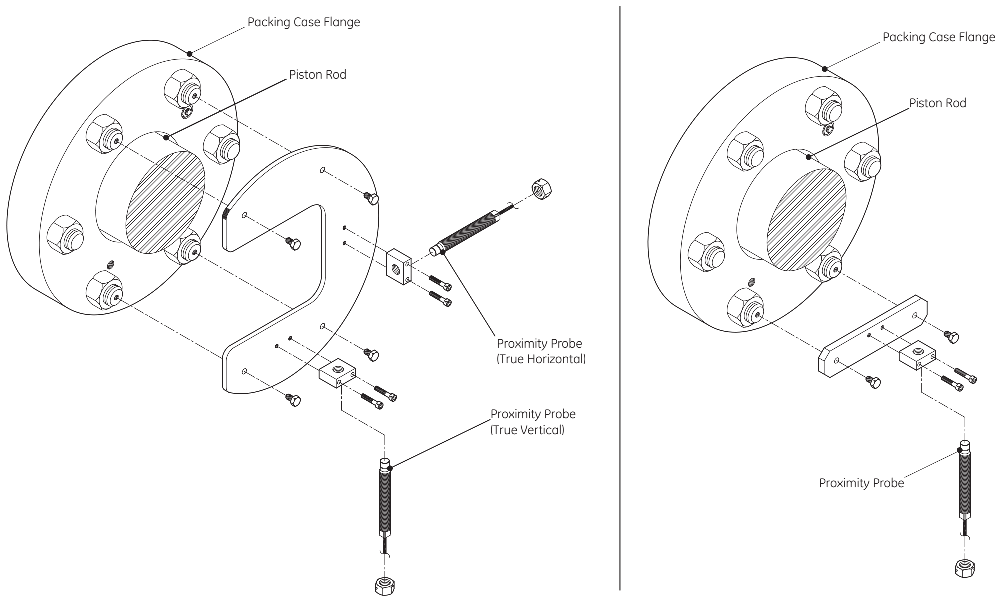

FIGURE 1A: This figure shows two examples of proximity probe mounting arrangements. An XY pair (left) allows monitoring of rod position in two dimensions within the measurement plane. A single vertical probe (right) can be used for simple rod drop measurements, which are only made in one dimension.

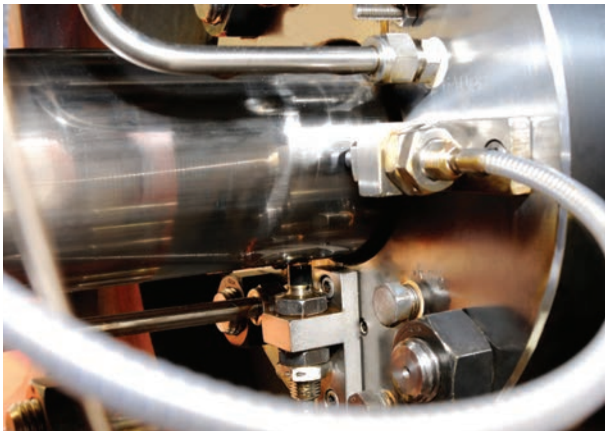

FIGURE 1B: In this photo of a GE HE-S compressor, the probes are mounted to the face of the packing case flange using individual brackets.

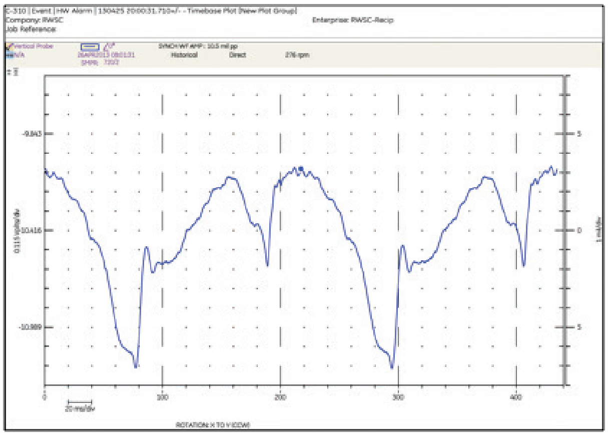

FIGURE 2: This plot shows a piston rod vibration signal with DC-coupled characteristics.

ROD DROP ASSUMPTIONS

- Gravity is the largest force acting on the reciprocating elements.
- Reciprocating elements are stiff and have negligible deflection during operation.
- Load changes have little effect on rod position.

Alternatively, the gap voltage of the probe could be measured with the machine at rest. Accounting for the piston size, piston material, and assembled clearances, this measured voltage could be corrected to the voltage the probe would give if the piston rod were exactly centered with the bore of the cylinder. This centerline gap voltage would then be used as a measurement reference to compare with the measured DC-coupled signal as the machine operates.

This measurement does not require the same assumptions that rod drop does and two probes can be used so that both horizontal and vertical movement may be tracked. The difference between the centerline gap voltage and the DC-coupled signal is rod position measurement. While both rod drop and rod position measurements provide diagnostic value, this article will focus on the analysis of the piston rod vibration signal itself.

Piston Rod Condition Monitoring

The signal generated by proximity probes viewing the piston rod typically has a complex shape that proves difficult to use directly. The following section provides some techniques for extracting useful information from these patterns.

SYMMETRY WITH RESPECT TO BOTTOM DEAD CENTER (BDC)

Proximity probes viewing the piston rod detect mechanical vibration as well as surface imperfections on the piston rod. In some cases, the two can be differentiated. For example, Figure 3 shows cylinder pressure (red, blue, green and orange lines) and piston rod vibration data (black and grey lines in the background). The black line shows piston rod vibration for the vertical probe and the grey line shows piston rod vibration for the horizontal probe.

By comparing the maximum deflection of the rod position lines with the distance scale at the right side of the plot, we can see that both probes show a maximum of nearly 600 microns (24 mils) of movement.

The large piston rod movement has some interesting features. It appears in both probes at the same time in the crank revolution and both probes show nearly the same values. This feature makes it unlikely that the apparent movement arises from mechanical movement as piston rods typically do not move in the same manner in both the horizontal and vertical planes.

The rod position data in Figure 3 has another feature of interest. The shape of the curves indicates symmetry about the bottom dead center (BDC) line at 180°. Figure 4 illustrates this symmetry more clearly. It was simplified to show only the piston rod vibration data from Figure 3. The data acquired while the piston moved from top dead center (TDC) to BDC has been colored black. Data acquired while the piston moved from BDC back to TDC has been colored grey. The dark black vertical line at 180° marks BDC.

Figure 5 shows another interesting characteristic of these curves. As machine speed and conditions change, the large dips occur in very nearly the same location in the stroke. This shows that the signals have little dependence on, or sensitivity, to the running conditions of the compressor.

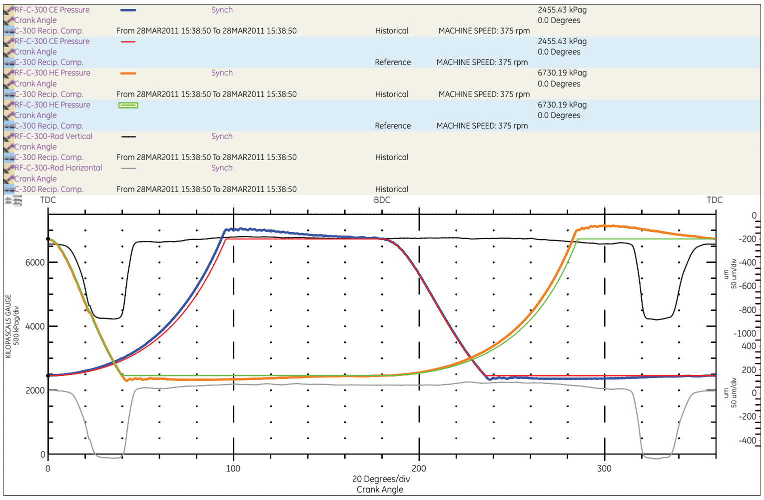

FIGURE 3: A plot showing cylinder pressure in the foreground and piston rod vibration in the background versus crank angle.

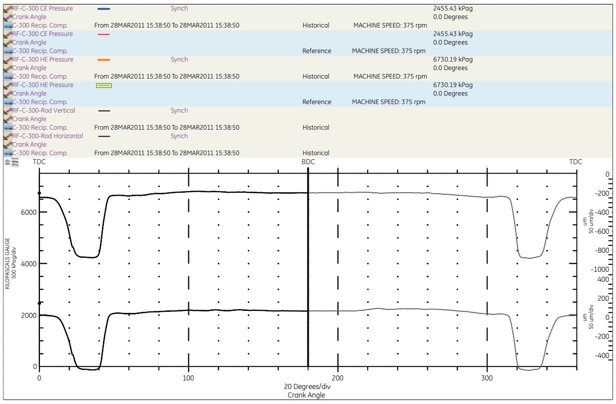

FIGURE 4: The piston motion from TDC to BDC (black lines) mirrors the piston motion from BDC to TDC (grey lines).

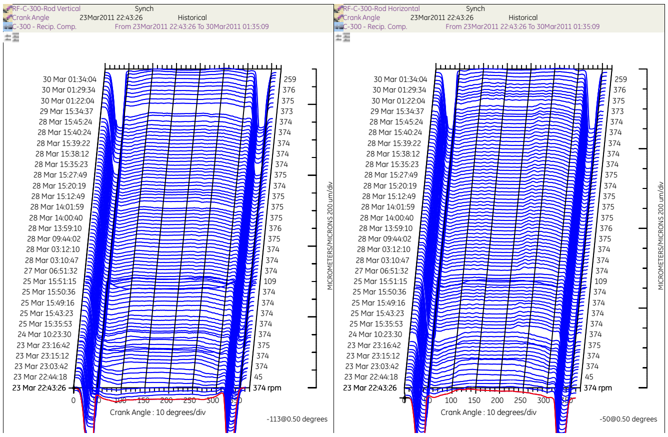

FIGURE 5: As the machine speed and operation conditions vary, the true vertical probe signal (left pane) and true horizontal probe (right pane) change very little.

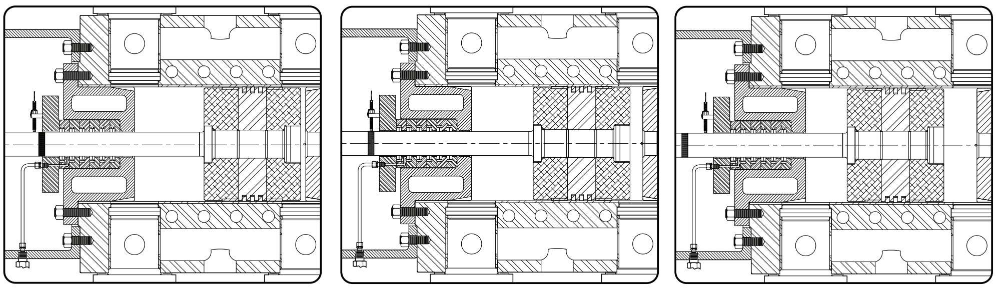

FIGURE 6: The probe viewing area shifts as the piston moves from TDC to BDC.

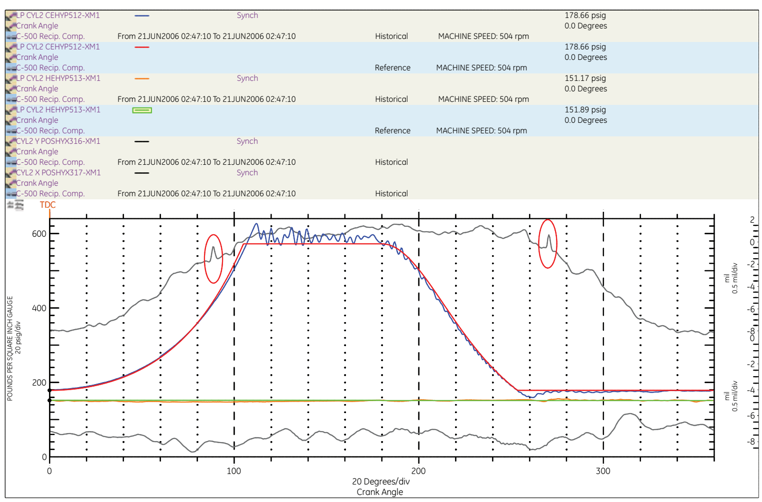

FIGURE 7: The vertical piston rod vibration signal (top grey line) shows two spikes that are symmetrical with respect to BDC.

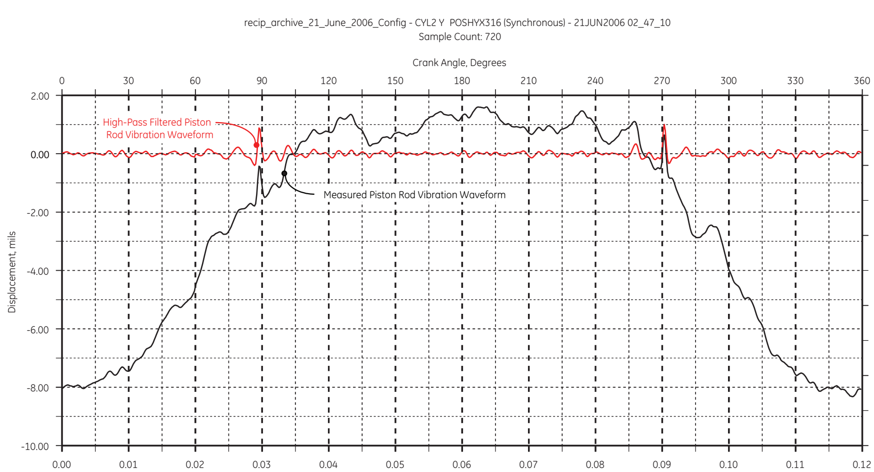

FIGURE 8: High-pass filtering the piston rod vibration signal makes symmetry with respect to BDC more visible.

The similarity of the event on both probes, the symmetric appearance of the waveforms with respect to BDC, and the consistency over different operating conditions and speeds strongly suggests that something about the piston rod itself is contributing to this signature. The most likely feature to account for the large amplitude would be either missing material or variation in material composition. In this case, the rod was known to be in good mechanical condition, having had a runout check at the pressure packing case. With a good runout check, it was likely variation in material composition that caused these dips in the piston rod vibration waveform.

Figure 6 shows a drawing of the probe and piston rod. The piston rod had been repaired in the past and part of the repair process included grinding and re-coating the rod. This process resulted in variation in materials in the probe viewing area. The left pane of Figure 6 shows the piston at TDC. In this position the probe reads the parent material of the rod. As the piston moves away from the head end head, the probe begins to detect the coating material, shown in the middle pane of Figure 6. This material has a different scale factor than the parent material of the piston rod, resulting in the apparent movement. As the piston continues to move toward the crank end head, the area of repair moves out from under the probe and it views the parent material of the rod. The right pane in Figure 6 shows this. The cycle reverses when the piston moves from BDC to TDC.

FILTERED SYMMETRY WITH RESPECT TO BDC.

Sometimes features in the piston rod vibration signature take more analysis to be seen clearly. Figure 7 shows cylinder pressure and piston rod vibration signals from a different compressor. The red ellipses in the figure highlight two spikes in the piston rod vibration signal.

As we will show in the second part of this article in a future issue, the piston rod vibration signal actually contains information related to events occurring on the running gear as well as information about the piston rod motion (References 1 & 2). Figure 8 shows the measured waveform and the high-pass filtered waveform. Much like the previous example, these spikes show up exactly symmetrical about BDC. They also persist over a variety of operating conditions. Together, this strongly suggests that a scratch or nick exists on the rod. While not an immediate problem, it should be noted and the rod inspected at the next outage.

Conclusion

Although piston rod vibration measurements have a long history, extracting information from the signal remains challenging. This article shows a few elementary techniques for detecting features in a piston rod vibration signal that relate to the condition of the rod itself. In future articles, additional techniques will show how further information can be extracted from the piston rod vibration signal. ■

References

1. Orbit Vol 33. No. 2, 2013, Rossi, Gaia, “Vibration Analysis for Reciprocating Compressors – Part 2.”

2. Hala, Roger, Brian Howard, Stephen Plaisance, and John Kitchens. “Detection of Anomalous Movement in a Reciprocating Device.” US Patent 8,297,123. October 30, 2012.

Monitoring Troublesome or Intermittently Operated Machinery with the SCOUT Portable Vibration Data Collector

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One of the biggest challenges we face is capturing diagnostic data on troublesome or intermittently operated machinery that does not have permanently-installed condition monitoring instrumentation. The SCOUT portable vibration data collector has some built-in capabilities that enable it to be used to collect data independently or via remote control. These methods can also be used to collect data from the buffered transducer outputs of a protection rack that is not connected to System 1* software.

Controlling SCOUT Remotely

The SCOUT portable vibration data collector can communicate with a host computer through either USB or Ethernet connection. All users are familiar with these capabilities because this is how routes are loaded to and collected data is unloaded from the instrument. Less well known is the fact that the Ascent* software has a mode that allows you to control a connected SCOUT instrument directly from your computer as though you were holding it in your hand. This is called the Screen Capture mode.

ENTERING SCREEN CAPTURE MODE

1. From the Edit menu, select **Manage** and then **vb Instruments** (Figure 1).
2. Select the connected instrument and click **Configure** (Figure 2).
3. From the Tasks tab, click **Screen Capture** then click **OK** (Figure 3).

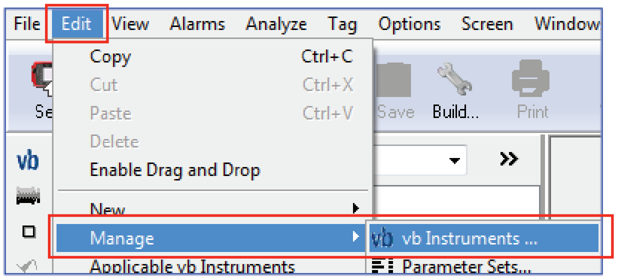

FIGURE 1: Opening the Manage Instruments dialog from the Edit menu.

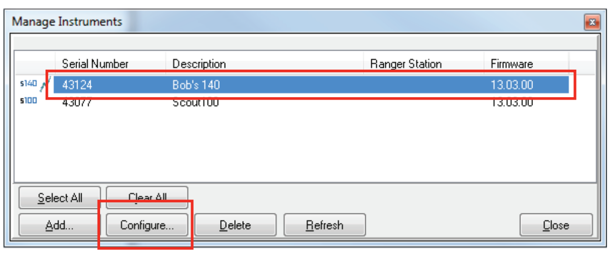

FIGURE 2: Selecting the specific SCOUT instrument and opening the Instrument Properties dialog from the Manage Instruments dialog.

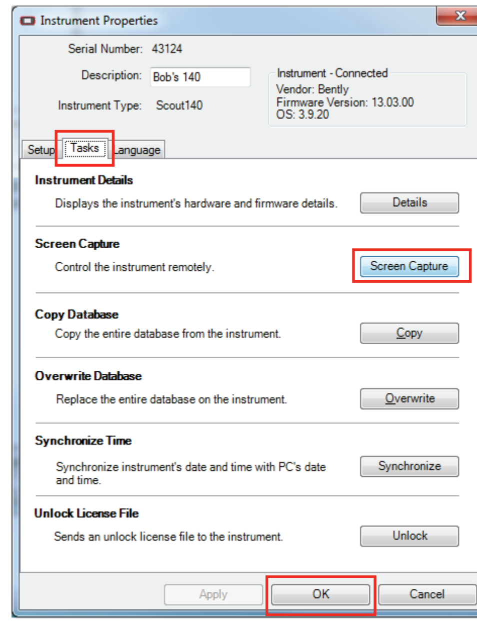

FIGURE 3: Selecting the Screen Capture operating mode from the Instrument Properties dialog.

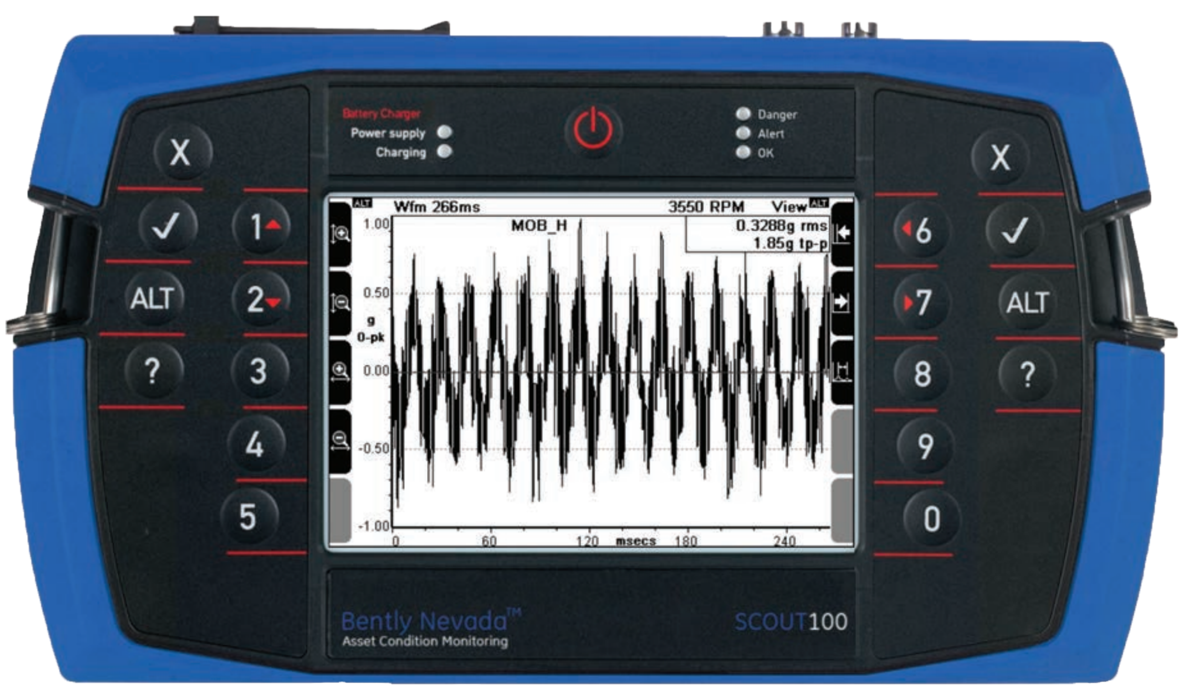

FIGURE 4: The Screen Capture display gives a virtual view of the SCOUT unit.

You now have complete control over the connected SCOUT instrument. Simply point to the button you would push if you were holding the instrument in your hand and click the mouse. The SCOUT instrument will respond and you will see the appropriate display on your computer screen (Figure 4).

The SCOUT instrument can be used in either the Route or Measure modes while connected remotely. The instrument should also be connected to an external power supply if the period of remote operation may exceed the internal battery endurance of about 10 hours.

The Route mode and several of the Measure mode options (Spectrum/Waveform, Demodulation, 6 Pack, Tachometer Display, Time Synchronous Averaging, Bump Test/Peak Hold, Orbit Plot & Average Value) require that each time you want to acquire and store a set of data, you must initiate the collection manually – that is by placing the mouse pointer over the 'accept' ✔ pushbutton on your computer screen and clicking the mouse. You will need to do this for every data set that you take.

The Route mode has an advantage over these Measure mode options as it allows you to load a route with multiple measurement types (schedule entries) and to acquire data for all of the included measurements with a single initiation. This can be a significant time saver if you need to collect measurement data in rapid succession from a machine that is under enhanced scrutiny. Increased collection frequency may be appropriate for a machine that has been returned to service following maintenance, or for one that is in some sort of distress. The Screen Capture mode allows you perform this enhanced surveillance (and also, to monitor Cross Channel Phase and Orbit plots) without leaving your desk.

While using the Route mode remotely, it is often convenient to load a single machine route into the instrument, with the locations and orientations where you plan to actually install temporary transducers (or the locations and orientations corresponding to the permanent transducers connected to a protection rack). Typically, two sensors are used with a 2-channel SCOUT100 and four sensors are used with a 4-channel SCOUT140. Of course the SCOUT laser tachometer transducer may be connected as well.

Running SCOUT Independently

The SCOUT instrument's Measure mode has two options that allow it to take data while it is unattended over long periods of time. These capabilities can be used without being remotely connected, although they can also be used when a remote connection has been established.

LONG TIME WAVEFORM

The first option is the Long Time Waveform mode. With this option, time waveform samples are collected from the sensors based on the data collection parameters that are established in the instrument. The length of time that the instrument can be used to collect the time domain data is a function of the selected signal processing parameters. It will be able to collect low resolution, low frequency data for a much longer time period than it will be able to collect high frequency, high resolution data. Once the long time waveform data has been uploaded into the Ascent database, further evaluation can be performed using advanced partial waveform analysis tools, as shown in Figure 5.

COAST-DOWN/RUN-UP

The Coast-Down/Run-Up mode is the second independent data collection option. This mode is often used to capture spectra and/or time waveforms at set speed intervals (delta rpm) during a machine startup or shutdown. SCOUT instruments also have the capability to capture and store the same data at a fixed, user selectable time interval (delta time).

Consider the case where a machine is intermittently exhibiting unusual vibration, but you have not been able to collect that data because every time that you are there for an inspection, it is behaving normally. A SCOUT instrument can be set up on the machine and instructed to collect a set of spectra and/or time waveforms every 5 minutes, for example. It can be left in place overnight or over the span of a weekend – or longer, if needed - using the external power supply, of course. The collected data is easily transferred to the Ascent database for evaluation.

A Challenging Example

I was recently asked if it would be possible to use a SCOUT insttrument to collect post-repair data from a wind turbine gearbox. This presents a unique scenario for a handheld portable vibration data collector because, for safety reasons, no one is allowed to be up in the nacelle of a wind turbine generator when it is operating! Figure 6 puts the challenge in "perspective."

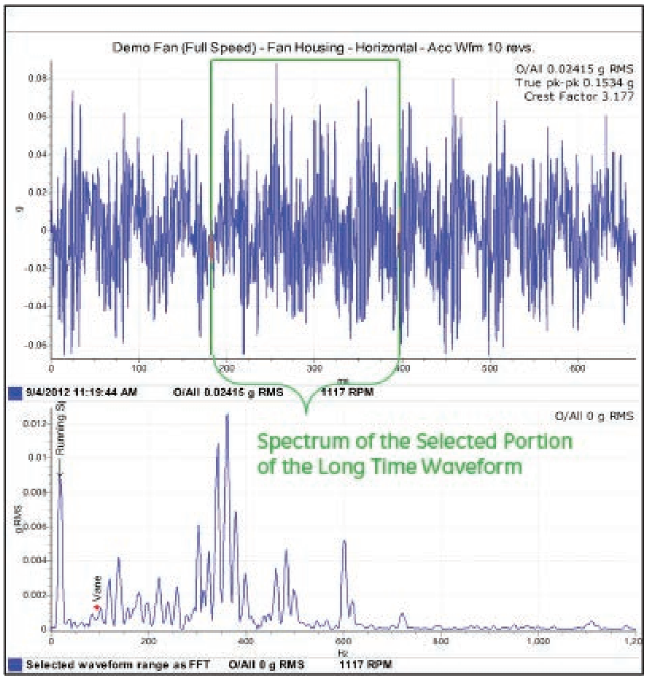

FIGURE 5: The Long Time Waveform function allows you to process and display a spectrum for a specific portion of the time waveform record that you select.

FIGURE 6: The wind turbine gearbox is in the nacelle at the top of the tower. The nacelle is not accessible during turbine operation.

Given both the instrument's remote control and independent operation capabilities, this turned out to be an easy problem to solve.

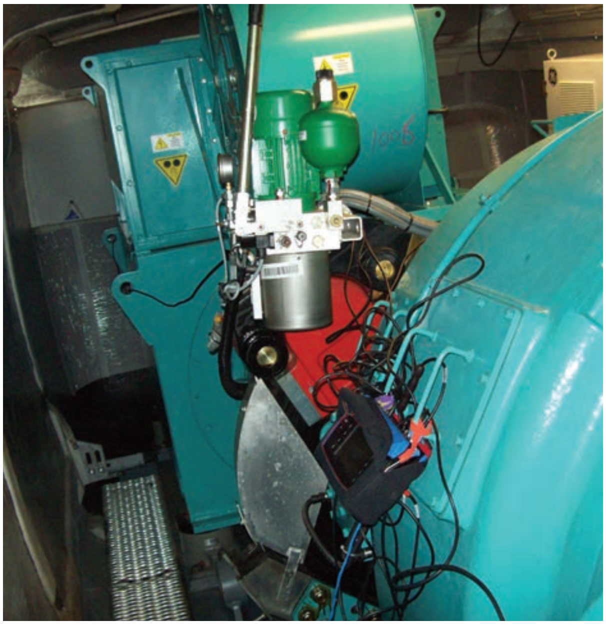

FIGURE 7: A view inside the nacelle shows the SCOUT unit temporarily attached to an inspection cover on the speed-increasing gearbox.

FIGURE 8: The down-tower computer (my laptop) was temporarily set up in the tower base.

Figure 7 shows my SCOUT140 temporarily attached to the handles on an inspection cover for the gearbox being monitored. The SCOUT140 data collector up-tower in the nacelle was connected to my laptop computer in the tower base (Figure 8) via a pair of GE's MDS** iNET-II industrial wireless access points that operate in the unlicensed industrial, scientific and medical frequency band.

After the SCOUT instrument was connected with the temporarily installed sensors, it was initially run remotely in the Route mode, taking a manually initiated series of measurements on all four channels. This was done a few times to ensure that we were collecting and loading the database with reliable, repeatable data, as is good practice with any special evaluation.

Unfortunately, there was not a lot of wind that morning, so the gearbox received only minimal load. We decided to leave the instrument in place for a few days and have it run independently in the Coast-Down/Run-Up mode, collecting speed, waveform and spectral data once every 15 minutes. This too was initiated remotely and then the remote connection was terminated, since the down-tower computer was my laptop and it had to leave the site with me. The instrument collected data independently for 10 days, after which time it was removed from the nacelle and the data was transferred into the Ascent database for evaluation.

Conclusion

If more than 4 channels of data, or more advanced signal processing capabilities are required for a machinery diagnostic application, an ADRE* unit may be more appropriate for the task. But the SCOUT instrument, combined with the Ascent software, can easily be used in machinery data acquisition and evaluation situations that are more challenging or that require more frequent data than one might consider for a typical portable vibration data collection system.

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**Denotes a trademark of General Electric Company.

Coming Attractions

In the OCT 2013 issue, we will share our latest product updates, including a discussion of the newest version of System 1* software and how it fits within GE's vision of the "Industrial Internet."

An insider's look at the re-engineered System 1 video provides insight into the changes that are coming to our software.

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