Connecting SCOUT* to Continuous Monitoring Systems

The most effective installations of continuous monitoring instruments—such as the 3500 system—include integration with the System 1* Condition Monitoring (CM) Platform. However, monitoring systems are sometimes used in a “stand-alone” installation, without the benefits of a CM platform. With such an application, the monitor system provides continuous automatic shutdown protection for the monitored assets, but it does not store data for use in condition monitoring and diagnostic evaluations.

One way to increase the CM capabilities of a stand-alone monitor system is to collect periodic samples from the buffered outputs as part of an existing “walk-around” program. Historical data from the monitor system is then available for long-term trending and diagnostics.

This document provides guidance on how to incorporate the collection of vibration data from an online monitoring system with a condition monitoring program enabled by SCOUT portable devices and Ascent software.

Plant Assets and Monitoring Philosophies

The typical industrial plant consists of a diverse range of assets that combine to provide a service such as the generation of electricity or production of petroleum based products. Maintenance and operational philosophies are generally established based on the criticality of the individual assets and their role in the given system. At a high level, assets fall into three categories: “continuously monitored,” “periodically monitored,” and “unmonitored.”

Continuously Monitored Assets

- Critical assets customarily have continuous monitoring systems that provide the operations team with real-time information about the asset’s condition. These systems can include automatic shutdown, and are the focus of this document.

Periodically Monitored Assets

- The majority of plant assets fall into this category. Monitoring can range from simple indicators (gauges, LEDs, visual, etc.) next to the machine that are periodically reviewed by operations to a full CM program with a portable data collector (PDC).

Unmonitored Assets

- Monitoring and/or CM are not practical due to low criticality (cost, spare capacity, etc.)

Condition Monitoring Overview

CM involves trending and alarming on important parameters that provide clues about the operating condition of an asset over time. Examples of such parameters include vibration, bearing temperature, process flow, and thermodynamic efficiency.

The goal of this strategy is to enable intelligent planning for asset maintenance based on conditional information, as opposed to reactively solving problems when they arise or applying premature maintenance to assets that could have continued to operate without consequence.

Well-organized CM programs can reduce maintenance costs and improve plant reliability
CM Platform Recommendations

System 1 for Continuously Monitored Assets

- Bently Nevada’s System 1 software platform represents the CM solution for continuously monitored machinery. Vibration data provided by Bently monitoring systems can be combined with process information to provide real-time asset health analysis with long-term trending, alarming, and analytical capabilities.

What to do when an online monitoring system like 3500 has not been connected to System 1

- GE’s Bently Nevada Ascent* software combined with a SCOUT series data analyzer can be configured to collect periodic data from these systems. This will enable basic condition monitoring for the critical asset.

Step 1: Understand the System

For optimal SCOUT configuration, consider the questions below prior to configuration:

- Is the monitoring system configured to automatically trip the machine, and if so what conditions will cause a trip?
- What application is the monitor configured for? (radial vibration, acceleration, thrust, etc.)
- How is the monitor configured? (Variables, filters, set points, etc.)

Step 2: Measurement Choices

Useful measurements supported by SCOUT instrumentation:

**Dynamic (Waveform) Data**
- Asynchronous [no tach] and Synchronous [tach] Sampling
- Spectrum (spec)
  - Overall [rms]
  - Spectral Bands [0.5X, 1X, Blade Pass etc...]
- Waveform (Wfm)
  - Waveform True Pk-Pk
  - Crest Factor
- Orbit Plots [Dual Channel Required]
  - Dynamic motion of the shaft centerline within bearing clearance

**Average Value Recording**
- Gap Voltage for Proximity Probes
  - Monitor position of shaft within bearing clearance
  - Monitor Sensor Health
  - Thrust Position
- Monitor the axial position of the shaft
- Bias Voltage for applicable acceleration and velocity probes
- Monitor Sensor Health

Coast-Down/Run-Up
- Bode plot analysis, identify and analyze resonant frequencies (rotor and structural)

Balancing
- Single and Multi-Plane

Step 3: Example Configuration

The subsequent example describes how to configure dual-channel synchronous measurements with gap voltage for radial vibration applications. Configuration is performed in Ascent* software and then downloaded to SCOUT instrumentation. Modifications can be made if single channel collection or asynchronous waveforms are preferred.

The same methodology can be used to configure measurements for acceleration or velocity data. Gap voltage will be replaced with bias voltage for applicable sensors.

Ascent* Software Configuration

Data Folder Configuration Steps (Figure 1):
1. Configure a “New Machine” for the asset. Set “Default Speed” and set “Main Shaft Rotation” direction so that Orbit Plots are drawn properly.
2. Create new “Point” for the bearing location.
3. Create “Measurement Location” for the sensor. Ascent has default Axis locations X and Y intended for proximity probe measurements. The angular orientation for these locations defaults to 0° and must be adjusted for each Axis so that Orbit Plots are drawn properly. See Figure 2.
4. Configure “Schedule Entry” [waveform/spectrum]. See Figure 3.
5. Configure **Average Value “Schedule Entry”** for the gap voltage measurement. See Figure 5.

6. Copy/Paste bearing configuration required number of times. Create Route for the newly created machine upon completion.

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**Axis Angular Orientation Configuration (Figure 2):**
1. Select “Add/Edit” from Measurement Location edit menu.
2. Select “Axis Name” to change the angular orientation, or add a new one if it does not exist.
3. Select “Edit” and type in angular location for selected axis.

**Wfm/Spec Configuration Steps (Figure 3):**
Waveforms and spectra also referred to as dynamic data provide the backbone of the analysis and CM capabilities within Ascent. Trended variables such as Waveform True Pk-Pk, Overall (O/All) Energy, and Spectral Bands are derived from dynamic data.

1. Select data type: spectrum, waveform or both, and desired units. This example demonstrates a radial vibration configuration.
2. If synchronous data is desired, check “Tach Triggered” box.
3. Select appropriate “Tach Type” for application. If tach type is a Keyphasor*, default selection should be “Keyphasor 13V.” SCOUT will prompt user to select a different option during data collection if necessary. Multiple Keyphasor “trigger” options are only available for SCOUT devices with serial numbers greater than 45,000.
4. Select sample resolution.
5. Select number of shaft revolutions desired and check “Order Tracked” box so that true synchronous sampling is enabled. Example shown will collect 128 samples per shaft revolution [2048 samples/16 revolutions].
6. Averaging is not typical for displacement measurements, so set “Number of Averages” to 1. This results in NO AVERAGING.
7. Configure “Channel/Sensor,” see Figure 4.

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**AC-Coupled Sensor Configuration (Figure 4):**
1. Select appropriate **Sensor**.
2. To add or edit existing sensor properties, select “Sensors.”

Sensor Setup Dialog Box:
3. Select appropriate “Sensor Units.”
4. Select “Input Range and Coupling” for sensor type.
   - Recommend AC +/- 8V for most applications.
   - Removes DC component (gap or bias voltage) so that time waveform can be centered around zero engineering units on Y-axis
5. Enter sensor “Sensitivity/Calibration.”
6. Ensure that “Enable Drive Current” checkbox is NOT selected.
   Click OK, sensor is configured.

1. Configure Duration (msec) over which average value is to be calculated. 1000 ms worked well in the example shown.
2. Select Sensor. Sensor output must NOT be AC-Coupled. Select Sensors button to add or edit a sensor configuration.

Sensor Setup Dialog Box:
3. Select Sensor Units. If voltage is desired, select Electro-Motive Force (mV/V).
4. Select appropriate DC-Coupled Input Range and Coupling for the given sensor. Typically, Bently Nevada probes are powered by negative voltage, so select DC -20...0V.
5. Select Sensitivity/Calibration for sensor, 1000 mV/V if measurement is in voltage.
6. Select 0 for DC Offset.

Thrust Position Configuration Steps (Figure 5):
Machines that experience axial loading during operation (Steam Turbine, Pump, Compressor, etc.) have thrust bearings designed to constrain the axial motion of the shaft. Proximity probes measure the axial position of the shaft relative to their installed position, which can be on the thrust bearing viewing the thrust collar, or if this is not feasible, a position very close to the thrust bearing viewing an exposed section of shaft.

Collecting thrust position from a monitor is very similar to that of gap voltage; with a few extra steps required to ensure that the SCOUT measurement matches that of the monitor. Start by configuring a new Average Value Schedule Entry for the thrust position measurement, and then refer to Figure 5 and follow the steps below:
1. Set Duration (msec) to 1000 ms.
2. A new sensor will likely have to be created for each thrust position application within the database because the DC Offset (0mV=) is unique for each application and dictated by the monitor configuration.
3. Select Sensor Units.
4. Select Input Range and Coupling to DC -20...0V.
5. Select Sensitivity/Calibration for sensor. Must be (+) for applications where the “Normal Thrust Direction” is “Toward Probe” and (-) when “Away From Probe.” This information is contained in the monitor configuration.
6. Set the DC Offset (0mV=) to the configured “Zero Position (Direct)” configured in the monitor. This value must be (+) for applications where the “Normal Thrust Direction” is “Toward Probe” and (-) when “Away From Probe.” The DC Offset (0mV=)

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Gap Voltage Configuration Steps (Figure 5):
Trending the “Gap Voltage” for proximity probes monitoring radial vibration is highly recommended. This important parameter represents the DC component of the proximity probe signal and provides information about the position of the shaft centerline within a journal bearing and the health of the sensor itself.

Valuable parameter for CM, as certain conditions can cause the position of a shaft to change within its bearing housing without causing a noticeable change to the radial vibration, which is why trending and alarming on gap voltage is very useful.

To produce the DC component of the transducer signal, an average value is calculated from a DC-Coupled waveform.
entry must be in units of displacement, refer to the example provided below.

**Thrust Example:**
A 3500 monitor has been configured to measure thrust position with a 3300-8 mm Proximitor. The "Normal Thrust Direction" is set to "Toward Probe" and the "Zero Position (Direct)" is set to -10.0 V, see Figure 6 that shows the 3500 rack configuration software dialog box.

1. Sensor sensitivity will be (+) 200mV/mil because the 3500 configuration is configured with Normal Thrust Direction to Toward Probe for a 3300-8 mm Proximitor.
2. Zero Position (Direct) is equal to -10.0 V. Ascent requires this information converted to displacement units, which can be done because the sensitivity of the Proximitor is known.

\[
\text{200 mV/mil} = 0.2 \text{ V/mil} = 5 \text{ mil/V}
\]

\[-10.0 \text{ V} \times 5 \text{ mil/V} = -50 \text{ mils}
\]

Now that the Zero Position (Direct) value has been converted to displacement, this value should be entered into Ascent as (+) 50 mils because "Normal Thrust Direct" is configured as "Toward Probe."

**If the monitor had been configured with "Normal Thrust Direction" set to "Away From Probe," Sensor Sensitivity and DC Offset (0mV =) would have been set (-).**

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**Configuring the SCOUT PDC for Dual Channel Recordings**
Now that the software has been configured and the route has been downloaded to the PDC, the instrument must be configured to take dual channel readings (only required when dual channel data collection is needed). See Figure 7.

1. **Configuring SCOUT for dual channel collection (Figure 7):**
   1. Enter the **Route** that was configured in the previous steps. Select "Axes," Button 5 on the instrument.
   2. Toggle **Button** 5 to "Multi-Axis (X and Y for Orbit)" for dual channel data collection. Older versions of SCOUT firmware may not have this selection, in this case, select "Multi-Axis" and manually map the appropriate axes to their respective channels.

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**Step 4: Alarm Considerations**
Now that the basic configuration has been completed, it is time to establish alarms on key parameters. Alarms are the key to an effective CM program because they provide the trigger for investigation. Time is a precious commodity for the rotating equipment engineer who is commonly in charge of hundreds of assets. It is therefore essential that their focus be directed to the assets experiencing problems which have the potential to negatively affect the business operation.
Where to Start?

The data being collected is from an online monitoring system that will typically be programmed with alarm set points on critical parameters based on OEM guidelines, common standards or end user requirements. These set points represent a great starting point when first applying alarms to the applicable parameters; however caution must be taken to ensure that a fair comparison can be made.

Protection Systems vs. Data Analyzers

Protection systems like 3500 series monitors serve a different purpose than data analyzers like SCOUT or ADRE and as such discrepancies in readings can arise. Refer to the following Orbit articles for an in-depth look into how readings are calculated by common instruments.

Orbit [Vol.25 No.2 2005], Page 18
“Understanding Discrepancies in Vibration Amplitude Readings Between Different Instruments, Part 1 of 2”

Orbit [Vol.26 No.1 2006], Page 40
“Understanding Discrepancies in Vibration Readings Between Different Instruments, Part 2 of 2”

What Parameters Should Have Alarms?

Condition monitoring platforms like Ascent and System 1 provide a wide range of alarming capabilities for trended parameters. It is helpful to configure parameters and alarms based on the machine being monitored and its failure modes.

A minimal set of recommended parameters that should be configured and have alarms is provided, see Table 1. Alarm bands are created by right clicking on the Schedule Entry of interest and selecting New>Alarm Band. See Figure 8.

Table 1: Trended Parameters by Application

<table>
<thead>
<tr>
<th>Application</th>
<th>Trended Parameters In Ascent SW</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Waveform True Pk-Pk</td>
</tr>
<tr>
<td>Radial</td>
<td>X</td>
</tr>
<tr>
<td>Thrust¹</td>
<td>X</td>
</tr>
<tr>
<td>Acceleration²</td>
<td>X</td>
</tr>
<tr>
<td>Velocity²</td>
<td>X</td>
</tr>
</tbody>
</table>

1. Thrust position alarms will be for the Average Value Recording. Monitoring the dynamic portion “True Pk-Pk” is also valuable however this parameter is not calculated by the monitor; review trend and set alarms accordingly.

2. **Monitor Sub Units = Pk** Alarm levels should be configured on the Waveform True Pk-Pk value for the waveform Schedule Entry of interest. Monitor produces readings in pk, so the set points must be multiplied by 2 in Ascent.

3. **Monitor Sub Units = RMS** Alarm levels should be configured on the O/All Power (RMS) level for the waveform/spectrum Schedule Entry of interest.

Configuring Alarm Bands in Ascent (Figure 8):

1. Choose the data type that the alarm band will apply too, example shown is for a Waveform.

2. Choose the desired type of alarm band. Example shown is for a Waveform True pk-pk value that will be applied to a displacement waveform Schedule Entry. If a Power level (rms) is desired for a velocity or acceleration measurement, select accordingly.

3. Choose alarm thresholds. If monitor set points are known, it is helpful to add these as “Alert” and “Danger” and then configure a third “Warning” or management alarm if the trended data is far below the monitor set points.

Initially the parameter sets may be limited to “overall or Pk-Pk” values, however as the CM program evolves, it can be advantageous...
to establish fault specific alarm bands based on the knowledge gained from the historical data.

“Management” Alarms
It is not uncommon for the trended parameter’s amplitude to be far lower than the monitor alarm levels, so it is useful to add an additional “management” alarm in order to catch smaller changes in the measured parameter, see trend plot in Figure 9. Create trend plots by selecting desired alarm band or trended parameter and pressing F4 on the keyboard. Management below the Alert and Danger set points will help expose issues prior to serious machine problems or trips.

Figure 9: Waveform Pk-Pk Alarm Set Points

Step 5: Viewing Data
Waveform/Spectrum Plot
To display a waveform and spectrum plot in Ascent, highlight desired Schedule Entry in the folder hierarchy and then select Chart>SpecWfm. Note, if a spectrum was not stored as part of the data collection, the SW can perform the FFT, in this case select Chart>WaveformFFT. Spectrum and waveform plots can be generated separately by using hot keys F2 and F3 respectively.

Figure 10: Spectrum Waveform Plot

Orbit Plot
To display an Orbit plot in Ascent, highlight the appropriate Schedule Entry in the folder hierarchy and then select Charts>Orbit+Waveform.

Figure 11: Orbit Plot
Viewing an Orbit Plot in Ascent (Figure 11):
1. Transducer Location
2. Shaft Rotation Direction
3. Number of shaft revolutions plotted and filter settings (if applied) to plot. These settings can be adjusted from the right click menu.
4. Vertical Probe “Y” waveform plot
5. Horizontal Probe “X” waveform plot
6. Keyphasor Dots
Comparing SCOUT data with 3500 Readings

The data depicted in Figure 12 shows a comparison between the Direct readings for an acceleration measurement from a 3500 monitor and a buffered output reading collected by SCOUT from the monitor. For comparison, the same accelerometer signal was fed into two monitor channels so that the rms and pk acceleration could be calculated.

As can be seen in Figure 12 and Table 2, the readings compare favorably for both RMS and Pk. Remember, the True Pk-Pk reading must be divided by two for a comparison to the 3500 Direct reading.

<table>
<thead>
<tr>
<th></th>
<th>Gs RMS</th>
<th>Gs Pk</th>
</tr>
</thead>
<tbody>
<tr>
<td>3500</td>
<td>0.29</td>
<td>0.93</td>
</tr>
<tr>
<td>SCOUT</td>
<td>0.28</td>
<td>0.89</td>
</tr>
<tr>
<td>% Diff</td>
<td>3.4</td>
<td>4.3</td>
</tr>
</tbody>
</table>

Bode Plot

SCOUT instrumentation can be configured to collect “startup”/“shutdown” data, which is a very valuable tool in the field of rotor dynamics. Collecting this type of data with SCOUT will enable the Bode plot in Ascent, shown in Figure 13. This powerful plot combines amplitude and phase information, and opens up the potential to identify many important characteristics about the system being investigated. Rotor and structural resonances can be identified in the Bode plot. Figure 13 displays a classic rotor balance resonance, notice the spike in amplitude and phase roll at 2350 rpm. SCOUT was used to collect this information from the buffered output of a 3500 rack monitoring radial vibration.

The Coast-Down/Run-Up measurement is configured in the SCOUT instrument (In field measurement), and requires a tachometer signal. Once collected, the data can be uploaded into the Ascent SW for review.

Figure 12: SCOUT and 3500 Data Comparison

Figure 13: Bode Plot

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