OSIsoft UC 2017 Lab

Incorporating Condition Monitoring Data - Vibration, Infrared and Acoustic for Condition-based Maintenance
Condition-based Maintenance – Hands-on Lab – OSIsoft Users Conference 2017

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Incorporating Condition Monitoring Data – Vibration, Infrared and Acoustic for Condition-based Maintenance

Lab Description

Traditionally, the PI System has worked with process data from plant instrumentation such as PLC and SCADA. However, newer IoT and edge device capabilities allow you to bring data from condition monitoring systems such as vibration, infrared (thermography), acoustic, etc. to the PI System. Take this lab to learn how to use condition-monitoring data along with process data in your condition-based maintenance programs to improve equipment uptime. The lab will also include the use of alert roll-ups, watch lists, KPIs and others for a holistic view of asset health and reliability.

Level: 200    Duration: 2 hours

Summary

Condition-based maintenance (CBM) is a strategy where you monitor the actual condition of an asset to decide what maintenance needs to be done – see wiki for a broader definition.

The learning objectives for this lab are:

- Understand the condition monitoring (CM) data collection process – with a live demo of a hand-held device used for collecting vibration, infrared and acoustic data for a motor
- Understand how the condition monitoring data is transformed and written to PI
- Configure condition assessment calculations for the CM data and recognize the use of dynamic thresholds for the CM data
- Incorporate CM data such as oil analysis (that may reside in external databases) in the condition assessment calculations
- Incorporate manual input CM data (aka operator rounds) from PI Manual Logger
- Create displays, notifications, alerts watch list etc. using various PI System capabilities and tools
- Review the PSE&G customer use case on combining PI System data with CM data for calculating asset health score

In this lab, we will use a hand-held device to collect vibration, infrared, and acoustic data. The device is a Windows 10 based unit (it can also be an iPad) with suitable attachments based on National Instruments http://www.ni.com technologies. Please see AR-C10 for hardware details.
With such condition monitoring (CM) data, typically we do not store the raw data in the PI System. Instead, the data is transformed, and aggregate/derived values are written to the PI System.

Even though you can store raw CM data in the PI System, it is out-of-scope for this lab.

For vibration data, the raw time-series wave form may have 10,000 or more values per second, and often data is collected for several seconds (depending on the motor rpm and other analysis requirements). This time-series (time domain) data is converted to frequency-domain using FFT (Fast Fourier transform). And, calculated values derived from both time-series wave-form and FFT analysis are written to the PI System.
Figure 3: rms value g (acceleration, y-axis) vs. frequency (x-axis) - Vibration time-series waveform data is converted to frequency domain using FFT analysis.
Figure 4: PI System Explorer screen showing the various AF attributes (see Category - Vibration data); values derived from time-series wave-form and FFT analysis for each sample are written to the PI System.

**Infrared** – a non-contact technology – is convenient for measuring temperatures of mechanical equipment (motors), electrical equipment (circuit contacts), and others. The device interprets the image and estimates the temperature at the crosshair location and the temperature(s) are written to the PI System.

Figure 5: Infrared camera image for a motor – the crosshair identifies the location for estimating the surface temperature – Motor at 69.6 °F (left image) and at 85.4 °F (right image)
Native infrared images can be stored in the PI System but is out-of-scope for this lab.

*Ultrasonic measurements* are made using acoustic sensors which measure sound waves, including high frequency sounds – above human hearing range. Acoustic sensors can “hear” the sounds from internal friction or metal deformation - in Figure 6, the ultrasound level increases from about 10dB to 40dB.

The raw acoustic waveform is similar to those for vibration. FFT analysis transforms the time-domain data to frequency-domain, and overall sound level in decibels (dB) is written to the PI System.

![Figure 6: Acoustic time-series wave form (in red) and frequency plot (in blue); sound level has increased from 10 dB to 40 dB between the left and right sample for the same motor](image)

*Regarding condition assessment*, with the CM data in the PI System, you can use the various PI System capabilities such as AF Analytics, Event Frames, Notifications, OSIsoft Visualization displays, watch-list, and others.

![Figure 7: OSIsoft Visualization screen – Watch list of Alerts from vibration measurements exceeding threshold limits](image)
Figure 8: Microsoft Power BI screen - Watch list of Alerts from vibration measurements exceeding threshold limits

Figure 9: OSIsoft Visualization screen for Pump P-4 Motor Inboard Vertical
An example condition assessment for infrared temperature measurement is a rate-of-change logic, say, an increase of more than 20 °F in a 24-hour period for a motor running under similar operating conditions.

For acoustic data, an increase in the overall sound level (decibels) above a threshold level can be used to set an alert.

With access to both CM data and process data in the PI System, you can also specify dynamic threshold limits for condition assessment – for example, a higher vibration threshold for a pump at full load vs. another at partial load.

Finally, you can also combine SCADA/PLC data with CM data to calculate asset health score.

Figure 10  PSE&G use case showing asset health (condition assessment) score for a distribution transformer – load tap changer (LTC)
As previously mentioned, the learning objectives for this lab are:

- Understand the condition monitoring (CM) data collection process – the lab includes a live demo with a portable device for collecting vibration, infrared and acoustic data for a motor
- Understand how the condition monitoring data is transformed and written to PI
- Configure condition assessment calculations for the CM data and understand the use of dynamic thresholds for the CM data
- Incorporate CM data such as oil analysis (that may reside in external databases) in the condition assessment calculations
- Incorporate manual input CM data (aka operator rounds) from PI Manual Logger
- Create displays, notifications, alerts watch list etc. using various PI System capabilities and tools
PI System software

The VM (virtual machine) used for this lab has the following PI System software installed:

<table>
<thead>
<tr>
<th>Software</th>
<th>Version</th>
</tr>
</thead>
<tbody>
<tr>
<td>PI Data Archive</td>
<td>2016 R2</td>
</tr>
<tr>
<td>PI Asset Framework (PI AF) server</td>
<td>2017 (pre-release)</td>
</tr>
<tr>
<td>PI Asset Framework (PI AF) client (PI System Explorer)</td>
<td>2017 (pre-release)</td>
</tr>
<tr>
<td>PI Analysis &amp; PI Notifications Services</td>
<td>2017 (pre-release)</td>
</tr>
<tr>
<td>OSIsoft Visualization</td>
<td>2017 (pre-release)</td>
</tr>
<tr>
<td>PI Web API</td>
<td>2017 (pre-release)</td>
</tr>
<tr>
<td>PI Connector for UFL</td>
<td>2016</td>
</tr>
</tbody>
</table>

For details on PI System software, please see [http://www.osisoft.com/pi-system/pi-capabilities/product-list/](http://www.osisoft.com/pi-system/pi-capabilities/product-list/)
Exercise 1 – Use a hand-held device to collect Vibration, Infrared and Acoustic data

The device is a Windows10 unit (can also be an iPad) with suitable attachments based on National Instruments [http://www.ni.com](http://www.ni.com) technologies. Please see [AR-C10](http://www.ni.com) for hardware details.

Figure 11: AR-C10 Device

**Video demo** – data collection with the AR-C10 device.

During the lab, the instructor will collect the data for a motor rotating at 1800 rpm.

Figure 12: AR-C10 device with three sensors connected to it.

In Exercise 2, since we need several vibration data samples for analysis, we will be using data from a continuous online system but with data similar to those collected by the hand-held device.
Exercise 2 – Analyze Vibration data

In this exercise, you analyze the accelerometer measurements from an online vibration data-collection system National Instruments InsightCM. Data is captured by the NI cRIO module, an FFT analysis is performed at the edge, and select data is written to the PI System.

The sensors installed on chilled water pumps (motor-pump assembly) are:

- Motor Inboard Vertical (MIV)
- Motor Inboard Horizontal (MIH)
- Motor Outboard Vertical (MOV)
- Pump Inboard Vertical (PIV)
- Pump Outboard Vertical (POV)
In Step 1, we review the vibration sensor data organized using the equipment hierarchy in PI Asset Framework. We also review the condition assessment calculations for setting alert levels when vibration exceeds defined threshold limits.

Step 1: AF configuration for sensor data

1. Open PI System Explorer, and connect to the National Instruments PI AF database. If the top bar of the window does not show \PI1\National Instruments, then click on the top toolbar button to select the PI AF database.
Exercise 2 – Analyze Vibration data

2. From the AF equipment hierarchy, drill down under Austin > Mopac C > CP > Chilled Water Pump P-1 > Motor_Inboard_MIV. Click on the Attributes tab.

![Image: PI System Explorer screen showing readings for the MIV (Motor Inboard Vertical) vibration sensor; note the Hi, and HIHI limit settings for the True Peak alert calculation]

3. Select the Crest Factor attribute and expand its child attributes to view the limits. Repeat the same for the True Peak attribute. The limits are defined in AF - but these can also be referenced from an external system using the Table Lookup feature.

4. Select the Motor_Inboard_MIH (horizontal sensor) element of the Chilled Water Pump P-1, and confirm that the attributes are the same. Both Pump P-1 and P-2 use same Element Template, named NI Device Vibration.

Note: Your vibration data collection vendor may not expose the same number of calculated values as provided by National Instruments and shown in the Attributes category.
The definition for a few of the attributes are:

<table>
<thead>
<tr>
<th>Vibration Data</th>
<th>Definition</th>
</tr>
</thead>
<tbody>
<tr>
<td>True Peak</td>
<td>The maximum of the positive peak and negative peak</td>
</tr>
<tr>
<td>Peak-Peak</td>
<td>The positive peak minus the negative peak</td>
</tr>
<tr>
<td>RMS</td>
<td>The root mean square of the signal</td>
</tr>
<tr>
<td>Derived Peak</td>
<td>RMS × √2</td>
</tr>
<tr>
<td>Crest Factor</td>
<td>True Peak / RMS</td>
</tr>
</tbody>
</table>


To better understand Peak, Peak-to-Peak, and RMS values, please see the diagrams below for a sine wave:
Step 2: Condition assessment
The vibration sensor measurements are written to the PI System every 5 minutes. The figure below shows a simple threshold-based Hi alert calculation for the Crest Factor.

![Figure 16: Alert calculation for Crest Factor](image)

1. Select Chilled Water Pump P-1 > Motor_Inboard_MIV element and review the calculations in the Analyses tab as shown in the above figure.
2. Select the Crest Factor Alert analysis and examine its Expression, then click the Evaluate button. Value at Evaluation will show 0 (Not Active) or 1 (Active).
3. Next, select the True Peak Alert analysis.
4. Write an expression to test whether or not the True Peak data is above the Hi limit.
   a. Position the cursor in the Variable1 Expression, where it states “Type an expression” (the previous row shows the syntax)
b. An If-Then-Else statement will be used along with a simple “greater-than” comparison to determine if the alert flag should be set to 0 or 1.

c. Start typing the following expression (Intellisense like feature helps you to quickly complete the expression):

   If 'True Peak' > Then 1 Else 0

5. Evaluate the newly added expression using the Evaluate button.

6. Save your changes by clicking the Check In button from the top toolbar.

7. This analysis expression now only exists for the inboard vertical vibration sensor of pump P-1.

   In order to deploy this analysis to all vibration sensors of the same type, right-click the True Peak Alert analysis from the list of analyses, and select Convert to Template.

8. Confirm that the analysis has propagated to all sensors with current Element template.

The analysis executes every time new vibration data comes into the PI System. If the value is above the Hi threshold, then the Alert flag will be set to 1 - for both Crest Factor and True Peak.
Step 3: Alert rollup
The individual alerts can be rolled up to get an overall Alert level for an asset or a group of assets. Please see ZZ_Overall Alert – it uses the Rollup calculation to sum all alerts from each sensor location.

1. Review ZZ_Overall Alert rollup analysis for one of the vibration sensor element as shown in the above figure.
2. Note the rollup configuration where a filter retrieves only the child attributes named Alert. The rollup analysis then sums the alert value for all the attributes, and writes the result to its own Alert attribute.
3. Click the Evaluate button, and confirm the same value is available by examining the Alert attribute of the element.
The total number of alerts is now at each sensor level, but it is also useful to have it at the pump level, and eventually, at the plant/site, division, company level.

This is especially useful when high-level dashboards need to show aggregated or rolled-up data. Let us now configure a rollup for the pump level assets.

4. Select the Chilled Water Pump P-1 element from the left hierarchy and select its Analyses tab.

5. Finalize the configuration of the Alert Rollup analysis.
   a. Filter by Attribute Name, by entering the value Alert.
   b. Confirm that the filter found an attribute from the right-hand side list of attributes.
   c. Check the Sum function to perform a sum of Alert values and map its output to the pump’s Alert attribute.

6. Click the Evaluate button to confirm a valid calculation.
7. Click on the Check In button from the top toolbar to save your changes.
8. Assign this analysis to the pump template by right-clicking the Alert Rollup analysis and selecting Convert to Template.

Note that this analysis is configured to execute periodically, every 30 seconds.
Step 4: Visualization of the data and alerts
We use OSIsoft Visualization to visualize the measurement data from the sensors. Click on the URL below to display the alert status for the chilled water pumps:

https://pi1.pischool.int/PIVision/#/Displays/38/Pumps-Alert-Overview

Figure 18: Home screen for the chilled water pumps alert monitoring
The following screen show how to drill-down and navigate among related displays:

Displays 2, 3, and 4 shown above are element relative and re-usable for similar assets.

Navigate to the Sensor Alerts display from the above figure (https://pi1.pischool.int/PIVision/#/Displays/40/Vibration-Sensor-Details).

1. From the Asset pick list, select a different vibration sensor. Hover over the element name to see the full AF path with the pump name.

The most recent release of OSIsoft Visualization introduces a new Collections feature.
Exercise 2 – Analyze Vibration data

2. Navigate to the Sensors in Alert display (https://pi1.pischool.int/PIVision/#/Displays/42/Vibration-Sensors-Alert-Overview) to view a list of all Alert attributes for all vibration sensors.

![Image of Vibration Sensors Alert Overview display]

*Figure 21: OSIsoft Visualization Vibration Sensors Alert Overview display*

In Collections, you can use dynamic filters:

3. Right-click the Collection symbol on the screen, and select Edit Collection Criteria...
4. Expand the Asset Type section in the right-hand pane. It already has a filter criterion; the next step shows the details for adding a filter.
5. Click the + sign to add an Asset Attribute filter criteria.
   a. Select the Alert attribute.
   b. Select the not equal sign.
   c. Type in a value of 0.
6. Click the Refresh button at the bottom of the pane to apply the changes.

![Image of Edit Collection Criteria]

![Image of Refresh button]
Step 5: Event Frames
The vibration sensor Elements include analyses to create event frames for each alert as shown in the figures below:

![Event Frames Diagram]

**Figure 22: AF Analysis to generate Event Frames**

**Figure 23: Alert events along with their severity**

The event frames use a template of type **Work Order**.

Event frames can be configured to include all the required information for integration with CMMS (Computerized Maintenance Management System) such as SAP PM, IBM Maximo, Oracle EAM, and others – to trigger a Work Order, or update a Meter reading etc.

1. From PI System Explorer, navigate to the **Event Frames** section.
2. Expand the **Event Frame Search 1** object.
3. Select any **True Peak Event** and explore its properties from the middle pane.

![Figure 24: Selecting a True Peak Event from the Event Frames section](image)

Let us now force the generation of some alerts, and some **Work Order** events. In order to trigger an alert, simply lower the value of the **Hi** limit of a sensor.

4. Navigate back to the **Elements** section of PI System Explorer.
5. Select the `\[PI1\]National Instruments\Austin\Mopac C\CP\Chilled Water Pump P-1\Motor_Inboard_MIV` element.
6. Look at its **Attributes**, and expand the **Crest Factor** or the **True Peak** attribute level.
7. Modify the value of the Hi attribute to a lower value such that Crest Factor or True Peak will go into Alert.

![Figure 25: Lowering the Hi limit of the Crest Factor attribute](image1.png)

8. While waiting for new vibration measurement data to come in (every 5 minutes), look in the Analyses tab to Evaluate the event frame generation analysis.

![Figure 26: True Peak - Analysis for event frame generation](image2.png)
Exercise 2 – Analyze Vibration data

Step 6: Event Frames as a Watch List using OSIsoft Visualization

OSIsoft Visualization **Events Table** (new feature) is used to build a watch list.

1. Navigate to the overview screen ([https://pi1.pischool.int/PIVision/#/Displays/38/Pumps-Alert-Overview](https://pi1.pischool.int/PIVision/#/Displays/38/Pumps-Alert-Overview)) and click the Vibration Sensors Alerts Watchlist link (will bring you to: [https://pi1.pischool.int/PIVision/#/Displays/45/Vibration-Sensor-Alerts-Watchlist](https://pi1.pischool.int/PIVision/#/Displays/45/Vibration-Sensor-Alerts-Watchlist)).
2. The watch list shows the event frames currently in progress. Confirm this by right-clicking the events table and selecting **Configure Table...**
3. From the right hand pane, expand the **Event State** section to see the **In Progress** filter.

![Watchlist of all Vibration Alerts](image)

*Figure 27: Alerts Watch List using OSIsoft Visualization Events Table*

4. Double-click on an event in the table to see the Details window. Items showing the red Critical state indicate those exceeding HiHi limit; the items in blue Warning indicate those exceeding the Hi limit.

![OSIsoft Visualization details page for an Event Frame](image)

*Figure 28: OSIsoft Visualization details page for an Event Frame*
Exercise 3 – Other Data Types

Other condition monitoring data, such as temperature readings, acoustic data, lab results from oil analysis, etc. are all part of the condition assessment done to ensure equipment reliability. In this exercise, let us look at three different kinds of measurements and how they are used for CBM.

A. Motor Oil Lab Results and AF Table

Motor oil analysis for critical motors are often performed on a regular basis.

![Sample Motor Oil Analysis Report](image)

These lab results may exist in an external database but they can be referenced and used as part of condition assessment in an AF calculation via PI AF Table.
Exercise 3 – Other Data Types

Step 1: Data from an external database

1. In PI System Explorer, navigate to the Library section.

2. Expand Table Connections, and select SQLServer. A connection has already been established between PI Asset Framework and a SQL Server database that holds lab results, called Lab Analyses.

3. Create a PI AF Table to reference the lab result. Right-click the Tables and select New Table.

4. Enter Oil Analysis in the Name field.
5. Click the Link button at the bottom of the configuration pane. Select SQLServer for the Connection field, and then enter the following SQL query to reference the Oil Analysis table:

```
SELECT * FROM [Oil Analysis]
```

The SQL query tells AF to select everything (or *) from the Oil Analysis table. Click OK to confirm the query.

6. Confirm that the data is now available by selecting the Table tab.

7. Click the top-toolbar Check In button to save the changes.
Step 2: Confirm that the Oil Analysis data is now available via PI AF attributes

1. Navigate to the Elements section in PI System Explorer and navigate to `\PI\National Instruments\Austin\Mopac C\CP\Secondary Chilled Water Pump P-4`.
2. Select the Attributes tab, and confirm that the attributes in Oil Analysis category show the oil analysis lab data. You may have to click the top-toolbar Refresh button.

The lab data for Oil Analysis can now be used (in the same manner as any other sensor data) as part of condition assessment and to trigger events and notifications.
B. Infrared Temperature Readings, PI Manual Logger, and Notifications

Often, temperature or infrared readings are collected using portable data collectors. If a device such as the AR-C10 (see Exercise 1) is available, then it sends the data directly to the PI System. However, if you are using another device without direct write capability to PI, then you can use PI Manual Logger on a tablet or phone to manually input the reading.

In this section, we review manual input data for a temperature reading and its use with PI Notification to send an email as an alert for an out-of-spec reading.

Step 1: Examine the available temperature data

1. Navigate to \PI\National Instruments\Austin\Mopac C\CP\Chilled Water Pump P-1, and check its Motor Inboard Temperature attribute. This temperature sensor is online and data is collected in real-time via an interface to the BMS (building management system). Right-click the attribute and select Trend to view its data.

2. Navigate to \PI\National Instruments\Austin\Mopac C\CP\Secondary Chilled Water Pump P-4. The secondary chilled water pumps have not been instrumented with temperature sensors for continuous online data collection. As such, temperature readings (from an infrared device) is entered manually in PI-Manual Logger.

Right-click the attribute and select Trend to view its data.
Step 2: Temperature rate of change analysis, and PI Notification

1. Select the Analyses tab of the Secondary Chilled Water Pump P-4 element.
2. Select the High Temperature RateOfChange analysis from the list. The expression triggers an event frame generation when the rate of change for the temperature is greater than 0.25 °F per day. The manual data collection via operator rounds is done once a week.

![Figure 30: Rate of change Expression analysis](image)

3. Evaluate the expressions to see whether the alert is true.

Step 3: Examine the Notification rule for the high temperature Event Frame

1. Select the Notification Rules tab for the Secondary Chilled Water Pump P-4 element.
2. Click the View/Edit Trigger to confirm that a notification will be triggered when a High Temperature RateOfChange Event Frame is triggered.
3. Click the View/Edit Subscriptions to review the email format; click the pencil icon next to the format field.

4. Note that the email includes URL links in the bottom portion of the email body, one URL for using from within the lab VM environment (internal link), and another URL that can be used from any external computer or device (external link).

Step 4: Modify the Student’s email address to receive the notification in your inbox

1. From PI System Explorer, select the Contacts section from the bottom left of the screen.

2. Type student in the search field near the top, then select the Student contact, and edit the Email address field to replace it with your own email.

3. Click the top-toolbar Check In button to save the changes.
Exercise 3 – Other Data Types

Step 5: Use PI Manual Logger to enter a value that will trigger an alert

1. **Launch PI Manual Logger Tour** shortcut from the VM desktop, or click the link below:
   This opens a new tour run to enter temperature and acoustic data for pumps P-4 and P-5. It shows the current timestamp at the top of the screen. Click the **Switch to grid data entry view** link found in the top right of the screen.

2. Expand the first tag to see the previous data entries:

3. Enter values for up to six (6) tags, making sure to enter at least one very high value for a temperature to trigger an event frame generation.

4. Click the **Save** button at the bottom to send the values to the PI Server.

5. In the PI Manual Logger Web homepage, click **Refresh** to clean any tour run information.
Step 6: Verify Notification delivery and web visualization of the alert

1. Confirm that an Event Frame has been generated for either Pump P-4 or P-5 and that you received an email.

   ![Event Frame Image]

   **Event:** HighTemp_2017-02-27 20:15  
   **Name:** High Temperature Rate Of Change Notification  
   **Start Time:** 2/27/2017 8:15:34 PM Pacific Standard Time (GMT-08:00:00)  
   **Target:** Austin/Mopac C/C/Secondary Chilled Water Pump P-4  
   **Trigger:** Start Trigger Name  
   **Severity:** Warning  

<table>
<thead>
<tr>
<th>Attribute</th>
<th>Value</th>
<th>Time</th>
</tr>
</thead>
<tbody>
<tr>
<td>Motor Inboard</td>
<td>96 °F</td>
<td>2/27/2017 8:15:34 PM Pacific Standard Time (GMT-08:00:00)</td>
</tr>
<tr>
<td>Temperature</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Pump Inboard</td>
<td>89 °F</td>
<td>2/27/2017 8:15:34 PM Pacific Standard Time (GMT-08:00:00)</td>
</tr>
<tr>
<td>Temperature</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

   View notification details  
   Internal link: https://p1.pl.pischoll.int/pvision/#/EventDetails?server=P1&eventid=2862dcb8-a70-4f21-0000-0000000974bd  
   External link: https://3796fissel.cloudapp.net/pvision/#/EventDetails?server=P1&eventid=2862dcb8-a70-4f21-0000-0000000974bd

   2. Use the links at the bottom to navigate to the Notification details page. The link takes you to a Coresight display.  
      Copy-paste the internal link in the browser address bar from within the lab VM.  
      If prompted for login, enter the following credentials (user: pischoll\student01, password: student). If you get an error, use the Notification Page Example shortcut from the desktop to open the details page from a previous notification.

   3. Review the notification details page. Note the **Acknowledge** button in the upper right (optional), and the **Add Comment** section. The acknowledgement workflow ensures that someone will look into the event.

   ![Notification Details Image]
Exercise 3 – Other Data Types

4. Acknowledge the notification by clicking the green Acknowledge button. Then enter a comment by typing in something inside the Add Comment box, and then by clicking the Add button. Note that you can also attach a file (including a picture, video etc.) to the event.

C. Acoustic Data and Dynamic Threshold

In the previous example, we used a rate of change logic to trigger an event/notification. However, for early detection of degrading equipment conditions, your condition assessment can be based dynamic thresholds for Limit values that reflect the current operating context. For example, the Hi Limit threshold for a chilled water pump at full load can be proportionately higher than one running at partial load.

As such, let us look at the acoustic readings, but in the context of the cooling power corresponding to the chilled water pump load.

Step 1: Examine the acoustic data and cooling power

1. Navigate to the \PI\National Instruments\Austin\Mopac C\CP\Secondary Chilled Water Pump P-4 element.
2. Examine its Attributes from the Acoustic category.
3. Right-click the Cooling Power attribute and select Trend to see that the cooling power varies with time.

![Graph of acoustic data and cooling power]

The varying cooling power is incorporated into the condition assessment as a dynamic threshold for the acoustic dB limit which determines whether the motor-pump assembly is making more noise than expected for a given cooling power value.
Step 2: Review the dynamic acoustic limit

1. Select the **Analyses** tab of the Pump P-4 asset.
2. Select the **Dynamic Acoustic Threshold** from the list.

3. The Curve() function is used to map the acoustic Hi limit (Y) with its corresponding cooling power value (X).

Using AF calculation, the acoustic limit is written to the PI Server to illustrate how it varies with the cooling power.

![Graph showing acoustic reading against dynamic Hi limit](image)

*Figure 31: OSIsoft Visualization trend showing the acoustic reading against its dynamic Hi limit*

Note that the Decibel Limit (purple trace) varies with the cooling power (orange trace). Also note that the acoustic readings (blue trace) are below the Decibel Limit (purple trace).
You can also use an XY chart to view the acoustic readings and its limit.

![Image](Figure 32: OSIsoft Visualization XY Chart showing the last 4 acoustic readings (purple) against its limit curve (blue))

This concludes the hands-on portion of the lab.
In summary, we covered the learning objectives stated at the beginning of the lab:

- Understand the condition monitoring (CM) data collection process – with a live demo of a hand-held device used for collecting vibration, infrared and acoustic data for a motor
- Understand how the condition monitoring data is transformed and written to PI
- Configure condition assessment calculations for the CM data and recognize the use of dynamic thresholds for the CM data
- Incorporate CM data such as oil analysis (that may reside in external databases) in the condition assessment calculations
- Incorporate manual input CM data (aka operator rounds) via PI Manual Logger
- Create displays, notifications, alerts watch list etc. using various PI System capabilities and tools
- Review the PSE&G customer use case on combining PI System data with CM data for calculating asset health score

Please take a few minutes to give us your feedback [https://www.surveymonkey.com/r/QMBJP2G](https://www.surveymonkey.com/r/QMBJP2G).
Other Resources

OSIsoft Users Conf. 2016 TechCon Lab Notes Condition-based Maintenance with PI AF

OSIsoft Users Conf. 2015 Presentation Keeping Assets Healthy – PI System’s Role in Asset Maintenance

Calculating Asset Health Score - OSIsoft vCampus 2013 Lab Notes

PSE&G use case showing asset health score http://www.osisoft.com/Presentations/Condition-Based-Maintenance/

http://www.ni.com/condition-monitoring/

National Instruments InsightCM™ Enterprise for Condition Monitoring

Allied Reliability Group AR-C10 Data Collector for Condition Monitoring

MetrixSetpoint Condition Monitoring

Emerson Vibration Monitoring