Monitoring Machinery Vibration Using Dynamic & Process Control Signals

VIBRATION ANALYSIS HARDWARE

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Narration

We are glad that you have taken the time to view this self-paced training module on Monitoring Machinery Vibration Using Dynamic & Process Control Signals.

This is a narrated slide show. The narration can be played through the speakers on your computer. Or, if you do not have speakers or wish not to disturb others around you, the entire narration for each slide will be displayed on the screen in a blue box such as this one.

Enjoy the training.

Objectives

"***Monitoring Machinery Vibration Using Dynamic & Process Control Signals***", was created and presented by **CTC** (Connection Technology Center, Inc.)

CTC manufactures a full line of Industrial Vibration Analysis Hardware, and Process and Protection Instruments, all backed by the Industry's only **Unconditional Lifetime Warranty**.

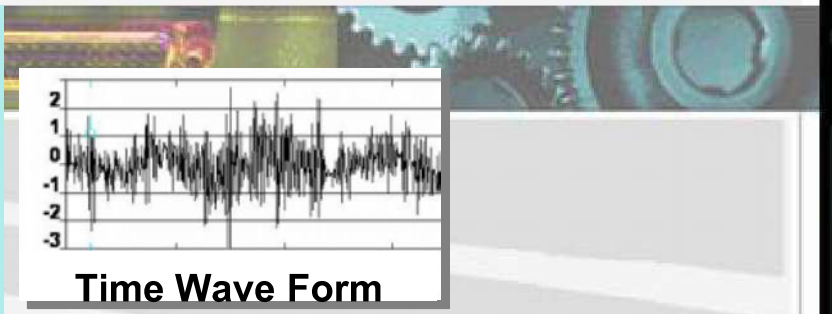
After taking this training module an analyst will understand the difference between a Dynamic Signal and a Process Control signal, what the strengths and limitations of each type of signal are, and how they can be used together in some instances to offer an optimal level of protection for critical machinery.

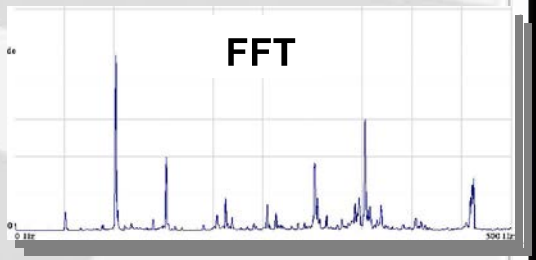
Traditional Vibration Monitoring

Traditionally, industry has been monitoring machinery vibration with various specialized Vibration Analyzers. The most widely used systems are designed to trend the vibration levels of various critical capital equipment. Typically a vibration sensor sends a dynamic signal (a mV output of the **Time Waveform**) to the analyzer. The Analyzer can then convert the time waveform into an **FFT** which displays the amplitudes of the individual frequencies which make up the complex time waveform.

A trained analyst can study the FFT and time waveform trends to determine what types of problems a piece of machinery might be experiencing, and further identify the root cause of such problems.

Vibration Analysis systems typically take the form of "**On-line Monitoring Systems**" which continually poll a series of measurement points; or "**Portable Data Collectors"** which can be used for periodic measurements. Either type of equipment can be very effective for analysts to trend vibration levels, set alarms and monitor a wide range of faults on a wide range of applications.





Traditional Methods for Vibration Alarms

Several methods have been used to establish vibration alarms. At their most basic, all methods attempt to establish a baseline at which a piece of machinery operates in a “normal “ or “healthy” state. Analysts will typically set 2 alarm levels (although some utilize more) at some level of increased vibration over this normal state. The alarms are designed to alert an analyst or end-user to a potential problem with the machinery.

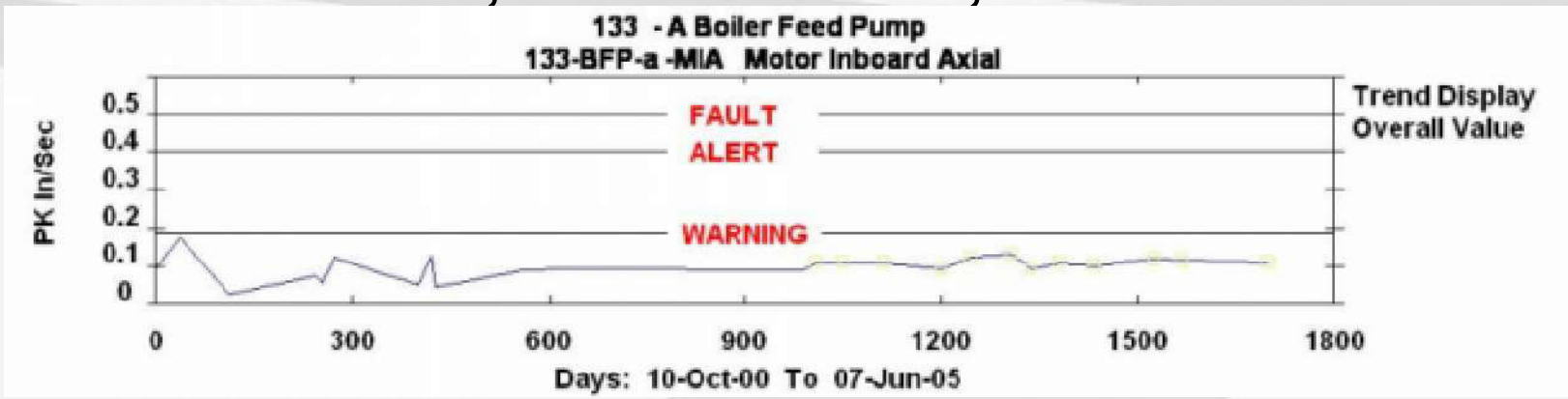
The first alarm, many times referred to as a “yellow alarm” would warn analysts or end-users that vibration levels have increased and an in-depth analysis of the machinery is in order. At higher vibration levels, typically a “red alarm” is triggered indicating that catastrophic failure is a serious near term threat. Sometimes red alarm levels can trigger either an automatic or manual shutdown of the machinery.

Some examples of typical Alarm methods are:

- Trending: Overall or Peak Values, or the Crest Factor
- Time Waveform Values: Peak, or Peak to Peak
- FFT Monitoring: Masking, Banding, or Enveloping

Trending

Overall Value, Peak Value, Crest Factor

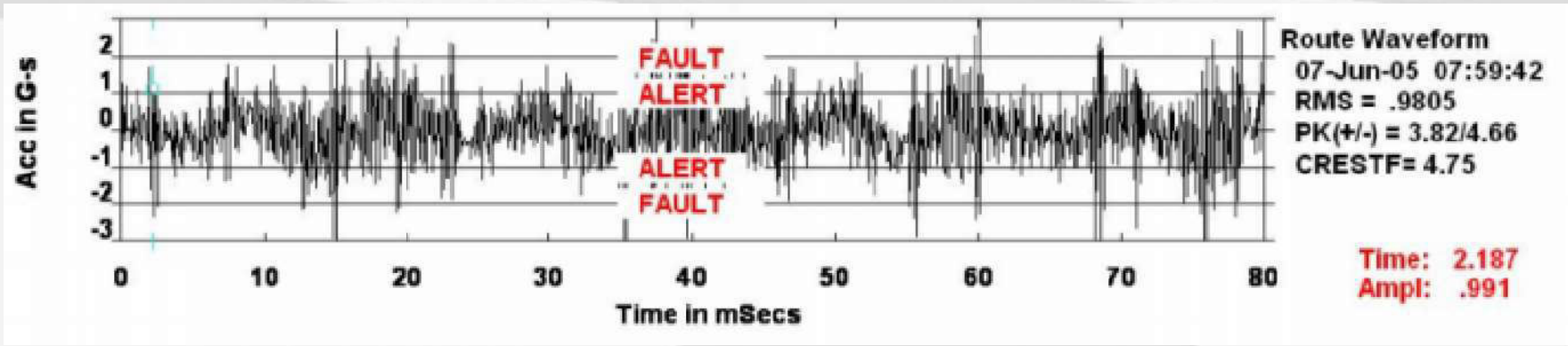


In this trend display, the Overall Value has been recorded over a period of 5 years. Warning, Alert, and Fault alarms were set, but never exceeded. You could have also trended the Peak Value or Crest Factor.

Trending alarms based on Overall, Peak or Crest Factor are very useful for alarming for a general vibration level. It is important to keep in mind that an individual fault frequency could be overshadowed by the increase or decrease in amplitudes of other fault frequencies; or it could be ignored or disproportionately weighted relative to other frequencies contributing to the trend value.

Time Waveform

Peak, or Peak to Peak Values



In this time waveform, the Peak, or Peak to Peak values of the time waveform can be alarmed. This is a much more instantaneous type of alarm, and the impacts in the time waveform are exceeding the " Alert" and "Fault" limits.

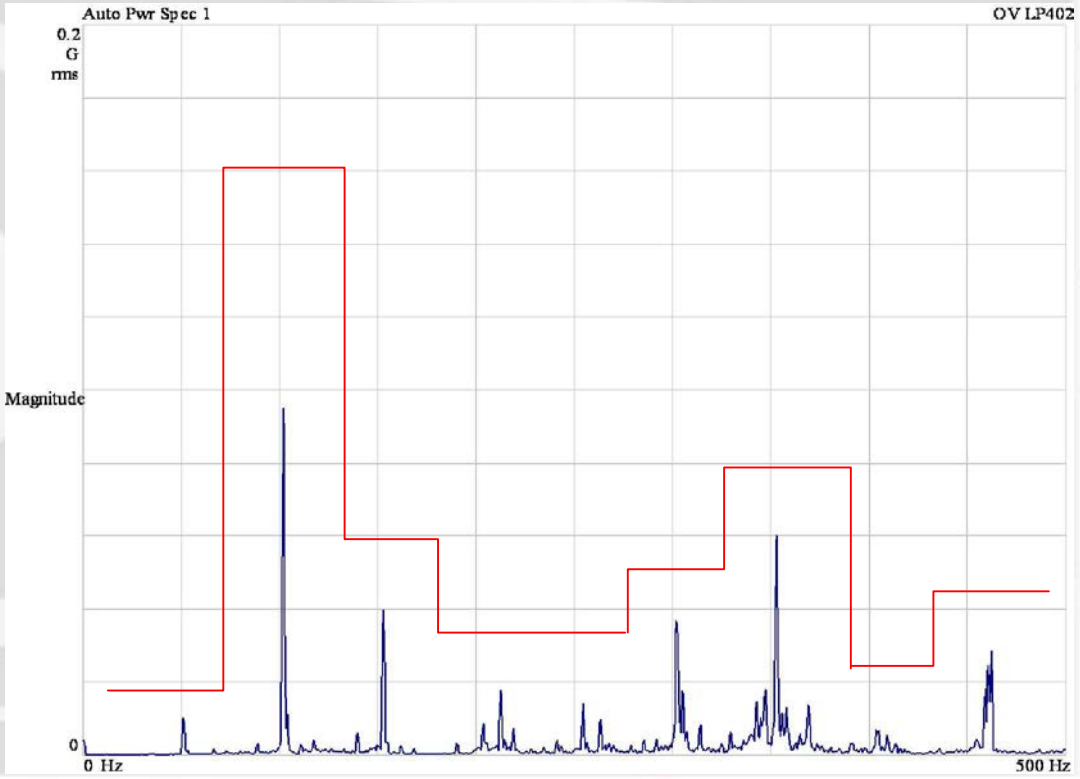
Again, a specific fault frequency which could indicate a bearing fault (for example) could be overshadowed by lower frequency, higher amplitude vibrations. This tends to be a good alarm method for catching lower frequency transients, and impacting.

FFT

Masking / Banding / Enveloping

In this FFT, a process of Masking, Banding, or Enveloping specific frequency regions is being used.

This method works very well when you want to have different alarm levels at different frequency ranges so that you can monitor for specific faults.



Traditional Vibration Monitoring

Historically, these monitoring methods have required specialized vibration instrumentation. However, in today's environment of Process Control, 4-20 mA current loops can be used with existing PLC's or DCS systems to generate vibration alarms, primarily using systems which many industrial plants already have on site.

Added Value of Process Control

A process control signal (such as 4-20 mA) can assist Traditional Vibration Analysis in protecting:

- Critical Applications
- Applications which can fail quickly
- Applications which can fail “dramatically”
- Applications which are remote, or where no operators can monitor the machinery

The PLC or DCS can constantly monitor for catastrophic failure and alarm analysts for potential problems. This allows Analysts to spend more time on analysis and less time putting out fires, or worrying about a catastrophic failure due to operator error or environmental issues between route measurements.

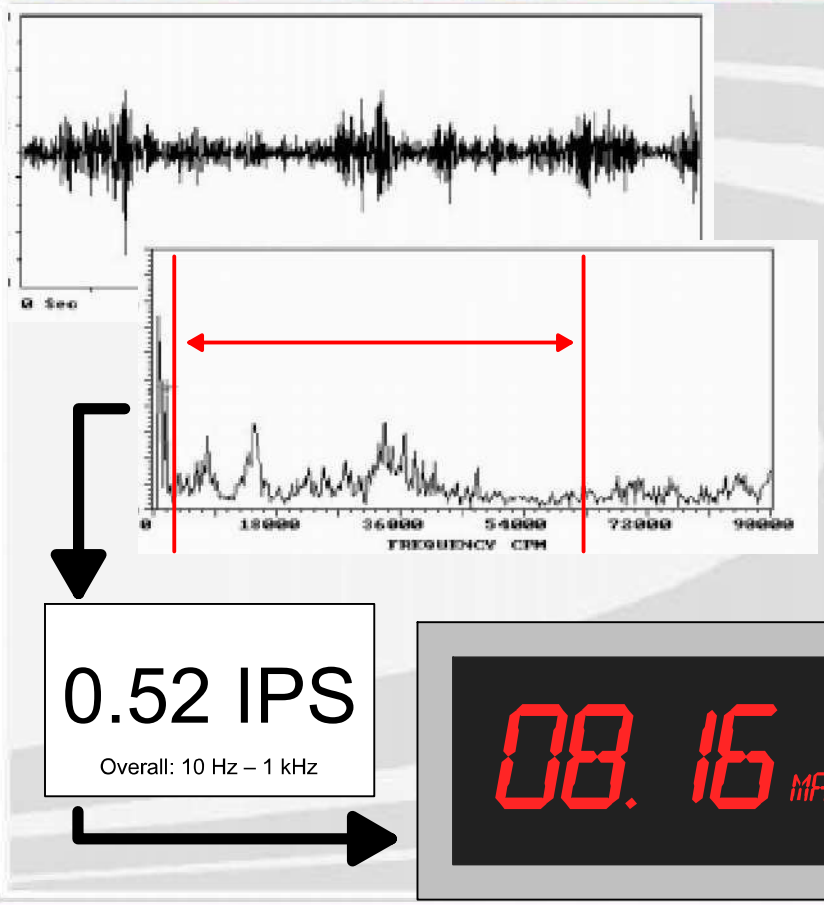
Process Control for PLC's or DCS Systems

The 4-20 mA signal can be provided to the PLC or DCS by any of the following methods:

- 4-20 mA Loop Power Sensor
- Dual Output Loop Power Sensor that provides 4-20 mA and a dynamic vibration signal
- Transmitter which converts or " conditions" a standard mV (dynamic) signal to a mA signal

PLC / DCS

How does it work?



The Loop Power (4-20 mA) sensor or transmitter generates a current signal which is scaled to the “ maximum load” (the highest vibration level the user would plan to alarm for) and is represented by a 20 mA output. An output of 4 mA represents “ no load” (no vibration).

It is important to understand that the 4-20 mA signal output is *proportional* to the *overall amplitude* generated *within a defined frequency band*. Therefore, the signal does not include data from frequencies outside the frequency band, and includes all vibration (critical faults and non-critical) within that band.

Process Scaling

Scaling is an important factor to consider when specifying a loop power sensor. The scale (or “Measurement Range”) you choose should position the vibration levels at “normal” or “healthy” conditions at roughly 8 to 10 mA of output. This will allow you to establish alarm limits (for example) at 12 to 16 mA and shutdown limits at 18 to 20 mA. It is important that you remember that the overall amplitude will be based on the frequency band you have selected for your sensor or transmitter.

See the Tech Resources Section at www.ctconline.com for a worksheet to assist with setting your scale or measurement range. The chart below shows the scaled output for a 0 to 2 g or 0 to 2 IPS (50.8 mm/s) scale.

g’s or IPS (Input)	0.00	0.25	0.50	0.75	1.00	1.25	1.50	1.75	2.00
mm/s (Input)	0.00	6.4	12.7	19.1	25.4	31.7	38.1	44.4	50.8
mA output	4	6	8	10	12	14	16	18	20
			Normal		Alarm			Shut Down	

Process Scaling

In some cases a broader than normal scale may be desired where a significant increase in vibration above normal can be tolerated before alarm and shutdown would be required.

For example your application might operate normally at 0.75 IPS and varying loads might make higher overall levels a normal occurrence that would not merit an alarm. Instead, alarms and shutdown might not be desired until 4.5 IPS.

Normal
= 0.75 IPS
= 6.40 mA

Shut Down
= 4.50 IPS
= 18.40 mA

IPS (Input)	0.00	0.63	1.25	1.88	2.50	3.13	3.75	4.38	5.00
mA output	4	6	8	10	12	14	16	18	20
		Normal					Alarm	Shut Down	

Loop Power Sensor: 4-20 mA

Loop Power Sensors are normally available in Acceleration or Velocity output. *Acceleration* output will give the higher frequencies more proportional value in the overall amplitude relative to a comparably specified *velocity* output sensor.

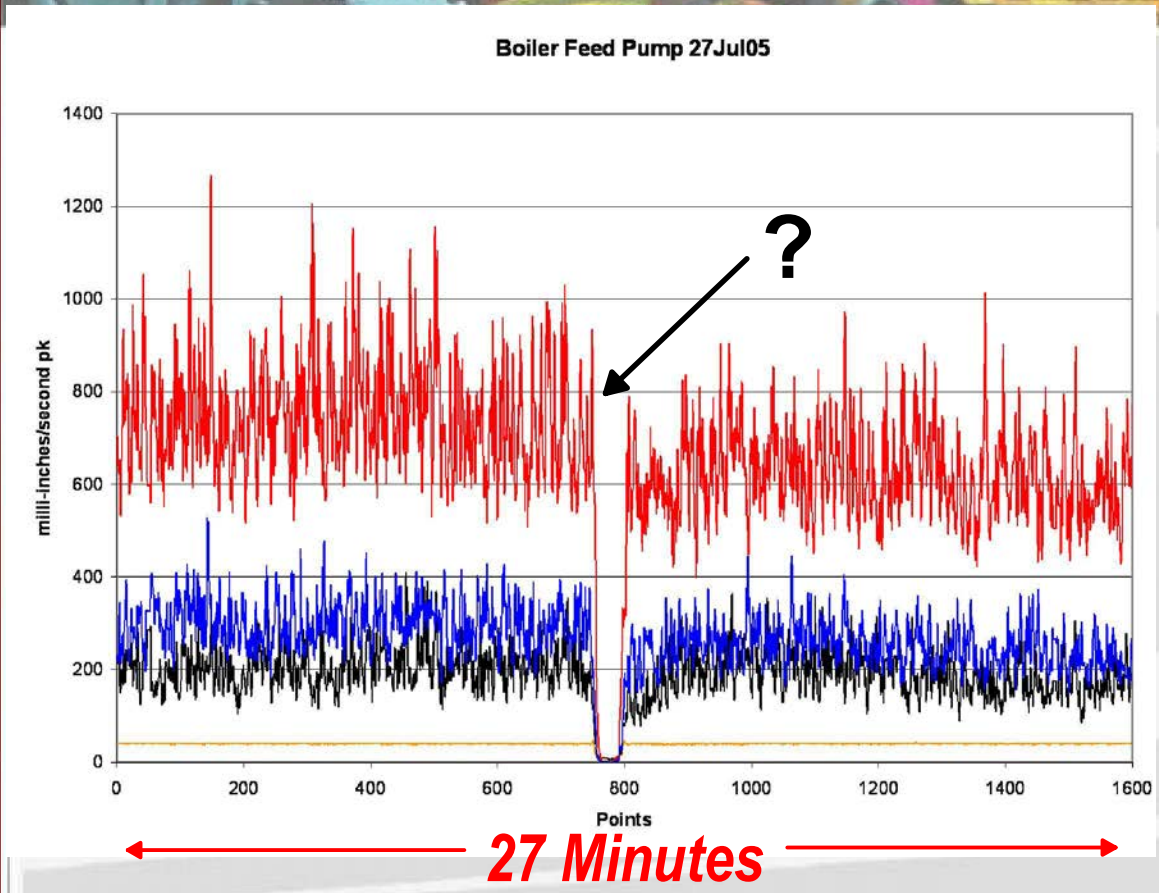
The acceleration or velocity units can be expressed as Peak or RMS values. Generally speaking, Peak will provide more information about transient vibrations, while RMS (which essentially averages the peaks) will give less attention to transients.

The frequency ranges for Loop Power Sensors, are generally available in two fixed bands, such as:

- 10 – 1000 Hz (600 – 60,000 CPM)
- 3 – 2500 Hz (180 – 150,000 CPM)

Loop Power sensors are great for trending and alarming the overall vibration. Just remember, that since there is no dynamic output from this sensor, there is also no time waveform or FFT, and therefore is not intended for *diagnosing* what the alarm might be caused by.

Process Control – Vibration Data



This is a 27 minute trend of process vibration data from a 600 HP Boiler Feed Pump. Initially, it looks as if the power failed on all 4 of the vibration sensors, creating the zero output in the center of the display.

- How can this be analyzed?
- What do you think we should start looking for as a cause for the loss of data?
- Could this be a powering issue with our PLC or sensors?

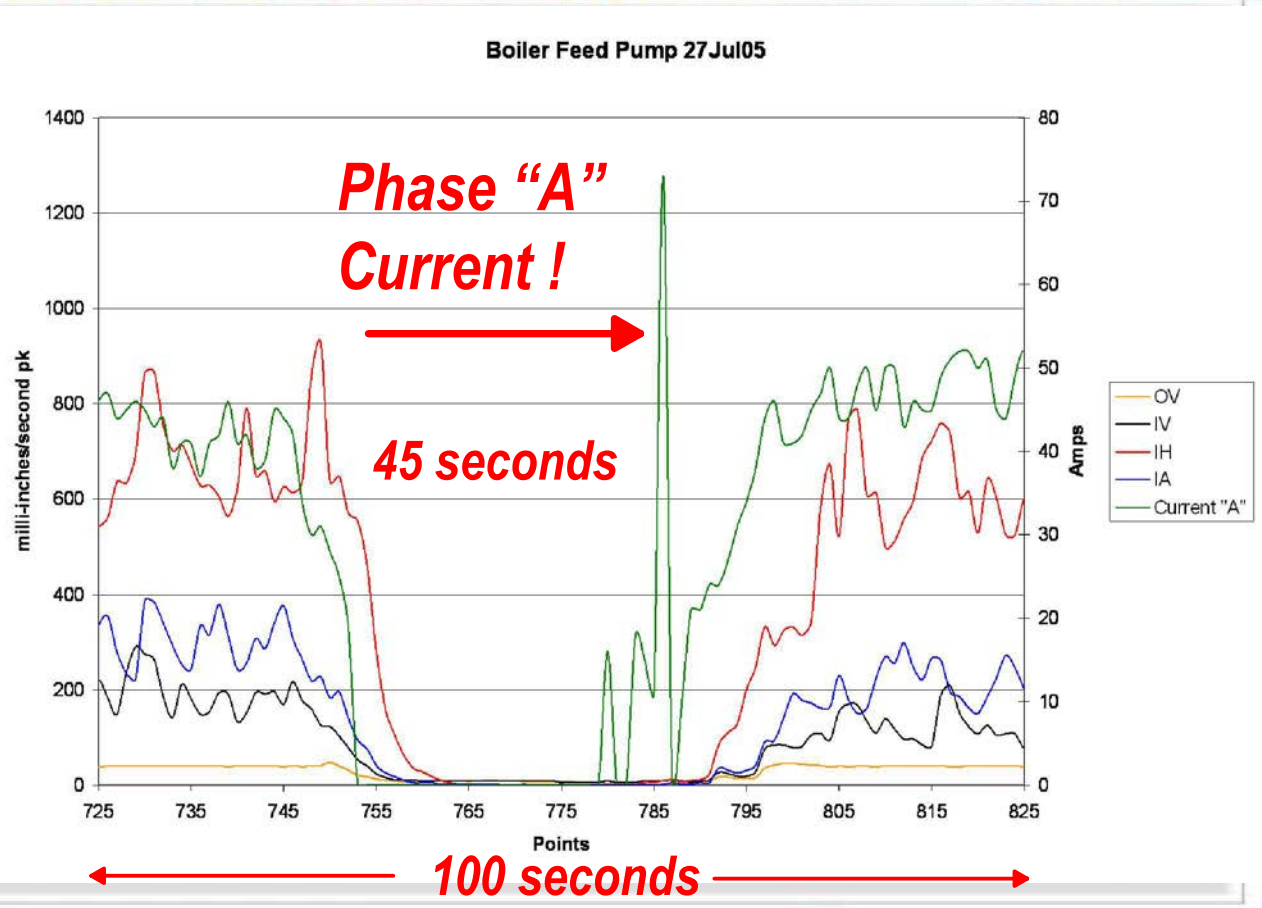
Process Control – Vibration Data w/ Motor Current

Let's re-display the data in a 100 second interval and add the motor current to the display.

The motor current also went to zero!

With the addition of other process control data, we can see that the motor, not the sensors, was accidentally shut off for 45 seconds, and then turned back on. This could be a topic for "coaching" the end-user, rather than searching for power issues on the vibration sensors.

This is a good example of how process control data can help to paint a fuller picture.



Best of both worlds

Vibration Analysis

Process Control

Dual output sensors and signal conditioners (Vibration Transmitters) provide a 4-20 mA output and a dynamic signal output. By utilizing both signals, companies have a solution that gives the best of both worlds:

- Continuous monitoring through the PLC or DCS system.
- Alarming for catastrophic failure through the PLC or DCS system.
- Diagnostic analysis and trending for specific fault frequencies via a dynamic signal analyzer.
- Convenient access to all data via permanently mounted sensors which speeds route collection, and increases the safety of technicians and analysts.
- Better use of analysts' time since the analyst can spend less time trending perfectly healthy equipment, and more time analyzing data.
- Team approach to protection and monitoring brings additional resources to protecting machinery and plant health.

Dual Output Sensor

Dual Output Loop Power Sensors are a 3 wire system that has a primary 4-20 mA output, and a secondary dynamic output.

The 4-20 mA current loop provides the power source and continuous monitoring output to the PLC or DCS systems.

The secondary voltage output is available in 100 mV/g or 100 mV/in/sec for dynamic analysis.

Dynamic Sensor & Transmitter

The dynamic signal from a permanently mounted vibration sensor can also be converted to a process control signal by a Vibration Transmitter (or signal conditioner).

The Transmitter receives a mV signal from the sensor, then filters and scales the signal to a 4-20 mA output. The 4-20 mA signal can then be passed to a PLC or DCS where it can be monitored with other process control data.

Transmitter systems also allow access to the dynamic signal so that analysts can trend specific fault frequencies, or diagnose the cause of any alarms. Most units offer a buffered output via a BNC on the face of the transmitter, as well as a pass-through via screw terminals so analysts can run the signal to a traditional switchbox.

The larger size of the transmitter allows manufacturers to offer greater flexibility for filter options than standard loop power sensors. This ability for analysts to choose from a menu of high pass and low pass filters provides the opportunity to target alarms more accurately around a fault, rather than relying on less specific overall values.

MADE IN THE USA

Dynamic Sensor & Transmitter

Standard sensors and Vibration Transmitters can also be configured with a local monitoring system to offer several options which are valuable in a variety of applications, making them an extremely versatile tool for Vibration Analysts, and Process Control Engineers. These systems can include:

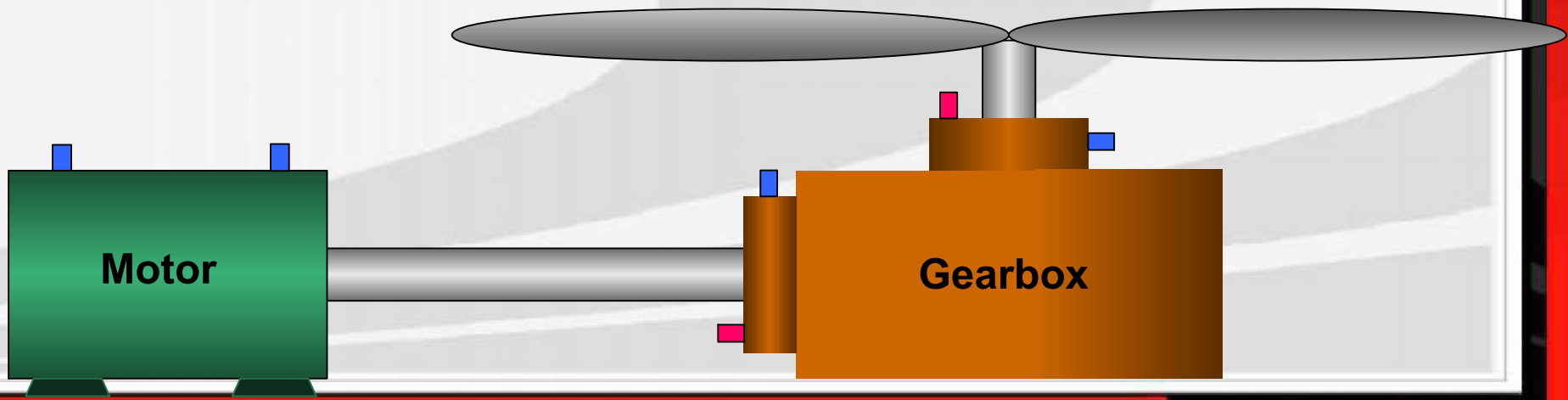
- **Relays** -- making it possible to shut machinery down in the event that vibration levels exceed a *user-defined* level.
- Digital **Displays** of vibration levels in the scaled or actual value.
- Visual or auditory **alarm options** such as lights or sirens.
- **Retransmission** of a process control signal to a PLC or DCS.

Cooling Tower Application

A good example of protecting equipment or processes using diagnostic and process control signals is a cooling tower application where the gearbox has been the primary source of problems:

- Dual output sensors (red) on the input and output shafts of the gearbox
- mV/g Sensors (blue) on all bearings

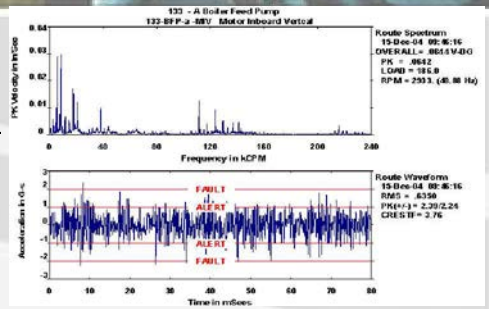
This allows Analysts to trend for bearing faults and alarm for imbalance or gear noise.



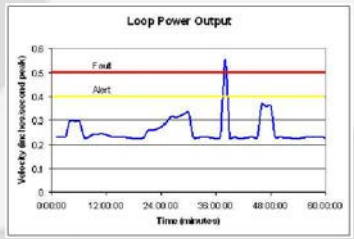
Integration

Dual Output Loop Power Sensors or Sensors & Transmitters

→ **Dynamic Vibration** →



→ **Process Control** →



Remember, integrating Dynamic Vibration with Process Control can make a very successful program for monitoring your machines!

Thank You!

Thank you for taking the time to review this training module. We hope that you learned something that will help you to collect more accurate data, and to allow you to make better “calls.”

CTC prides itself on it’s customer and technical support. Did you know that CTC employs several Vibration Institute Certified **Category 2** and **Category 3** Analysts, and one **Category 4** Analyst who also trains for the Vibration Institute? It is all part of our commitment to providing the industry’s best service and support.

For more technical information, additional white papers, and training materials, we invite you to visit our website at www.ctconline.com, or contact one of our Analysts at (800) 999-5290 (in the US and Canada); or at +1-585-924-5900 (international).

Thank You !

Next time you need Sensors, Cables, Junction Boxes or Mounting Hardware and accessories, we would appreciate it if you would keep us in mind.

CTC offers a full range of vibration analysis hardware and process and protection instruments for industrial use. Our customers choose us based on:

- Superior Durability
- Accuracy and Performance
- Quick Service (shipping most orders in 3 days)
- Knowledgeable support staff
- Industry's only ***UNCONDITIONAL LIFETIME WARRANTY***

Thanks again for your time.

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