

4-20 mA LPS™ Series Transducer Selection Guide



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Introduction

With the availability of 4-20 mA vibration transducers, plant personnel can now input vibration information directly to their Programmable Logic Controller (PLC) or Distributed Control System (DCS). This capability allows plant personnel to trend overall vibration data on their machines and correlate vibration data to plant operating conditions, and allows plant operators to schedule maintenance tasks on machinery.

A trained vibration analysis technician has, traditionally, been the person to evaluate the mechanical condition of machinery in a Condition Based Maintenance (CBM) program. Now, transducers that can provide plant personnel with an indication of the overall vibration levels can help guide a CBM program even when there is no vibration technician available to determine machinery condition.

Wilcoxon's Loop Powered Sensors (LPS™) are self-contained 4-20 mA vibration transmitters. LPS transducers can directly input a 4-20 mA signal to a plant's control system and make the vibration condition of machines available to operating personnel. Machinery critical to the operation of the plant can be monitored continuously. This data can then be used to aid and assist the operating personnel in determining when to perform maintenance, as well as direct them to machines with the most severe vibration problems.

This selection guide will help in choosing the proper range and type of transducer.

It is not the purpose of this document to provide detailed instructions for analyzing machinery vibration problems. There are many other useful publications that can aid in diagnosing vibration problems. Links to such useful information can be obtained from the Wilcoxon web site at www.wilcoxon.com or by calling Wilcoxon at 301-330-8811.

Predictive Maintenance and Vibration Monitoring

Using Predictive Maintenance (PdM) technologies to track machine health is a proven industry best practice. Vibration Monitoring is a critical part of any effective PdM strategy. Monitoring plant machinery health reduces outages and downtime, and Wilcoxon's customers save money.

Using Vibration Monitoring, PdM can detect:

- ❖ Shaft Misalignment
- ❖ Rotor Imbalance
- ❖ Gear Failure, and
- ❖ Bearing Faults

Wilcoxon supplies an extensive line of vibration monitoring sensors and monitoring instruments that provide a multitude of machinery condition information. Wilcoxon's 4-20 mA series of Loop Powered Sensors makes machine health monitoring a convenient, reliable and cost-effective option for a wide array of plant assets. The LPS Series of sensors outputs a signal between 4 mA and 20 mA that correlates directly to the average vibration of the machine being monitored. This provides a simple means to trend the relative level of vibration and drive your maintenance strategy only as needed for a cost effective operation and prevent machine failures before they occur.

Wilcoxon's LPS Series transducers are available with a host of features to meet every application:

- Configured with Peak, True Peak or RMS output signals, representing either velocity or acceleration.
- Dual output of temperature and 4-20 mA vibration signal provide critical data for temperature-sensitive operations.
- Dual output of dynamic and 4-20 mA vibration signal units provide an effective way to trend vibration data (4-20 mA signal) and still have access to the dynamic vibration signal for more extensive analysis.
- For those really harsh environments, many units are available with Intrinsically Safe operation or with Explosion Proof cases.

Selection Considerations

Velocity is the primary measurement of machinery vibration. While there are some applications that require displacement limits, velocity is most often used for vibration measurements on the external case of machines. Since Wilcoxon's LPS Series transducers are mounted on the external case of machines, velocity would be the best measure to use for condition assessment. The LPS Series is available in units that measure vibration in terms of velocity or acceleration for condition assessment.

LPS Series transducers are purchased with a specific full-scale setting. The full-scale is not adjustable by the user. Condition evaluation and the ISO 10816 standard for vibration measurement should be used to determine the best full-scale range for a particular monitoring environment.

Full Scale Selection Guidelines

What is the normal overall vibration level of the machine?

When the normal vibration level of a machine is used to guide selection, the transducer will be able to give a reliable reading with enough resolution to determine minor variations from normal vibration levels. The normal level of vibration should fall within 10% to 20% of the full-scale range of the transducer. For example, a machine that has a normal overall vibration velocity of 0.15 inches per second (ips), peak, might be monitored best with a transducer having a full-scale range of 1.0 ips peak.

What is the limit for unacceptable vibration?

Manufacturer specified limits for the machine's vibration should be used as a guide to selecting the proper range for a LPS Series transducer. When the manufacturer has not specified limits, the ISO standard can be used as a guide. For example, the ISO standard indicates that a 200 HP (150 kW) motor with a rigid rotor would have an unacceptable vibration at 0.25 in/sec (Peak) which is 4.5 mm/sec (RMS).

Is over-range capability for trending desired?

The standard ranges available in the LPS Series will allow for some over-range capability, but some users may wish to have more. Consider the example of a 50 HP motor driving a fan with a history of cracks. When cracked, the fan may exhibit vibration of 1 to 2 IPS. Here it may be desirable to use a transducer with a full-scale range of 2.0 IPS to accommodate measuring the fan imbalance when cracked blades occur.

ISO 10816 Guidance

Assistance in determining rotating machinery condition is now available within the ISO 10816 Standard, "Mechanical vibration – Evaluation of machine vibration by measurements on non-rotating parts." The portion of the ISO 10816 that is most useful for helping to determine vibration limits and, hence transducer selection, is part 3, "Industrial machines with nominal power above 15 kW and nominal speeds between 120 revolutions per minute and 15,000 revolutions per minute when measured *in situ*."

Machines are classified into groups according to machine type, rated power or shaft height. Additionally, the group vibration zones are separated according to whether the machines operate above or below 80% of the first shaft critical speed. Machines that have their main excitation frequency (usually running speed) below 80% of the first critical speed in the direction of measurement are considered to be operating in the **rigid** rotor mode. Machines with their main excitation frequency above 80% are considered to be operating in the **flexible** rotor mode.

Equipment Groups

Group 1: Large machines with rated power above 300 kW (~400 HP); electrical machines with a shaft height at or above 315 mm (12.4"). These machines normally have sleeve (journal) bearings.

Group 2: Medium-size machines with a rated power above 15 kW (~20 HP) up to and including 300 kW (~400 HP); electrical machines with a shaft height between 160 mm and 315 mm (6.3" to 12.4"). These machines usually have rolling element bearings and run at speeds above 600 revolutions per minute.

Group 3: Pumps with multivane impeller and with separate driver (centrifugal, mixed flow, or axial flow) with rated power above 15 kW.

Group 4: Pumps with multivane impeller and with integrated driver (centrifugal, mixed flow, or axial flow) with rated power above 15 kW.

Evaluation Zones

The following evaluation zones are defined to permit a qualitative assessment of the vibration of a given machine and provide guidelines on possible actions.

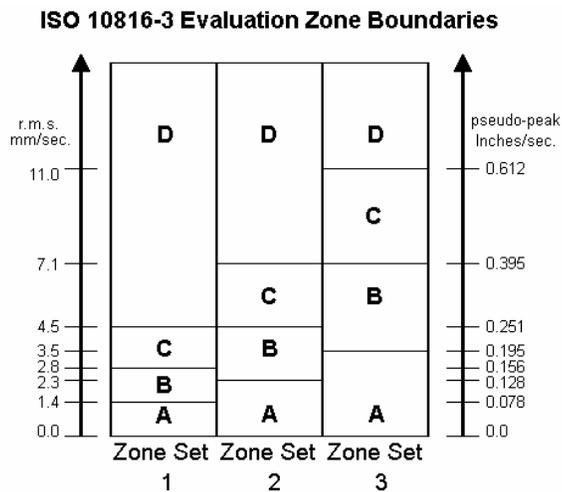
Zone A: The vibration of newly commissioned machines would normally fall within this zone.

Zone B: Machines with vibration within this zone are normally considered acceptable for unrestricted long-term operation.

Zone C: Machines with vibration within this zone are normally considered unsatisfactory for long-term continuous operation.

Generally, the machine may be operated for a limited period in this condition until a suitable opportunity arises for remedial action.

Zone D: Vibration values within this zone may be of sufficient severity to cause damage to the machine.



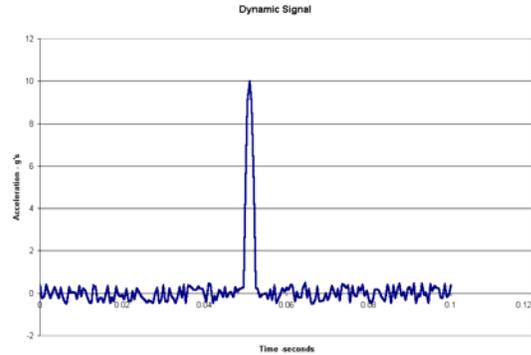
The ISO 10816-3 recommended evaluation zone boundaries for the various groups of equipment, referring to the table of Zone Set boundaries, are as follows:

Equipment	Rotor mode: Rigid	Rotor mode: Flexible
Group 1 Machines over 300 kW	Zone Set 2	Zone Set 3
Group 2 Machines between 15 and 300 kW	Zone Set 1	Zone Set 2
Group 3 Pumps, Separate driver, >30 kW	Zone Set 2	Zone Set 3
Group 4 Pumps, Integrated driver, >30 kW	Zone Set 1	Zone Set 2

Output Types Available with Wilcoxon 4-20 mA Transducers

All Wilcoxon broadband LPS Series transducers are available with output calibration in terms of Peak, RMS or True Peak. The frequency banded versions only offer Peak or RMS output calibration.

In the figure to the right there is a simulated pulse of 10g amplitude and 2.5 millisecond duration. This kind of pulse will not produce a significant change in the output of the traditional Root-Mean-Square (RMS) output transmitter. The RMS energy in such a short duration pulse is not significant enough to produce much change in the output loop current.



This chart shows the difference between the response of an RMS transmitter, a Peak transmitter, and the Wilcoxon True Peak transmitter. The RMS and Peak outputs change very little as a result of the transient acceleration pulse. However, the true peak signal actually "captures" the pulse level accurately.



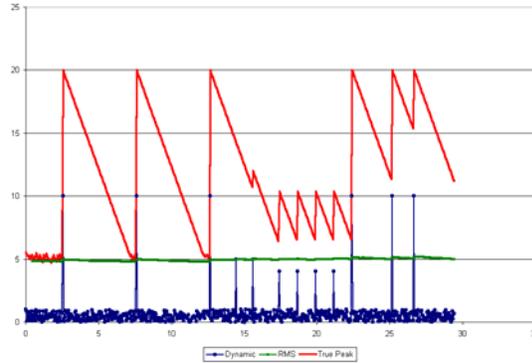
Capturing the peak is only one part of the function of true peak detection. If the transmitter were to simply track the true peak, the output would be changing rapidly all during the sampling process of the PLC/DCS system. Most PLC/DCS systems will sample input just once per second. So how can the system know when a transient signal has occurred?



The Wilcoxon True Peak detector will capture the peak then ramp back to the ambient vibration peak level at 20% of full scale per second. The chart here illustrates that the output current went up to 20 mA at the occurrence of the peak. It then ramped back down over a time period of almost 5

seconds. During this "ramp down" the PLC/DCS has multiple opportunities to sample the signal and record the transient event.

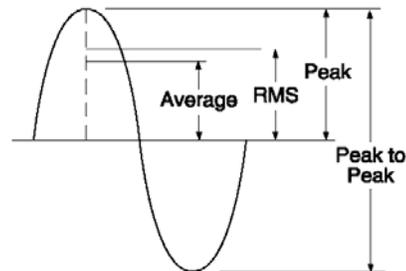
So how do these peak detecting transmitters handle multiple transient signals such as loose components or parts? The chart here illustrates the relative output differences between the RMS and True Peak transmitters.



As more and more transient pulses are detected, the True Peak output tends to "remain" at a high level. As long as the incoming new pulse exceeds the current value being output from the transmitter, the output will rise to the new level before ramping down.

This capability allows using the True Peak detection units for detecting the beginning of impacting events resulting from loose components. It is also useful for monitoring other transient events that produce high acceleration "spikes" during operation. Pump cavitation often produces a sound characterized as "pumping rocks" when cavitation occurs. The "water hammer" of piping systems can also be monitored since the peak detection unit is sensitive enough to capture those events as well.

Vibration transmitters generally compute the RMS value of the vibration signal. "Peak" output transmitters simply use the convention of multiplying by the ratio of the RMS to Peak in order to calibrate their output. This results in a "pseudo-peak" output in that it is peak value if the entire energy of the vibration were a single sinusoidal signal. In a traditional transmitter calibrated for 1.0 ips, Peak, on the 4-20 mA output, an RMS sinusoidal signal at 0.707 ips, rms, will produce the full 20 mA of loop current.



The True Peak detection method overcomes the insensitivity of transmitters to short-duration transient events. The Peak and RMS calibrated models produce an output signal representative of the overall vibrational energy of the machine. The overall vibration is often the value that should be trended to maintain a good picture of the overall condition of the machine. The ISO standard, in fact, is based on measuring the overall RMS value of the machine vibration. However, when fault conditions for a particular machine can be associated with looseness of components it may be better to use an LPS Series transducer that has True Peak detection.

Frequency Banded Transducers

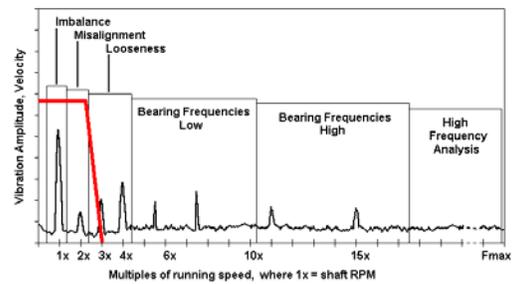
The broad frequency range that the typical 4-20 mA vibration transmitter monitors does not allow for using the typical 4-20 mA transducers for machinery diagnostics. That is because the output is a sum of the total energy of vibration. Machinery diagnostic work

requires knowing more about what is happening with the vibration within a narrow range of frequencies.

Frequency Banded Low Frequency Velocity Sensor

Most work orders generated within plants for maintenance actions are to re-balance or re-align machines. The frequency components generated by balance and alignment problems are at the running speed of machines or twice the running speed. Most plant heavy machinery is motor-driven and the motors typically run at speeds between 600 RPM (10 Hz) and 1200 RPM (20 Hz). Using a transducer that is focused on the frequency span that encompasses imbalance or misalignment frequencies can have a great benefit for maintenance actions.

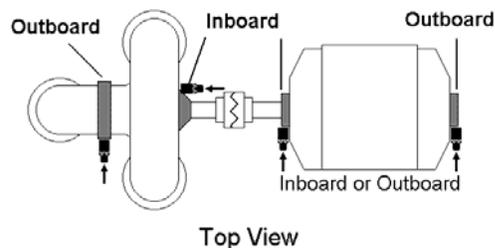
Wilcoxon now has available special frequency banded 4-20 mA transducers. The PC420VP-10-B3041 uses high-pass and low-pass filters before the detection circuitry to focus the output detection to the range between 3 Hz (300 RPM) and 40 Hz (2400 RPM). The model PC420VP-10-B3041 uses only the frequencies between 3 Hz (180 CPM) and 40 Hz (2400 CPM) to process and compute the vibration level output to the 4-20 mA process loop. This focus of analysis enables users to trend only the low frequencies of vibration associated with balance or alignment problems. These low frequencies are where vibration from unbalance or misalignment will occur on most heavy machines.



The PC420VP-10-B3041 transducer gives plant personnel the opportunity to trend the vibration level at the fundamental running speed for a wide variety of plant machines. For example, a motor or pump running at 1200 RPM has its fundamental speed at 20 Hz. When using the PC420VP-10-B3041 to measure horizontal vibration levels at the bearings, the major contributor to the output vibration level of the PC420VP-10-B3041 frequency banded transducer will be the 1200 RPM (1X) component of shaft vibration.

Separating this running speed (1X) value from all the other potential vibration contributors to the overall vibration level allows plant personnel to determine unbalance effects. This can be particularly important in fan operation. Using the PC420VP-10-B3041 along with a PC420VP-10 transducer will allow personnel to be able to better distinguish the 1X vibration from all the other possible vibration frequencies present.

For plants wanting to fully monitor the balance and alignment condition of machines, three PC420VP-10-B3041 transducers should be used. In this illustration of a motor-pump set the inboard bearing of the pump has thrust bearing capacity. It will be the position that will best indicate any alignment problems. One PC420VP-10-B3041 should be mounted there in the axial direction. Two more PC420VP-10-B3041 transducers should be used to monitor for imbalance, one on each of the shafts. The outboard pump bearing is



the best location on the pump. Either the inboard or the outboard location on the motor can be used, but the position should be guided by historical failure data. Many users favor the inboard location as it can assist in detecting radial vibration problems with the inboard pump bearing.

Frequency Banded High Frequency Acceleration Sensor

Wilcoxon also has available a special high frequency banded acceleration 4-20 mA sensor. The PC420AR-10-3223 uses high-pass and low-pass filters before the detection circuitry to focus the output detection to the range between 300 Hz and 2,000 Hz. The model PC420AR-10-3223 uses only the frequencies between 300 Hz and 2,000 Hz to process and compute the vibration level output to the 4-20 mA process loop. This focus of analysis enables users to trend only the frequencies of vibration associated with pump cavitation problems. These frequencies are where vibration from pump cavitation will occur on heavy pumps

Dual Output 4-20 mA Transducers

The dual output transducers have both a 4-20 mA loop signal output and a broadband dynamic signal output. These types of transducers are useful where plant personnel have portable spectrum analyzer equipment. With the dual output type the user has access to the dynamic vibration signal that is being used to drive the 4-20mA output loop. This has been very beneficial to many users since they can use their portable FFT analyzer to check the spectrum of the signal. This option is often used in plants with on-site vibration technicians since it permits both the operating and the maintenance personnel to have access to the type of data each needs and only use one transducer. The dynamic output can be either 100 mV/g (acceleration) or 100 mV/ips (velocity).

One of the benefits of the Wilcoxon LPS Series transducer family is the ability to have either acceleration or velocity for the dynamic signal regardless of the type of 4-20 mA loop signal. Velocity loop output transducers can have the dynamic output be acceleration or velocity. The same is true for the Acceleration loop output transducers which can also have either acceleration or velocity as the dynamic output signal.

Hazardous Area Installations

Wilcoxon has 4-20 mA transducers certified for hazardous (classified) area installations. The Wilcoxon transducers carry CSA approvals for the U.S. and Canada as well as LCIE ATEX certification. LPS Series transducers are available for intrinsically safe installations as well as explosion-proof installations. The intrinsically safe certified units have part numbers ending in **IS** while the explosion-proof certified units have part numbers ending in **EX**.

Hazardous Area Installations

	Approval Agency	Installation Areas
Intrinsically Safe Model	CSA	CL1, Div 1, GRPS A, B, C, D T3C Ta=85°C Max Exia
Intrinsically Safe Model	LCIE - ATEX	EEx ia IIC T3 -40°C ≤ Ta ≤ 85°C
Explosion Proof Model	CSA	CL1, Div 1, 2 GRPS A, B, C, D CIII, Div 1, 2 GRPS E, F, G CLIII, DIV 1, 2 T3C Ta=85°C Max
Explosion Proof Model	LCIE - ATEX	EEx d IIC T3 EEx nA IIC T3 -40°C ≤ Ta ≤ 85°C

APPENDIX - Model Number Ordering Guide

PC42X selects the type of sensor

PC 420 Top Exit, Connector

PC420Vxx-yy-zz for **Velocity 4-20 mA** loop output models, and
PC420Axx-yy-zz for **Acceleration 4-20 mA** loop output models

PC421 Side Exit, Connector¹

PC421Vxx-yy-zz for **Velocity 4-20 mA** loop output models, and
PC421Axx-yy-zz for **Acceleration 4-20 mA** loop output models

PC423 Side Exit, Integral Cable²

PC423Vxx-yy-zz for **Velocity 4-20 mA** loop output models, and
PC423Axx-yy-zz for **Acceleration 4-20 mA** loop output models

PC425 Side Exit with Temperature, Connector³

PC425Vxx-yy-zz for **Velocity 4-20 mA** loop output models, and
PC425Axx-yy-zz for **Acceleration 4-20 mA** loop output models

PC427 Side Exit with Temperature, Integral Cable⁴

PC427Vxx-yy-zz for **Velocity 4-20 mA** loop output models, and
PC427Axx-yy-zz for **Acceleration 4-20 mA** loop output models

All integral cable sensors come standard with 16' of cable. Alternative lengths of cable must be requested when placing an order. A per-foot charge may apply.

XX selects the type of detection.

R for root-mean-square, **RMS**

P for equivalent **Peak** (pseudo-peak)

TP for **True Peak**

YY selects the full scale range.

For Velocity output models the output is in terms of the velocity in **inches-per-second (ips)**. For Acceleration output models the output is in terms of the acceleration in **g's**, where 1g is the gravitational constant. A **g** is 386 inches-per-second squared or 9.81 meters-per-second squared. Here is a table of the selections:

yy	PC42xV	PC42xA
05	0.5 ips	5 g's
10	1.0 ips	10 g's
20	2.0 ips	20 g's
30	3.0 ips	not available
50	5.0 ips	not available

¹ Not all side exit models have all options available. See the individual data sheets of side exit model for option availability

² Not all side exit models have all options available. See the individual data sheets of side exit model for option availability

³ Not all side exit models have all options available. See the individual data sheets of side exit model for option availability

⁴ Not all side exit models have all options available. See the individual data sheets of side exit model for option availability

ZZ selects certain available optional configurations of the PC42x-series units.

zz	Option	Description
DA	Dynamic Acceleration	An additional output wire with 100 mV/g broadband vibration acceleration signal
DV	Dynamic Velocity	An additional output wire with 100 mV/ips broadband vibration velocity signal
EX	Explosion Proof Case	Class 1, Division I explosion-proof certification ⁵
IS	Intrinsically Safe Certified	Certified for Class 1, Division I or Zone 0 ⁶
B1fhf	Frequency Banded	Limited frequencies used for overall calculation ⁷

Examples

- A **PC420VP-10** is a Peak (pseudo-peak) calibrated output with a full scale range of 1.0 inches-per-second.
- A **PC420VP-10-DA** is a Peak (pseudo-peak) calibrated output with a full scale range of 1.0 inches-per-second and has an addition output with a dynamic acceleration signal of 100 mV/g.
- A **PC420VP-10-IS** would be the same as the PC42-VP-10 described above, but carry an intrinsically safe rating for Zone 0 or Class 1, Division I installations.
- A **PC420VP-10-B3041** is a Velocity, Peak calibrated, 1.0 ips full-scale, band-limited 3Hz-to-40Hz.
- A **PC420AR-10-B3223** is an acceleration, rms calibrated, 10g full-scale, band-limited 300Hz-to-2,000Hz.

⁵ See Wilcoxon PC420Axx-yy-EX or PC420Vxx-yy-EX data sheet for more detailed information

⁶ See Wilcoxon PC420Axx-yy-IS or PC420Vxx-yy-IS data sheet for more detailed information

⁷ See Wilcoxon PC420VP-10-B3041 data sheet for more detailed information