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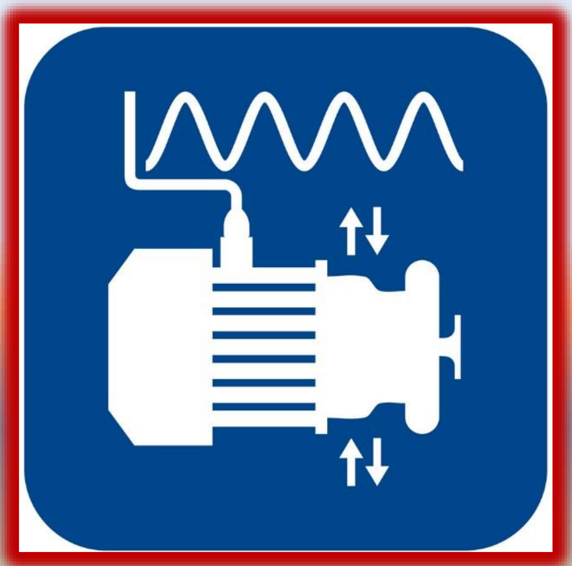
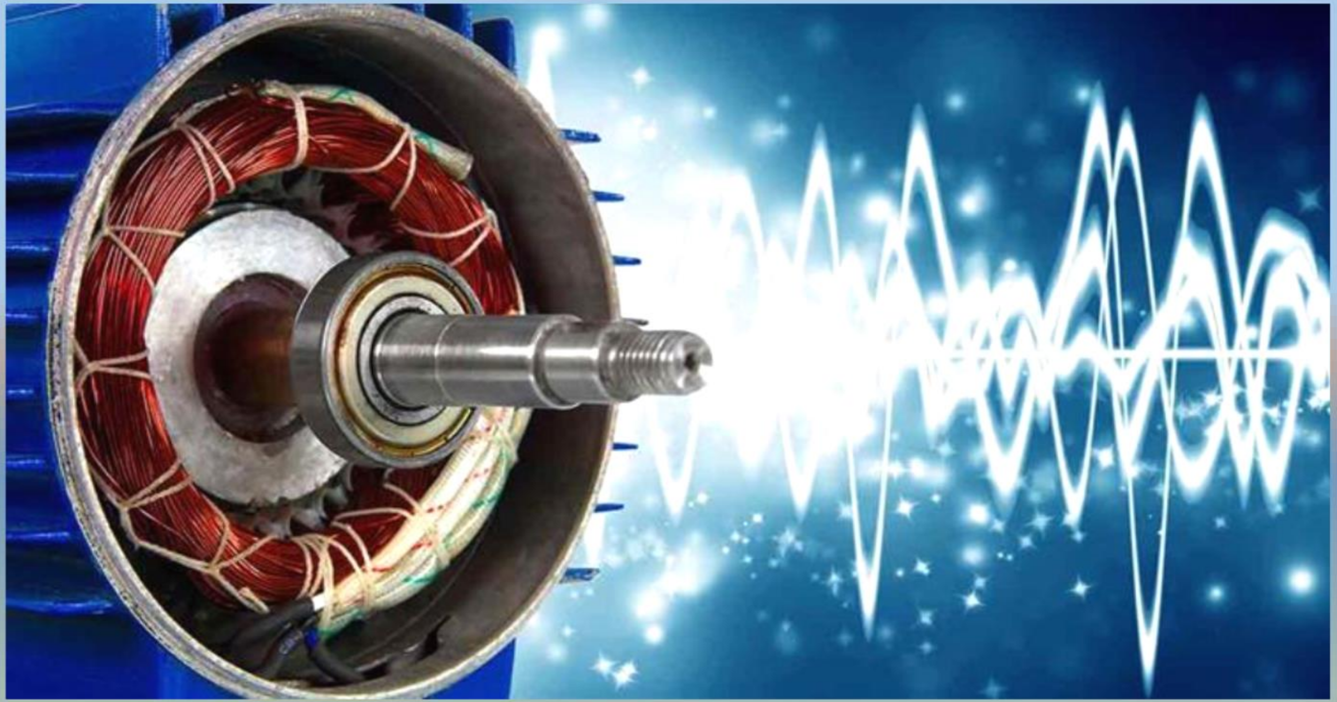
Vibration Test in Electric Motors





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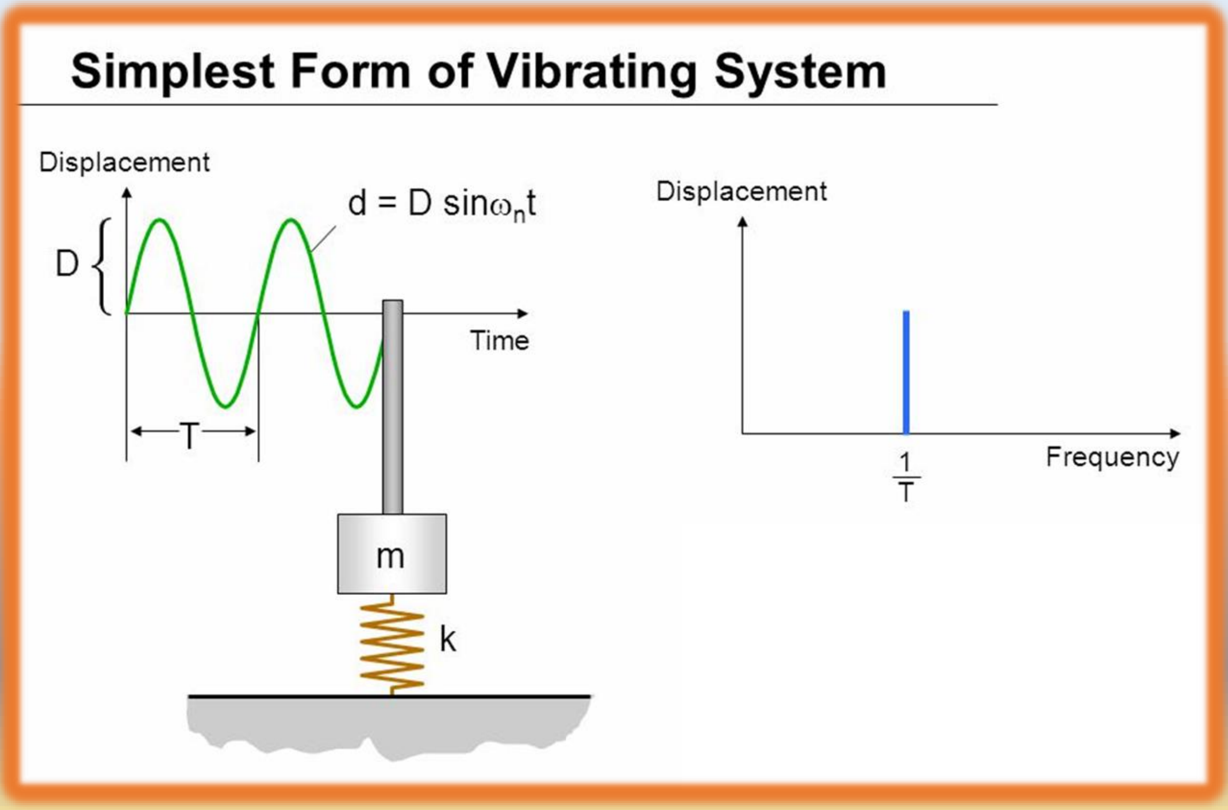
In all industries and factories, about 90% of the equipment is rotating type (electric motors, fans, pumps, etc.) and these equipment need a regular and accurate repair and maintenance program. One of the most important tests on these equipment Vibration test is in the periodic maintenance checklist.

Vibration: Vibration is a type of movement in rotational and dynamic systems that is oscillatory and repeats in a cycle.



The characteristics of the parameters of vibration movement:

1- Amplitude

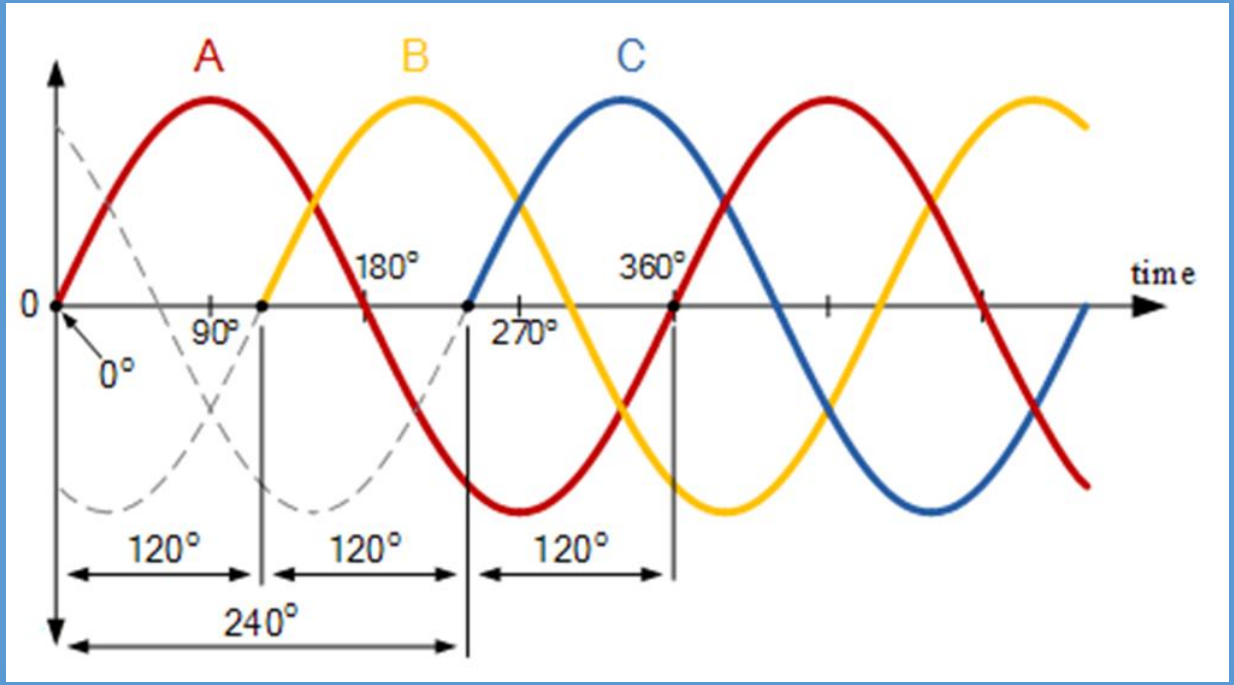
2-Frequency

3- Velocity

4-Acceleration

5-Displacement rate

6-Phase difference angle



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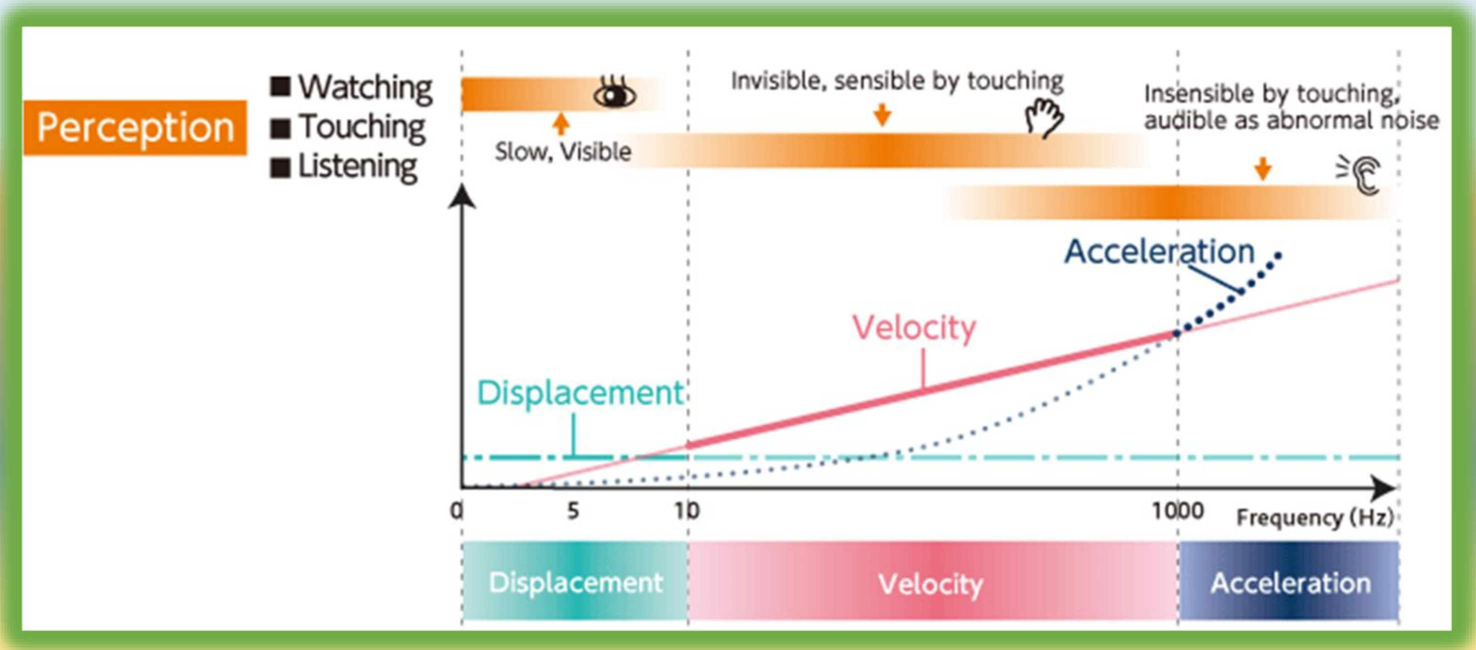
Vibrational movement based on the understanding of each person:

1- Slow and visible vibrational movement

2-Invisible but palpable vibrational movement

3-Invisible and untouchable vibrating movement but audible as an abnormal sound

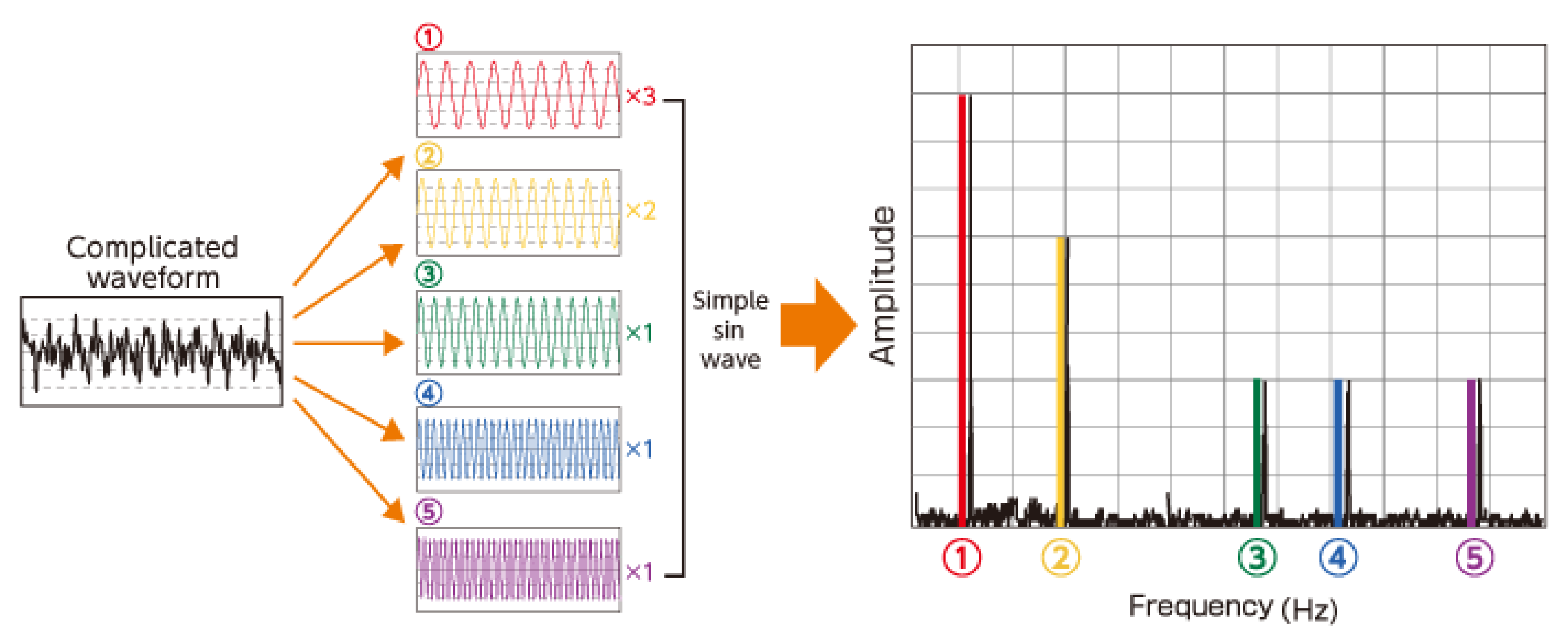


Faults identified through vibration analysis techniques

Vibration analysis technique is capable of identifying almost all the faults that a machine can have. As a result, occasional analysis needs complementary methods to confirm a diagnosis. The following are the most common faults that vibration analysis identifies:

Imbalance
Bearing failures
Mechanical looseness
Misalignment
Resonance and natural frequencies
Electrical faults in motors
Bent shaft
Gearbox failures
Cavitation in pumps
Critical speeds

The vibration of electric motors is usually a combination of several signals, which we use Fourier series expansion or FFT analysis to analyze.



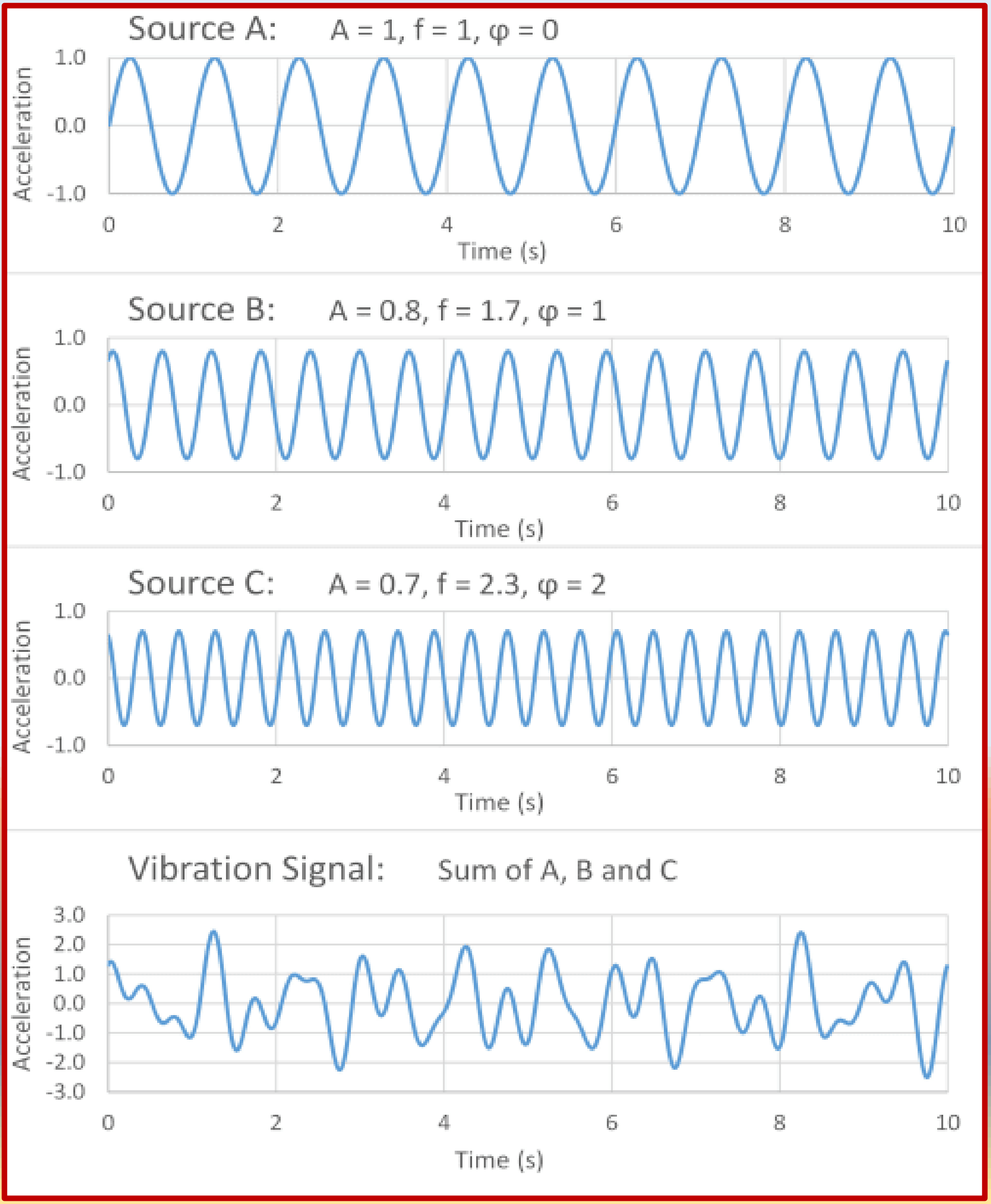
Fourier Series - The Fourier Coefficients

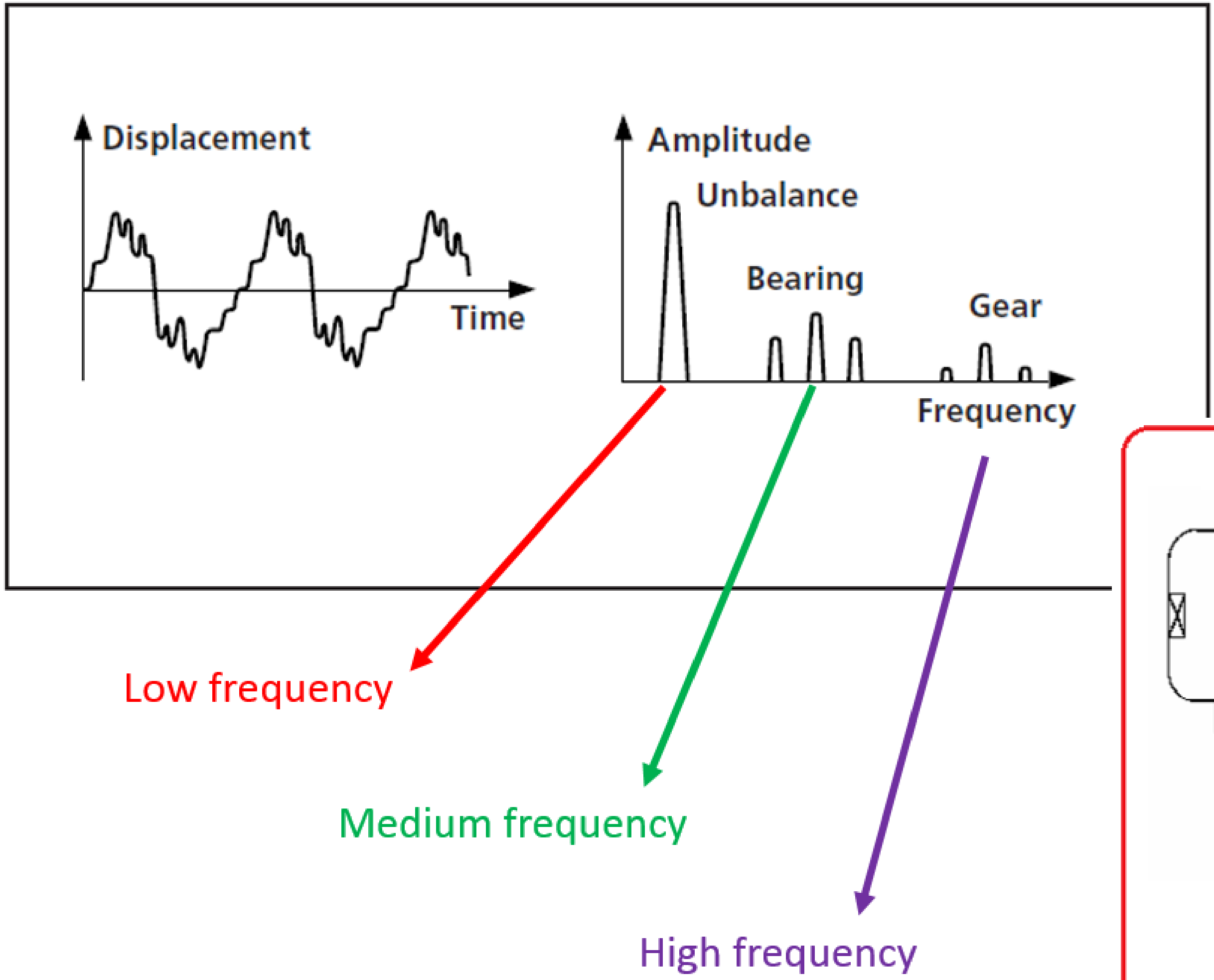
$$g(t) = a_0 + \sum_{m=1}^{\infty} a_m \cos\left(\frac{2\pi mt}{T}\right) + \sum_{n=1}^{\infty} b_n \sin\left(\frac{2\pi nt}{T}\right)$$

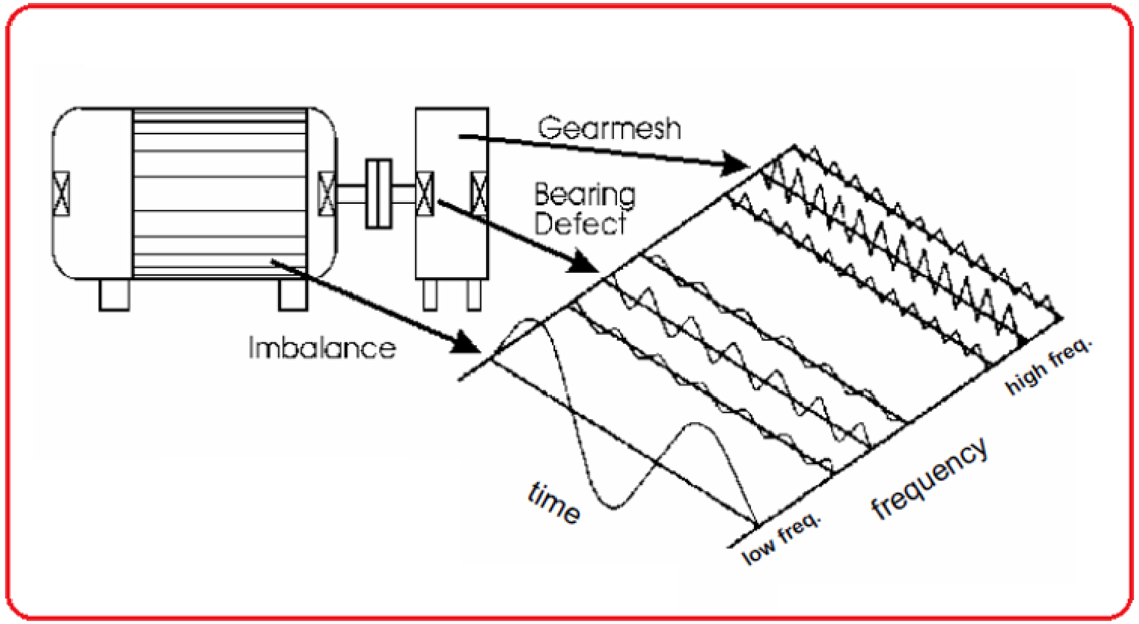
$$a_0 = \frac{1}{T}\int_0^T f(t)dt$$

$$a_m = \frac{2}{T}\int_0^T f(t)\cos\left(\frac{2\pi mt}{T}\right)dt$$

$$b_n = \frac{2}{T}\int_0^T f(t)\sin\left(\frac{2\pi nt}{T}\right)dt$$




Displacement
Time
Amplitude
Unbalance
Bearing
Gear
Frequency
Low frequency
Medium frequency
High frequency


Gearmesh
Bearing Defect
Imbalance
time
frequency
low freq.
high freq.

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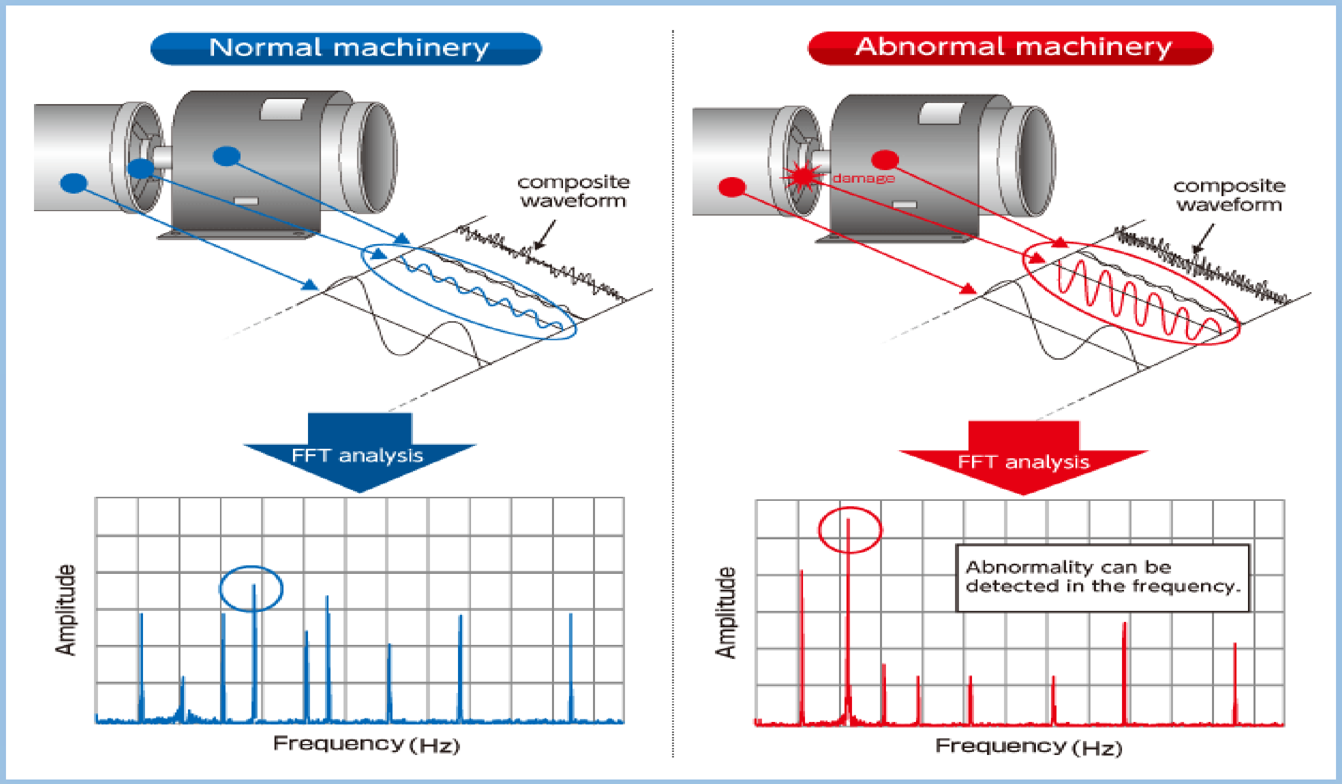
When a machine is operating abnormally, for example due to imbalance or bearing damage, it produces various vibrations that can be detected using FFT.



The parameters measured in the vibration test:

1- Velocity

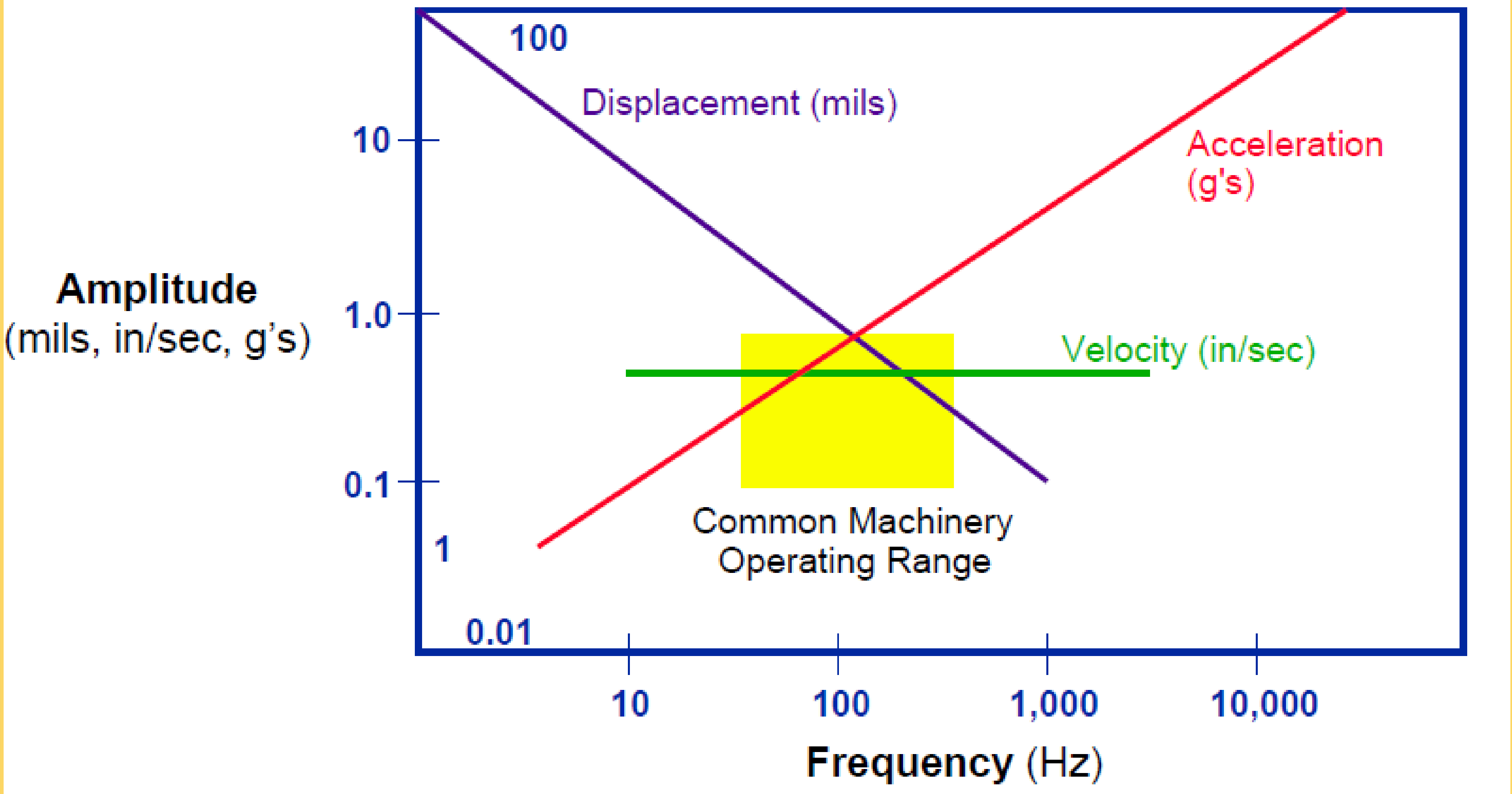
mm/s - inch/s - m/s

2- Acceleration

mm/s^2 - $inch/s^2$ - m/s^2

3-Displacement rate

mm-cm-inch


100
Displacement (mils)
10
Acceleration
(g's)
Amplitude
(mils, in/sec, g's)
1.0
Velocity (in/sec)
0.1
1
Common Machinery
Operating Range
0.01
10
100
1,000
10,000
Frequency (Hz)

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Tips and instructions for choosing the position of the vibration test device sensor:

1- Installing the sensor on the axial center line of the shaft

2-Measurement on the horizontal axis of the bearings

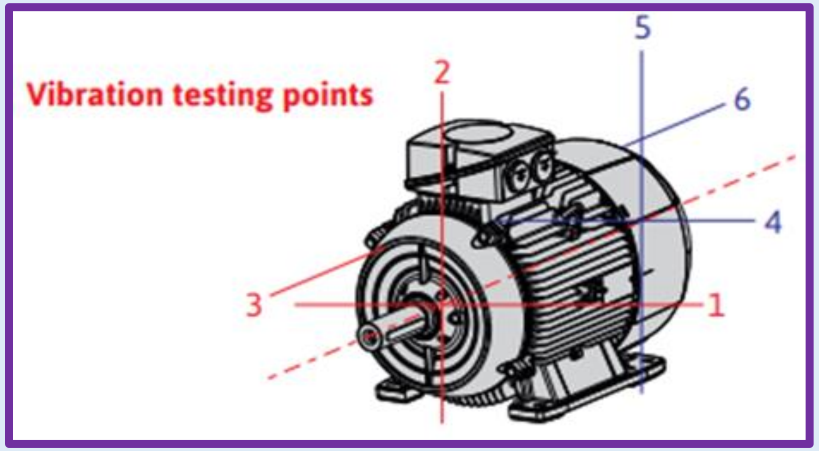
3-Measurement on the vertical axis of the bearings

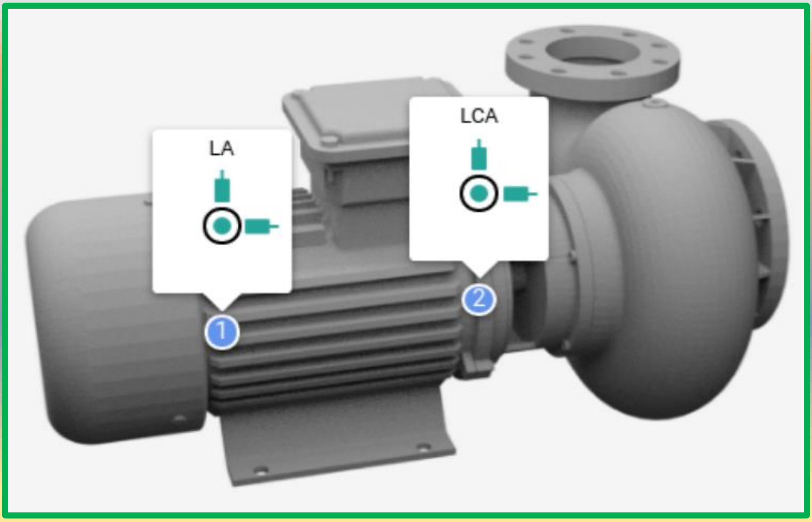
4- Minimum influence from external conditions

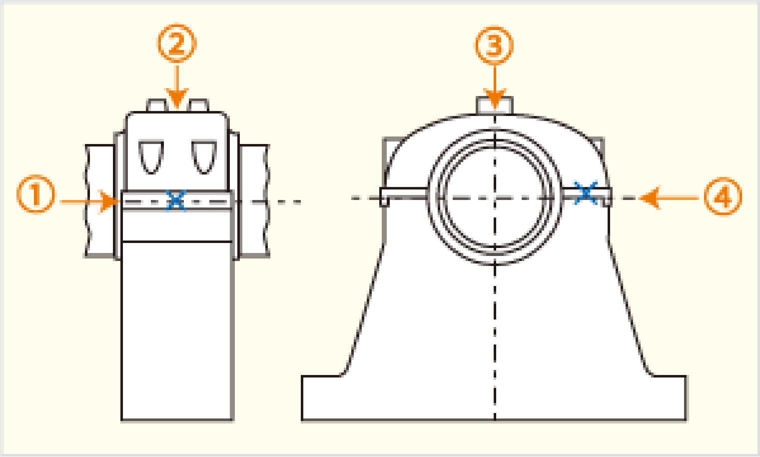
5- Maximum susceptibility to abnormal conditions

6- minimum amplification of the

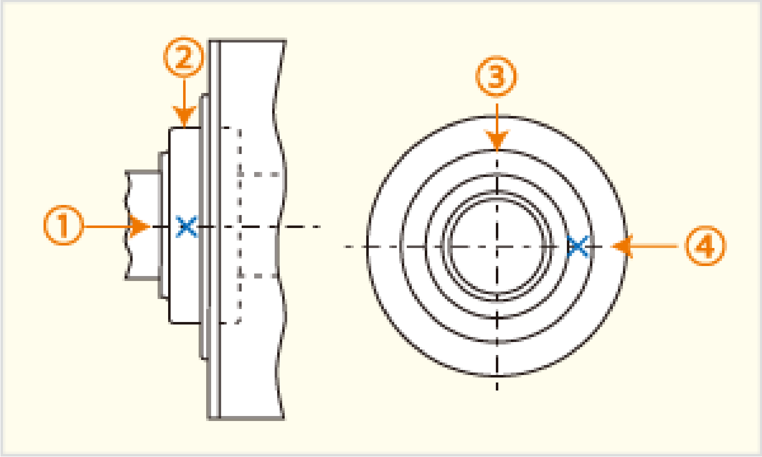
measured signal (system tolerance)



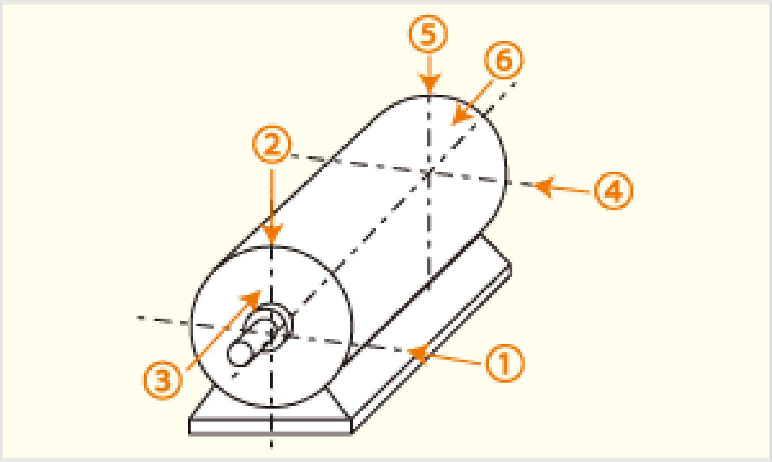




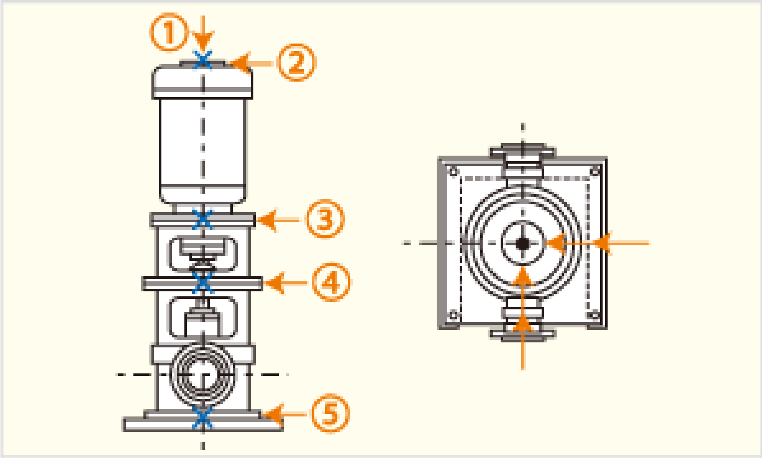
Measuring point of bearing stand



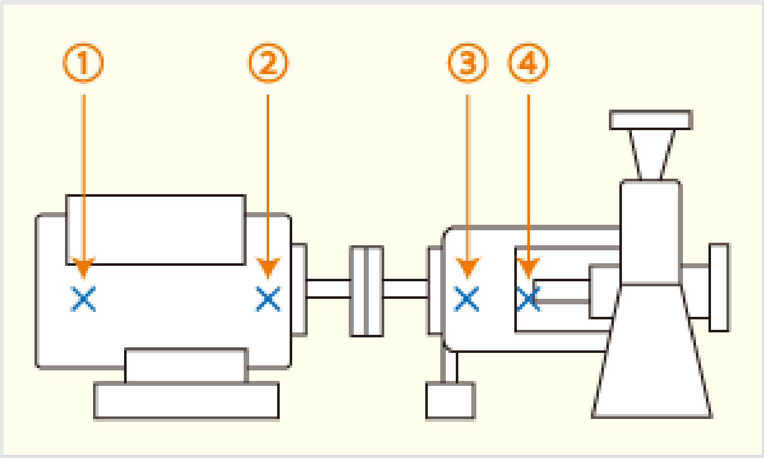
Measuring point of built-in bearing



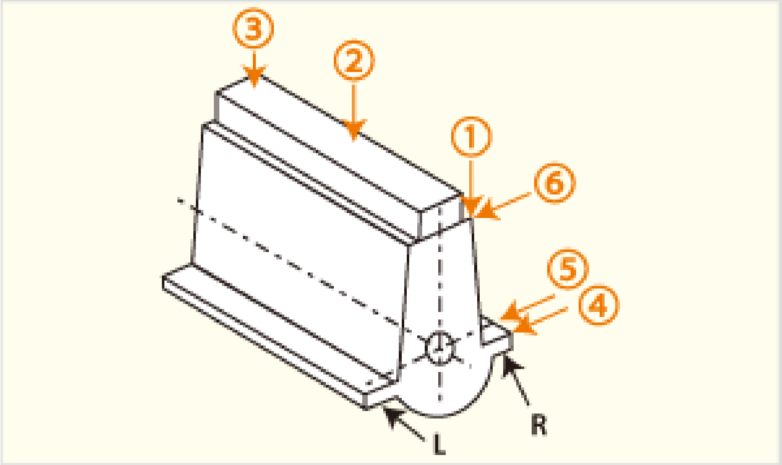
Measuring point of small electric equipment



Measuring point of vertical machine

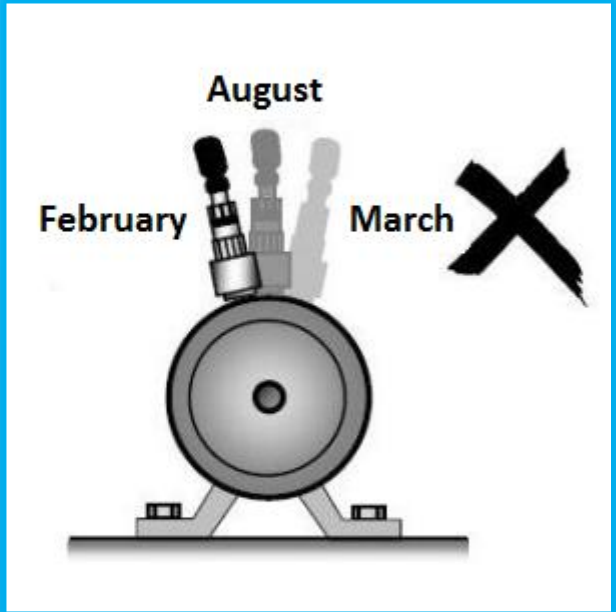


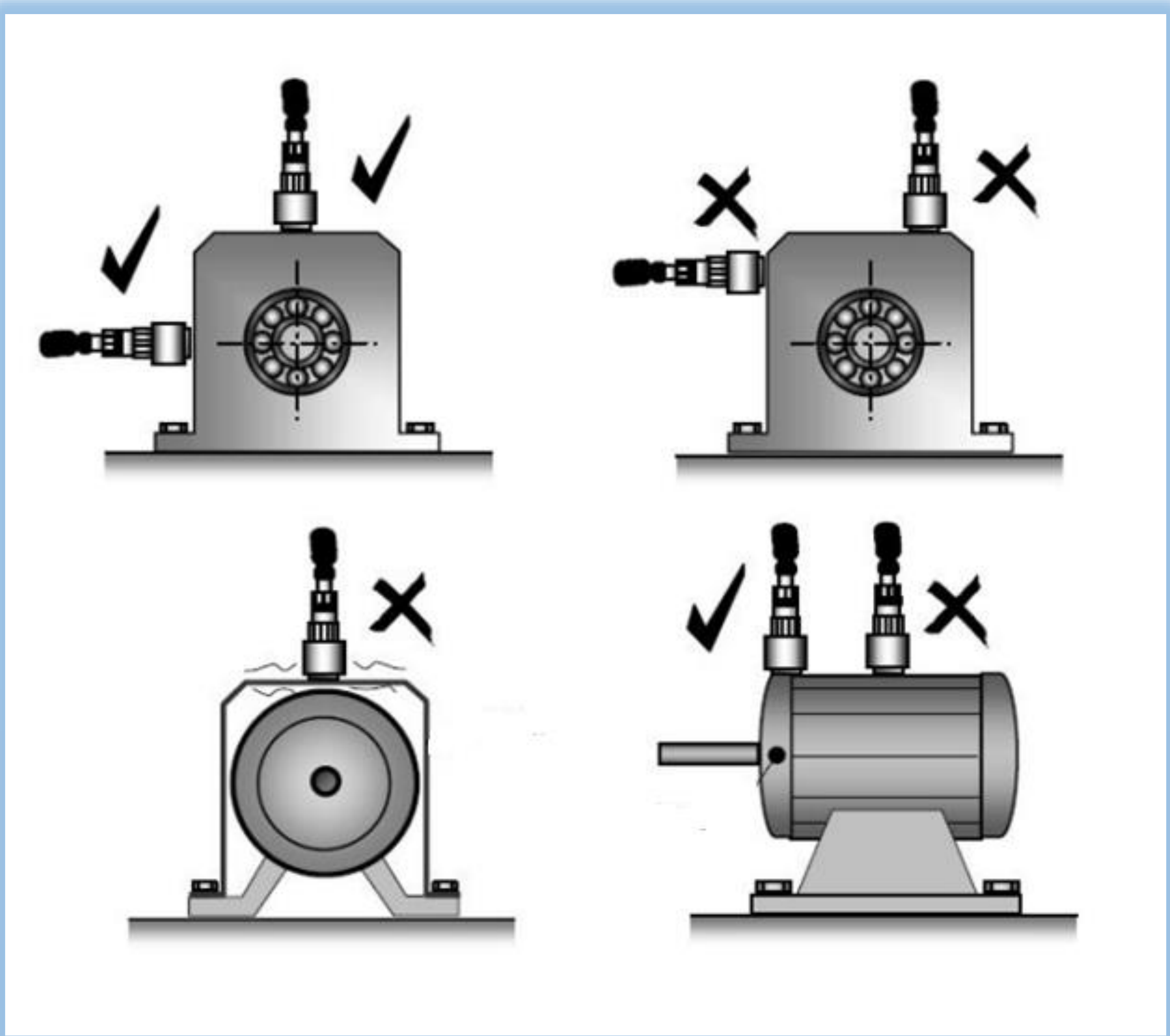
Measuring point of cantilever type pump



Measuring point of reciprocating engine

Important points in installing the vibration sensor

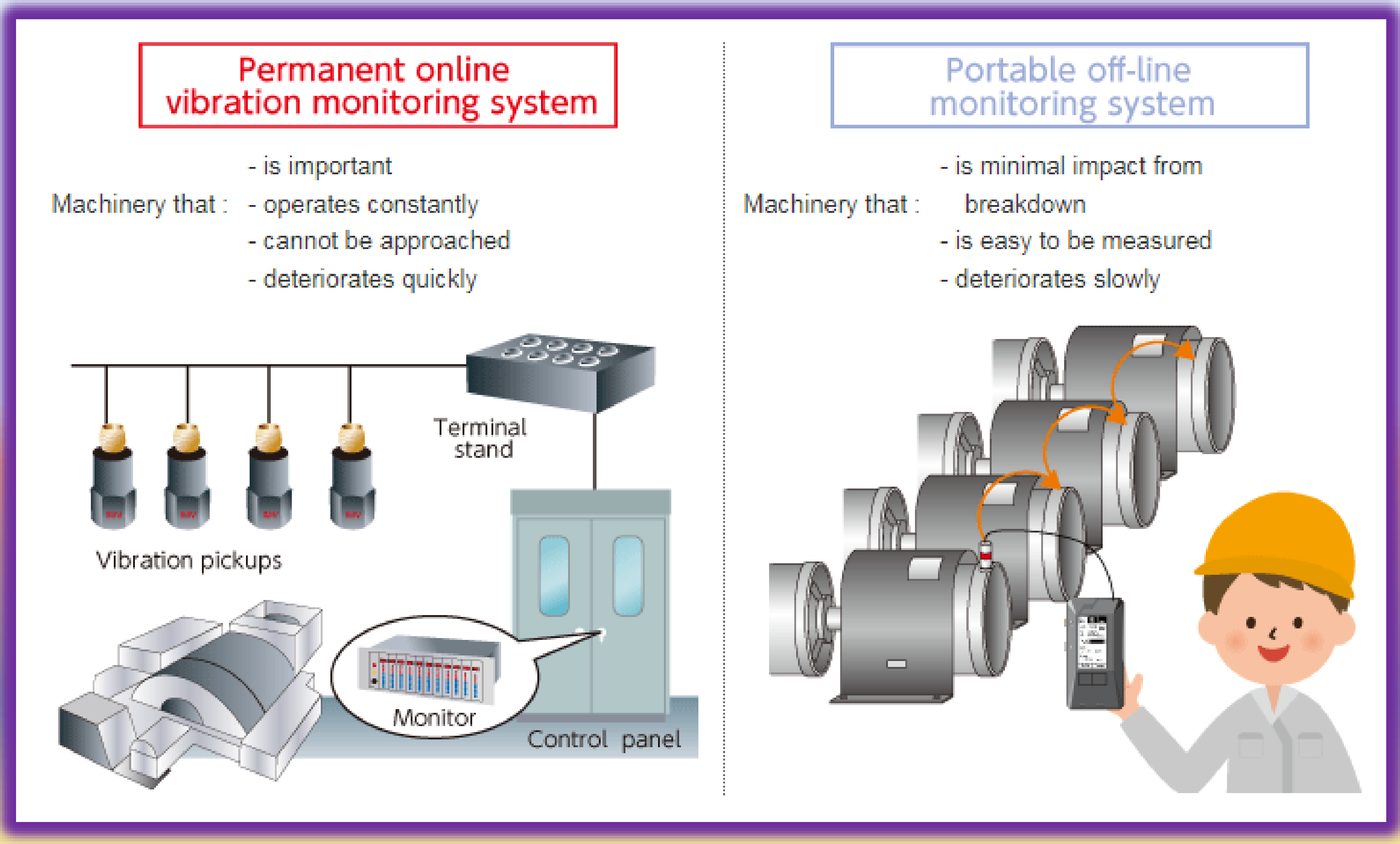




The system for monitoring the state of the vibration test is performed in the following two ways:

1- Offline status monitoring

2- Online status monitoring



Common faults in electric motors detectable by vibration test analysis:

1- Imbalance

* Failure to properly install and balance the electric motor

* The problem of doing the foundation, breaking and destroying it

* Deformation of the rotor due to excessive heat

* Coupling wear or breakage

* Wear, breakage or failure to properly install the cooling fan

When an imbalance is detected in an electric motor, the following actions are recommended :

*Reviewing the maintenance checklist (date, type of electric motor, replacement, etc.)

*Checking coupling cooling fan

* Internal inspection of the deformation of the retro shaft axis

* Re-calibrating the motor shaft element (coaxial)

2-Absence of element

* Re-do laser alignment

* Fracture of the electric motor bases or destruction of the foundation

*Excessive thermal expansion

* Abrasion or breakage and wear of the coupling

Recommended actions:

Re-testing of the axial alignment of the element and the effect of thermal expansion

Foundation test

Coupling test

3-Bearing problems

* Incorrect assembly and installation

* Engine overload or wear

* Improper workflow

* Creation of voltage on the shaft and lack of direct connection to the ground wire or insulating ring

Recommended actions:

Check the installation of the bearing and its wear

Check the lubrication and oiling process

Check the insulating earth wire

4-Electrical problems

* Improper air gap between rotor and stator

* Breaking and changing the shape of the rotor rods (squirrel cage) or breaking its coils and coils (winding rotors)

* Low power quality (voltage imbalance, high harmonics, inverter failure, phase disconnection, improper electrical connections)

* System insulation problems

Recommended actions:

Check power quality with proper measuring devices

Check rotor and stator air gap and rotor parameters

Do the motor insulation test with a megger

Velocity Test

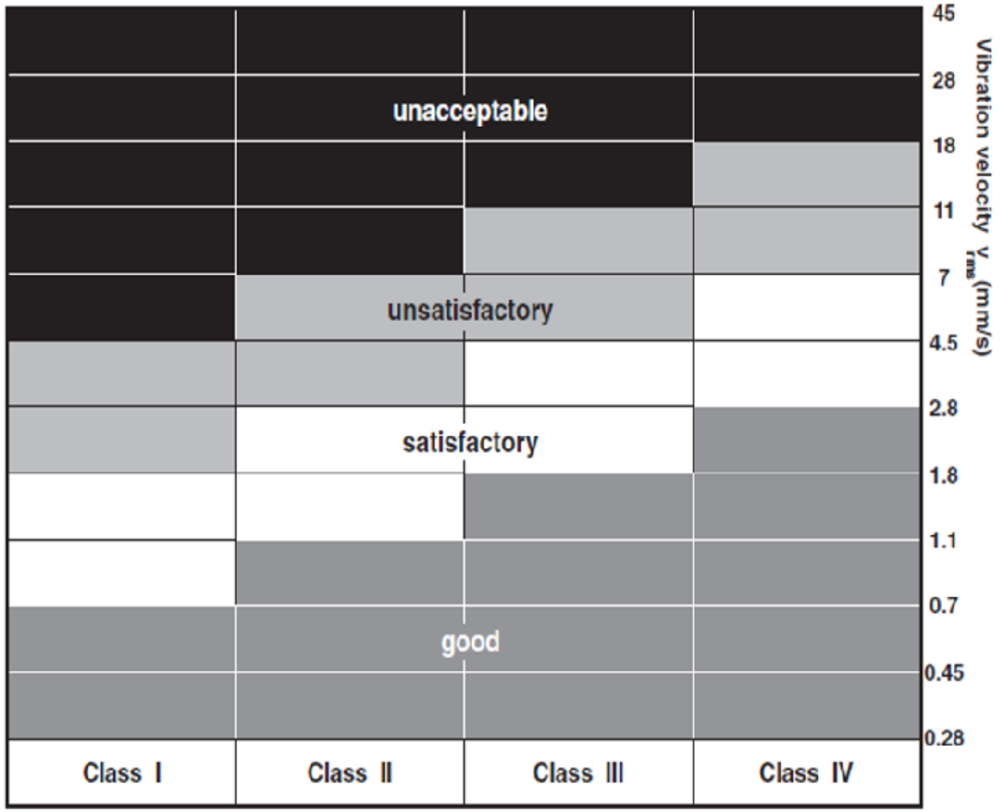


Table Vibration Severity - ISO 10816-1

Machine (Vibration Velocity Vrms) in/s	mm/s	Class I Small Machines	Class II Medium Machines	Class III Large Rigid Foundation	Class IV Large Soft Foundation
0.01	0.28				
0.02	0.45				
0.03	0.71		GOOD		
0.04	1.12				
0.07	1.80				
0.11	2.80		SATISFACTORY		
0.18	4.50				
0.28	7.10		UNSATISFACTORY		
0.44	11.20				
0.70	18.00				
1.10	28.00		UNACCEPTABLE		
1.77	45.9				

Class 1: P<15Kw
Class 2 :15Kw<P<75Kw
Class 3 :75Kw<P<300KW
Class 4 : 300Kw<P

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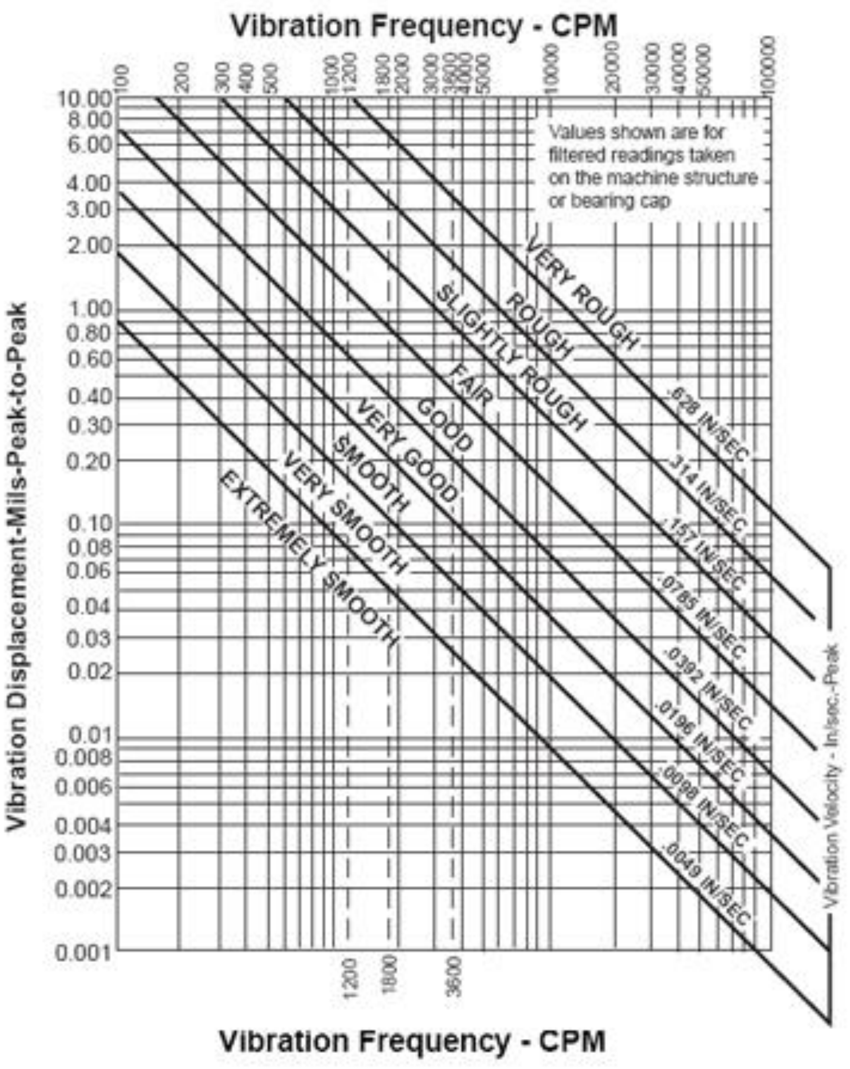

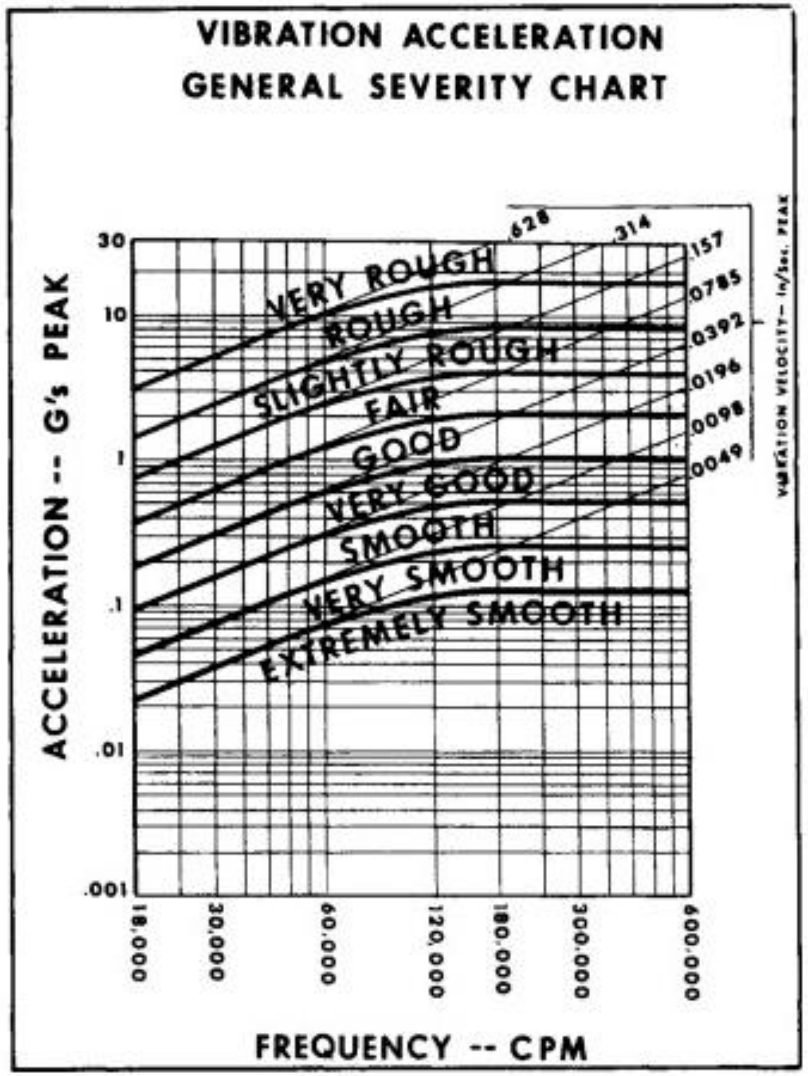

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Fluke 805 FC Vibration Meter

Vibration test device and rapid test of bearings, bearings and chambers of electric motors and mechanical rotating systems without the need to open the system

Table Crest Factor+

CF+	Severity
1 to 5	Good
6 to 10	Satisfactory
11 to 15	Unsatisfactory
above 15	Unacceptable

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Vibration causes and their characteristic frequencies

Possible cause	Dominant frequency	Direction	Comments
Imbalance	1x rotation frequency	Radial for dynamic imb., possibly axial	Amplitude proportional to imbalance and RPM; causes severe vibration to occur
Misalignment; bent shaft	1x rotation frequency often 2x and higher multiples	Radial and axial	Severe axial vibration and 2nd harmonic; best realigned with OPTALIGN® V or SYSTEM 2 TURBALIGN®
Bearing damage	High-frequency vibration	Radial and axial	May be diagnosed from vibration only through use of diagnostic functions or shock pulse analysis (SPM)
Sleeve bearing play	Subharmonic, exactly 1/2 or 1/3 of rotation frequency	Radial	Usually dependent upon RPM and operating temperature
Oil film whirl or whip (sleeve bearings)	40% - 50% of rotation frequency	Radial	Occurs with high-speed machines; phase fluctuates.

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Hysteresis whirl	Critical shaft rotation frequency	Radial	Vibrations are excited as machine climbs through critical RPM and remain at higher speeds. Remedy: Rotor must be reworked (mounting improved).
Gear tooth damage	Tooth mesh frequency and multiples thereof with sidebands located at multiples of rotation frequency	Radial and axial	Sidebands occur from modulation of tooth mesh vibration at rotation frequency; difficult to isolate due to superimposition.
Belt drive damage	Rotation frequency and multiples thereof	Radial	Additionally recommended: combined RPM and belt speed measurements to check for belt slippage.
Turbulence; cavitation	Blade/vane passing frequency	Radial and axial	Additionally recommended for pumps: shock pulse measurement at the pump housing.
Electrically induced vibration	Rotation frequency, 2x line frequency	Radial and axial	Sidebands may also occur located at multiples of the rotation frequency; vibration ceases when power is cut off.

Proposed measuring devices for vibration testing of electric motors

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FLUKE

Fluke 805 FC Vibration Meter

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FLUKE

Fluke 810 Vibration Tester

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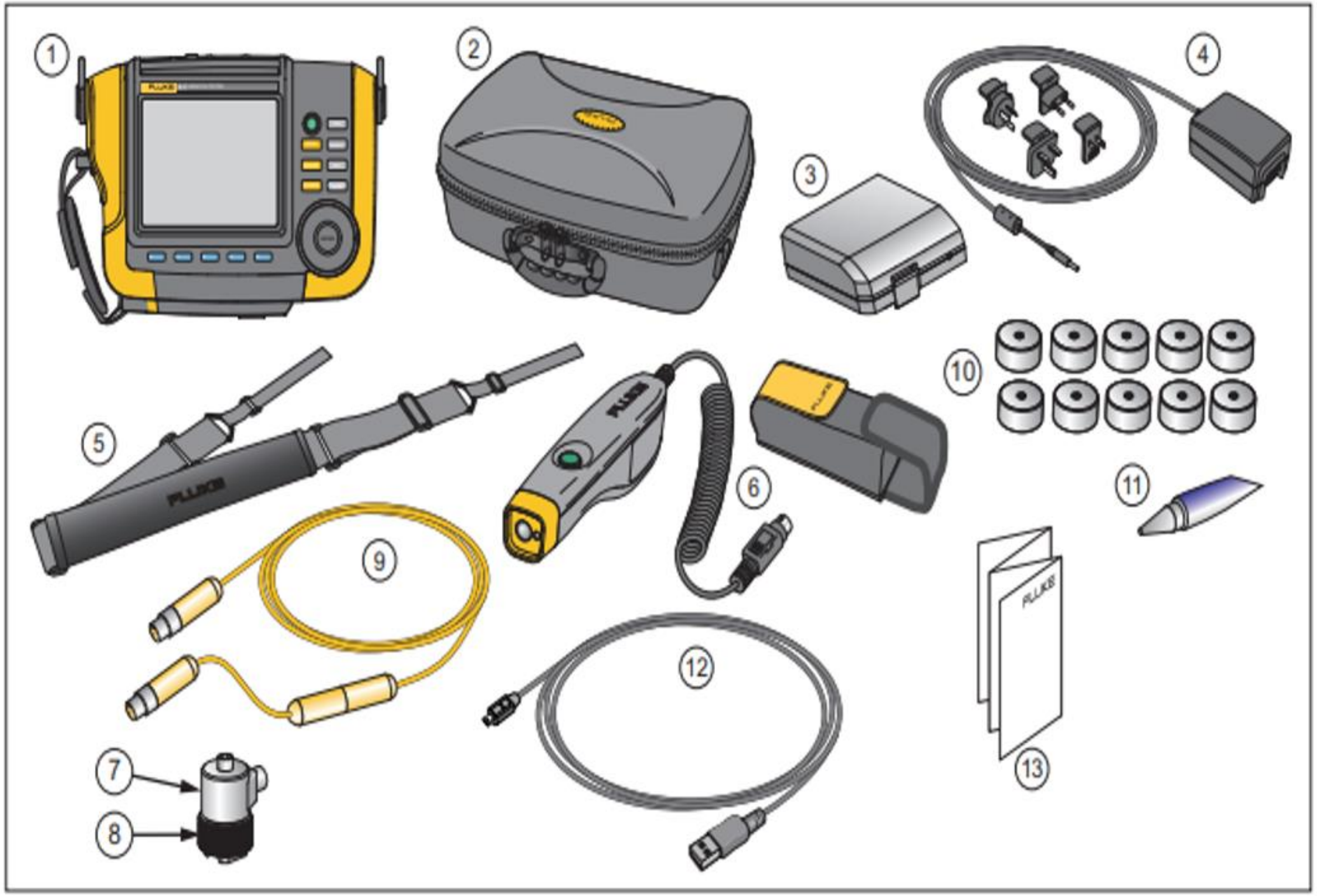

1. Vibration Tester
2. Storage Case
3. Smart Battery Pack
4. Smart Battery Pack Charger and Adapters
5. Shoulder Strap
6. Tachometer and Pouch
7. Sensor
8. Sensor Magnet Mount
9. Sensor Quick Disconnect Cable
10. Sensor Mounting Pads (10-pack)
11. Adhesive
12. Mini USB to USB Cable
13. Quick Reference Guide

SDT340

with Ultranalysis® Suite 3

Detect, measure, analyze ultrasound and vibration

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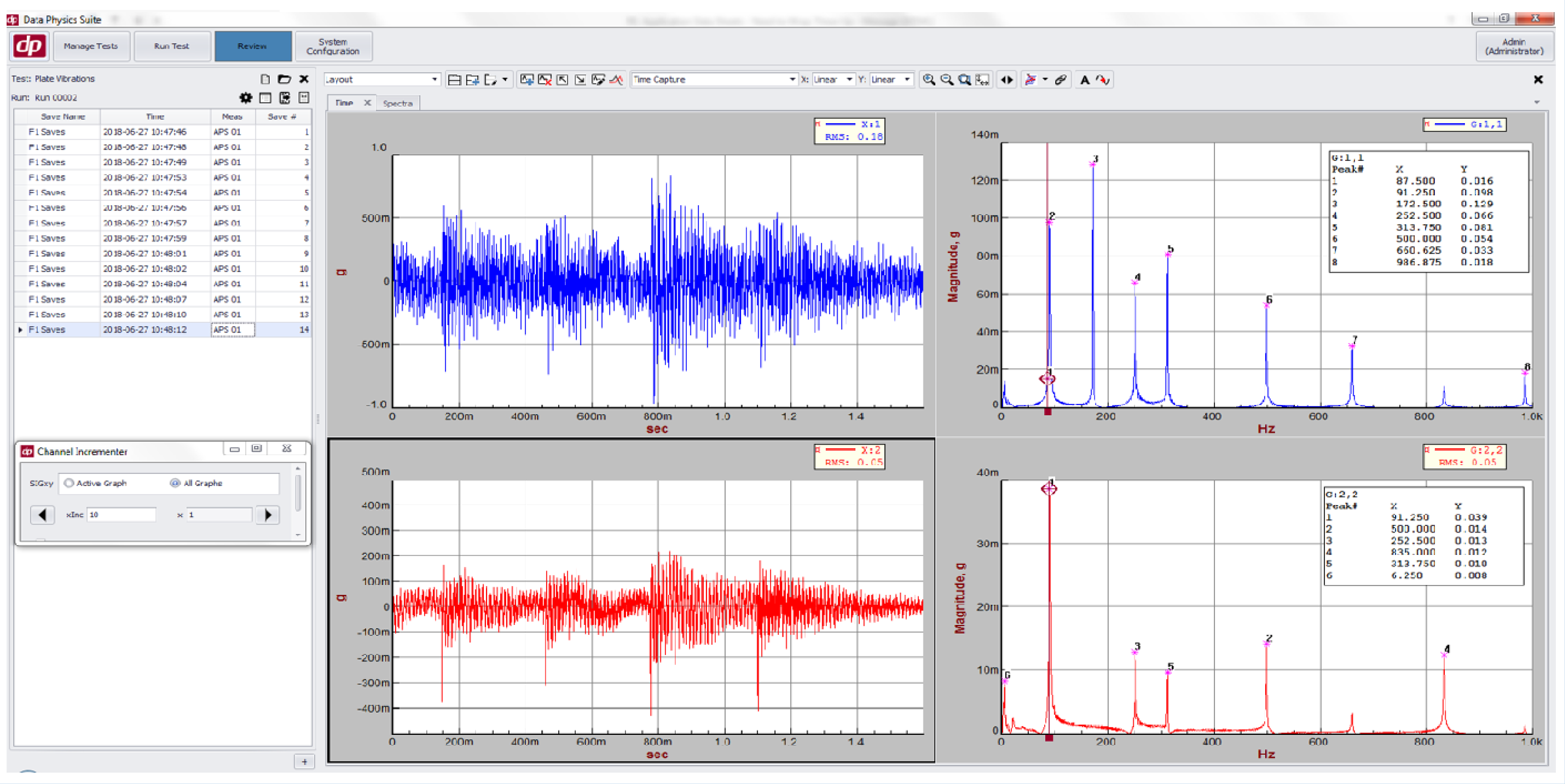

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SKF Pulse™

Sensor controls and indicators:

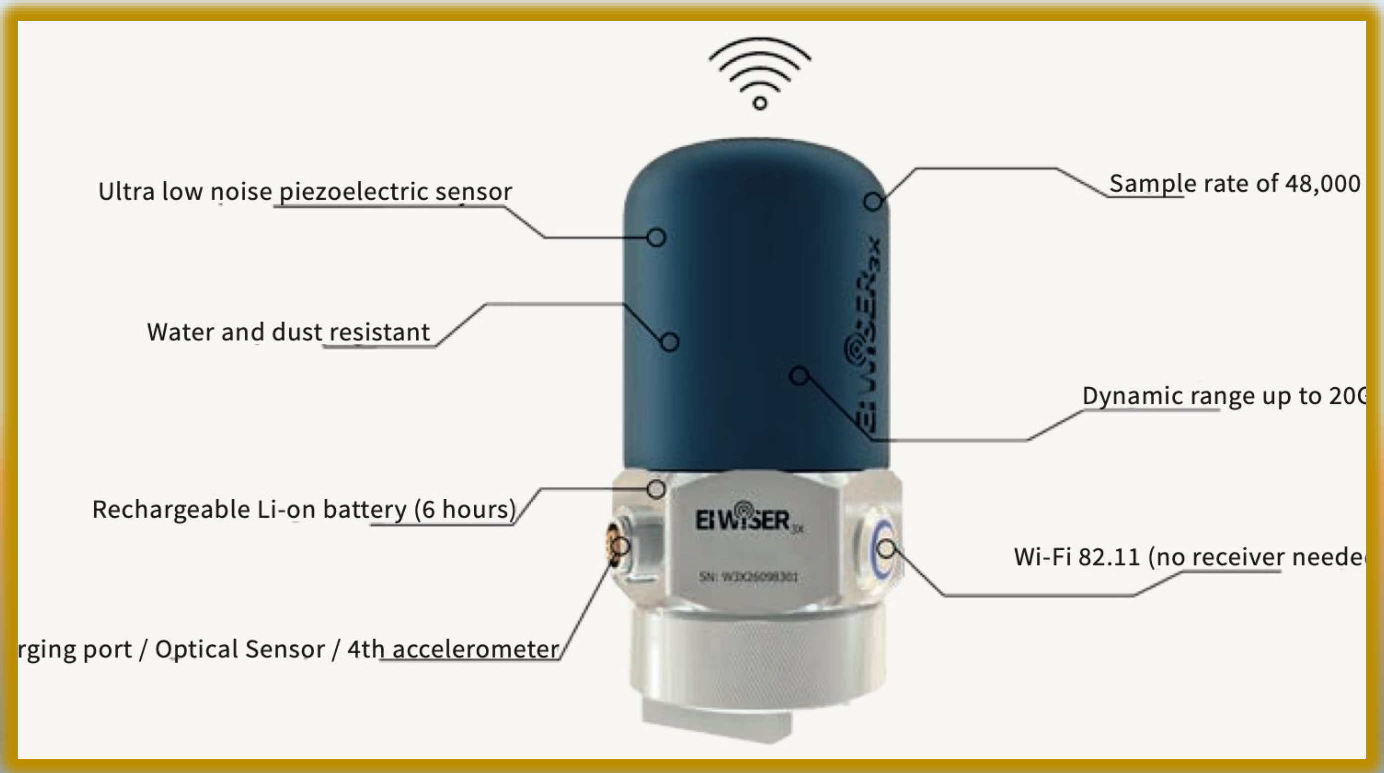
1 **Power button –**
Powers the sensor on and off

2 **Battery LED (green, red) –**
Indicates status of battery charge

3 **Communication LED (green, red) –**
Indicates sensor connection status to app and when firmware updates are in progress

4 **All-purpose check LED –**
For future use

WiSER 3X Triaxial Wireless Accelerometer



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MarMonix
Promote your assessment

MVB-200

Vibration meter

Parameter	Values
Acceleration range	0.1~199.9 m/s^2
Velocity range	0.1~1999.9 m/s
Displacement	0.001~1.999 mm (P - P)
Acceleration (Freq)	10Hz~1KHz (LO); 1KHz~15KHz (HI)
Velocity (Freq)	10Hz~1KHz (LO)
Displacement (Freq)	10Hz~1KHz (LO)
Accuracy	±5%H±2digits
LCD display	3 1/2 digits display
Data output	AC output 2 V peak (display full scale)
Load impedance	10K or more earphones can be connected
Operation temperature	0~40
Power supply	1*9V battery
Dimensions	175*67*33MM
Weight	134.5g

SKF CMAS 100-SL Handheld Vibration Meter