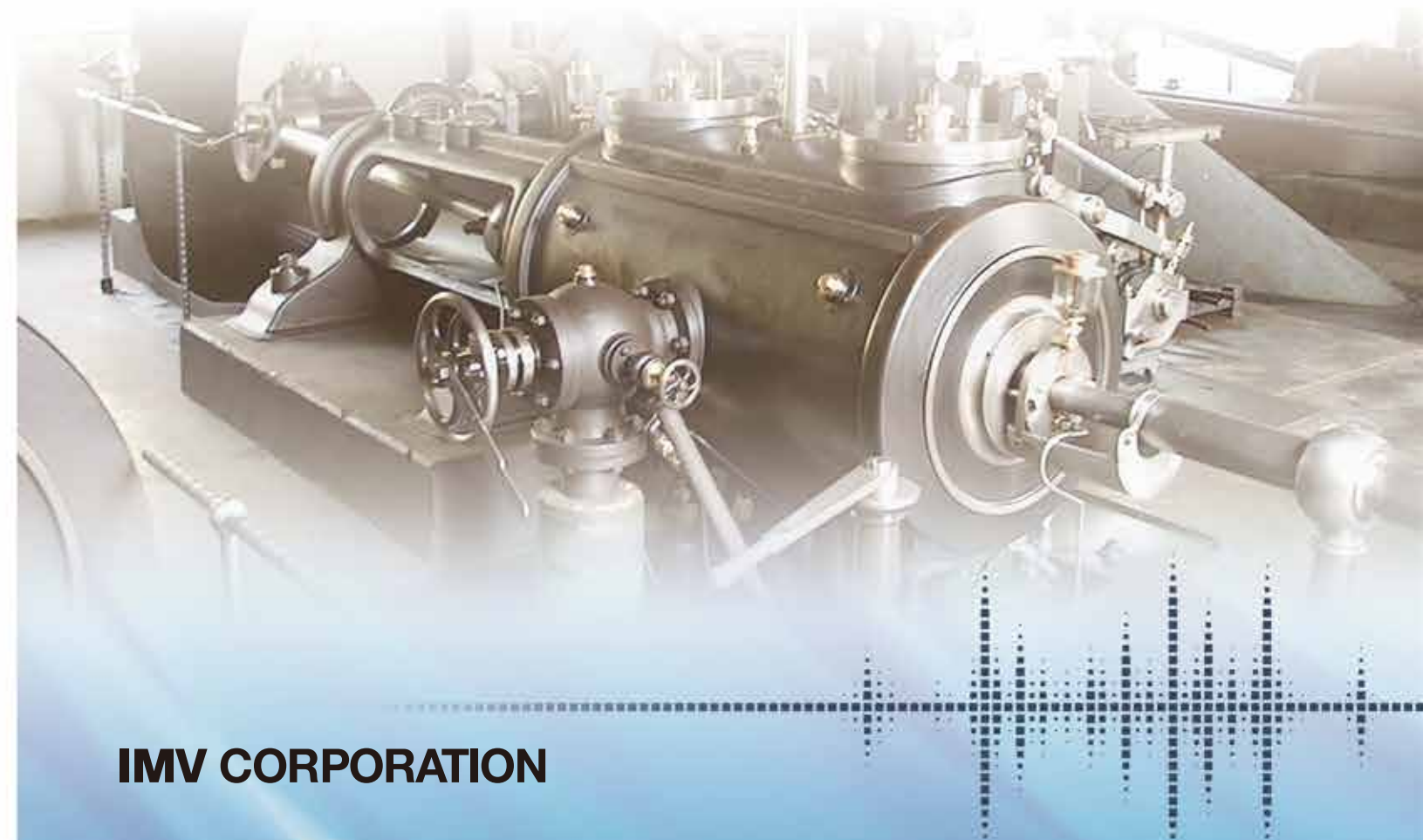




All about

Vibration Measuring Systems

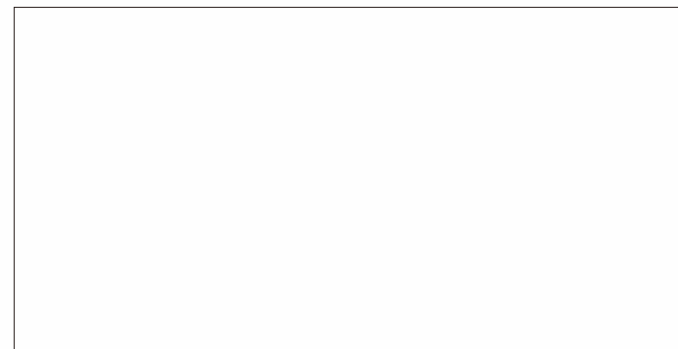


IMV CORPORATION

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web <https://we-are-imv.com/>

*The specifications and design are subject to change without notice.



January 2023

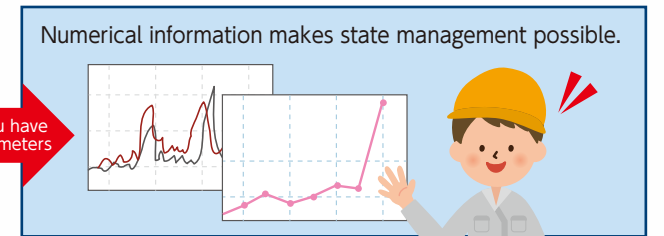
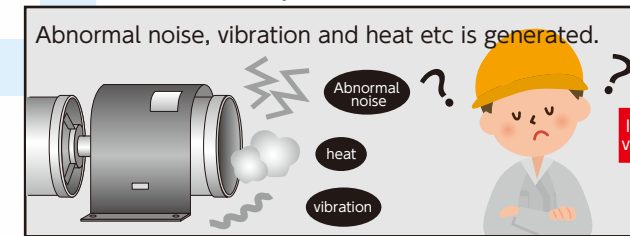
IMV CORPORATION

Chapter 1

Why do we need to measure vibration?

1 Need for facility diagnosis

When machinery deteriorates ...



When machinery breaks down...



If you prevent machinery from breaking down in advance

To prevent machinery from breaking down, precise diagnosis is essential.

All about

Vibration Measuring Systems

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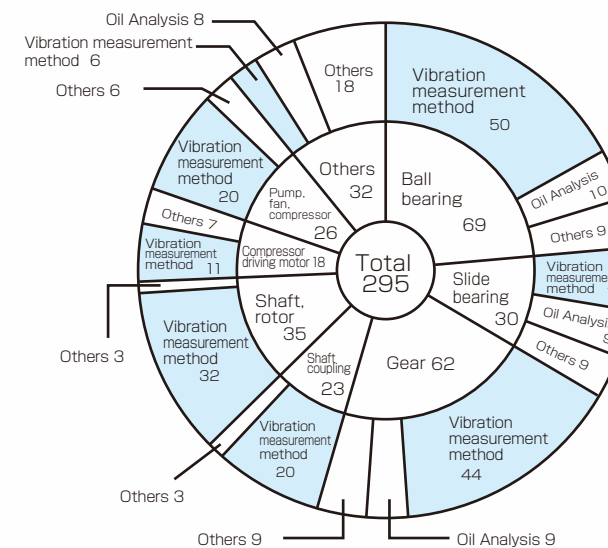
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- 2 Cardvibro Air2
- 3 Smartvibro
- 4 Vibration level meter
- 5 DC4~20mA output accelerometer
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- 8 Maintenance guide

2 Merits of vibration measurement

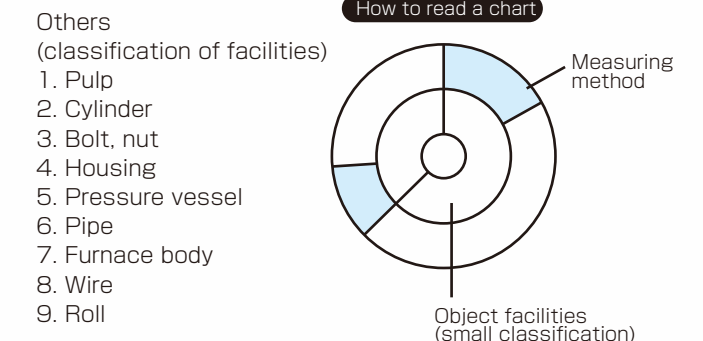
Predictive maintenance is widely applied using various instruments. Vibration measurement is by far the most popular method.

Merits of vibration measurement

- It is most suited to early diagnosis because of its high sensitivity.
- Provides high volume of technical data making it easier to determine the method of analysis
- Low cost and easy to install



How to read a chart

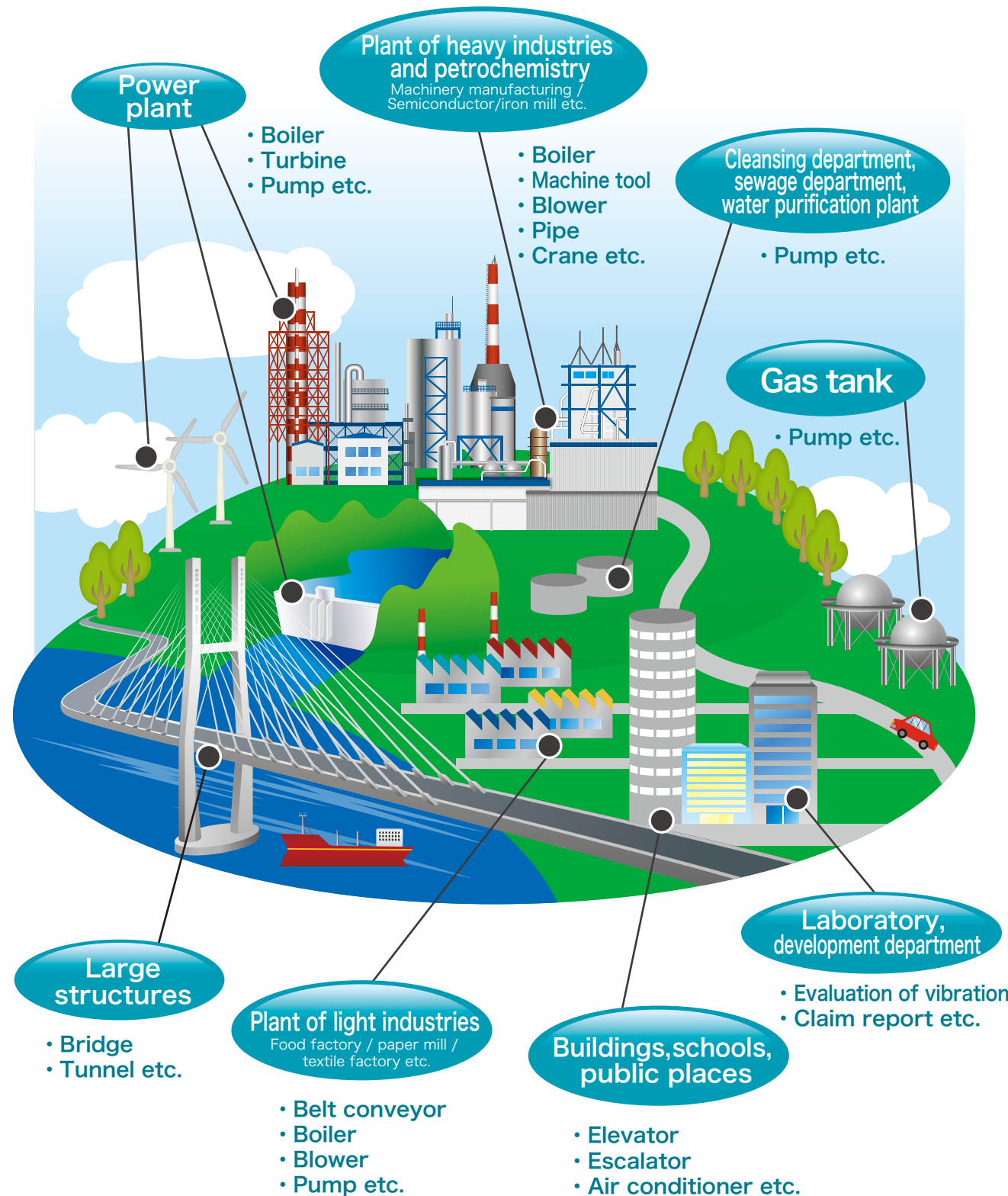


Reference : ISO machine condition monitoring diagnosis (vibration category II) issued by Vibration Research Association(Shindo Gijyutu Kenkyukai)

The role of vibrometers

1 Where can we use vibrometers?

Vibrometers are used in various fields. Vibration may influence the durability and reliability of the machinery systems of structures. Taking accurate vibration measurements before machinery breaks down, infrastructure is brought to a halt and disaster occur is vital in order to prevent secondary accidents.



2 Applications

For example

Safety management of factories

To prevent machinery breakdown or accident, vibration must be measured regularly and compared with the initial state to pinpoint any potential source of failure.



For example

Research and development

To develop or invent industrial products with high reliability, measurement results can be used to feed back into product design.



For example

Quality improvement

Vibration measurement is essential to enhance product reliability by investigating the cause of problems.



For example

Daily Maintenance

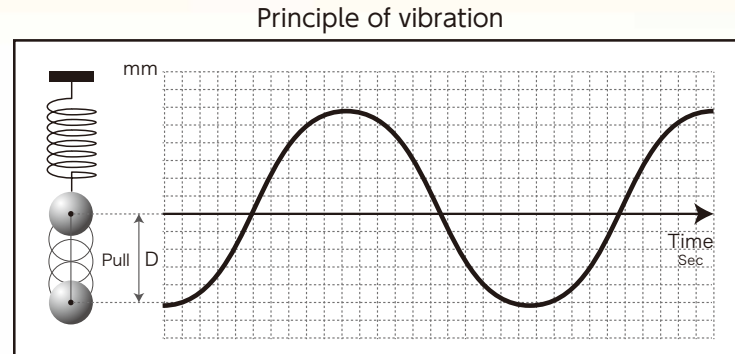
Daily vibration inspections improve product lifespan.



Vibration technical guide

1 Vibration terminology

Vibration means the state of an object moving repetitively back/forward, right/ left or up/down and is generally expressed by Frequency, Displacement, Velocity, and Acceleration. These 4 elements are generally denoted as F, D, V, A. This is illustrated simply as a spring and mass. When the mass is pulled down from the start position and released, the mass moves just like the vibration waveform shown in the graph on the right.



Frequency (F)

Frequency means the number of times that vibrating object generates a repetitive motion in 1 second.
Unit : Hz

Velocity (V)

Velocity means the changing rate of displacement (D) to time
Unit : mm/s, cm/s

H function

Effective function to detect abnormal bearing noise. 2kHz~15kHz filtering to acceleration waveform can remove noise for waveform analysis.

Displacement (D)

Displacement means the amplitude (distance) between the peaks of vibration.
Unit : μm, mm

Acceleration (A)

Acceleration means the changing rate of velocity (V) to time
Unit : m/s², g

2 Measurement functions

These are the means to express the vibration in absolute value basing upon the waveforms measured by the modes shown above.

1. PEAK (Peak amplitude)

Peak value in a certain time duration. It is used to measure shocks or waves which are rather stable.

$$V_{PEAK} = |v(t)|_{max}$$

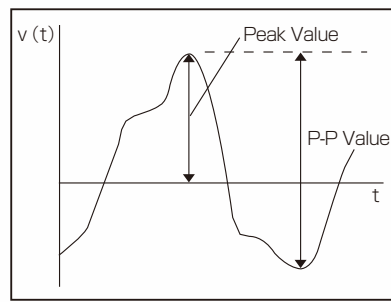


Fig: Peak Value

3. C · F (Peak factor · Crest factor)

PEAK to RMS ratio
It is used to determine deterioration of bearings by relative comparison.
C · F = PEAK/rms

2. rms (Root Mean Square value)

Root mean square value of the instantaneous values in a certain time duration. It relates to the power of the wave. The rms value of velocity is one of the important factors for machinery status diagnosis.

$$V_{rms} = \sqrt{\frac{1}{T} \int_{t1}^{t2} v(t)^2 dt}$$

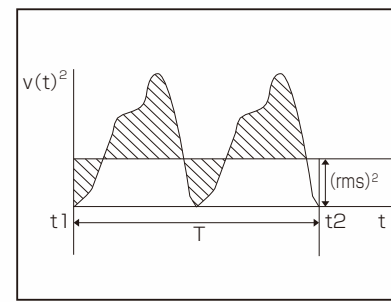


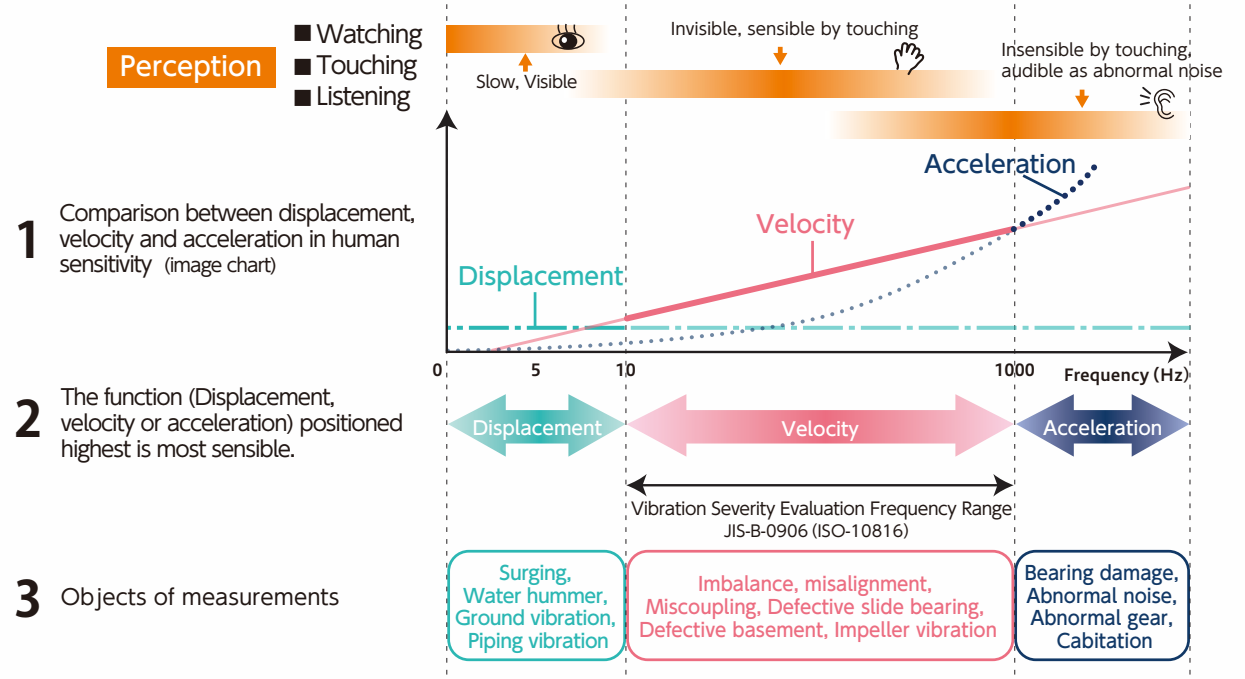
Fig: Root mean square value

4. EQP (Equivalent Peak value)

It is a sine peak assumed by the rms value.
For Sine wave, the relationship $rms \times \sqrt{2} = PEAK$ is valid. For a vibration monitoring system, there is a case that EPQ is monitored instead of the peak value avoiding to trigger the erroneous alarm by any accidental signal.

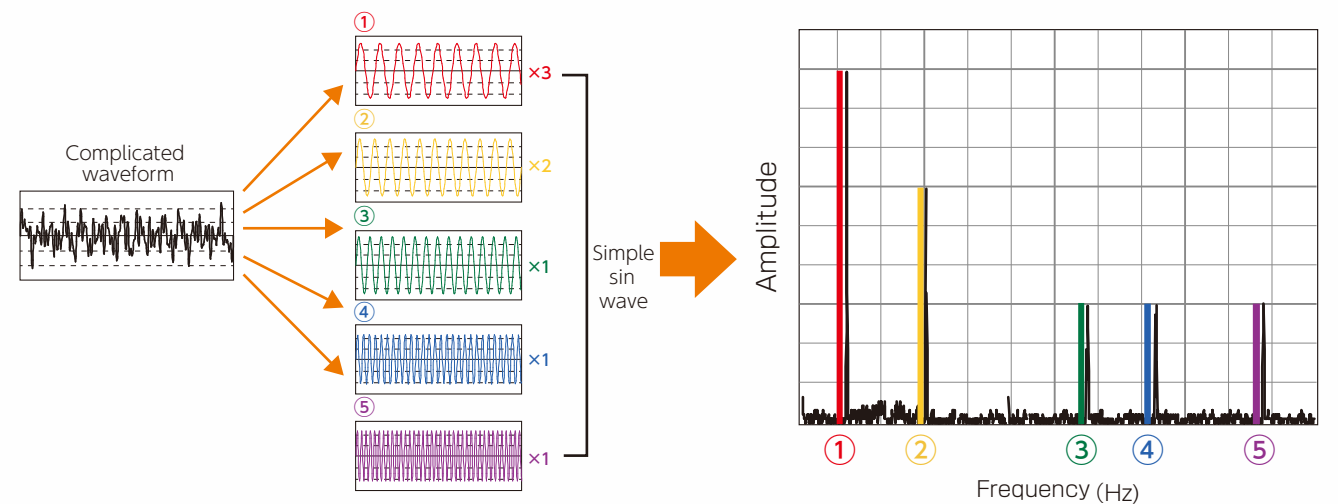
3 Types of vibration

Vibration can be divided into three types based on human perceptions; "slow motion and visible" "invisible but sensible by touching" and "insensible by touching, but audible as abnormal noise".



4 What is FFT (Fast Fourier Transform) ?

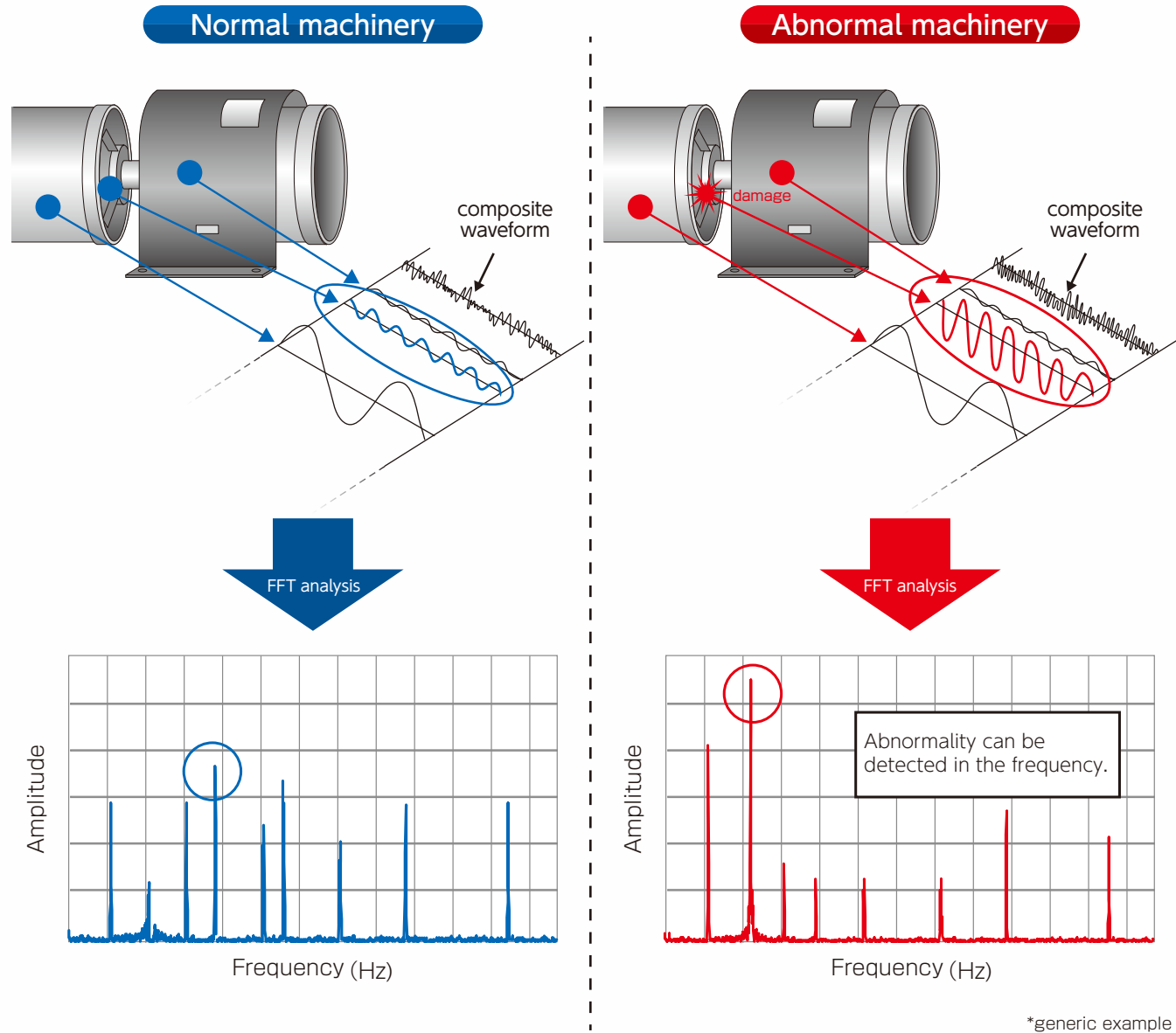
FFT is one method of analysis, based on vibration waveform. Generally, waveforms are complicated and difficult to analyze. In FFT, we break waveforms down into a series of discrete sin waves, (left chart) and evaluate each individually. (right chart)



*generic example

5 Making use of FFT spectrum analysis for vibration analysis

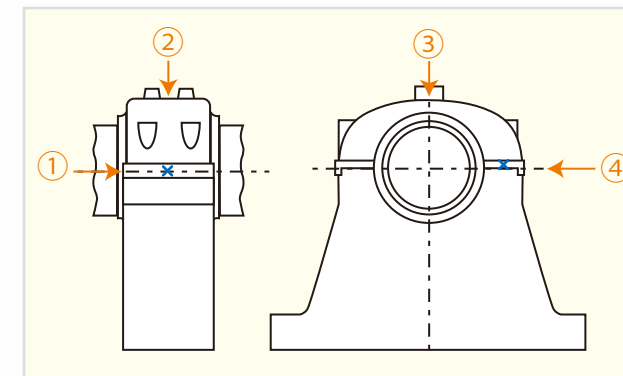
When a machine functions abnormally, for example due to imbalance or bearing damage, it will produce different vibrations that can be detected using FFT.



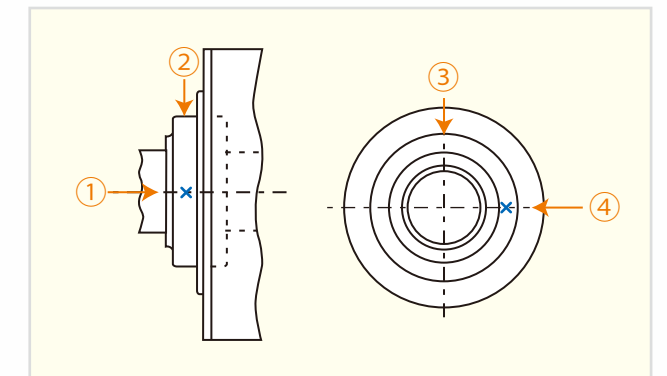
6 Selection of measuring points

Some points to be considered when selecting the positions of monitoring status.

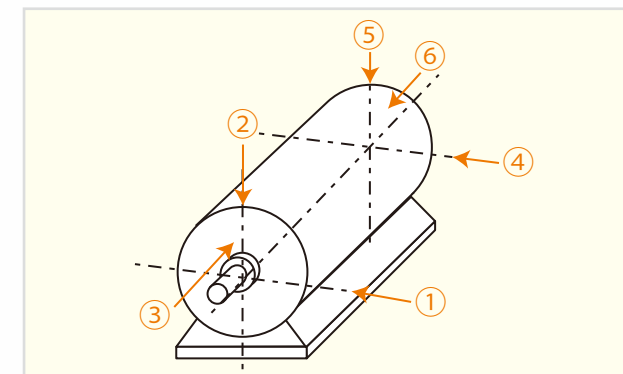
- (1) Ease of access
- (2) Minimum impact from external condition
- (3) Maximum sensitivity to abnormal conditions
- (4) Minimum signal attenuation or signal loss caused by abnormality
- (5) Reliability of measurement



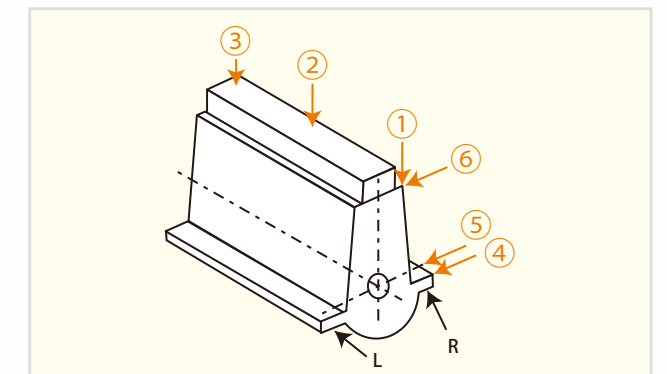
Measuring point of bearing stand



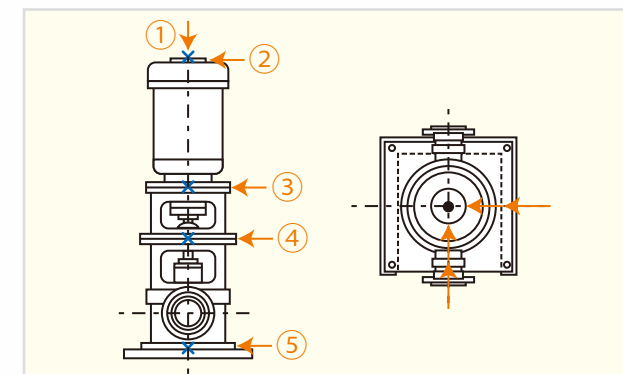
Measuring point of built-in bearing



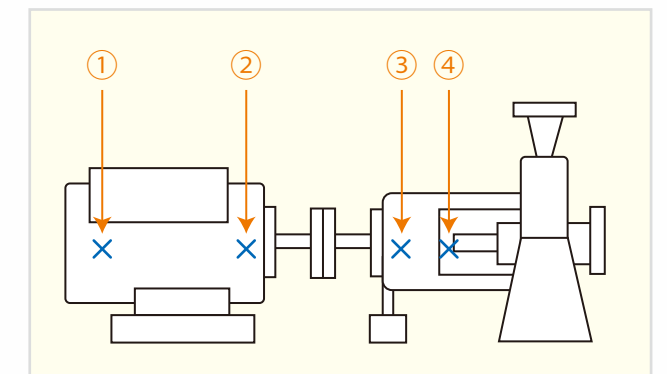
Measuring point of small electric equipment



Measuring point of reciprocating engine



Measuring point of vertical machine

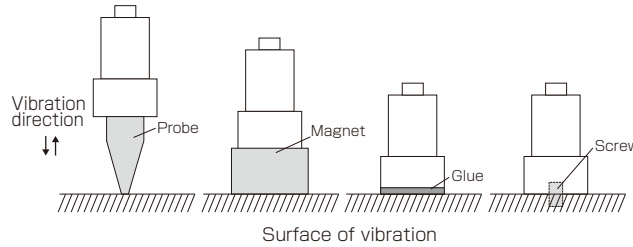


Measuring point of cantilever type pump

Reference : ISO machine condition monitoring diagnosis (vibration category II) issued by Vibration Research Association(Shindo Gijyutu Kenkyukai)

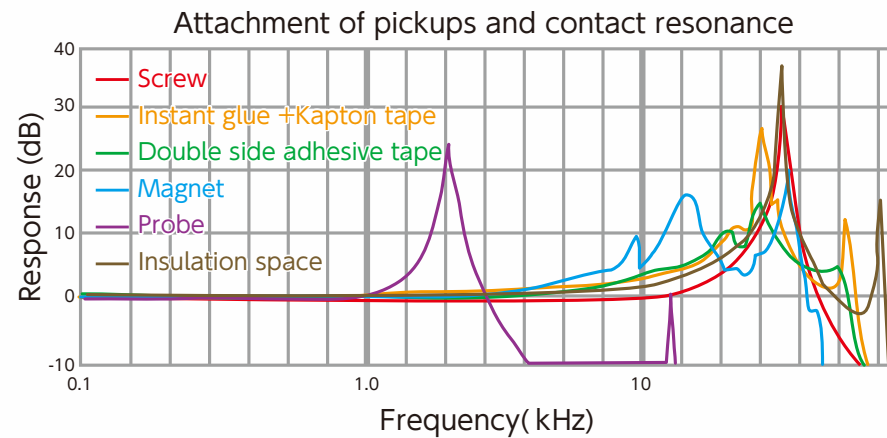
7 Method for fixing pickup

Attaching pickups incorrectly may cause dispersion of data or inaccurate measurement. Please be aware of the following points.



1. Place or attach firmly
2. Make all mount surface adhere closely
3. Align vertically or horizontally to the axis of the object

Be aware that installation of vibration sensors may differ according to measurement frequency range. Wrongly attached pickups or accelerometers may cause unstable measurement and incorrect data. Generally, measurement is 1/3 of resonance frequency.



8 Measurement method

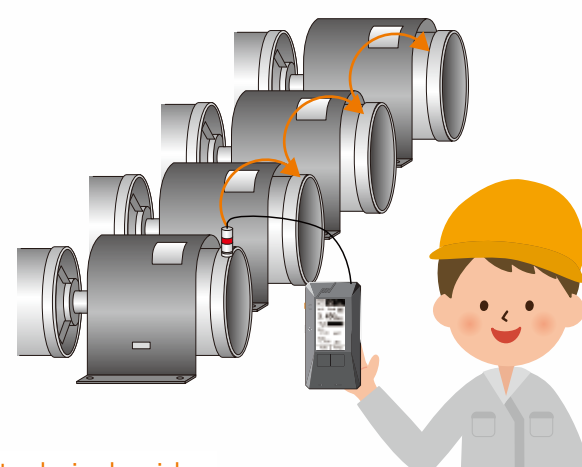
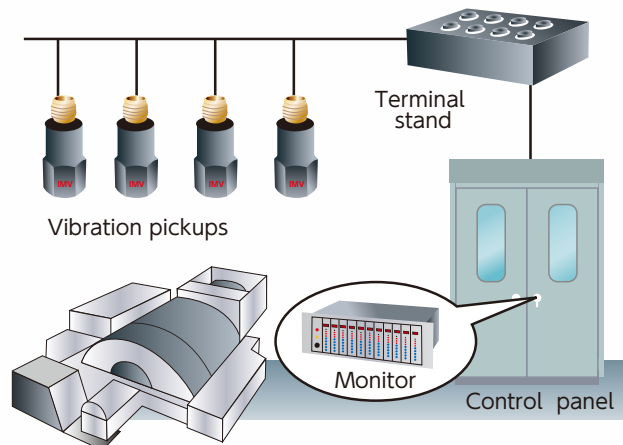
There are two types of measurement method: "Permanently online vibration monitoring system" and "Portable off-line monitoring system". It is generally used properly depending on priority of equipment importance.

Permanently online vibration monitoring system

- Machinery that :
- is important
 - operates constantly
 - cannot be approached
 - deteriorates slowly

Portable off-line monitoring system

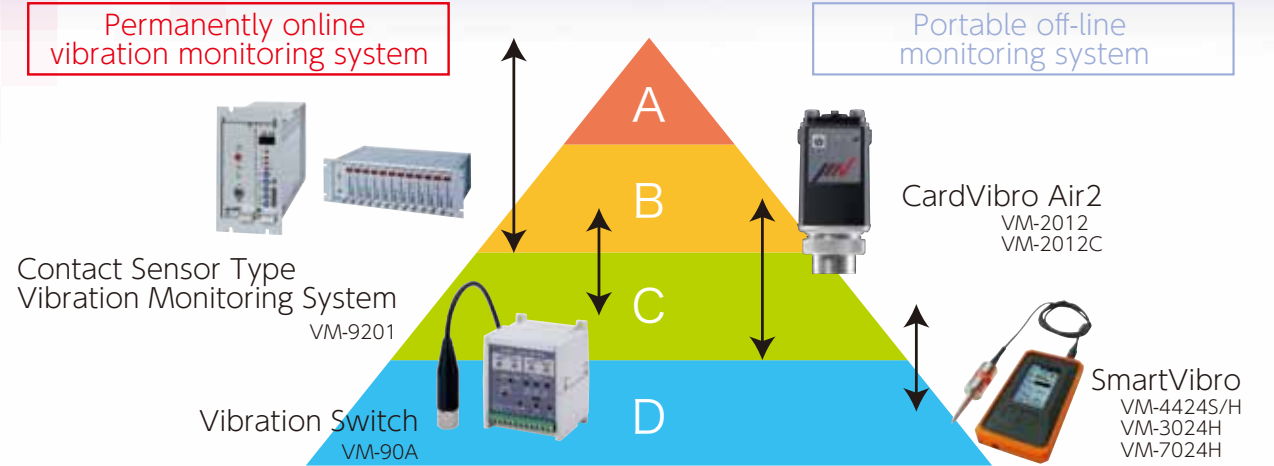
- Machinery that :
- is minimal impact from breakdown
 - is easy to be measured
 - deteriorates quickly



Chapter 4

Evaluation of vibration

1 Evaluation of facility importance



A: High value machinery
(Private power generator, High pressure compressor etc.)
Mechanical failure is directly linked to stop of operation

C: Ordinary machinery
(Intake or exhaust fan etc.)
Mechanical failure may cause inconvenient for operation

B: Important machinery
(Boiler, Pump, Compressor etc.)
Mechanical failure may cause a decrease of production

D: Low value machinery
(Small general purpose motor etc.)
Mechanical failure is not linked to operation and repair/replacement is much cheaper

2 What is simple diagnosis?

The aim is to diagnose facilities and clearly show the degree of deterioration by measuring vibration. Judgment value will be needed for precise evaluation. There are three main judgment methods in simple diagnosis. Using these three methods will ensure more accurate measurement.

1. Absolute value judgment

Facilities are classified into several types (small type, medium type, large type). It is a method that if measured vibration exceed a certain level, it is diagnosed as abnormality.

Advantage Judgment is easy because diagnosis standard is already established.

Disadvantage Judgment may change depending on types or parts of facilities and makers.

Judgement example

ISO vibration evaluation standard

This standard is widely used for synthetic judgment of rotational machinery. The current ISO standard 10816-3 : 2009 describes the absolute value judgment by velocity rms

Objective machinery is classified into 2 major groups

Machinery Group 1

Large machinery
Output: 300kW~50MW, Shaft height : > 315mm

Machinery Group 2

Medium machinery
Output: 15kW~300kW, Shaft height : 160mm~315mm

ISO 10816-3:2009 Vibration Standard Evaluation

Velocity severity (mm/s RMS)	Machinery Group2		Machinery Group1	
0.71	A	A	A	A
1.4	A	A	A	A
2.3	B	B	B	A
2.8	B	B	B	B
3.5	C	C	C	B
4.5	C	C	C	B
7.1	D	D	D	C
11.0	D	D	D	D
Foundation	Rigid	Flexible	Rigid	Flexible

A:Good B:Satisfactory C:Unsatisfactory(alert) D:Unacceptable(danger)

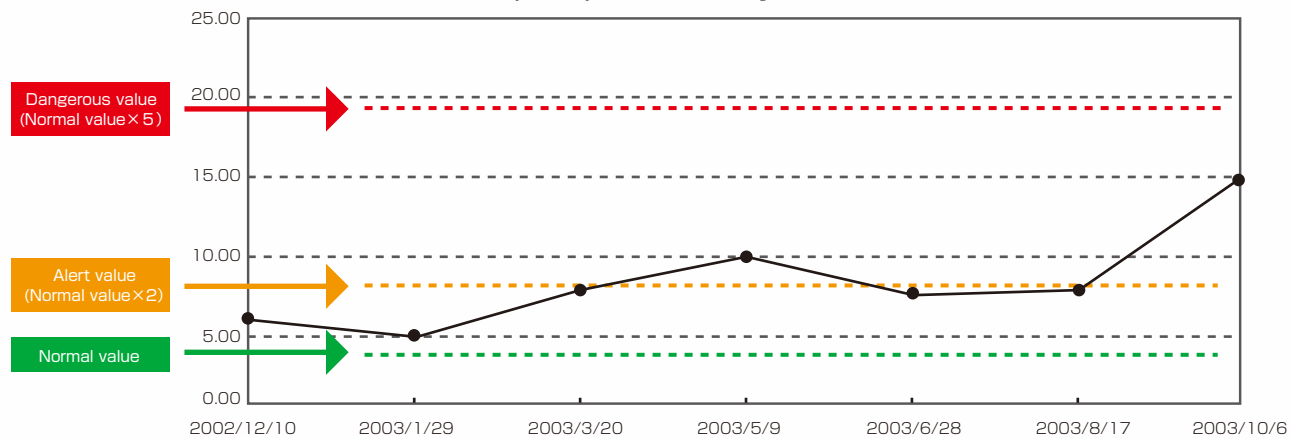
2. Relative value judgment

The method of setting up the standard velocity RMS value and comparing the normal value with some absolute values for judgment. Normal value of velocity RMS which is originally set up by someone is multiplied by x times to be regarded as "alert value" or "dangerous value". For example, when the velocity RMS value of motor shows 5.00 most of times after more than ten times measurement, "5.00" can be set up to be the normal value. 10.00 (two times as high as normal value) is set up to be alert value, 25.00 (five times as high as normal value) is "dangerous value." The normal value should be decided after more than ten times measurement.

Advantage More precise than absolute value judgment **Disadvantage** Because the normal value is decided according to each personal experiences, so ambiguity remains in the validity of the judgment values.

Judgement example This is a case which alert value is set to be two times as high as normal value. Dangerous value is set to be five times as high as normal value.

V(RMS) Trend Analysis Chart

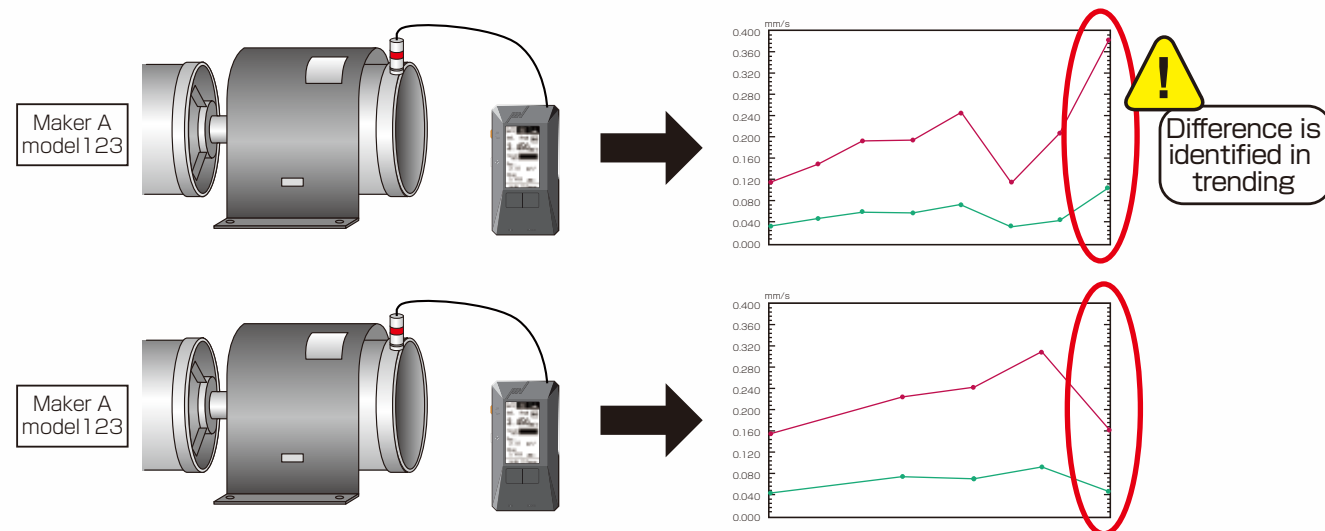


3. Intercomparison value judgment

A method of judgement by comparing vibration amount at the same measuring point of the same machine. If numerical value is more than twice as big as equivalent facilities, there is a possibility of abnormality.

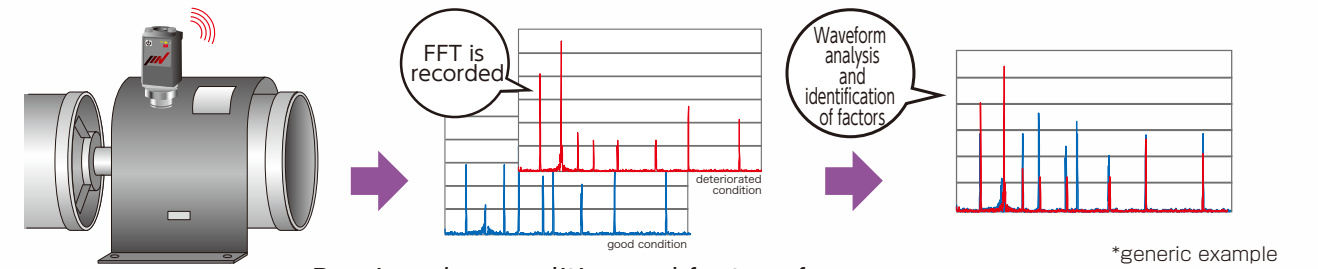
Advantage More precise than relative value judgment **Disadvantage** Applicable machinery is limited

Judgement example When there is over two times difference between the two same machinery, there may be an abnormality.



3 What is precise diagnosis?

The aim is to analyze waveform with FFT and identify machine part that have deteriorated with frequency distribution, producing more reliable results than simple diagnosis. When a normal machinery and an abnormal machinery are compared with FFT, it may show a big change at a feature frequency value. The following chart is about the feature frequency and the kinds of abnormal state.



Bearing abnormalities and feature frequency

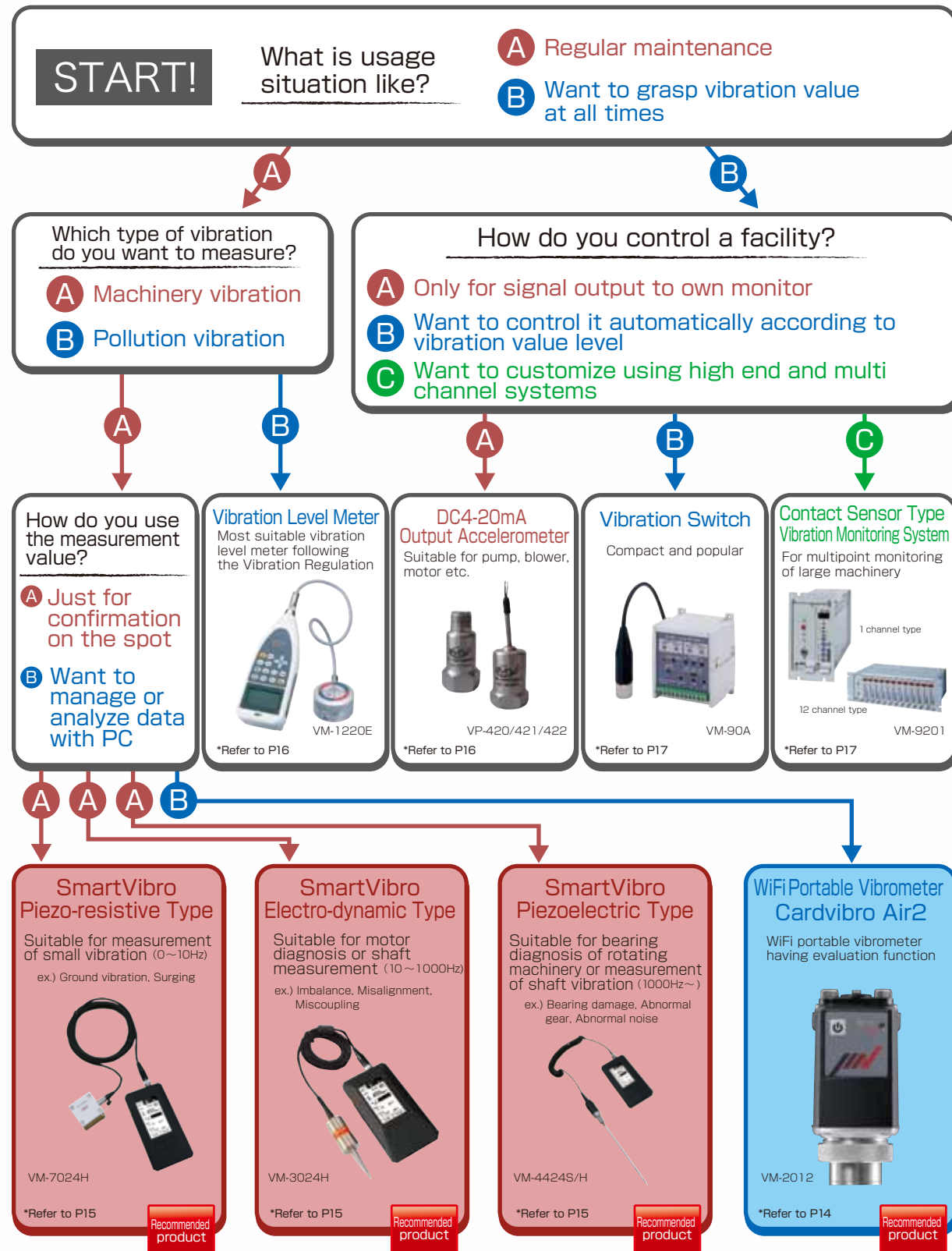
	Kinds of abnormal state	Mode to be checked*	feature frequency	
1	Imbalance	Velocity	$1 \times N/60$ and its frequency (little)	
2	Misalignment	Velocity	$M \times N/60$	
3	Ball bearing scratch	Outer ring damage	Acceleration	$0.4 \times (\text{number of ball}) \times N/60$ and its harmonics
		Inner ring damage	Acceleration	$0.6 \times (\text{number of ball}) \times N/60$ and its harmonics
		Rolling element damage	Acceleration	$2.5 \times N/60$ and its harmonics
		Cage damage	Acceleration	$0.4 \times N/60$ and its harmonics
		Grease or oil lacking	Acceleration	$N/60$ and its harmonics
		Progress of deterioration, worn-out	Acceleration	$0.4 \times (\text{number of ball}) \times N/60$ and its harmonics or $0.6 \times (\text{number of ball}) \times N/60$ and its harmonics or $0.4 \times N/60$ and its harmonics or $2.5 \times N/60$ and its harmonics
4	Gear	Grease or oil lacking	Velocity/Envelope	PHz (pitching frequency)
		Pitching (defect of tooth surface)	Velocity/Envelope	P
		Chipped tooth (partial wear)	Velocity/Envelope	$P \pm MN$
		Chipped tooth	Velocity/Envelope	MN
		Eccentricity	Velocity/Envelope	MN or $P \pm MN$ $P = Z \times N/60$
5	Bending shaft	Velocity	$1 \times N/60$ and its harmonics	
6	Cracking shaft	Velocity	$1 \times N/60$ and its harmonics	
7	Resonance	Velocity/Acceleration/Envelope	Vibration of natural frequency	
8	Electrical signal	Velocity	50 or 60 Hz	
9	Rubbing	Envelope	High frequency vibration (>1 kHz)	
10	External vibration	Velocity/Acceleration/Envelope	Depending on other facilities	

N=Number of circulation(rpm), M=Multiple(1,2,3...), P=Pitching frequency
*Abnormality described above can be recognized correctly by checking the specified mode.

Product Lineup

1 How to select a vibrometer

Your choice will depend on what type of vibration you want to measure. We have various types of vibrometer to fit your needs.



2 CardVibro Air2 (VM2012 / VM-2012C)

The first WiFi portable vibrometer in the industry. Capable of precise measurement even in the most severe conditions.



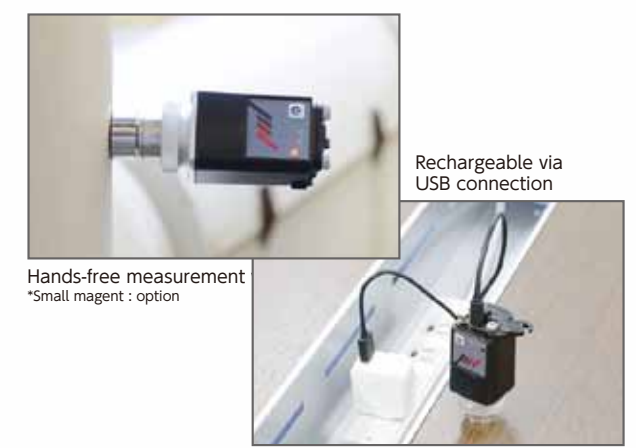
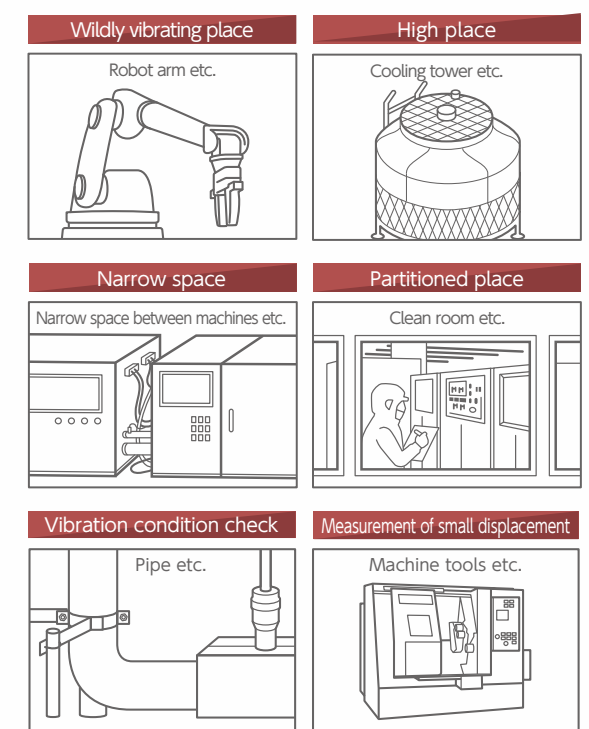
Features

- OA value, FFT and waveform can be saved
- Light and compact size
- Low power consumption (continuous 6 hour operation with 2 AAA batteries)

Remote measuring with WiFi



Wireless CardVibro Air2 is available at any measuring situation



Find more on the web

3 SmartVibro (VM4424S·H / VM3024H / VM7024H)

Simultaneously measures acceleration, velocity and displacement

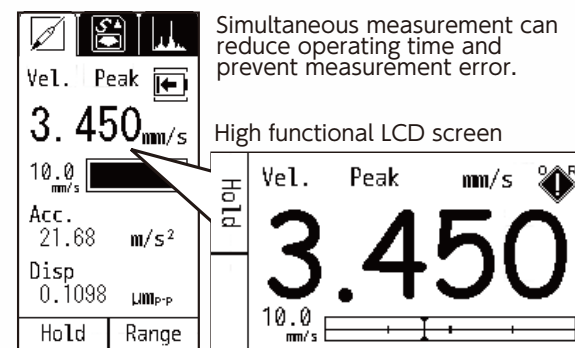
Features

- Low price and high efficiency
- Simultaneous measurement of acceleration, velocity and displacement
- Measurement of PEAK, RMS and EQP
- FFT analysis*
- Waveform data is saved to SD card*

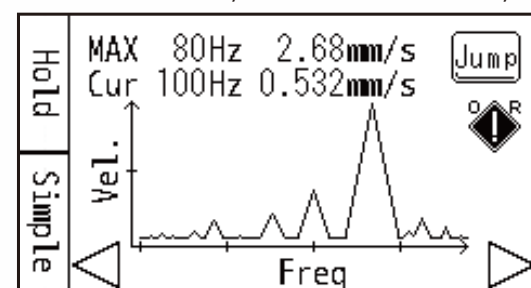
*VM-3024H/VM-4424H/VM-7024H only



VM-3024H
*Rubber jacket is option

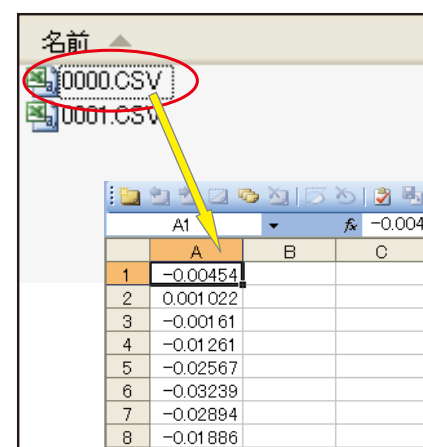


Immediate FFT analysis in case of abnormality



*VM-3024H/VM-4424H/VM-7024H only

CSV data can be saved to attached SD card



*VM-3024H/VM-4424H/VM-7024H only



Find more on the web

4 Vibration level meter (VM1220E)

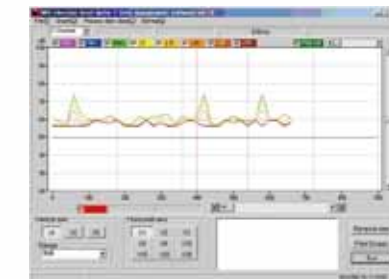
Ideal for measurements of construction vibration or traffic vibration.

Features

- Awarded Model Approval as a "Vibration Level Meter" according to Japanese Industrial Standard JIS C 1510-1995 by Measurement Act (Model Approval NO. W033)
- Three-directional operation simultaneously measures vibration level, vibration acceleration level, and power average
- Approx. 550 operation value data capacity



VM-1220E



data management screen image



Find more on the web

5 DC4-20mA output accelerometer (VP-420 / VP-421 / VP-422)

Pickup for pump, blower, motor etc. Easy installation

Features

- Small size, light weight
- Alarm controller is not necessary
- Varied lineup according to field environment
- Choice of studs for easy setup

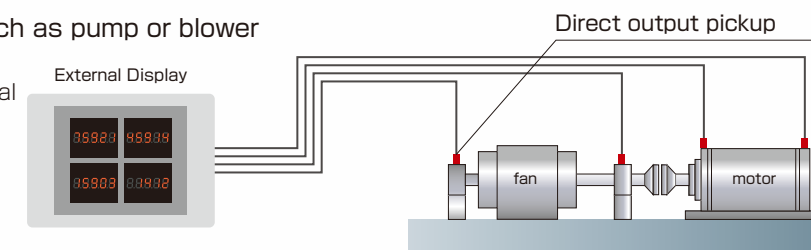


VP-420/421/422

Application

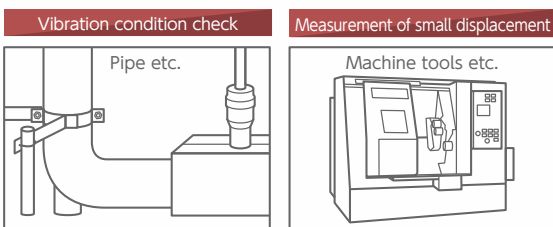
Rotating machinery such as pump or blower

With direct connection of sensor cable to an external display, trend monitoring is available.



Find more on the web

SmartVibro is available at any measuring situation



Three usable pickups ... suitable for various measurement scenes

VP-4316 Piezoelectric type for wide frequency range
(most suitable vibrometer) VM-4424S/VM-4424H

VP-3024 Electro-dynamic type for small amplitude displacement
(most suitable vibrometer) VM-3024H

VP-7000L Piezo-resistive type for low frequency vibration
(most suitable vibrometer) VM-7024H

6 Vibration switch (VM-90A)

Compact and popular type



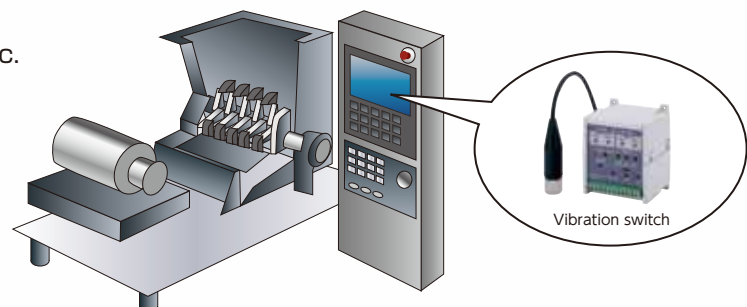
VM-90A

Features

- Short delivery, low cost
- Changeover type for measurement mode and range
- Two step alarm setting, level output
- Compatible with intrinsically safe pickups

Application

Machine tool, crusher etc.
Installs inside machine tool or crusher.
Halts operation in case of abnormality.



Vibration switch



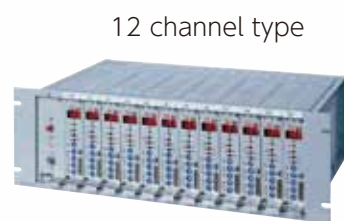
Find more on the web

7 Contact sensor type vibration monitoring system (VM-9201)

For multipoint monitoring of large machinery



1 channel type



12 channel type

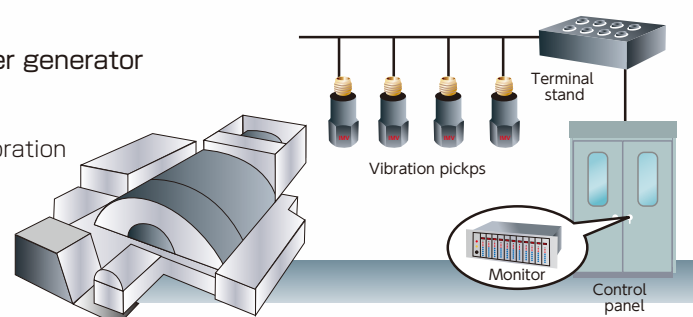
VM-9201

Features

- High performance, multi channel, customizable
- Individual setting of range and function is settable by each channel
- Various pickups are prepared according to frequency or temperature

Application

Large motor inside private power generator
Cable is connected from pickups to monitoring systems.
Monitoring systems can monitor vibration values and sound the alarm in an emergency.



Monitor

Control panel



Find more on the web

8 Maintenance guide

Vibration measuring systems

Systems to be inspected at our factory

- Details
 - Inspection / calibration / comprehensive dynamic calibration after operation verification
 - Submission of reports and test results
 - Traceability chart and calibration certificate are issued on request.
 - *Cost estimation will be presented for repair or replacement of consumables.
- Required days
 - Ten days after receipt at our factory
 - *Required days may be changed depending on situation.
- Covered equipments
 - [Portable type] VM-4424S/H, VM-2004Neo etc



VM-4424S/H

Vibration monitoring systems

Inspection is carried out at site

- Details
 - Function inspection for each section by input of equivalent electronic signal
 - Sensitivity calibration or performance check by exiting pickup using a calibration system
 - Submission of report and test results
 - *Cost estimation will be presented for repair or replacement of consumables.
- Maintenance check at site
 - Carrying out above check items and replacement of consumables
 - Drawing up maintenance contract
- Required days
 - Inspection will be finished in two weeks after order.



VM-9201

Systems to be inspected at our factory

- Details
 - Inspection / calibration / operation verification/ comprehensive dynamic calibration
 - Submission of reports and test results
 - *Cost estimation will be presented for repair or replacement of consumables.
- Covered equipments
 - Vibration switch / Vibration monitoring system

Check or inspection examples

Period	Check contents	Replacement parts
On delivery	System work check	—
1~3yrs	Periodic inspection	—
3~6yrs	Periodic inspection	—
6~10yrs	Overhaul	Power supply/Relays/Capacitors
10~14yrs	Periodic inspection	—
14~16yrs	Overhaul	Power supply/Relays/Pickup
16yrs~	Periodic inspection	—

*Replacement parts may vary model to model.