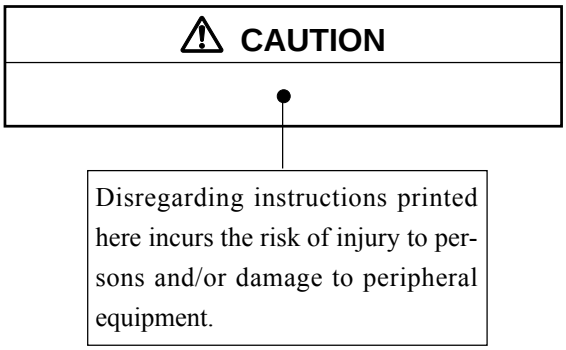
INSTRUCTION MANUAL
Multi Machine Checker
VM-70

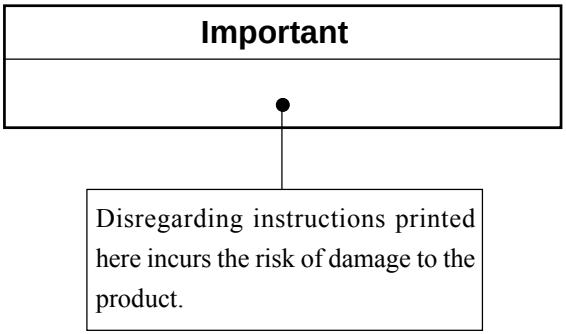
RION CO., LTD.

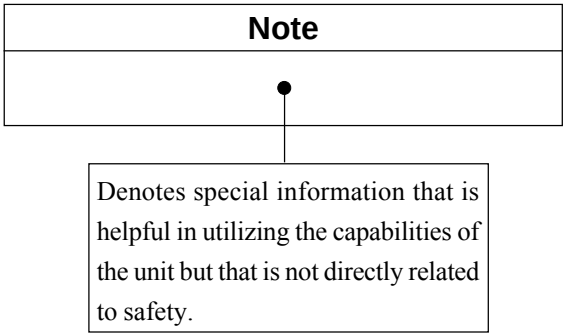
3-20-41 Higashimotomachi, Kokubunji, Tokyo 185-8533, Japan

For Safety

In this manual, important safety instructions are specially marked as shown below and next page. To prevent the risk of death or injury to persons and damage to the unit or peripheral equipment, make sure that all instructions are fully understood and observed.







Precautions

- Operate the unit only as described in this manual.

- Do not disassemble the unit or attempt internal alterations.

- Use the unit only under the following ambient conditions: -10 to +50ºC, relative humidity between 30 % and 90 %.

- Do not store or use the unit in locations where the unit may be subject to
  - splashes of water or oil, or high levels of dust,
  - air with high salt or sulphur content, or other gases or chemicals,
  - high temperature, high humidity, or direct sunlight,
  - directly transmitted strong vibrations or shock.

- Service and maintenance
  This unit has undergone strict quality testing and performance checks at the factory before shipping. However, due to factors such as
  - improper handling
  - excessive shocks (such as dropping the unit)
  - long exposure to high temperatures or high humidity,

  malfunction can occur which requires servicing. In such a case, please pack the unit in its original box or other suitable material to protect it from damage during transport and contact your supplier.

- Do not exert force on the LCD panel and temperature sensor, to prevent possible malfunction or damage.

- Take care that the unit does not get caught in rotating machinery, and take precautions against burns when making temperature measurements.

Contents

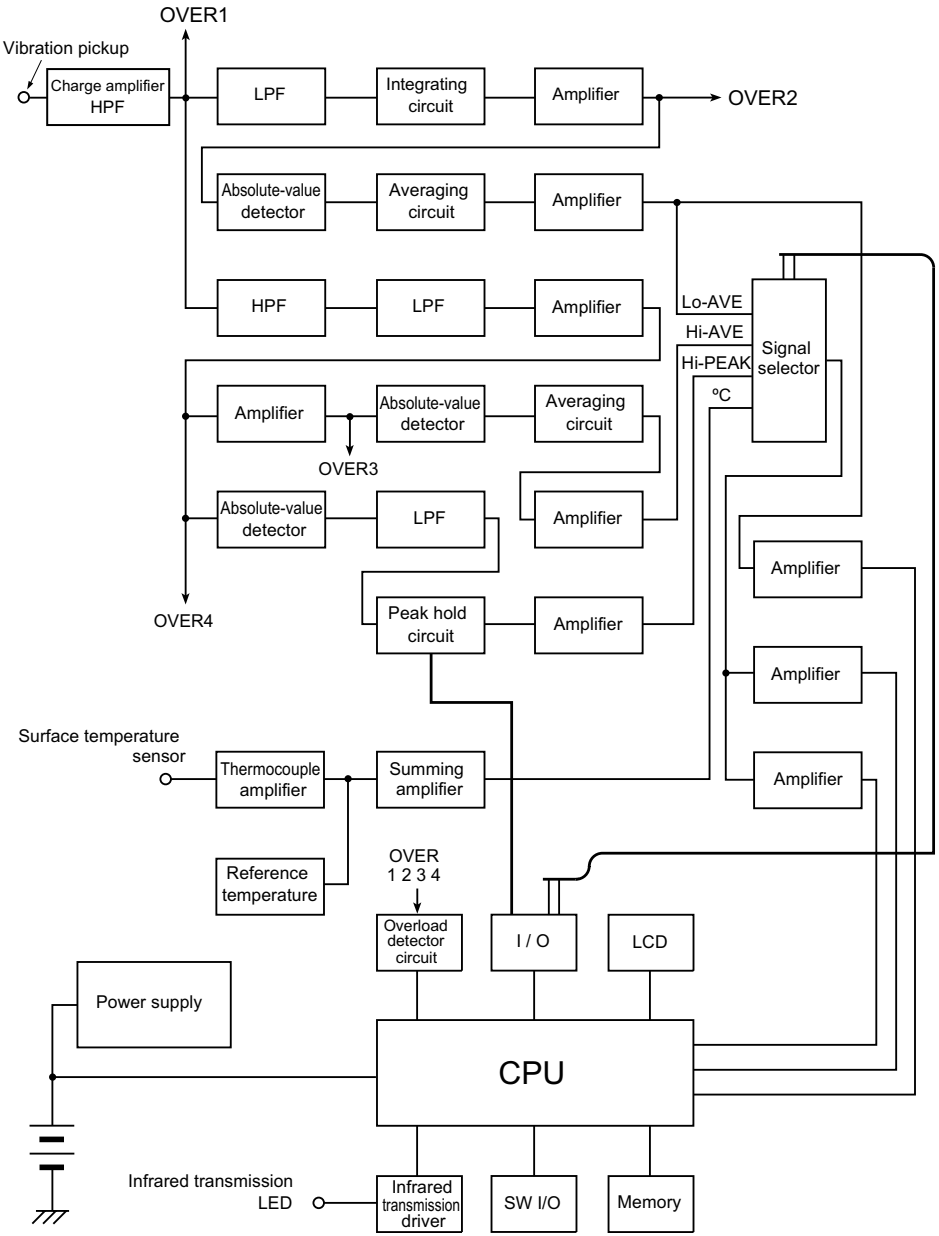
Simple Diagnostic Checks of Rotating Machinery 27

Outline

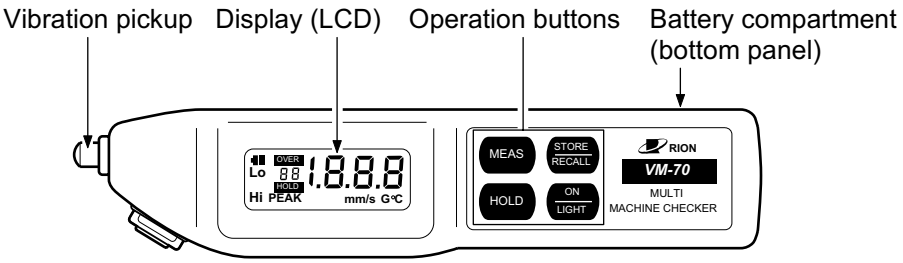
The Multi Machine Checker VM-70 is designed to perform simple diagnostic checks on rotating machinery. The unit simultaneously measures vibration velocity--suitable for identifying unbalanced rotation, misalignment, rattle, oil whipping, etc.--and acceleration in the high frequency range suitable for diagnosis of bearing problems and aging. A built-in temperature sensor allows concurrent measurement of the machinery surface temperature.

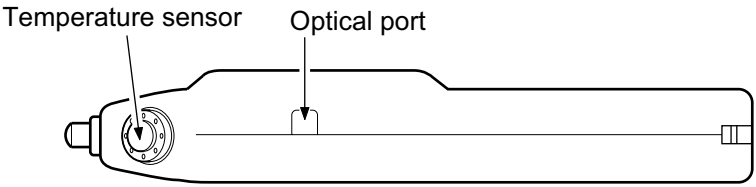
Data for up to 100 points can be stored in the internal memory. Using the built in IrDA compatible optical port, data can be transferred to a computer via an infrared link.

Block Diagram



Controls and Features





Vibration pickup Hold this section against the point where vibrations are to be measured.

Temperature sensor Hold this section against the point where temperature is to be measured.

Display (LCD) Shows measurement values and unit settings.

Battery compartment Contains two IEC R03 (size AAA) alkaline batteries.

Optical port Infrared port which serves for sending data to a computer equipped with a compatible port. The maximum distance for transmission is 10 cm.

Operation buttons

MEAS button

During measurement, hold, or recall, each push of this button switches the measurement mode in the following sequence:
ºC (temperature) → Lo (vibration velocity average) → Hi (vibration acceleration average) → Hi PEAK (vibration acceleration peak) → ºC (temperature)
During hold and recall, keeping the button depressed for at least 2 seconds switches to normal measurement.

STORE/RECALL button

During normal measurement:
The button serves as recall button to call data stored in the memory onto the display.

During hold: The button serves as store button to store hold data only in memory. After storing, the unit automatically reverts to normal measurement mode.

During recall: The button moves through recalled data addresses in descending order. Keeping the button depressed for at least 2 seconds causes fast switching.

When unit is OFF:
Turning the unit ON while keeping this button depressed clears data from memory.

HOLD button

During normal measurement:
Vibration and temperature values are held separately. When vibration measurement mode is selected, the three vibration data only are held. When temperature measurement mode is selected, the temperature value only is held.

During hold: Hold data are sent out via the optical port.

During recall: Data from up to 10 addresses in descending order are sent out via the optical port.

ON/LIGHT button

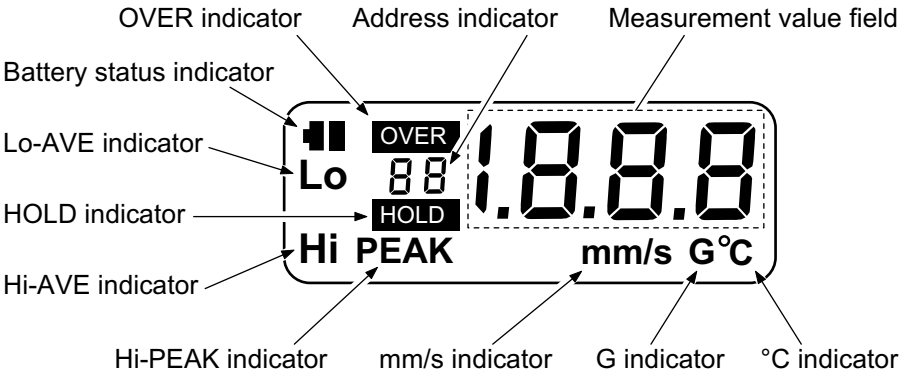
When unit is ON:

The button serves to turn the display backlight on and off.

When unit is OFF:

The button turns power to the unit on. The unit does not have a power OFF switch. It automatically turns itself off when no buttons have been operated for 10 minutes.

● Display



Battery status indicator

Regardless of the measurement mode, this indicator shows the remaining battery capacity in two stages. When the remaining battery capacity is low, the entire indicator flashes.

OVER indicator

This indicator appears when the measurement value has exceeded the measurement range. It also appears when held or recalled data contain overload.

HOLD indicator

This indicator appears when the unit is in hold mode. Hold mode can be controlled separately for vibration and temperature values.

Address indicator

In the hold mode and recall mode, this field shows addresses in the range from 00 to 99. During normal measurement, the display is blank.

Measurement value field

The measured value is shown here. The display is updated every 2 seconds.

Lo-AVE indicator

The "Lo" indicator appears when the Lo-AVE (low average) mode is selected.

Hi-AVE indicator

The "Hi" indicator appears when the Hi-AVE (high average) mode is selected.

Hi PEAK indicator

The "Hi PEAK" indicator appears when the Hi PEAK (high peak) mode is selected.

mm/s indicator

This indicator is shown when the measurement mode is "Lo-AVE".

G indicator

This indicator is shown when the measurement mode is "Hi-AVE" or "Hi-PEAK".

°C indicator

This indicator is shown when the temperature measurement mode is selected.

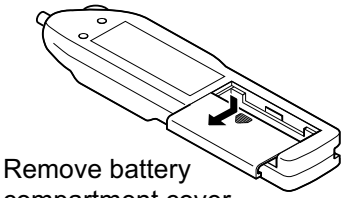
Preparations

● Inserting the Batteries

1. Open the battery compartment cover on the rear of the unit.

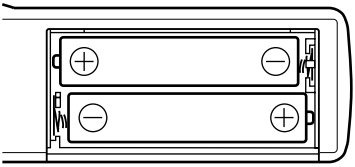
2. Insert two IEC R03 (size AAA) alkaline batteries. Take care to establish correct polarity, as shown in the compartment.

3. Replace the battery compartment cover.



Remove battery compartment cover

Insert batteries



Important
Replace both batteries at the same time, and use only fresh batteries of the same type. Remove the batteries from the unit if it is not to be used for an extended period, to prevent possible damage caused by battery fluid leakage.

Power ON/OFF

● Power ON

Press the ON/LIGHT button to turn the unit on.

Note
If the ambient temperature is very low (under about 10 ºC) or if the batteries are nearly exhausted, it may be difficult to turn the unit on.

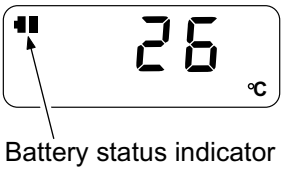
● Power OFF

This unit does not have a power OFF switch. It automatically turns itself off when no buttons have been operated for 10 minutes (auto power off).

Battery Status Indicator and Battery Life

● Battery Status Indicator

A rough indication of remaining battery capacity is given by the indicator in the upper left corner of the display. When this indicator begins to flash, replace both batteries with fresh ones.



Indicator shape	Battery status
	Battery capacity high
	Battery capacity medium
 (flashing)	Replace batteries

● Battery Life

The approximate life of one set of batteries is approx. **8 hours** of continuous operation
(at 20ºC, without using the backlight and infrared data transfer).

Note
When backlight and infrared data transfer are used, battery life will be about 15 % shorter. Actual battery life will vary, depending on usage conditions, ambient conditions, battery type, etc. At very low temperatures (10ºC and below), battery life will be considerably shorter.

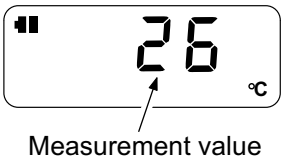
Measurement

When the unit is turned on by pressing the ON/LIGHT button, the normal measurement mode is activated. Using the MEAS button, you can select measurement modes. The button cycles through the modes as shown below.

Measurement	Display indication
Temperature	ºC
Vibration velocity average (Lo-AVE)	Lo, mm/s
Vibration acceleration average (Hi-AVE)	Hi, G
Vibration acceleration peak (Hi-PEAK)	Hi PEAK, G

Temperature

Hold the temperature sensor against the measurement object. The measurement range is 0.1 to 100ºC.



Vibration

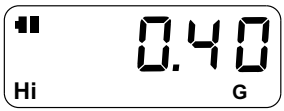
Hold the vibration pickup against the measurement object.

• Vibration velocity average (Lo-AVE)

The average vibration velocity value in the range from 5 Hz to 1 kHz is displayed.

• Vibration acceleration average (Hi-AVE)

The average vibration acceleration value in the high frequency range is displayed. This is a relative value, not an absolute value.



• Vibration acceleration peak (Hi-PEAK)

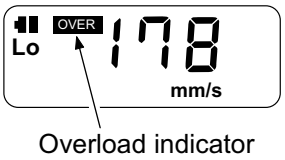
The peak vibration acceleration value in the high frequency range is displayed. This is also a relative value, not an absolute value.

• An overview of the different display modes is given in the table below.

Display	Measurement mode	Vibration frequency range
ºC	Temperature	–
Lo mm/s	Vibration velocity average Lo-AVE	5 Hz to 1 kHz
Hi G	Vibration acceleration average Hi-AVE	Center frequency 32 kHz Bandwidth approx. 550 Hz (-3 dB)
Hi-PEAK G	Vibration acceleration peak Hi-PEAK	

• Overload indicator (OVER)

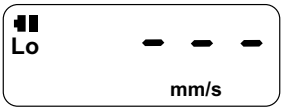
This indicator appears when saturation has occurred in the input circuit. In this case, accurate measurement results will not be obtained.



Overload indicator

• – – – display

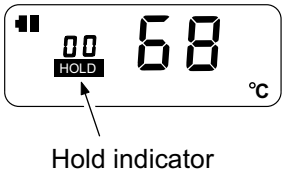
The display only shows "– – –" if the measurement value exceeds 199 (19.9 in Hi-AVE mode).



● Measurement Value Hold

Pressing the HOLD button during measurement causes the measurement value to be held (maintained) by the unit. The HOLD indicator and the address appear on the display.

- The address indicator shows the address that will be used if the value is stored. When 100 data have already been stored, the address indicator shows "– –".



Hold indicator

Note
When hold is activated while a vibration measurement mode is selected, all 3 vibration values are held. When hold is activated while the temperature measurement mode is selected, only the temperature value is held. To hold the values of all 4 modes, activate hold in vibration and temperature mode.

• Deactivating hold

In the hold condition, keeping the MEAS button depressed for at least 2 seconds cancels hold and returns the unit to normal measurement mode.

Note
Deactivating hold in any vibration mode will cancel hold for all three vibration modes. If hold was activated both in temperature and vibration measurement mode, it must be deactivated separately in a vibration measurement mode and in the temperature measurement mode.

● Measurement Value Store

Pressing the STORE/RECALL button while a measurement value is held causes the value to be stored in the memory of the unit.

The following information is stored:

- Measurement value
- Measurement mode
- Overload status

When the STORE/RECALL button is pressed, the display briefly goes off, shows the address for 0.5 seconds, and then reverts to normal measurement mode.

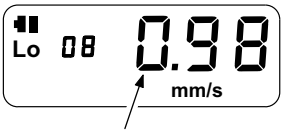
Up to 100 data (address 00 to 99) can be stored.

Note

- Addresses are automatically selected by the unit, in ascending order of free addresses. It is not possible to specify an address.
- When 100 data have been stored, further data cannot be stored without clearing the memory. To do this, turn the unit off, and then keep the STORE/RECALL button depressed while you turn the unit on. All data stored in the memory will be cleared.

● Recall Mode

When the STORE/RECALL button is pressed in normal measurement mode, an address number and the data stored in that address are shown.



Stored measurement value

• Changing the measurement mode

Press the MEAS button to change the measurement mode.

• Changing the address

Each push of the STORE/RECALL button in recall mode switches the address down by one count. Keeping the button depressed for at least 2 seconds switches addresses quickly.

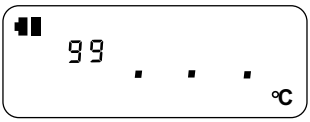
• Canceling the recall mode

Keeping the MEAS button depressed in recall mode for 2 seconds or more will cancel recall mode. The unit switches back to normal measurement.

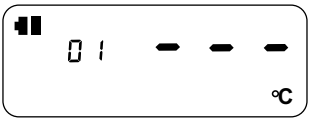
Note

Display if there are no stored data

- If there are no stored temperature or vibration data at the current address, the display shows "**. . .**".



- If there are either temperature or vibration data at the current address, the display shows "– – – ".



● Memory Clear

Turning the unit on while holding down STORE/RECALL clears the memory.

● Backlight

Each push of the ON/LIGHT button toggles the display backlight on and off. Also if not turned off by the user, the backlight will turn itself off automatically after about one minute.

Note

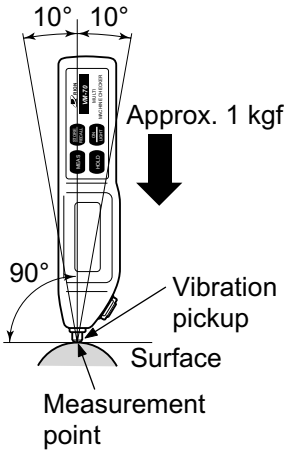
If the batteries are nearing exhaustion, the backlight will be darker.

Measurement Precautions

● Vibration Measurement

Measurement point

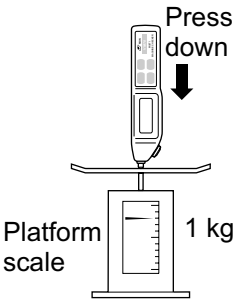
Choose a point on the housing of the bearing or a point where surrounding parts have high rigidity. A flat, metal surface to which the pickup of this unit can be directly pressed is best. Measure vibration in three planes: axial direction, horizontal direction and vertical direction. For details, please refer to the section "Measurement Points" (page 33).



Measurement procedure

1. Select the measurement mode with the MEAS button.
2. Hold the vibration pickup against the measurement surface of the machine. The probe should be held at a right angle (90° ±10°), and the pressure should be about 1 kgf.

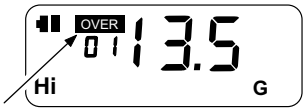
Note
When measuring vibration acceleration (indication mode Hi-AVE or Hi-PEAK), the reading will vary slightly, depending on the pressure with which the probe tip of the unit is pressed against the measurement surface. If you are new to this kind of measurement, it may be advisable to use a platform scale or the like to practice achieving the right amount of pressure. Please refer to the illustration at right.



3. Verify that the reading has stabilized, and press the HOLD button.
   The value will be held also after removing the unit, allowing you to easily read the display. You can also select a different measurement mode by pressing the MEAS button.

Note

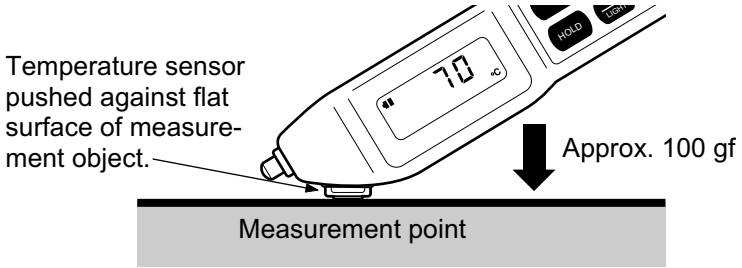
When the display range of this unit is exceeded, the indication "OVER" appears on the display, and the indicated value is not reliable.



Indicates overload

● Temperature Measurement

1. Select the measurement mode with the MEAS button.
2. Hold the temperature sensor against a flat, stationary measurement surface of the measurement object. The pressure should be about 100 gf.
3. Use the hold mode to easily read the measurement value after removing the unit from the measurement object.



Important

- Do not measure temperatures above the rated limit of the unit (100 °C).
- After a measurement, the temperature sensor may be hot and should not be touched.
- Do not exert excessive force on the temperature sensor to prevent deformation. Avoid pushing it with your finger or with sharp objects.

Infrared Data Transfer

The internal optical (infrared) port of the unit can be used to send hold data and store data to a computer equipped with an IrDA compatible port.

Note
On some computers it may not be possible to select IrDA communications (such as on desktop computers where the IrDA port was later added as an option).

● Transfer Principle

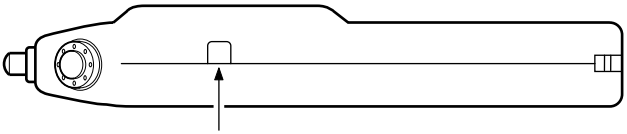
Transfer principle	:	Unidirectional transfer
Data word length	:	8 bits
Stop bits	:	1bit
Parity	:	None
Baud rate	:	9600 bps

● Hold Data Transfer

Pressing the HOLD button while the unit is in hold mode sends the data that are being held at the moment.

● Store Data Transfer

Pressing the HOLD button while the unit is in recall mode sends recall data stored in the unit. Data from up to 10 addresses in descending order are sent out via the optical port.



Place the unit so that the optical port faces the optical port on the computer. The maximum distance between the two units is 10 cm.

Note
The VM-70 is a send-only unit. It does not have reception capability.

Infrared data transfer

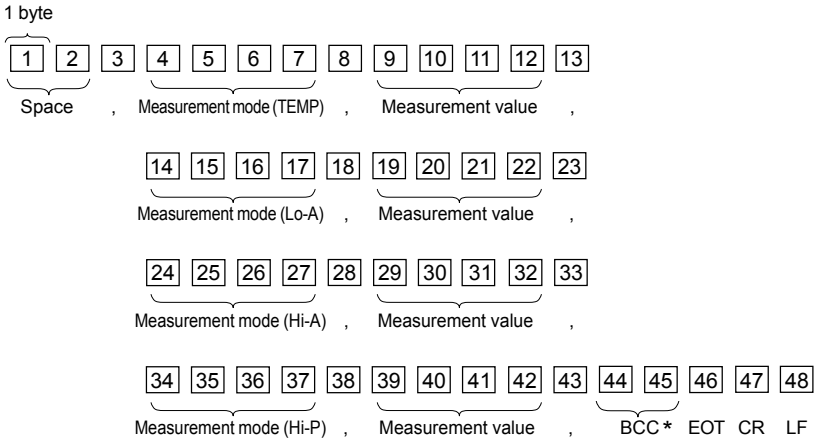
- Infrared data transfer can be adversely affected by strong external light as well as by the angle of the units to each other and the distance between them. Avoid direct sunlight and strong light sources when making a transfer.
- The maximum allowable distance between the units is 10 cm, but this may be shorter if the batteries in the VM-70 are not fresh.
- Before attempting to use the infrared data transfer feature, check the specifications and documentation for the computer and make sure that it is compatible. Even on some computers equipped with an optical port, data transfer with the VM-70 may not be possible.

● Send Data

Data structure

1. Hold data

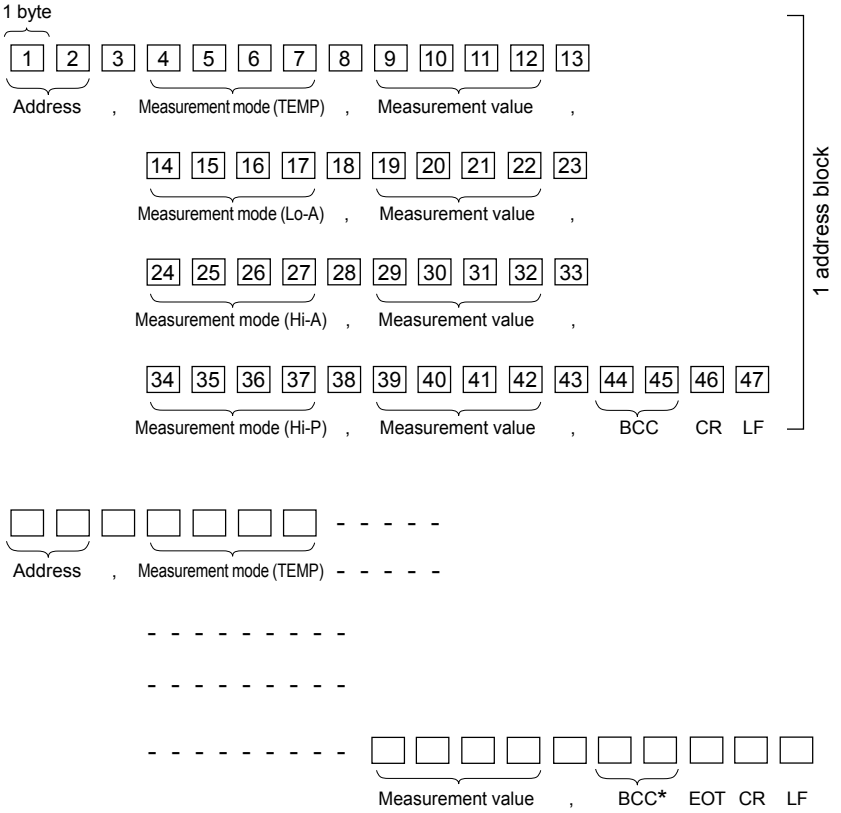
Measurement values are sent in the order temperature (TEMP), Lo-AVE, Hi-AVE, Hi-PEAK.



*BCC is calculated for 1 to 43.

2. Recall data

The address and the measurement values for the four modes form one block. Up to 10 blocks (data for 10 addresses) are sent.



*BCC is calculated for 1 to 43, for each block.

- Address : 2 bytes, ASCII string
- Measurement mode :

  4 bytes, ASCII string

Temperature	"TEMP"
Lo-AVE	"Lo-A"
Hi-AVE	"Hi-A"
Hi-PEAK	"Hi-P"

- Measurement value :

  4 bytes for each value, ASCII string

  Padded with spaces if measurement value is less than 4 bytes.
- BCC : Block check code

  2 bytes, ASCII string

<BCC principle used by VM-70>

XOR is determined for each data byte.

The XOR result is divided into the upper byte and lower byte.

30H is added to each, for use as BCC.

Example

If XOR result is 7AH, the BCC is 37H 3AH.

Reference (ASCII code shown in brackets)

"0"	(30H)	" : "	(3AH)
"1"	(31H)	" ; "	(3BH)
"2"	(32H)	"<"	(3CH)
"3"	(33H)	"="	(3DH)
•	•	">"	(3EH)
•	•	"?"	(3FH)
"9"	(39H)		

• Other data :	Data delimiter	" , " (2CH)
	Measurement block delimiter	CR LF (0DH 0AH)
	Transfer end	EOT CR LF (04H 0DH 0AH)
	Space	"_" (20H)
	Decimal point	" . " (2EH)

<Example>

Data : address = 01, TEMP 45, Lo-A 0.10, Hi-A 2.3, Hi-P 100

Output codes : 30H 31H 2CH 54H 45H 4DH 50H 2CH 20H 20H 34H 35H 2CH
(0 1 , T E M P , _ _ 4 5 ,

4CH 6FH 2DH 41H 2CH 30H 2EH 31H 30H 2CH
L o - A , 0 . 1 0 ,

48H 69H 2DH 41H 2CH 20H 32H 2EH 33H 2CH
H i - A , _ 2 . 3 ,

48H 69H 2DH 50H 2CH 20H 31H 30H 30H 2CH
H i - P , _ 1 0 0 ,

37H 3FH 04H 0DH 0AH
BCC EOT CR LF)

Note
When the measurement value was "OVER", "– – – –" is sent.

Example for Infrared Data Transfer Procedure

Using the Windows 95 software application HyperTerminal, measurement data can be transferred to a computer via the infrared link. However, some computers, even if equipped with an optical port, may not be compatible. Please consult the documentation of the computer and of Windows 95 before proceeding.

To access HyperTerminal, open the Start menu and select "Programs", then "Accessories". In HyperTerminal, make the following settings.

Baud rate	:	9600 bps
Data bits	:	8 bits
Parity	:	None
Stop bits	:	1 bit
Flow control	:	None

After the settings have been made, you can send data. Point the optical port on the VM-70 towards the optical port of the computer.

Data transfer example on the Japanese platform

Note

The data received with HyperTerminal can be saved as a file and then imported for example into spreadsheet software for further processing. (Specify "comma" as a delimiter.)

Specifications

Vibration pickup

Type	Piezoelectric acceleration pickup (shear-type)
Measurement pressure	1 kgf
Resonance frequency	Approx. 32 kHz
Resonance frequency range	Approx. 550 Hz (-3 dB point)
Sensitivity	Approx. 18 pC/G (at 80 Hz)
	Approx. 55 pC/G (at resonance frequency)

Temperature sensor

Type	Thermocouple sensor
Measurement pressure	Max. 100 gf
Maximum allowable temperature	100 ºC
Response time	Max. 10 s

Measurement modes

Lo-AVE (vibration velocity average)

Frequency range	5 to 1000 Hz
Display range	0.10 to 1.99, 2.0 to 19.9, 20 to 199 mm/s

Hi-AVE (vibration acceleration average)

Frequency range	Center frequency 32 kHz, bandwidth approx. 550 Hz
Display range	0.01 to 1.99, 2.0 to 19.9 G (relative value)

Hi-PEAK (vibration acceleration peak)

Frequency range	Center frequency 32 kHz, bandwidth approx. 550 Hz
Display range	0.1 to 19.9, 20 to 199 G (relative value)

Temperature

Display range	0.1 to 19.9, 20 to 100ºC

Display modes

Lo-AVE, Hi-AVE	Average of 10 sampled data, 200 ms cycle
Hi-PEAK	Median of 10 sampled data, 200 ms cycle
TEMP	Sampled data, 2 s cycle
Display cycle	Approx. 2 s
HOLD	Display value is maintained

Liquid-crystal display

Measurement value	Display range 001 to 199
Measurement modes	Lo-AVE (mm/s), Hi-AVE (G), Hi-PEAK (G), TEMP (ºC)
Memory addresses	00 to 99
Overload indication	OVER
Data hold indication	HOLD
Battery status indication	Two-segment display
Backlighting	LED backlight

Data memory Manual store of up to 100 data sets (00 to 99). All display items (except battery status) are stored.

Infrared communication port (for data transfer to devices with IrDA compatible port)

Maximum distance	10 cm
Data word length	8 bits
Stop bits	1 bit
Baud rate	9600 bps

Ambient temperature range for use -10 to +50 ºC, 30 to 90 % RH

Power supply IEC R03 (size AAA) battery × 2

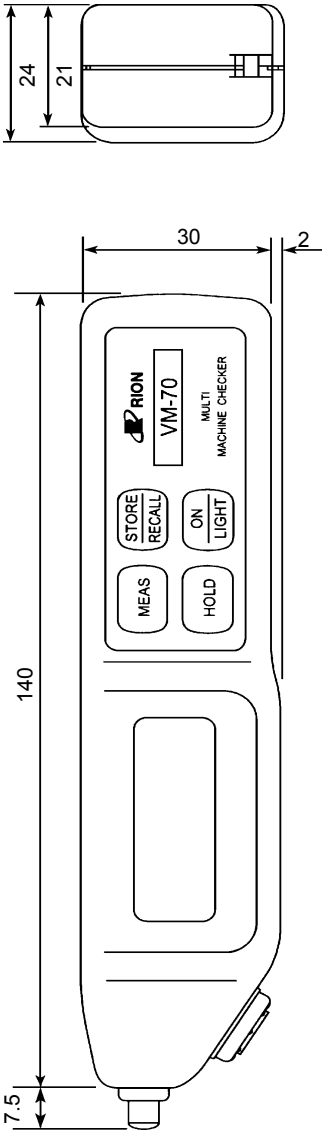
Power consumption	Approx. 75 mA (power supply voltage 3 V, backlight off)
Battery life with continuous use	Approx. 8 hours (with alkaline batteries, at 20 ºC)
Auto power-off function	Automatic shutoff after 10 minutes of switch inactivity

Dimensions / Weight 147.5 (D) × 32 (W) × 24 (H) mm / Approx. 70 g

Supplied accessories

Carrying case	1
IEC R03 (size AAA) battery	2
Instruction manual	1
Inspection certificate	1

Dimensional Drawing (unit: mm)



Dimensional drawing of Multi Machine Checker VM-70

Simple Diagnostic Checks of Rotating Machinery

Rotating Machinery Vibrations and Diagnosis Principles

Various kinds of vibrations occur in rotating machinery, ranging from low to high frequencies. When there are problems such as unbalanced rotation, misalignment, rattle, or oil whipping, vibrations in the low frequency range will increase in level. The Lo-AVE mode of the VM-70 is designed to measure such vibrations.

When the inner or outer ring or the runner of a roller bearing is damaged, the shaft will contact these parts with each rotation, causing shock pulses of varying intensity. If the problem is still in the early stages, the shock pulse intensity will increase in proportion to the amount of damage. When the shock pulses are represented as vibration, a damped high-frequency waveform such as shown in Fig. 1 is the result. The Hi-AVE and Hi-PEAK modes of the VM-70 serve to detect such phenomena in the high-frequency range.

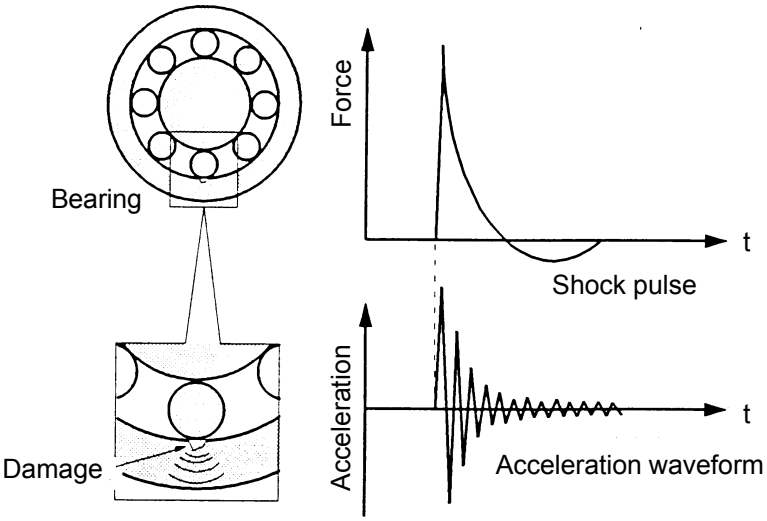


Fig. 1 Shock vibrations in a roller bearing

The amplitude of vibration acceleration is proportional to the magnitude of the roller bearing defect.

Therefore the shock waveform peak value (P) shown in Fig. 2 (a) or the waveform average value (A), obtained from processing the shock waveform absolute value, shown in Fig. 2 (b) can both be used as a reference for diagnosing problems. For reasons of display stability, the average value is normally used. In machinery with low rotation speeds (below 300 rpm), the average value will be fairly low, making it difficult to judge the normal/abnormal condition. In such cases, the peak reading will be useful.

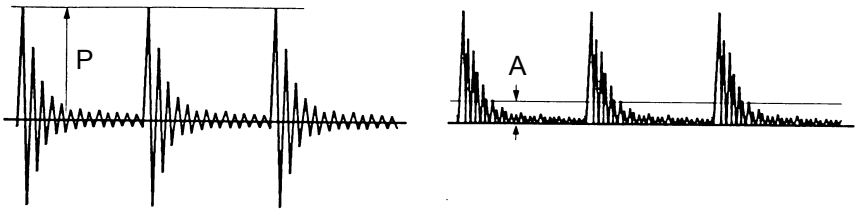


Fig. 2 Shock waveform peak and average values

Measurement Objects

For reasons of efficiency, it is usually not practical to perform measurements on all facilities of a plant or factory. Also, not all types of machinery are suitable for diagnostic checks with this unit. Therefore it is necessary to plan the use of the unit beforehand, taking into account various factors.

Generally it is best to concentrate on the following types of equipment:

- Machinery directly related to production.
- Auxiliary machinery whose malfunction can significantly affect production.
- Machinery whose malfunction can cause secondary problems.
- Machinery with high maintenance costs.

Measurement Cycle

In order to diagnose equipment problems at an early stage, a regular schedule of diagnostic checks is essential. The intervals between measurements should not be too long, but for economic reasons, extremely short intervals are also often not feasible.

The following points should be taken into consideration when determining the measurement cycle:

- History of previous equipment failures.
- Aging rate of the equipment.

For equipment with a previous failure history, the measurement cycle should be 1/10 or less of the failure occurrence interval. Parts subject to aging by gradual wear may be measured at fairly long intervals. However, machinery with high-speed rotational parts where a change can lead to sudden and drastic failure should be measured daily or constantly monitored with a special device.

Table 1 shows standard measurement cycles for general types of equipment. These data are intended only as rough guidelines. When measurement results show symptoms of change or when a critical phase of the equipment is reached, measurements should be performed more frequently.

Table 1 Representative measurement cycle examples

High-speed rotating machinery	Turbo compressors, gas/steam turbines	Daily
Ordinary rotating machinery	Pumps, ventilators, blowers, steam turbines	Weekly

Normally, aging effects of bearings progress fairly slowly, but when suitable countermeasures are not taken, deterioration accelerates considerably from a certain point on. Therefore bearings are usually checked more often than other structural parts of machinery. To be on the safe side, daily checks are advisable, if feasible. The measurement cycle should also be based on comparison of results with the evaluation standards. While results are still well within the normal range, the cycle may be longer, progressing to shorter intervals when the critical area is approached.

Measurement Points

The measurement point (where the probe tip of the VM-70 is applied) should be on a firm, rigid surface which provides good mechanical contact. Normally, this would be on the housing of the bearing. Vibration is checked in three planes, i.e. the axial, horizontal and vertical direction. Normally, the axial and horizontal direction are diagnosed by the height of axle center (Fig. 3).

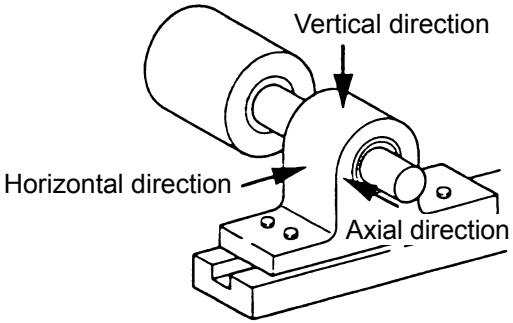


Fig. 3 Measurement points and vibration directions

Since different kinds of aging phenomena cause vibration in different directions, all three planes should be checked. For example, unbalanced rotation will likely cause horizontal vibrations, misalignment axial vibration, and rattle vertical vibrations. When checking high-frequency vibrations in roller bearings, it suffices to choose one plane which is most convenient to measure (normally the vertical plane), because high-frequency vibrations spread in all directions.

When there are many measurement points, selecting only certain vibration planes for measurement based on the characteristics of the respective point can increase diagnosis efficiency and reduce the time required for a check run.

Once a measurement point has been decided, the same point should always be used. With high-frequency vibrations, a measurement point difference of only a few millimeters can affect readings by as much as a factor of 6 (Fig. 4). The surface condition of the measurement point also has a considerable influence on the results. Paint and grease etc. should be removed if possible, to ensure measurement on a smooth surface.

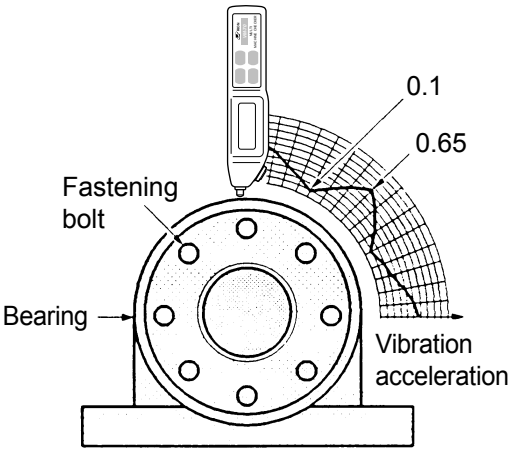


Fig. 4 Analysis of high-frequency vibration distribution in circular direction

In order to facilitate consistent measurements, a label mark indicating the measurement point should be attached to the bearing housing. It is recommended to use a ring-shaped label with the measurement point in the center cutout, as shown in Fig. 5. Using a punch mark is not recommended, as this impairs contact characteristics for the probe tip.

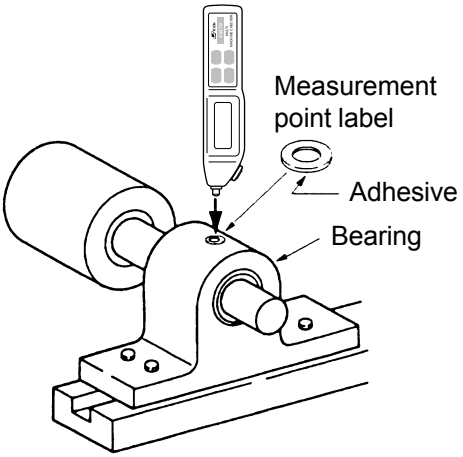


Fig. 5 Use of a label

Evaluation Standards

The vibration values measured with the VM-70 should be used to determine whether the rotating equipment is operating normally or not. Choose a suitable combination of the following three general principles which are commonly used for evaluation.

- **Absolute Evaluation**
  Measured values are compared to an absolute reference standard (see pages 36 to 42) in order to determine the "Normal", "Alert" (uncertain), or "Danger" status.

- **Relative Evaluation**
  Measurements are carried out at a fixed point at regular intervals, and results are evaluated using a time-reference, i.e. by comparing later results to the initial (normal) value.

- **Reciprocal Evaluation**
  Several machines of a similar type are measured under the same conditions and the results are judged by mutual comparison.

Note that no single absolute standard exists which can be applied to all roller bearings. For most effective management of machinery, it is recommended to use both the absolute and the relative evaluation methods.

Absolute Evaluation

Currently, several standards exist for evaluating high-frequency vibrations caused by damage in roller bearings. These standards are based on the following kinds of data.

- Theoretical examination of vibration effects caused by damage
- Experimental examination of vibration effects
- Statistical evaluation of measurement data
- Reference material and international standards

Concrete examples are shown on the following pages.

● Absolute Evaluation Using Vibration Velocity

Table 2 shows an absolute evaluation standard for average (Lo-AVE) vibration velocity values. These data are based on long-term maintenance data gathered at Nippon Steel Corporation. If there are no data for your own application yet, these data may serve as a starting point for evaluation.
Table 2 lists values separately for medium-size machinery (10 to 300 kW, above 300 rpm) and large-size machinery (above 300 kW, above 300 rpm). However, some machinery even of the same size range may require different standards. For such machinery, relative evaluation or reciprocal evaluation may be preferred.

Table 2 Absolute evaluation standard
(M: measurement value average, unit: mm/s)

	Normal	Alert	Danger
10 to 300 kW	M<1	1≤M<7	M≥7
above 300 kW	M<2	2≤M<11	M≥11

For 300 rpm and above

Use the table as follows.

1) Measure vibrations at the bearing in three planes (vertical, horizontal, axial) 3 times for each plane.
2) Determine the average value (M) for the 3 data, and use it for evaluation as follows.
3) • Medium-size machinery (10 to 300 kW, above 300 rpm)
   M is less than 1 mm/s → Normal
   M is between 1 and 7 mm/s → Alert
   M is 7 mm/s or higher → Danger
   • Large-size machinery (above 300 kW, above 300 rpm)
   M is less than 2 mm/s → Normal
   M is between 2 and 11 mm/s → Alert
   M is 11 mm/s or higher → Danger

● Absolute Evaluation Using Vibration Acceleration

This section describes an absolute evaluation example for average (Hi-AVE) vibration velocity values.

• Absolute evaluation of medium to high speed roller bearings

Fig. 6-1 (page 40) shows an example for absolute evaluation of medium to high speed roller bearings. Use this diagram as follows.

1. The left scale represents the rotation speed. Plot rotation as a ratio of 1200 rpm.
2. The right scale represents the shaft diameter. Plot shaft diameter as a ratio of 100 mm.
3. Draw a straight line between the points on the two scales.
4. The line intersects the evaluation scale at the "Alert" and "Danger" points.

Use the Normal/Alert/Danger values determined in this way to perform the diagnosis. If values are under the "Alert" point in the graph, operation is normal. If they are between the "Alert" and the "Danger" point, the "Alert" status is diagnosed. In this case, checks should be performed more frequently. If values are above the "Danger" point, the "Danger" status is diagnosed.

In the example, rotation speed is 600 rpm (600/1200 = 0.5), and shaft diameter is 70 mm (70/100 = 0.7). The evaluation standard in this case becomes as follows.

"Alert" threshold : 0.08
"Danger" threshold : 0.24

(Additional information)

In Fig. 6-1, a rotation speed of 1200 rpm and shaft diameter of 100 mm will result in a horizontal line. In this case, the "Alert" threshold is 0.5 and the "Danger" threshold 1.5.

Since a rotation speed of 1200 rpm and shaft diameter of 100 mm are typical values for standard rotating machinery, these reference threshold values may be used as a starting point if the actual rotation speed and shaft diameter are not known.

The "Danger" value is normally higher than the "Alert" value by a factor of 3.

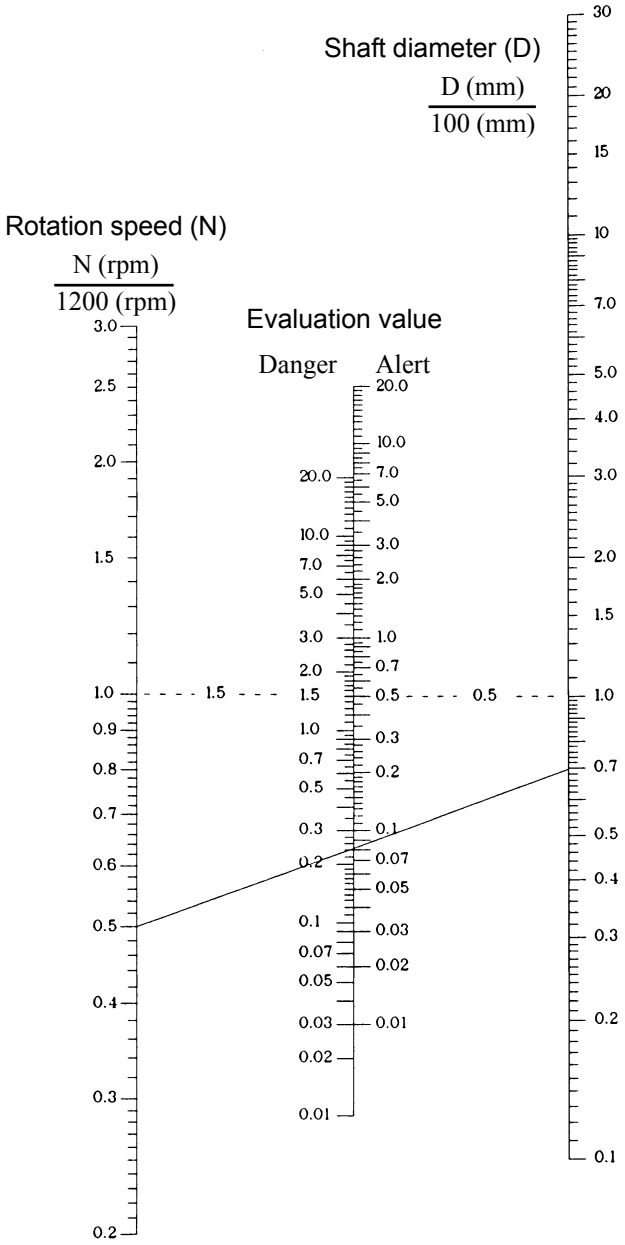


Fig. 6-1 Sample evaluation standard for medium to high speed roller bearings (Hi-AVE)

• Absolute evaluation of gear devices

Fig. 6-2 (page 42) shows an example for absolute evaluation of gear devices. Use this diagram as follows.

1. The left scale represents rotation speed. Plot rotation as a ratio of 1200 rpm.
2. The right scale represents the number of gears. Plot number of gears as a ratio of 30.
3. Draw a straight line between the points on the two scales.
4. The line intersects the evaluation scale at the "Alert" and "Danger" points.

Use the Normal/Alert/Danger values determined in this way to perform the diagnosis. If values are under the "Alert" point in the graph, operation is normal. If they are between the "Alert" and the "Danger" point, the "Alert" status is diagnosed. In this case, checks should be performed more frequently. If values are above the "Danger" point, the "Danger" status is diagnosed.

In the example, rotation speed is 600 rpm (600/1200 = 0.5), and number of gears is 24 (24/30 = 0.8). The evaluation standard in this case becomes as follows.

"Alert" threshold : 0.11
"Danger" threshold : 0.33

(Additional information)

In Fig. 6-2, a rotation speed of 1200 rpm and gear number of 30 will result in a horizontal line. In this case, the "Alert" threshold is 0.7 and the "Danger" threshold 2.1. If the actual rotation speed and number of gears are not known, these reference threshold values may be used as a starting point.
The "Danger" value is normally higher than the "Alert" value by a factor of 3.

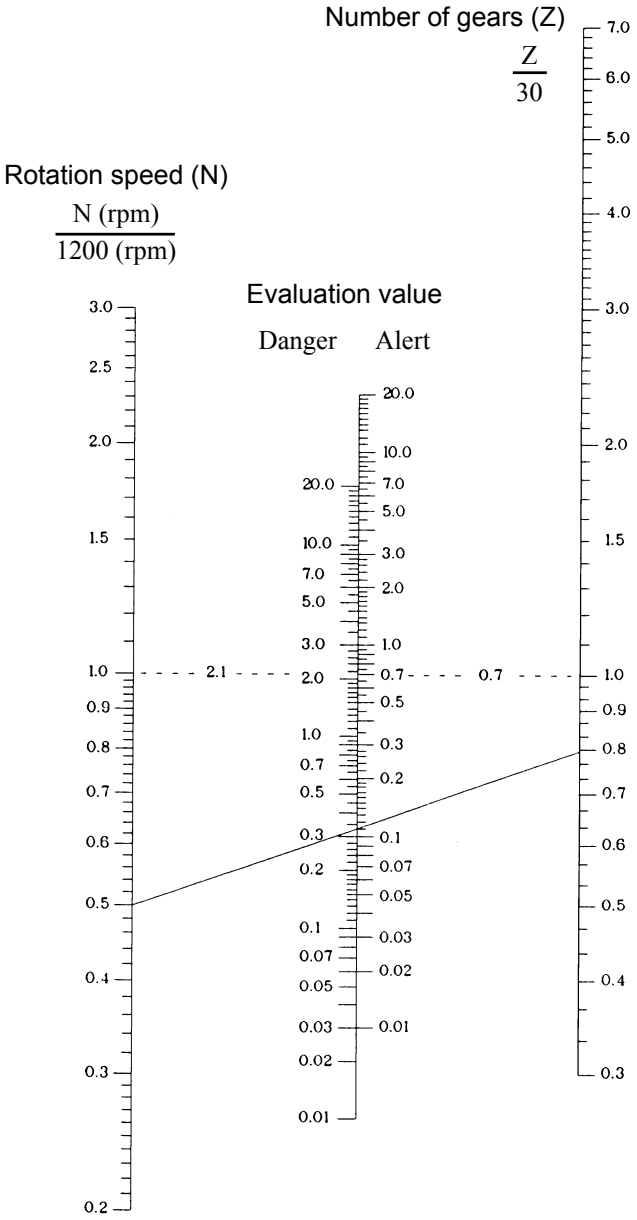


Fig. 6-2 Sample evaluation standard for gear devices (Hi-AVE)

Relative Evaluation

Determine a reference value to be used for evaluation as follows.

1. Confirm that the machine to be measured is operating normally.

2. Determine the measurement point(s).

3. Perform at least 25 measurements for each measurement point with the VM-70. Do not keep the probe tip applied continuously, but rather release and reapply it for each measurement.

4. Calculate the average value (Mg) and the standard deviation (σ) for each measurement point.

$$\text{Average value (Mg)} = \frac{X_1 + X_2 + \cdots + Xn}{N}$$

$$\text{Standard deviation } (\sigma) = \sqrt{\frac{(X_1 - Mg)^2 + (X_2 - Mg)^2 + \cdots + (Xn - Mg)^2}{N - 1}}$$

$$= \sqrt{\frac{\Sigma Xi^2 - N \bullet Mg^2}{N - 1}}$$

where Xn : nth measurement value
N : total number of measurements

5. Use the following equation to predict the average value for the "Alert" condition and "Danger" condition from the average value (Mg) and the standard deviation (σ).

"Alert" condition average value (Mc) = $Mg + 2\sigma$
"Danger" condition average value (Md) = $3Mc$

When the measured value exceeds Mc, the "Alert" status is diagnosed. When the measured value exceeds Md, the "Danger" status is diagnosed.

When the vibration velocity (Hi-AVE, Hi-PEAK) exceeds Mc, it is not clear whether it also reaches the "Danger" point, and whether the current status is normal or dangerous. Therefore "Normal" is diagnosed when the value is below Mc, and "Danger" is diagnosed when the value exceeds Md. When it is between Mc and Mc, Normal/Danger evaluation is not possible.

Note
When performing diagnostic checks using the above reference values, observe the following precautions: Perform three measurements for each point and use the average of these three measurements for comparison against the reference value. Perform measurements always at the same point, and keep the angle and pressure of the probe tip roughly identical.

● Relative Evaluation Precautions

1) For prediction of Mc and Md, it is assumed that the standard deviation (σ) in the "Alert" (uncertain) and "Danger" range is the same as in the "Normal" range.

2) When performing diagnostic checks using the Mc "Alert" (uncertain) and Md "Danger" reference values, the probability for false identification of the "Alert" (uncertain) condition is 2.3 % and of the "Danger" condition 0.1 %. False identification means that the condition is diagnosed although the equipment is operating normally.

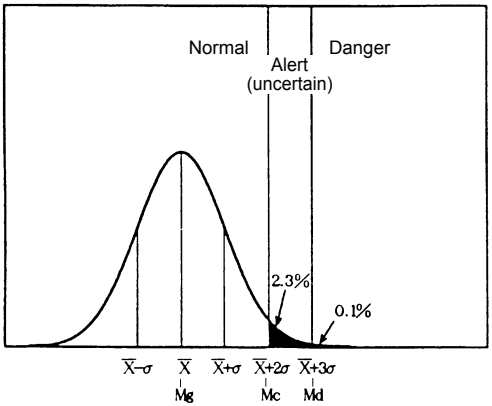


Fig. 7 Distribution of normal condition and Mg, Mc, Md

When the unusual condition of the measurement object progresses and the average measurement value equals Mc, indicating that the equipment is in the "Alert" (uncertain) state, the probability for identifying the "Normal" condition becomes 50 %, and for the "Danger" condition 15.9 %.

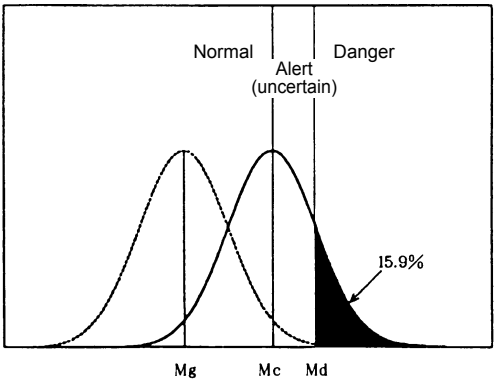


Fig. 8 Distribution in "Alert (uncertain)" condition

When the average measurement value equals Md and the equipment is in the "Danger" condition, the probability for false identification of the "Normal" condition is 15.9 %.

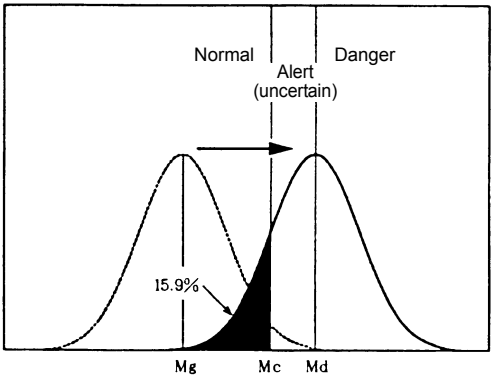


Fig. 9 Distribution in "Danger" condition

To reduce such errors, observe the precautions on page 48, which are aimed at reducing the measurement value variance (standard deviation to the second power). Performing three measurements reduces variance to 1/3.

3) The values for Mc {"Alert" (uncertain) range} and Md ("Danger" condition range) were predicted from the vibration measurement results in the normal condition. It is desirable to use auxiliary data such as machine specifications, previous servicing or maintenance data etc. to adjust the values to approximate the absolute evaluation method.

Reciprocal Evaluation

When several identical machines are used under the same conditions, evaluation can be carried out by measuring all machines at the same points and comparing the results.

Precautions for Simple Diagnostic Checks

The preceding section contains information on simple diagnostic checks of rotating machinery. This chapter summarizes a few of the most important points to consider when carrying out such checks.

Depending on the type of roller bearing and other factors, damage can cause either low-frequency or high-frequency vibrations. Low-frequency vibrations should be evaluated by the vibration speed, and high-frequency vibrations by the vibration acceleration. The results of both measurements should be considered to permit meaningful evaluation.

The measurement point should preferably be located on the housing of the bearing. Out of the three planes (axial, horizontal and vertical), all three planes should be measured for vibration velocity measurement, and one plane for vibration acceleration measurements.

Avoid using only the absolute or only the relative evaluation method. Both methods should be combined for effective observation. When checking special equipment such as attenuators without exposed bearing housings, absolute standards may have to be modified to suit the respective installation.

Even when there is no mechanical damage, lubrication problems and other factors in roller bearings can cause increased vibrations especially in the high-frequency range. Before diagnosing a fault, be sure to check the lubrication condition of the equipment. Lubricate if necessary and repeat the check after an interval of several hours or days, depending on the equipment type.

Tabulation of Aging Record Data

Keeping records of measurement data is useful to determine aging characteristics of equipment and to plan maintenance procedures. Data sheets and record charts should be designed so that they are easy to use for operating personnel. The following points must be included, to ensure precise evaluation and continuity, also in case of a change of personnel.

1) Name of factory or installation (machine code)
2) Equipment designation
3) Basic specifications (rotation speed, output, type of bearing, etc.)
4) Simple layout diagram
5) Measurement parameters
6) Measurement points and direction
7) Measurement cycle
8) Evaluation method
9) Initial (or normal) value
10) Measurement conditions
11) Measurement results (measurement date, measurement values)
12) Maintenance record
13) Graphical representation of aging characteristics

No. 27651 04-12