

Vibration

1-1. Evaluation method

When evaluating the magnitude of vibration, three types of vibration amplitudes are considered: displacement, velocity, and acceleration. Each vibration amplitude has its maximum value, average value, and effective value, which can be used depending on the purpose of evaluation.

Which of the displacement, velocity, and acceleration is used depends on the purpose of the evaluation. For example, displacement is often used to evaluate earthquakes themselves, while acceleration, which is closely related to force, is often used when considering the effects of earthquakes on buildings, bridges, and other structures. When considering the destruction of structures due to earthquakes, the maximum value (peak value) of the waveform of displacement and acceleration becomes a problem.

On the other hand, when considering the vibration from the viewpoint of pollution, the method of evaluating it by focusing on how the human body feels the vibration is adopted.

(1) Vibration acceleration level (La) The acceleration level of vibration for which the effective value of acceleration is "a" is shown by the following formula.

$$La = 20 \log_{10} \left(\frac{A}{a_0} \right)$$

$$a_0 = 10^{-5} \text{ [m/s}^2\text{]} \text{ (Japanese standard)}$$

(2) JIS C1510, which prescribes vibration level meters for measuring vibration from the view point of pollution, applies frequency correction to the vibration acceleration level as shown in Fig.1, and calls it the vibration level. The measurement method is defined in JIS Z 8735.

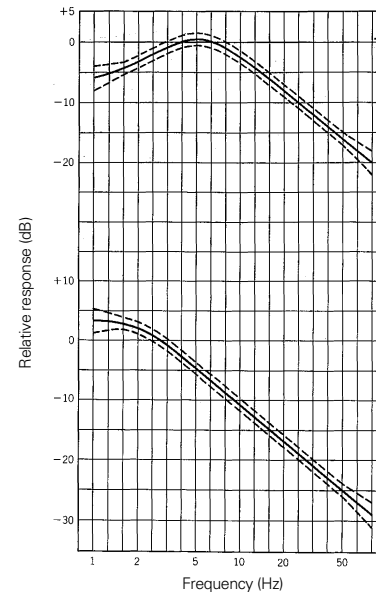


Fig. 1. Reference response and tolerance of vertical and horizontal characteristics of vibration level meter (JIS C 1510-1995)

1-2. Allowable vibration level

(1) Allowable vibration level The standards for factory vibration and construction work vibration under the Vibration Regulation Law are shown in Table 1. Local governments are supposed to set the specific time zones and regulation values for factory vibration on these standards.

Table 1. Standards for factory vibration

Category of area	Time zone	
	Daytime	Nighttime
Class 1 Area	60 to 65dB	55 to 60dB
Class 2 Area	65 to 70dB	60 to 65dB

Table 2. Conversion of amplitude values to each other

	Displacement X_0	Speed V_0	Acceleration a_0
Convert displacement X_0 to others	x_0	$2\pi f x_0$	$(2\pi f)^2 x_0$
Convert speed V_0 to others	$v_0 / (2\pi f)$	v_0	$2\pi f v_0$
Convert acceleration a_0 to others	$a_0 / (2\pi f)^2$	$a_0 / (2\pi f)$	a_0

[Examples]

ALF-III E-60 1800 min⁻¹, 2.2 kW, 4P

Calculation of displacement, acceleration and vibration levels at velocity V=6mm/sec

Table 3.

	Calculation	Figure
Vibration frequency (primary)	$f = \frac{n}{60} = \frac{1800}{60} = 30\text{Hz}$	—
Vibration displacement (Single amplitude)	$x = \frac{30000v}{\pi n} = \frac{30000 \times 6}{1800 \pi} \approx 32 \mu\text{m}$	About 32 μm
Acceleration amplitude	$A = v \cdot 2\pi \cdot f \cdot 10^{-3}$ $= 6 \times 2\pi \times 30 \times 10^{-3}$ $\approx 1.13\text{m/sec}^2$ $= 113\text{Gal} = 0.113\text{G}$	About 1.1m/sec ²
Acceleration level	$AL = 20 \log_{10} (A \times 10^5) = 20 \log_{10} (1.13 \times 10^5) \approx 101\text{dB}$	About 101dB (Fig.2)
Relative response	—	Vertical direction, at f Hz -12dB (Fig.1)
Vibration level	$AL - \text{relative response} = 101 - 12 = 89\text{dB}$	—

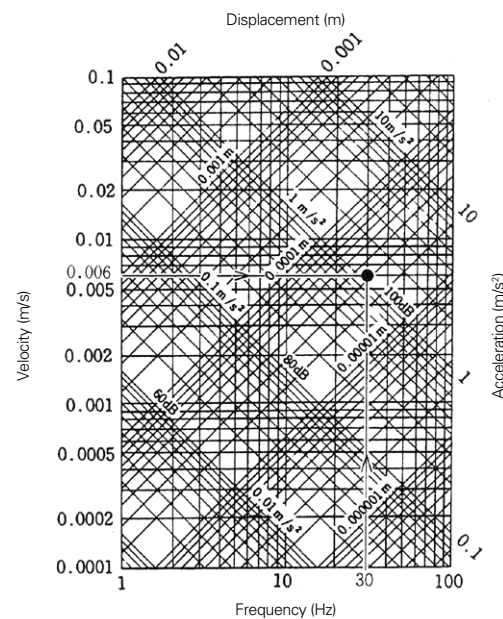


Fig. 2. Relationship between the effective values of displacement, velocity, and acceleration (dB value is the acceleration level)

(NOTE) 1. In the Vibration Regulation Law, only the vertical component is subject to regulation.

1-3. Vibration isolation

Appropriate vibration isolation measures may be required, such as regulating the amplitude of vibration, to prevent the vibration of equipment from affecting living rooms and other areas through propagation. Depending on the type of equipment, the standard vibration isolation grade is specified as shown in Table 4.

Table 4. Vibration isolation class (estimated values)

Building structure	Machine installation locations	Allowable noise from vibration in rooms near machinery rooms		Installed equipment														
				Reciprocating freezers		Screw-type freezers		Pumps			Fans			Air conditioners		Cooling towers		
				Less than 18.5kW	18.5kW or more	Less than 60kW	60kW or more	2.2kW or less	15kW or less	18.5kW or more	#2.5 or less	#5.5 or less	#6 or more	Less than 10,000m ³ /h	10,000m ³ /h or more	Less than 100RT	100RT or more	
Steel structure	Intermediate and top floors	VL<45 NC<25	Studio															
		VL<50 NC<35	High-grade rooms Reception room	I				I	I			I	I		II	II	II	II
		VL<55 NC<40	Conference room	I	I	I	I	III	II	II	III	II	II	III	III	*	II	
		VL<55 NC<45	Office Dining hall Lobby	I	I	I	I	IV	III	II	*	III	II	III	III	*	III	
		VL<60 NC<50	Parking lots	*	I	*	I	*	*	*	III	*	*	III	*	*	*	*
Reinforced concrete construction	Intermediate and top floors	VL<45 NC<25	Studio															
		VL<50 NC<35	High-grade rooms Reception room	I	I	I	I	I	I			I	I		II	II	II	II
		VL<55 NC<40	Conference room	I	I	I	I	III	II	II	III	II	II	III	III	*	III	
		VL<55 NC<45	Office Dining hall Lobby	*	I	I	I	*	III	II	*	III	II	IV	IV	*	*	
		VL<60 NC<50	Parking lots	*	II	*	II	*	*	*	*	*	III	*	*	*	*	*
	Ground floors	VL<40 NC<25	Studio														-	-
		VL<55 NC<45	Office	II	II	II	II	IV	IV	IV	IV	IV	IV	IV	IV	IV	-	-
		VL<60 NC<50	Parking lots	*	II	*	II	*	*	*	*	*	*	*	*	-	-	

Notes (1) I, II, III, and IV show the vibration isolation grade; * indicates that vibration-isolating equipment is not necessary.
 (2) For blank fields, solid sound insulation is to be considered separately.
 (3) VL indicates the vibration tolerance level (the dB level calculated by correcting the vibration acceleration level (VAL) to account for human sensitivity).

Table 5 shows the approximate values of vibration.

Table 5. Standard values for vibration and noise

Vibration	VL (dB)	45	50	55	60	65
	Annoyance		Indifference	Vague sense of vibration	Does not bother people	People feel that it is annoying

In Fig. 3 "Vibration isolation class chart", determine the material of the vibration isolation material based on the rotational speed of the equipment and the vibration isolation rating. See Fig.4 for instructions.

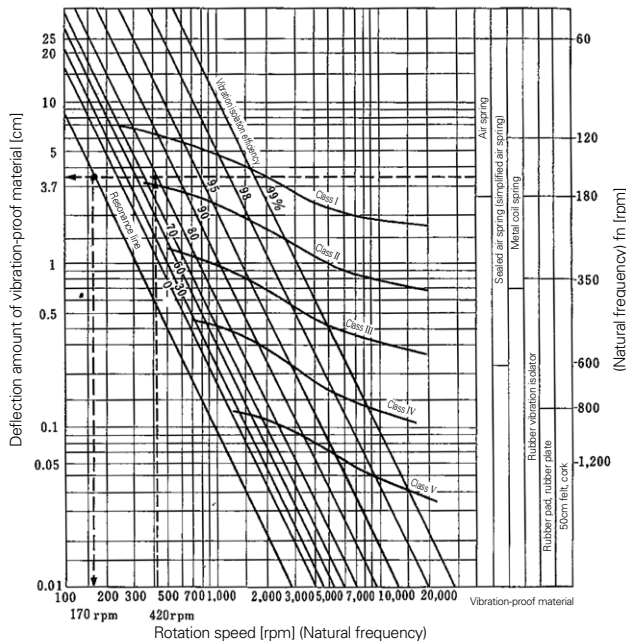


Fig.3 Vibration isolation class chart

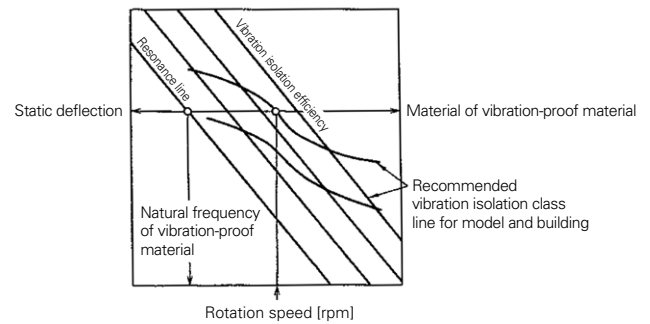


Fig. 4. How to use the vibration isolation class chart

Cited from 2006 edition of the Building Equipment Design Standards published by the Public Building Association