複数工具使用時のリスク評価方法

				部分暴露 A(8)	部分暴露点 Point	一日の作業可能時間 H	

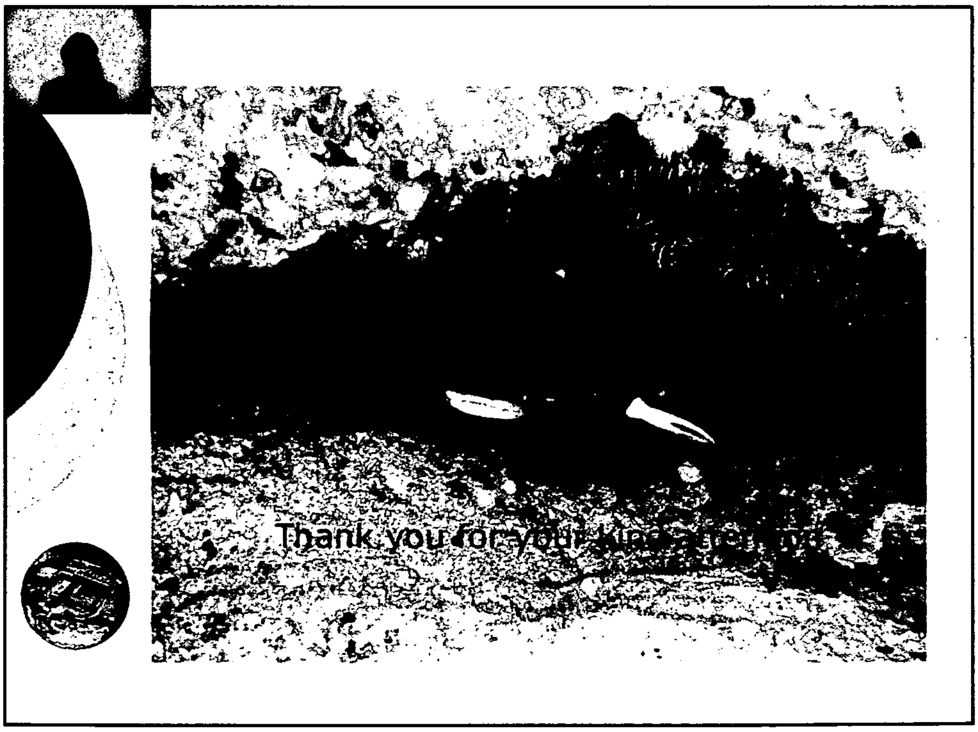
Critevia 判断規準

A(8)⊆5 < 400 Points
A(8)⊆2.5 ⊆ 100 Points

日振動暴露 m/s² A(8)	合計暴露 ポイント	危険度 RM

危害 / 一日の作業可能時間	危害の可能性	危害の重大性	リスクレベル	評価
8時間以上				
6～8時間				
4～6時間				
2～4時間	高い	有害	Ⅱ´	問題あり
1～2時間				
0～1時間				

RM>12000	
3000<RM<12000	毎日の暴露限界を超過しない
RM<3000	



機械指令・EN規格・EU加盟国規格・ISO規格 Non－EU加盟国規格（例：JIS規格）の関係

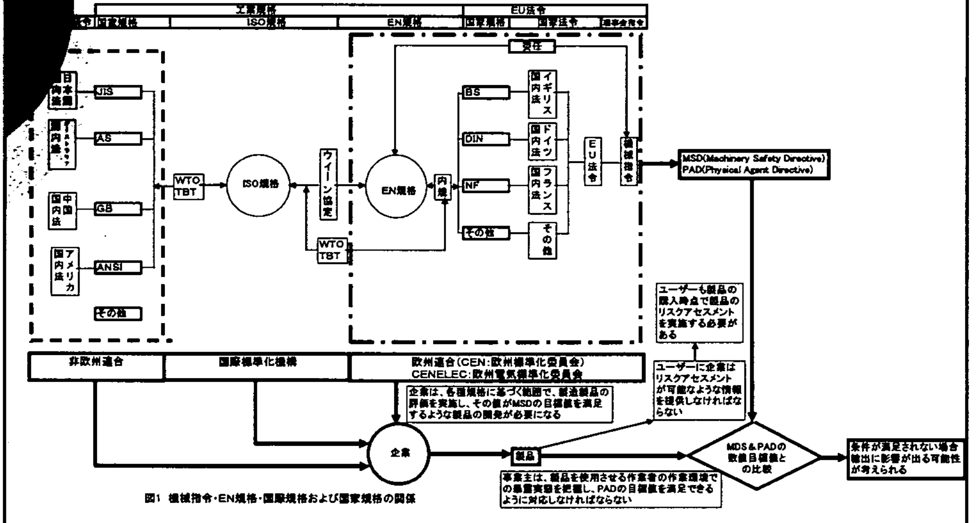


図1　機械指令・EN規格・国際規格および国家規格の関係

89/392/EEC (Machinery Safety Directive)

－　機械の設計・製作・設備は、操作員がハンドルから手を放した後偶発的な始動及び／又は運転の継続による危険を生じないようにすること。この要求事項を技術的に満足できない場合、同等の対策を講じること。

－　携行把握式の機械の設計・製作は、必要に応じて、処理対象材料への工具の接触を目視で点検できるようにすること。

指示書

指示書には、携行把握式及び手案内式の機械で伝達される振動に関して、次の情報を明示すること。

－　腕部が受ける加重二乗平均平方根の加速度を適当な試験規則で求めた際に、これが２．５ｍ／ｓ^2 を超える場合はその値。加速度が２．５ｍ／ｓ^2 を超えない場合その旨を記すこと。

適用すべき試験規則が存在しない場合、製造業者は測定法及び測定に用いた条件を明示すること。

89/392/EEC(製造メーカー向け)

Directive 98/37/EC of the European Parliament and of the council of 22 June 1998 on the approximation of the laws of Member States relating to machinery (Machinery Safety Directive)　2006年5月17日に改定された

Machinery Safety Directive

(機械設備に関する加盟国の法律を近似させるための指令)

"振動：機械の設計・製作は、特に振動源での振動低減技術の発展とその方法の利用可能性を考慮の上、振動による危険を最低レベルに抑えるようにすること。"

"人が受ける周波数補正振動加速度実効値が適当な試験規則で求めた際に、2.5 m/s² rms [手腕](0.5 m/s² rms [全身])を超える場合はその値、加速度が2.5 m/s² rms (0.5 m/s² rms)を超えない場合はその旨記すこと。"

研究成果の刊行物・別刷

13:S. Maeda, N. Shibata : Problems of A(8) Evaluation. Proceedings of 15th Japan Conference on Human Response to Vibration, p158-164, 2007.

S2-2-16

Problems of A(8) Evaluation

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Abstract

This study reports results of an investigation into A(8) evaluation effects of hand-transmitted vibration on temporary threshold shifts of vibratory sensation on the finger. The hand-transmitted vibration was applied with an electric tool to the right hand of five male subjects with four different working postures. The threshold of 125 Hz vibratory sensation was measured at the tip of the right forefinger before and after vibration exposure. As a result, the TTS following vibration exposure did not have the same values after vibration exposure with four different working postures, even though the A(8) value was the same. The results suggest that the A(8) method of vibration evaluation in ISO 5349-1 is inappropriate for the prediction of the TTS after hand-transmitted vibration exposure with different working postures.

Introduction

On 6th July 2005, the EU Physical Agents (Vibration) Directive (2002) came into force across all member states. This will mean that legally enforceable limits on hand-arm vibration exposures will be introduced and that risk management must be set in place at work. The first course of action for those at risk from vibration is to assess and, if necessary, measure the vibration exposures. The total daily exposure to vibration is a function of both the magnitude and the duration of vibration. This is expressed in terms of the frequency-weighted eight-hour energy-equivalent level and reported in m/s^2 A(8). For any vibration magnitude, an allowable exposure duration before exceeding an exposure criteria can be calculated. And in the ISO 5349-1 standard, it is assumed that the method for obtaining the 8-h energy-equivalent vibration total value appropriately reflects the relationship between different vibration magnitudes and daily exposure durations. Also, vibration exposure is dependent on the magnitude of the vibration and on the duration of the exposure. In order to apply the guidance on health effects given in annex C of ISO 5349-1, the vibration magnitude is represented by the vibration total value a_{hv}. Daily vibration exposure is derived from the magnitude of the vibration (vibration total value) and the daily exposure duration. In order to facilitate comparisons between

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Presented at the 15th Japan Conference on Human Responses to Vibration, Training center of Nichii Gakkan Company., Kobe, Hyogo, Japan,<u>August 1 to 3rd, 2007</u>

daily exposures of different durations, the daily vibration exposure shall be expressed in terms of the 8-h energy-equivalent frequency-weighted vibration total value, $a_{hv(eq,8h)}$, as shown in equation (1). For convenience, $a_{hv(eq,8h)}$ is denoted A(8):

$$A(8) = a_{hv} \sqrt{(T/T_0)} \quad (1)$$

where

T is the total daily duration of exposure to the vibration a_{hv};

T_0 is the reference duration of 8h (28800 s).

If the daily vibration exposure is the same value, it is also assumed that the health effects are the same effects in the ISO 5349-1 standard.

In this paper, in order to clarify and to validate this A(8) assumption, the temporary threshold shifts of fingertip vibratory sensation produced by hand-transmitted vibration different working postures with the same A(8) values was undertaken to compare the effects of short exposures to hand-transmitted vibration using five male subjects, one electric tools, and four different working postures. The operating hypothesis was that exposure to hand-transmitted vibration with different working postures would produce equal vibrotactile TTSs when the hand-transmitted vibration had equal daily vibration exposure value, A(8).

Postures

The experiment was performed at four different postures to investigate the TTS after hand-transmitted vibration exposure. The directions of using the tools were upwards, horizontal, and downwards as shown in Figure 1, respectively.

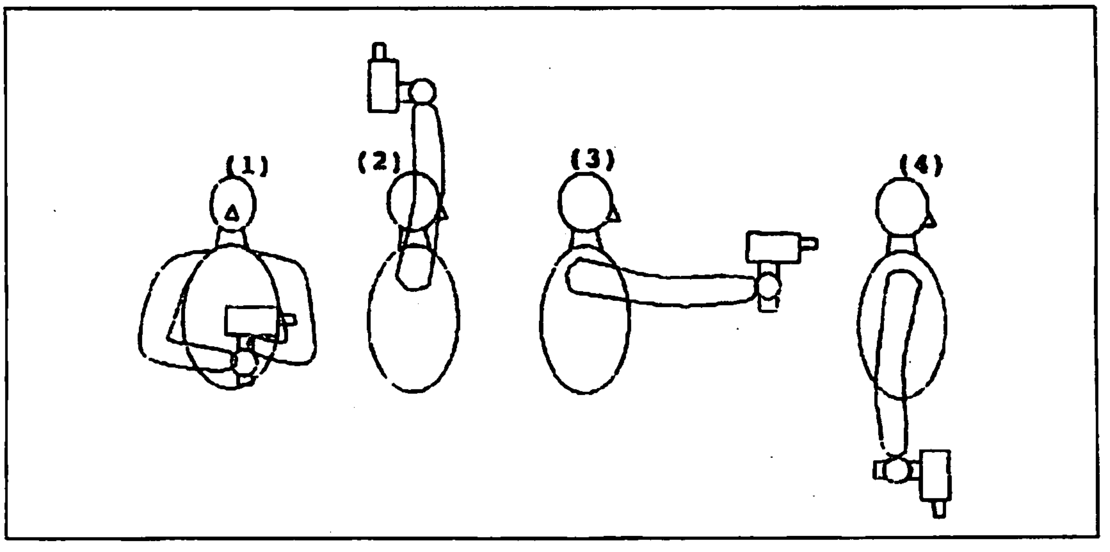

Figure 1. Four different working postures.

Stmuli

The stimuli was generated using a real electric tool as shown in Figure 2. The tool was an angle grinder.

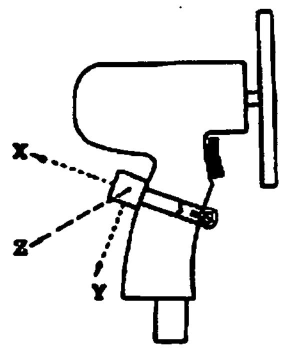

Figure 2. An electric tool used in the experiment.

The frequency-weighted r.m.s. accelerations on the tool was measured with the system which was calibrated using a vibration reference source (Bruel and Kjaer type 4292). With an accelerometer mounted on the calibrator, a channel of the system was checked against a reference excitation of 10 ms-2 r.m.s. at 159.2 Hz. The laboratory vibration measurements were made using three piezoelectric accelerometers simultaneously in three orthogonal axes. These were Bruel and Kjaer type 8301 (sensitivity 1.185 pC/ms-2). They were attached to three faces of a steel cube. This cube was welded to a hose clip. The mass of the entire assembly was approximately 130g. The acceleration signals of the accelerometer type 8301 were conditioned by charge amplifiers (Bruel and Kjaer type 2626). The position of a hose clip accelerometer mounted on the tool's handle is shown in Figure 2. The signals from the charge amplifier were low-pass filtered at 1260 Hz to prevent aliasing and digitized by a 12-bit analogue to digital converter at a rate of 5000 samples per second. Analysis of digitized vibration data was carried out by personal computer with the HVLab software package. Acceleration time histories of five seconds duration were measured to calculate power spectral density functions. The power spectra had a resolution of 2.44 Hz and 52 degrees of freedom. The measured acceleration waveforms and the power spectral density on the handle are shown in Figure 3.

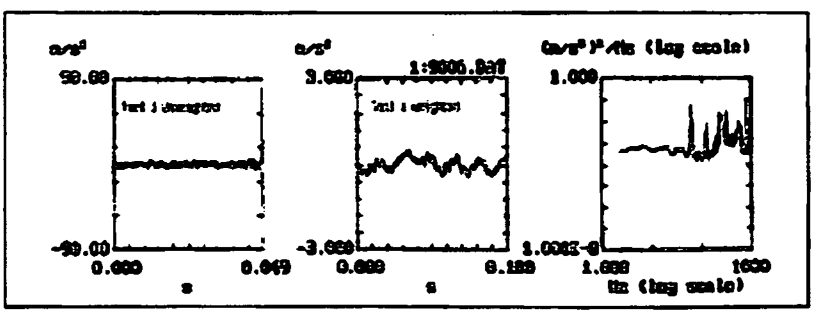

Figure 3. Measured acceleration time history and power spectral density of an electric tool.

The tool vibration is shown in Table 1.

Table 1. Conditions of an electric tool used in this experiment.

Conditions	Tool
Frequency-weighted acceleration: ms-2 r.m.s.	0.676
Tool weight: kg	1.75
r.p.m.	2800
A(8)	0.07

Subject

Five subjects participated in the study (mean age 21.8 years, SD 0.8 years). All subjects were healthy male students, having no history of neuromuscular or vascular disorders and who had not suffered any serious injuries of the upper extremities.

Procedures

In order to study the TTS in fingertip vibratory sensation, the vibratory sensation threshold was measured before and after subjects were exposed to hand-transmitted vibration. The experiment was carried out in a sound-proof room. The room temperature was held at about 25℃. Vibration was applied to the right hand through a handle of the electric tool. The subjects were instructed to clasp the handle tightly and constantly with part of the palm and fingers with a real grip force in the appointed posture. The exposure time was 5 minutes. The threshold of 125 Hz vibratory sensation was measured at the index finger of the right hand. Vibration thresholds were determined with the vibrotactile sensation meter (RION type AU-02A). Vibrotactile thresholds were determined by the method of adjustment. In this method, the measurement was performed three times. Thresholds were calculated by the mean values of three measurements obtained less than 30 seconds after the end of the vibration exposure. The TTS was defined as the difference (in decibels) of the vibrotactile thresholds before and after vibration exposure. The experiment was performed on 12 different days.

Results

Table 2 and Figure 4 show the results of the experiment. Even though A(8) was the same value in the individual postures, the TTS after exposure to vibration depended on the different working postures. The TTSs for the conditions were 0 dB in all four postures. Compared with the TTS in the control condition in which subjects clasped the handle but were not exposed to vibration, the exposure to vibration at each posture induced a significant ($p<0.01$) according to the difference between means for independent groups.

Table 2. The results of TTS (dB) immediately following vibration exposure.

Subjects	Posture 1	Posture 2	Posture 3	Posture 4
1	8.37	13.76	11.74	9.16
2	9.97	9.96	9.86	10.67
3	10.67	13.39	11.72	14.35
4	10.00	12.95	13.25	12.61
5	6.63	10.87	6.56	9.96
Mean TTS	9.13	12.19	10.65	11.35

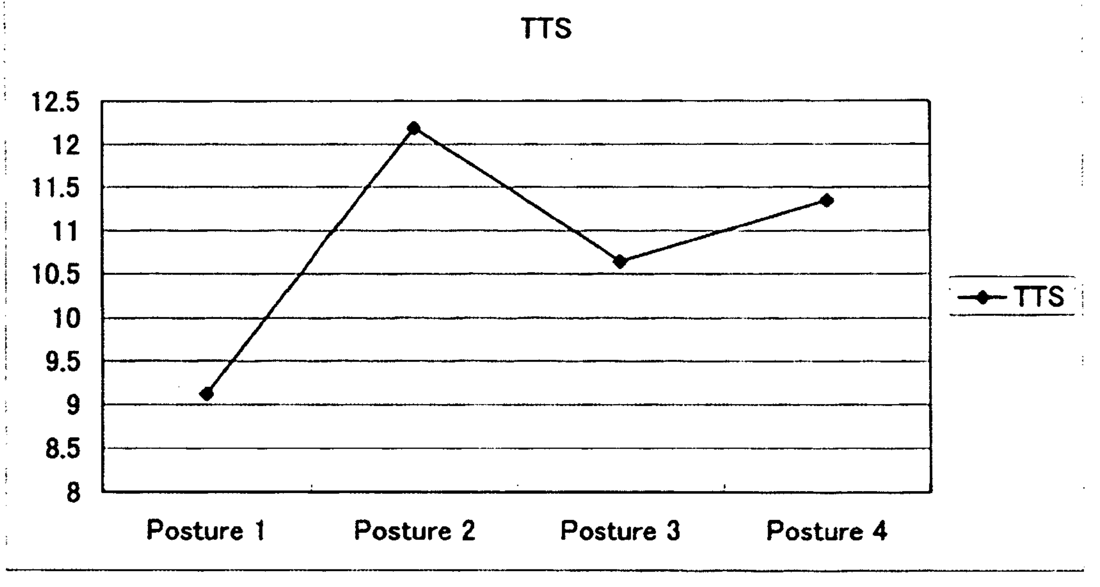

Figure 4. TTS with different postures.

Table 3 shows the results of the analysis of variance. The posture effect was statistically significant ($p<0.05$), and the subject effect was also statistically significant ($p<0.01$).

Table 3. Analysis of variance summary table.

Factors	SS	df	MS	F
Postures	25.199	3	8.399	4.334*
Subjects	42.677	4	10.669	5.505**
Error	23.258	12	1.938	
Total	91.134	19		

(* $p<0.05$, ** $p<0.01$)

Discussion

The purpose of this paper was to investigate the TTS after hand-transmitted vibration exposure in different posture with the same A(8) value. In Figure 4, the TTS after exposure to hand-transmitted vibration varies with posture, even though the A(8) value transmitted to the hand was the same. Figure 4 shows that the TTS depends on the posture in which the tool is used.

The results of workload at different working heights when using manual and battery powered screwdrivers show that the working heights have a greater influence on the workload, and the similarity to real work is high enough to recommended an increased use of battery powered screwdrivers as one way of reducing overload disorders (Ortengren et al., 1991).

From this present study, the upwards working posture had the greatest effect on TTS after vibration exposure rather than other posture, even though the A(8) value or the frequency-weighted r.m.s. acceleration had the same value. Radzyukevich (1969) suggested that the temporary threshold shifts (TTS) in vibration sensation thresholds at the end of a working day were collated with the parmanent thresholds shifts (PTS) which develop over a long period. Malinskaya (1964) found that the mean TTS of workers after a day of work that included vibration exposure, corresponded to the PTS of vibratory sensation that occurred in that group after 10 years of exposure. This suggests that the TTS after daily vibration exposure might be used to indicate PTS after prolonged vibration exposure. Although the frequency-weighted r.m.s. acceleration (0.676 ms-2 r.m.s.) or the A(8)(0.07) were smaller than 2.8 ms-2 r.m.s. of the 8-h 'energy-equivalent' frequency-weighted r.m.s. acceleration value, if the tool is used for about 10 years, vibrotactile perception thresholds will be shifted by 12 dB in the upwards posture from the results of Malinskaya (1964). Patients having this value will be diagnosed as having the vibration syndrom by the Japanese diagnostic system: the 12 dB value is greater than the diagnostic threshold value of 7.5 dB value.

Therefore, the posture and the A(8) method have to be investigated again the setting safety criteria for hand-transmitted vibration relevant to neurological disorders.

Conclusion

This study has investigated the relative TTS produced by hand-transmitted vibration with different working postures and the same A(8) value. From the findings of this experiment, the conclusions are as follows:

1) when the vibration transmitted to the hand has equal A(8) value, the TTS after vibration exposure with different working postures did not produce the same value;
2) an upwards working posture had a more severe effect on the TTS after vibration exposure rather than horizontal and downwards postures.

Reference

Directive 98/37/EC of the European Parliament and of the council of 22 June 1998 on the approximation of the laws of Member States relating to machinery. (Machinery Safety Directive)

Directive 2002/44/EC of the European parliament and of the council of 25 June 2002 on the minimum health and safety requirements regarding the exposure of workers to the risks arising from physical agents (vibration)

International Organization for Standardization (2001) Mechanical vibration measurement and evaluation of human exposure to hand-transmitted vibration - Part 1: General requirements. ISO 5349-1.

Malinskaya, N.N., Filin, A.P. and Shkarinov, L.N. (1964) Problem of occupational hygiene in operating mechanized tools. Vestnik Academy of Medical Science U.S.S.R. 19 31-36.

Ortengren, R., Cederqvist, T., Lindberg, M. and Magnusson, B. (1991) Workload in lower arm and shoulder when using manual and powered screwdrivers at different working heights. Int J Ind Ergonomics 8 225-235.

Radzyukevich, T.M. (1969) Interrelation of temporary and parmanent shifts of vibration and pain sensitivity threshold under the efeect of local vibration. Gigiena Truda I Professional'nye Zabolevanija 14(12) 20-23.

研究成果の刊行物・別刷

14:N. Shibata, S. Maeda : Establishment of ISO 10819 based vibration transmissibility measurement system for anti-vibration gloves. Proceedings of 15^{th} Japan Conference on Human Response to Vibration, p165-171, 2007.

ESTABLISHMENT OF ISO10819 BASED VIBRATION TRANSMISSIBILITY MEASUREMENT SYSTEM FOR ANTI-VIBRATION GLOVES

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Abstract

A new Japan industrial standard JIS T8114 that is fully compatible with the international standard ISO 10819 has started to be effective in Japan in May 2007. A new vibration measurement system that fully satisfies the requirements defined in ISO 10819 was installed in the Japan National Institute of Occupational Safety and Health (Japan NIOSH). This paper presents the detail specification of the ISO 10819 based vibration measurement system installed in the JNIOSH. Also several measurement results of vibration transmissibility of anti-vibration gloves distributed in the Japan market were exhibited in this paper.

Introduction

A new Japan industrial standard JIS T8114 that is precisely compatible with international standard ISO 10819 (International Organization for Standardization, 1996) has started to be effective in Japan in May 2007. The standard of ISO 10819 specifies the measurement and evaluation of vibration transmissibility of anti-vibration gloves. The specification of a vibration system required to measure and evaluate the vibration transmissibility of anti-vibration gloves has been described in detail in this standard, which means that a novel vibration measurement system has to be developed instead of the old JIS T8114 based vibration measurement system.

Japan National Institute of Occupational Safety and Health (Japan NIOSH) has developed a novel vibration measurement system that precisely follows the requirements defined in ISO 10819. This vibration measurement is the only system that follows ISO 10819 in Japan. In this aspect, this system is expected to be used to evaluate anti-vibration gloves spread in the Japan market and hence to offer fundamental data for development of excellent anti-vibration gloves.

Presented at the 15th Japan Conference on Human Responses to Vibration, Training center of Nichii Gakkan Company., Kobe, Hyogo, Japan, August 1 to 3rd, 2007

This paper introduces the detail specification of the ISO 10819 based vibration measurement system installed in the Japan NIOSH. Also several anti-vibration gloves were measured and evaluated with respect to vibration transmissibility by using this system. These results are presented in this paper.

Methods

Experimental apparatus

Figure 1 shows the schematic signal flow diagram of the 1DOF hand-arm vibration system installed in the Japan NIOSH. As mentioned in Introduction section, this vibration system was fabricated based on the requirements specified in the international standard ISO10819 that defines the method for measurement and evaluation of vibration transmissibility of anti-vibration gloves. This system consists of mainly four major system components: the driving, measuring, control, and monitoring components (Fig. 1).

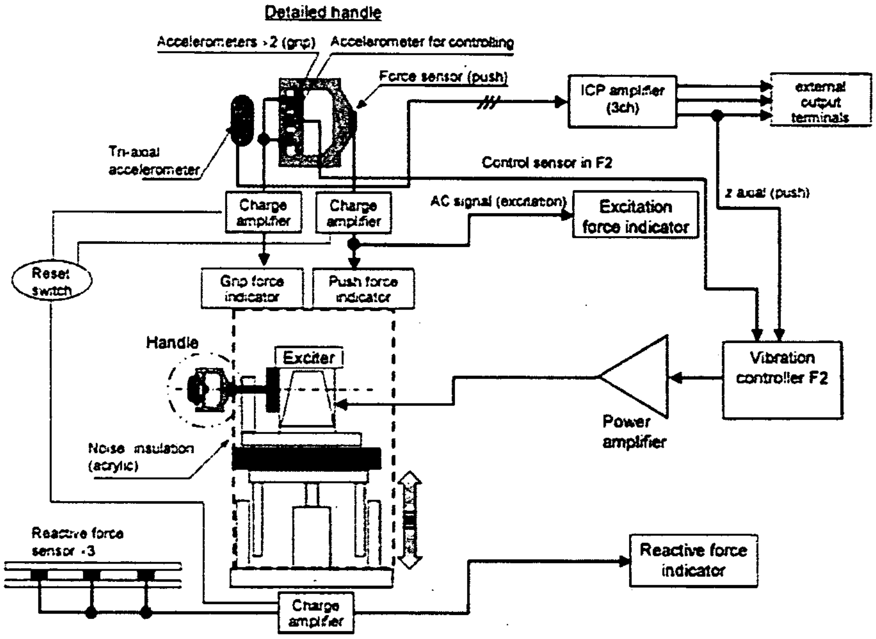

Figure 1 A schematic signal flow diagram of the 1DOF hand-arm vibration system.

An electro-dynamic shaker (VE-100S; IMV Corporation, Osaka, Japan), which generates Z_h axis vibration, was set up on the horizontal stage driven with an actuator fixed in the noise insulation box. A handle was secured with the shaker shaft. The handle height can be flexibly changed according to subject's body size. The specifications of the shaker are summarized in Table 1. This shaker allows a vibration frequency range up to 2000 Hz, which fully covers the frequency range required in measurement based on ISO10819 and ISO10068.

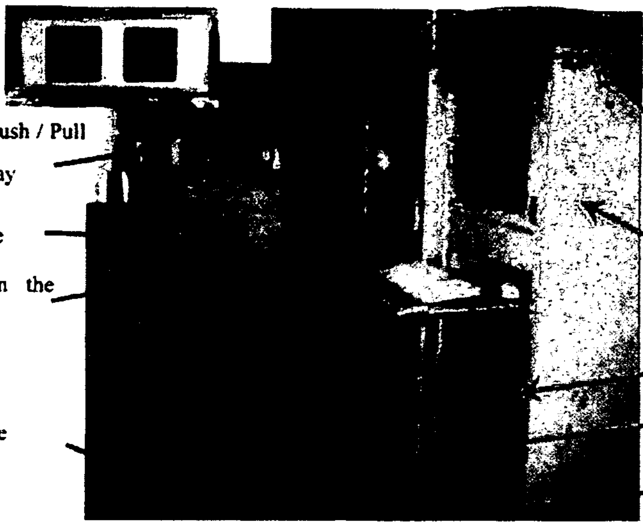

Figure 2 Entire photo view of the vibration measurement system.

Table 1. Specifications of the shaker set up in the hand-arm vibration system.

Frequency range	- 2000 Hz
Excitation force	
- Sinusoidal	450 N
- Random	320 N (r.m.s.)
Maximum acceleration	
- Sinusoidal	140 m/s^2
- Random	100 m/s^2 (r.m.s.)
Maximum velocity	0.13 m/s
Maximum displacement	15 mm p-p

Physical quantities measured in this system are accelerations and forces. Two acceleration signals, required in ISO10819 are measured: the acceleration at the handle and that at the palm surface of the hand. The acceleration data at the handle is obtained from an accelerometer (PCB 356A12) secured at the center of the handle while that at the palm from an accelerometer embedded in an adaptor whose dimension was designed according to ISO10819. Two force components, the feed force and gripping force, which act on an instrumented handle, are measured. The feed force is measured with a force plate (9286AA; Kistler Inc., Winterthur, Switzerland) by measuring the horizontal component of the force applied by subjects' feet to the force plate fixed on the floor. This measuring method assumes that the feed force is balanced against the horizontal component of the force applied to the platform. The gripping force is measured with two piezoelectric single-axis force sensors (9212 Kistler Inc., Winterthur, Switzerland) embedded in the handle.

The acceleration signal measured at the handle is feedbacked to a vibration signal controller (F2 waveform generation and control software, IMV corporation Inc.; Osaka, Japan) to appropriately control the vibratory acceleration at the handle. This software also takes charge of a signal generator that can make an arbitrary vibration signal not only in sinusoidal but in random spectrum waveforms. ISO 10819 defines two vibration spectra called M and H (see Fig. 3) as test vibration spectra imposed on the handle-hand system. Spectrum M covers a frequency range of 12.5 – 400 Hz wile spectrum H a frequency range of 125 – 2000 Hz.

The feed force and gripping force can be monitored with a display, through which subjects can see and control real time magnitudes of these two forces during HAV exposure tests.

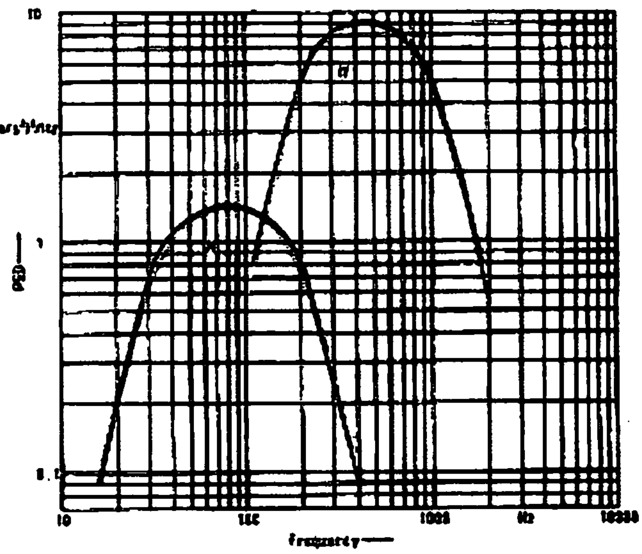

Figure 3 Two vibration spectra M and H defiened in ISO 10819.

Handle set up

As shown in Fig. 4, this vibration system has a cylindrical handle with a diameter of 40 mm and an effective grip length of 100 mm, which has been horizontally connected with a shaker so that the centerline axis of the handle is directed vertically. This handle mainly consists of two parts: the handle base and the measuring cap. The two piezoelectric single-axis force sensors were sandwiched between the two parts along the centerline of the handle to measure the grip force. Signal outputs of these two force sensors were passed through a low-pass filter with a 5 Hz cutting frequency and were then summed to obtain the gripping force. Also an accelerometer (PCB 356A12) was secured at the center of the measuring cap to measure the vibratory acceleration of the handle.

Evaluation criteria

As specified in ISO 10819, the vibration transmissibility of the bare hand TR_{sb} can be given as the ratio of the r.m.s. acceleration magnitude measured at the palm a_{wsPb} to the r.m.s. acceleration magnitude measured at the handle a_{wsHb}.

$$TR_{sb} = a_{wsPb} / a_{wsHb} \qquad (1)$$

The vibration transmissibility of the hand with gloves TR_{sg} can be given as the ratio of the r.m.s. acceleration magnitude measured with the accelerometer sandwiched between the glove and the palm a_{wsPg} to that measured at the handle a_{wsRg}.

$$TR_{sg} = a_{wsPg} / a_{wsRg} \qquad (2)$$

The vibration transmissibility of anti-vibration gloves TR_s is defined as follows:

$$TR_s = TR_{sg} / TR_{sb} \qquad (3)$$

TR_s values measured two times for each subject are arithmetically averaged to obtain the averaged vibration transmissibility TR, which was used to judge whether a certain anti-vibration glove satisfies the requirements specified in the ISO 10819. The TR values required to the ISO10819-satisfied anti-vibration gloves are less than 1.0 for spectrum M and less than 0.6 for spectrum H, respectively.

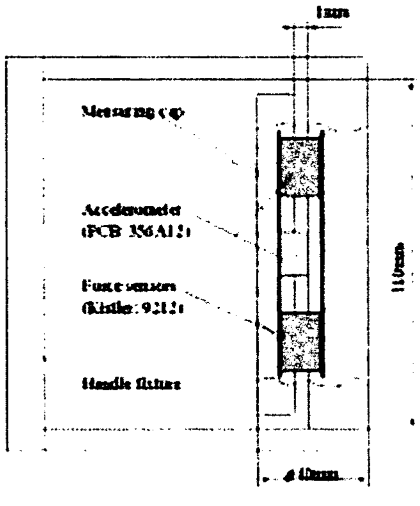

Figure 4 Schematic illustration of the instrumented handle.

Measurement of vibration transmissibility of gloves

Preparation of anti-vibration gloves

Five types of anti-vibration gloves distributed in the Japan market were prepared for test samples in this study. The vibration transmissibility of these gloves was measured according to the international standard of ISO 10819.

Subjects

According to the requirement specified in ISO10819, three healthy male subjects were used as subjects. No subjects have experienced high levels of hand-arm vibration occupationally or in their leisure activity. Anthropometric data of these subjects are summarized in Table 2. Prior to the measurement, the subjects were sufficiently trained to precisely follow the experimental scheme specified in ISO 10819. This experiment was approved by the Ethic Committee of the Japan National Institute of Occupational Safety and Health.

Table 2 Anthropometric data of subjects' hands

Subject No.	Hand length (mm)	Hand circumference (mm)	Size
1	194	200	8
2	190	202	8
3	190	203	8

Experimental procedure

For both vibration spectra, each subject performed the bare hand vibration transmissibility measurement followed by two times of vibration transmissibility measurements with anti-vibration gloves.

Results and Discussion

Results obtained from the vibration transmissibility measurements are summarized in Table 3. All the samples cannot satisfy the evaluation criteria specified in ISO10819. The reproductiveness of the measured data was excellent in the same subjects. The maximum discrepancy of the vibration transmissibility observed between subjects was about 26 %.

Table 3. Results of vibration transmissibility evaluation for anti-vibration gloves

Sample No.	TRs for spectrum M				TRs for spectrum H			
	Subject 1	Subject 2	Subject 3	Average	Subject 1	Subject 2	Subject 3	Average
1	0.944	0.914	0.954	0.938	0.835	0.97	0.918	0.908
	0.944	0.916	0.954		0.835	0.97	0.918	
2	0.968	0.965	0.868	0.934	0.89	0.86	0.706	0.919
	0.967	0.965	0.869		0.89	0.86	0.706	
3	0.993	1.092	0.985	1.02	0.979	1.177	1.093	1.08
	0.992	1.091	0.986		0.979	1.177	1.093	
4	0.899	0.932	0.838	0.89	0.766	0.802	0.722	0.722
	0.899	0.932	0.838		0.766	0.802	0.722	
5	0.957	1.04	1.019	1.005	1.096	1.151	1.148	1.132
	0.957	1.04	1.019		1.096	1.151	1.148	

Conclusion

This paper explained the specifications of the ISO10819 based hand-arm vibration system installed in the Japan NIOSH. A new Japan industrial standard JIS T8114 that is precisely compatible with international standard ISO 10819 has started to be effective in Japan in May 2007. In this aspect, this vibration system is expected to contribute to the development and improvement of the performance of anti-vibration gloves in Japan.

Also evaluation of vibration transmissibility of ant-vibration gloves were performed by using this vibration system for five types of anti-vibration gloves distributed in the Japan market. No tested samples satisfied the evaluation criteria of ISO10819.

Reference

International Organization for Standardization (1996) Mechanical vibration and shock – hand-arm vibration method for the measurement and evaluation of the vibration transmissibility of gloves at the palm of the hand, ISO 10819.

研究成果の刊行物・別刷

15:柴田延幸, 前田節雄：「防振手袋関連規格 JIS T8114 の ISO 整合化と国内防振手袋の対応状況」日本音響学会　建築音響・振動騒音研究会：平成 20 年 3 月 11 日発表