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Development of hand-arm vibration measurement device

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Abstract

About the indicator concerning the vibration put out newly than the Ministry of Health, Labour and Welfare on July 10, 2009.

Three axis synthetic value of the RMS value is calculated, and the measurement device of the hand-transmitted vibration corresponding to the management of day amount A(8) of the vibration exposure is developed.

(1) **Device spread to tool manager**

The device by which the measurement of three axis synthetic value of the RMS value that is an important duty of "Person in charge of the vibration tool management" becomes simple is developed.

(2) **Device spread to worker**

The performance as the general-purpose type measurement device is secured, and the low price is commercialized.

: The vibration trouble prevention measures indicator that lies "Chainsaw handling work indicator" and "Handling business of the vibration tool other than the chainsaw" is considered, too.

1. Introduction

As for the device that measures the vibration, various products have already been sold by each manufacturer. These products are making to high performance and the price of the product is expensive settings. When "Management representative" and "Worker" use it, it makes it to an easy-to-use device.

1) Concept to "Person in charge of vibration tool management"

The product that can be used at ease is offered to the management Representative. And, it is valued to be able to use it easily.

2) Concept to "Vibration tool use worker"

The product to which the switch operation is small and lightened by an easy operation of few, simple functions is offered to the worker.

3) Form of vibration measurement device

Commercialization that makes measurement operation part specification of wristwatch type to consider worker's work efficiency.

The vibration measurement sensor is arranged near the tool grasp part.

2. Equipment specification

1) Pick up for vibration detection(3 axis acceleration sensor)

The price of the marketed vibration pick-up is about 100,000~300,000 yen now. In the demanded measurement device, the thing that the worker daily uses is a precondition. Picking up has the necessity of the product that can be supplied as parts of the articles of consumption from the use. The acceleration sensor that is generally called MEMS as picking up is advanced as an examination.

① About MEMS

The one that mechanical parts and CMOSIC made by the micro machining technology were accumulated in one semiconductor chip is MEMS. [1]

(Principal use)

- Game machine
- Cellular phone
Gravitational acceleration is measured, and the direction of the screen is corrected. [2]
- Life-saving automotive air bags
- Robot control and arm
- Machine tool

There are four kinds of the following by the difference of an internal structure.

- ① Electrostatic capacity type
- ② Piezo resistance type
- ③ Piezo-electric ceramic type
- ④ Analysis of temperature of gas type

(Feature)

- Productivity is good, and the adjustment is unnecessary.
- The miniaturization and making to intelligence were achieved. [1]

The sensor of the acceleration of the semiconductor is widespread from two points of the above-mentioned.

② Current state of pick up (MEMS acceleration sensor)

What suits the specification and the purpose is checked from the investigation of three axis (X,Y,Z) MEMS of the sold each manufacturer now.

Manufacturer for investigation 14 companies

Number of investigation target products About 100 kinds

Category for investigation Three axis detection simultaneously and analog output

(Selection condition)

- Acceleration input range $\pm 10g$ or more (three axis commonness)
- Range of frequency input 5Hz or less or $\sim 1200\text{Hz}$ or more (three axis commonness)
- Impact 5000g or more

Table 1 Comparison table of MEMS acceleration sensor

	Part Number	# of Axes	Output Type	Range	Sensitivity (mV/g)	Sensitivity Accuracy (%)	Typical Bandwidth (Hz)	Voltage Supply (V)	Current Supply (mA)	Temp Range (°C)	Package (mm)
A社	H34C	3	Analog	$\pm 3g$	333	± 10	100	2.2to3.6	0.36	-25to75	3.4x3.7x0.92
B社	LIS344ALH	3	Analog	$\pm 8g$	333	± 10	1800	2.4to3.6	0.68	-40to85	4.8x4.8x1.5
C社	HAAM-346A	3	Analog	$\pm 3g$	333	± 10	500	2.2to3.6	0.70	-25to75	3.0x3.0x1.0
D社	ADXL326	3	Analog	$\pm 16g$	57	± 10	1600	1.8to3.6	0.35	-40to85	4.0x4.0x1.45
E社	XC3334	3	Analog	$\pm 3g$	333	± 10	100	2.2to3.6	0.36	-25to75	3.4x3.7x0.92
F社	BMA140	3	Analog	$\pm 4g$	300	± 32	1500	1.8to3.5	0.20	-40to85	3.0x3.0x0.9
G社	KXD94-2802	3	Analog	$\pm 10g$	200	± 2.5	800	2.5to5.25	1.2	-40to85	5.0x5.0x1.2
H社		1or2	Analog	—	—	—	—	—	—	—	—
I社		1or2	Analog	—	—	—	—	—	—	—	—
J社		1or2	Analog	—	—	—	—	—	—	—	—
K社		—	—	—	—	—	—	—	—	—	—
L社		3	Digital	—	—	—	—	—	—	—	—
M社		—	—	—	—	—	—	—	—	—	—
N社		3	Digital	—	—	—	—	—	—	—	—

表1. ピックアップ(加速度センサ)の現状

About the manufacturer that manufactures the sensor of the analog output.

Data is not filled in of the manufacturer where the product of three axes doesn't exist and the manufacturer of the digital output type that turns into the feature.

Two module manufacturer companies were assumed to be similar.

Features in the investigation are the following two points.

1. The product with low value of sensitivity is a main current.

The product of lower sensitivity (10g or less) is from an investigation to the majority.

In the reason, at first, the one that corresponded to higher acceleration detection was a main current where the MEMS acceleration sensor had been developed.

However, it is a result of the summary in the specification that each company considered generality because of market trends few.

2. There are a lot of products of the digital output.

With the serial communications interface, the analog amplification circuit and the noise measures, etc. can easily unnecessarily use every acceleration sensor for the digital output product. In the manufacturer (Table 1) that specializes in digital goods, they are only two companies. In the manufacturer that manufactures analog goods, 80% commercializes digital goods.

It is thought that the current state cannot be used in the point that a digital sensor can be used to measure the hand arm vibration this time by occasion of the following.

- The data processing speed is slow.
- The data accuracy is low. (relation of resolution)

However, we want to advance the evaluation of the sample goods continuously.

③ Problem of pick up (MEMS acceleration sensor)

In the MEMS chip, there are one point problem by constructional. Each product is 10mm or less. the size of the package. It is a point that a mechanical part and CMOSIC have been cumulated in this. A movable range is necessary for the mechanical part. When it is Z axis, a movable range is about 1/3 in the mechanical part compared with the length of the X · Y axis as for the direction of thickness of the chip. Because the frequency band region that can correspond is decided depending on length within this movable range, z axis becomes it up to 550Hz though the x · y axis can correspond up to 1500Hz for instance in the product of D company.

The current state is thought the influence of the point of not marketable as for these. The MEMS chip can be evaluated as a product that suits very small, this theme as an acceleration sensor. It is thought that the investigation of the module goods is necessary again whether to modulate or to use the modulated product.

2) Achievement of miniaturization and price cutting of main body of measurement device

It aims at the miniaturization and the price cutting according to the following composition.

- The latest processor (CPU · DSP)
- Analog to digital conversion machine (Type $\Delta\Sigma$)
- USB communication interface

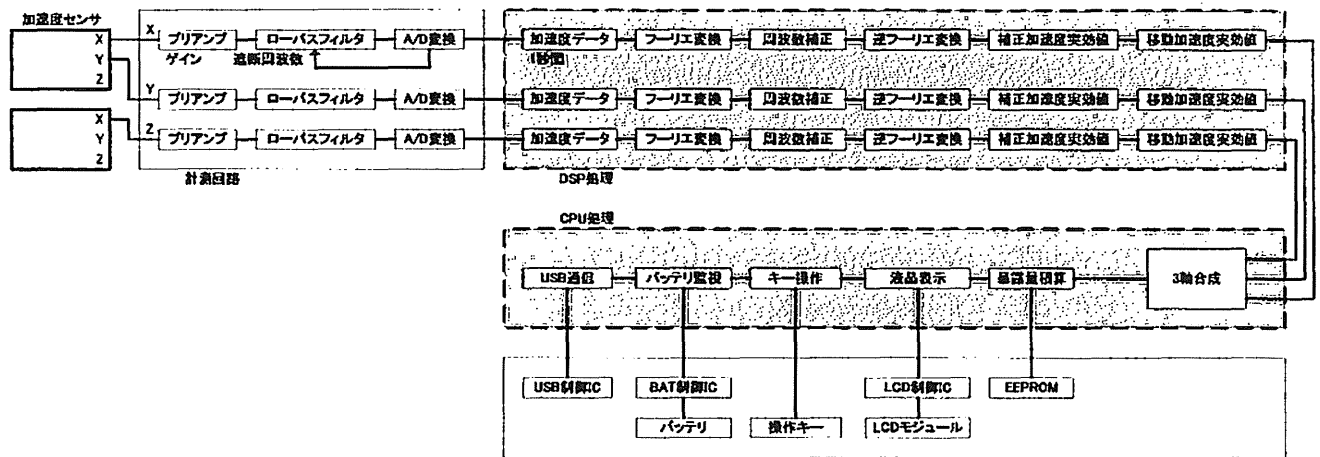


Fig.1 Block chart where MEMS was used

3. Results and Agenda

The following evaluation problem in the future is executed in advancing development, and the stabilization of a further product is evaluated now.

- **Vibration pick up**

 - Evaluation test and durability test on each manufacturer sample.

- **Environmental performance examination as measurement device**

 - It evaluates it from the regular vibration examination and the field test in a site in making of the device a system requirements.

- **Data management after measurement is processed**

 - The tool that makes information management easy is made for the tool manager.

 - To be easily treatable of making to the data link data base, the interface is constructed.

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The 18th Japan Conference on Human Response to Vibration (JCHRV2010)

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**New Japanese Guidelines for Preventing
Hand-Arm Vibration Syndrome**

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Abstract

The purpose of this paper is to describe the implementation of the new Japanese Guidelines for preventing Hand-Arm Vibration Syndrome. It was published on 10th July 2009 by the Ministry of Health, Labour and Welfare.

1. Introduction

Figure 1 shows the number of new officially acknowledged victims of Hand-Arm Vibration Syndrome who qualify for worker's compensation. In order to reduce the number of injured workers and the number of workers needing compensation, the Ministry of Health, Labour and Welfare launched the 10th Industrial Accident Prevention Plan from 2003 to 2007. In addition, special consideration was given to the current high incidences of vibration-related disorders caused by construction equipment, such as jackhammers and pick hammers as shown in Table 1.

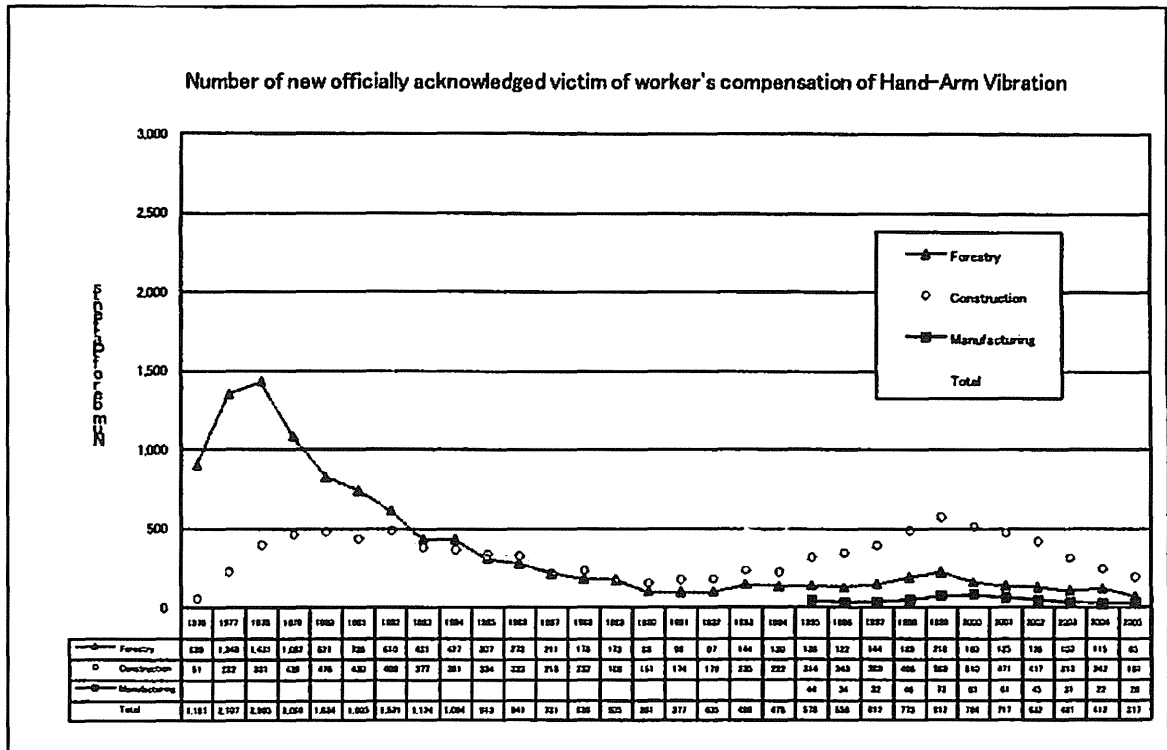


Figure 1 - Number of new officially acknowledged victims of Hand-Arm Vibration Syndrome receiving worker's compensation

Table 1 - Number of cases by tools in 1999 (The longest usage tools)

- | | |
|-------------------------|----------------------------|
| 1)Rockdrill 229 | 10)Impact wrench 11 |
| 2)Chainsaw 229 | 11)Chippinghammer 8 |
| 3)Pick hammer 143 | 12)Electric hammer 7 |
| 4)Concrete vibrator 127 | 13)Sand rammer 6 |
| 5)Bush cutter 34 | 14)Engine cutter 3 |
| 6)Sander 34 | 15)Portable tight tamper 2 |
| 7)Concrete breaker 27 | 16)Baby hammer 1 |
| 8)Portable grinder 26 | 17)Others 12 |
| 9)Vibration drill 13 | Total 912 |

The number of recognized cases of vibration-related disorders is over 700 a year and primarily occurs in the construction industry. In order to reduce vibration-related disorders, the Ministry program will review the effectiveness of safety measures to prevent vibration-related disorders, and it will devise necessary measures to minimize such injuries.

In 1947, hand-arm vibration disease was described in the Enforcement Regulation of New Labour Standards Law. The Ministry of Labour issued a number of National Labour Standards Bureau Notification notices to private industries from 1970 to 1992 as part of the comprehensive health, safety and injury prevention system to promote the improvement of worker's health and safety in the workplace. It provides for a general framework that incorporates European principles while at the same time honoring common international principles. The list of Notifications is shown in Table 2.

Table 2 - Labour Standards Bureau Notifications

Year	Industrial Health-Related Laws, Regulations, Ordinances and Other Notifications in Japan
1947	The Labour Standards Law
1953	Examination of the evaluation index of the vibration syndrome
1970	Labour Standards Bureau Notification No. 134 Guidelines for the Prevention of Vibration-induced Disorders Guidelines for the Prevention of Vibration-induced Disorders in Chainsaw Handling Work
1973	Labour Standards Bureau Notification No. 597 Guidelines for the Medical Examinations of Vibration-induced Disorders in Chainsaw Handling Work
1975	Labour Standards Bureau Notification No. 610 Guidelines for the Medical Examinations of Vibration-induced Disorders in Chainsaw Handling Work Labour Standards Bureau Notification No. 608 Guidelines for the Prevention of Vibration-induced Disorders in Handling Tools Other Than Cainsaws
1976	Labour Standards Bureau Notification No. 494 Guidelines for the Medical Treatment of Vibration-induced Disorders
1978	The Labour Standards Law No. 35 Start of Compensation
1983	Labour Standards Bureau Notification No. 258 Promotion of Safety and Health Education to Workers in Handling Tools Other Than Cainsaws
1988	Labour Standards Bureau Notification No. 11 Measurement method of tool vibration level in Hand-held Power Tools (Except Chaisaw)
1993	Labour Standards Bureau Notification No. 203 Promotion of Comprehensive Measures against Vibration Disorders

Moreover, as part of the measures based on the comprehensive safety standards of machinery, the plan will encourage manufacturers of vibrating equipment to implement risk reduction measures, and to provide information on the hazard of vibration to employees.

Figure 2 shows the relationship among Machinery Directives, the EU directive, International Standards and National Standards. This directive aims to introduce measures that promote

the improvement of worker's health and safety in the workplace. It provides for a general framework that executes European principles while at the same time honoring common international principles.

The guiding principles of the content are as follows.

- 1) This directive is applied to the activities of all public and private sections.
- 2) The employer's responsibilities
- 3) Responsibilities of workers and workers rights

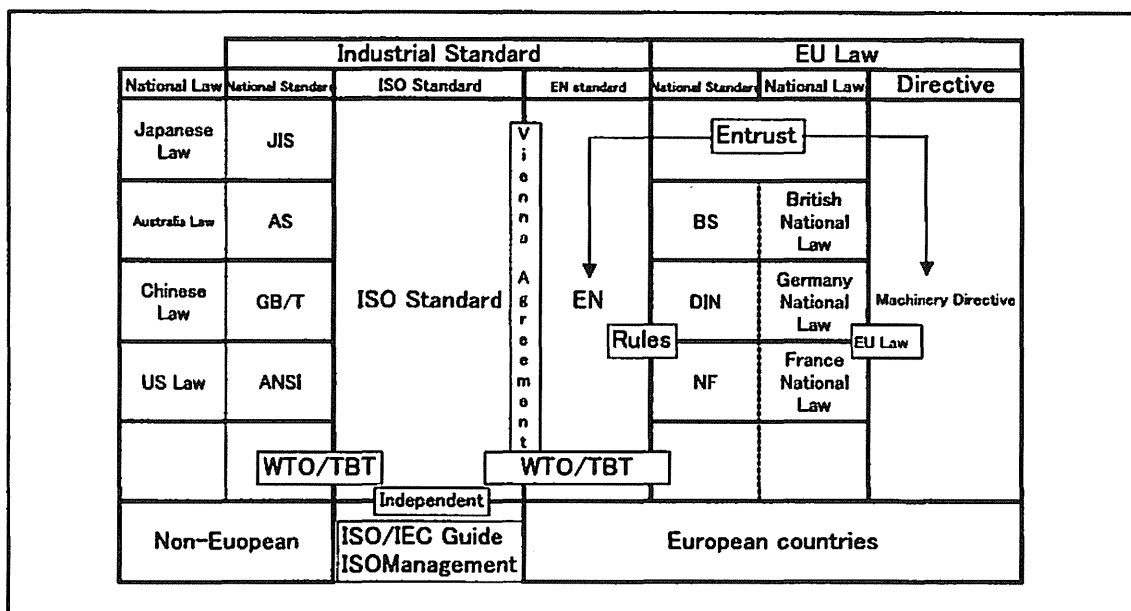


Figure 2. The relationships among Machinery Directives, EU Directives, International Standards and National Standards

In achieving the market integration of Europe, it seems that it is an indicator that the "Framework instructions" concerning this Machinery Directive and labor safety hygiene (board of directors instruction 89/391/EEC, which introduces measures to promote the improvement of labor safety hygiene and the following 98/37/EC: (1998) are the safety hygiene policy. In the design and the production of machines, it is mandated that both limiting the dangers associated with vibration in the vibratory source and improved methods in which the machine is used that minimize injury should be considered. The vibration in the tool or equipment should be suppressed to the lowest level consistent with the development of vibration decreasing technology. The following daily exposure limit value and daily exposure action value are

provided for hand-transmitted vibration.

1. In the case of hand-transmitted vibration

- (a) The daily exposure limit value standardized to an eight-hour reference period shall be 5m/s^2 .
- (b) The daily exposure action value standardized to an eight-hour reference period shall be 2.5m/s^2 .

The assessment is based on the calculation of the daily exposure value normalized to an eight-hour reference period as defined in ISO 5349-1 standard. The minimum condition is to protect the worker from danger and ensure safety and health when being exposed to mechanical vibration exposure in the workplace.

Directive 98/37/EC (Machinery Safety Directive) and Directive 2002/44/EC(Physical Agent Directive-Vibration) have been in force since July, 2005, and thus, the effort target value of the vibration reduction are well established and have been incorporated by the hand-transmitted vibration tool manufacturers. The manufacturers use international standards and make international adjustments to test and classify the hand-transmitted vibration value tool. Moreover, the company has the additional obligation to protect the worker from the possible danger to ensure safety and health while exposed to mechanical vibration caused by the equipment or situation. Therefore, the hand-held power tool manufacturer should measure the tool vibration value based on international test standards before the tool can be made available to consumers, and declare the vibration value so that the user may perform a risk assessment of the tool. Moreover, the tool manufacturer is required to evaluate the safety of each tool, and to meet the machine instruction standards.

The EU Commission is expected to make the guidelines provided in the Machinery Directive legally mandatory within three years after publishing the instructions as a legal notice in the official gazette as stipulated by EU law. These Machinery Directives are mandating the necessary standards that machine-made goods etc. must achieve without specifying the technology companies may utilize. The result is that the EU and EFTA (European Free Trade Association) will conform to an EN standard assuming that necessary the regulations are implemented, supplemented and supported by CEN (European Committee for Standardization) and CENELEC (European Electric Standardization Committee). The EN standard then is adopted by each EU country as a national standard under the bylaws of CEN and CENELEC. Moreover, this EN standard is offered as a proposed agreement in Vienna as

an ISO standard, and the ISO standard becomes a national standard in countries that are members of the WTO when an agreement is reached through the WTO/TBT (World Trade Organization)/TBT(Technical Barriers to Trade) (Agreement concerning technical barriers to trade).

For preventing HAVS, the A (8) introduces risk assessment. The A (8) consists of the vibration total value of frequency-weighted r.m.s. acceleration and the daily exposure times. In the work place, managers of vibration tool users must consider the risk to employees of using the 'tool work tasks' before considering 'real work tasks' according to A (8). For this reason, managers need the vibration total value of frequency-weighted r.m.s. acceleration of the individual tool. According to the EU Directive, the manufacturers have to declare the magnitude of the individual tool according to test protocols or to field measurements for preventing the HAVS in the workplace.

In March of 2006, the Ministry of Health, Labour and Welfare appointed a special committee to examine work management for the prevention of hand-arm vibration syndrome. This committee recommended adopting the EU Directive of MSD and PAD (Vibration) principles in the committee's final report in 2007.

On 10th of July 2009, the Ministry of Health, Labour and Welfare published the following 4 guidelines [1]-[4]:.

1: LSB (Labour Standards Bureau) Issue No.0710-1

Guidelines for Handling Chain Saws

2: LSB (Labour Standards Bureau) Issue No.0710-2

Guidelines for Preventive Measures against Vibration Hazards in Work with Vibratory Tools other than Chain Saws

3: LSB (Labour Standards Bureau) Issue No.0710-3

Management and Indication of Vibration Total Value of Frequency-Weighted r.m.s. Acceleration" of the individual tools

4: LSB (Labour Standards Bureau) Issue No.0710-5

Promotion of Comprehensive Measures against Vibration Hazards

The purpose of this section of the paper is to describe the implementation of the new Japanese Guidelines for preventing Hand-Arm Vibration Syndrome that was published on 10th July 2009 from the Ministry of Health Labour and Welfare.

2. Work Management for Preventing HAVS (Hand-Arm Vibration Syndrome) to Workers in Japan

In July 2002, the European Union published the Directive 2002/44/EC the Physical Agents (Vibration) Directive (PA(V)D). It outlines new guidelines for exposure to vibration in the workplace. It sets action and limit values for vibration exposure, and it describes the employer's obligations to manage the risks from exposure to vibration. This chapter is intended as a guide for the employer who has employees using vibrating hand-held power tools. We also give practical tips regarding what can be done to reduce vibration exposure from hand-held power tools. The Physical Agents (Vibration) Directive was developed from an original proposal made by the European Commission in 1993. This proposal was revised, amended and eventually agreed to by Member States and the European Parliament and came into force on 6 July 2002. The Directive lays down the minimum standards for the health and safety of workers exposed to hand-arm vibration and supports the general requirements for improving health and safety that are outlined in the Framework Directive (89/391 /EEC).

For preventing HAVS, the A (8) is introducing risk assessment. The A (8) consists of the vibration total value of frequency-weighted r.m.s. acceleration and the daily exposure times. In the work place, managers of the vibration tool users must consider the risk to employees of using of 'tool work tasks' before considering 'real work tasks' according to A(8).

For this reason, managers need the vibration total value of frequency-weighted r.m.s. acceleration of the individual tool. According to the EU Directive, the manufacturers have to declare the magnitude of the individual tool according to test protocols or to the field measurements for preventing the HAVS in the workplace.

2.1 Vibration Magnitude of Tools (The responsibility of the manufacturers)

The responsibility of the manufacturers is regulated according to Machinery Directive (98/37/EC) which was later reissued as (2006/42/EC) in December 2009. All manufacturers have to declare the vibration total value of frequency-weighted r.m.s. acceleration of the individual tool. The manufacturers also have to follow two methods of deriving the vibration total value of frequency-weighted r.m.s. acceleration of the individual tool:

(1) The vibration total value of frequency-weighted r.m.s. acceleration by test protocol; This test protocol is used by vibration tool manufacturers. The measurement of the tool vibration value based on the test protocol is performed using the International Standards as shown in Table 1, and the manufacturers must provide users with a declaration value of the

vibration value from the vibration tool before the tool can be put on the market. As for this declaration value, it is necessary to obtain a vibration value that conforms to international standards so that the testing methods and the vibration evaluations of the hand-held vibration tool are consistent regardless of the country where the tests are conducted.

(2) The vibration total value of frequency-weighted r.m.s. acceleration by measurement in the workplace;

The vibration total value of frequency-weighted r.m.s. acceleration from hand-held vibration tools cannot be specified according to the vibration value obtained by the test protocol such as the International Standards as shown Table 1. It is necessary to evaluate the physical value of the vibration tool in the workplace according to the ISO 5349-2 standard.

2.1.1 Manufacturer's declared vibration value by Test Protocol

In order for these measures to be adopted by the businesses whose workers use vibratory tools, vibratory tool manufacturers need to measure and declare the "the vibration total value of frequency-weighted r.m.s. acceleration " of such tools.

With regard to vibratory tools, the "the vibration total value of frequency-weighted r.m.s. acceleration" shall be measured and calculated as follows:

Vibration acceleration shall be measured (hereinafter referred to as "vibration measurement") and declared conforming with the following notes and applicable measuring standards from orders ISO 8662 or ISO 28927-series, ISO 22867, EN 60745, and EN 50144.

If these measuring standards are deemed inapplicable, vibration measurement shall be conducted in accordance with ISO 5349-2 as shown in Figure 3.

Considering the above, vibratory tools shall comply with the measuring standards, such as test protocols, specified in Table 3.