Where, a_w (t) is the instantaneous value (ms^{-2}) of the frequency-weighted vibration acceleration.

Then, the directional vibration of the X, Y and Z axes are measured at the same time, and the a_{hv} (the vibration total value of frequency-weighted r.m.s. acceleration) may be obtained from each value (a_{hwx}, a_{hwy} and a_{hwz}) in the direction of the 3 axes from the following Equation (2) :

$$a_{hv} = \sqrt{a_{hwx}^2 + a_{hwy}^2 + a_{hwz}^2} \qquad (2)$$

The standards based on an equivalent-vibration root mean square acceleration of eight hours per day (daily vibration exposure A(8), have been adopted by the International Organization for Standardization (ISO). These values are calculated by the vibration total value of frequency-weighted r.m.s. acceleration and the exposure times. The exposure of workers to hand-transmitted vibration shall be determined by either measuring the actual vibration values to which workers are exposed or by using appropriate vibration data supplied by equipment manufacturers and then calculating the corresponding vibration total values, a_{hv} (r.m.s.), and the related daily vibration exposure, A(8). Vibration data supplied by equipment manufacturers shall be obtained for conditions that closely represent how their equipment is used in actual work conditions. Equipment manufacturers shall document the test conditions under which their data were obtained.

3 Procedures of Work Management for Preventing Hand-Arm Vibration Syndrome (The responsibility of the employers and the workers)

Figure 6 shows the management method for preventing the hand-arm vibration syndrome based on the Daily Vibration Exposure A(8).

Procedure 1: Understanding the vibration total value of frequency-weighted r.m.s. acceleration of the individual tool

Employers must monitor the hazards of the vibration from the usage of the vibration tool in the workplace, and specify the hazards (the vibration total value of frequency-weighted r.m.s. acceleration of the individual tool) of vibration tool.

Procedure 2: Calculation of Daily Personal Vibration Exposure (A(8))

Employers must calculate the A(8) from the vibration total value of frequency-weighted r.m.s. acceleration from Procedure 1 and the Daily Vibration Exposure Times.

Procedure 3: Evaluating the necessity of a Vibration reduction plan according to the Daily Vibration Exposure A(8)

① In cases when A (8)>5.0 (Above the exposure limit value)

Take immediate action to bring exposure below the exposure limit value. In addition, management should implement controls on vibration exposure times and increase the utilization of low vibration tools.

② In cases of 2.5 < A (8)≦ 5.0 (Above the exposure action value, but the exposure limit value is not exceeded)

Implement a program of measures to reduce exposure and risks to a minimum. In addition, management should implement controls on vibration exposure times and increase the utilization of low vibration tools.

Procedure 4: Design and implementation of concrete vibration reduction plans according to Daily Vibration Exposure A(8)

The measures for limiting the daily amount A (8) of the vibration exposure is examined and implemented.

Figure 6 Procedures of Work Management for Preventing Hand-Arm Vibration Syndrome

3.1 Procedure 1. Evaluating the vibration total value of frequency-weighted r.m.s. acceleration of the individual tool

Employers must obtain the vibration total value of frequency-weighted r.m.s. acceleration of the individual tool.

3.2 Procedure 2: Calculation method of the Daily Vibration Exposure A(8)

In Procedure 2 calculations are made of on the amount of Daily Vibration Exposure A(8) consistent with the equivalent vibration acceleration value (Daily Vibration Exposure A(8)) from "the vibration total value of frequency-weighted r.m.s. acceleration" of the vibration tool which employers obtained through Procedure 1 and "the exposure time (the tool usage time)".

How to calculate daily vibration exposure A(8)

Daily vibration exposure A(8) is calculated from the declared values of "the vibration total value of frequency-weighted r.m.s. acceleration" that are provided by manufacturers, importers and employers, and the exposure time. Daily vibration exposure A(8) (an 8-hour energy equivalent frequency-weighted r.m.s. acceleration value) are found by Equation (3) using the vibration total value of frequency-weighted r.m.s. acceleration and the daily vibration exposure time. Therefore, easy comparisons can be made with the different daily vibration exposure times.

$$\text{The daily vibration exposure } A(8) = a \times \sqrt{\frac{T}{8}} \quad \left[m/s^2\right] \quad (3)$$

Where, a [m/s^2] is the vibration total value of frequency-weighted r.m.s. acceleration.
T [time] is the daily vibration exposure time.

And, when the same worker uses more than one vibration tool on the same day, employers have to calculate the daily vibration exposure A(8) of the worker concerned by the Equation (4) from " The vibration total value of frequency-weighted r.m.s. acceleration" for each and every tool.

$$a_{hv(rms)} = \sqrt{\frac{1}{T_v}\sum_{i=1}^{n}\left(a^2_{hv(rms)\,i}\,T_i\right)} \quad \left[m/s^2\right]$$

The daily vibration exposure

$$A(8) = a_{hv(rms)} \sqrt{\frac{Tv}{8}} \quad [m/s^2] \quad \cdots (4)$$

Where, $a_{hv(rms)i}$ is the vibration total value of frequency-weighted r.m.s. acceleration of the work of the i turn; Ti is the tool usage time (vibration exposure time) of the work of the i turn; n is the total amount of work (number of jobs), Tv is the total vibration exposure time of the work of the n individual.

3.3 Procedure 3: Evaluating the necessity of a Vibration reduction plan according to the Daily Vibration Exposure A(8)

The employers must evaluate the necessity of decreasing the worker's vibration exposure from the daily vibration exposure A(8) obtained through Procedure 2 when daily vibration exposure A(8) exceeds the vibration exposure limit value 5.0 (m/s^2).

The employers must evaluate the necessity to decrease the vibration exposure to the worker when it exceeds 2.5 (m/s^2) even if the daily vibration exposure A(8) is less than 5.0 (m/s^2).

3.4 Procedure 4: Design and implementation of concrete vibration reduction plans according to Daily Vibration Exposure A(8)

(1) When the daily vibration exposure A(8) exceeds 5.0 (m/s^2):

When the daily vibration exposure A(8) exceeds 5.0 (m/s^2), the employers must investigate the cause, and depending on that cause, may need to limit exposure times and increase the use of low vibration tools.

(2) When daily vibration exposure A(8) exceeds 2.5 (m/s^2).

When the daily vibration exposure A(8) exceeds 2.5 (m/s^2), even if it is less than 5.0 (m/s^2), employers investigate the cause, and depending on that cause, may need to limit exposure times and increase the use of low vibration tools.

The Design and Implementation of vibration reduction plans according to the vibration exposure limit time

Calculation of Vibration Exposure Limit Time:

The vibration exposure limit time corresponding to the day vibration exposure limit value ($5.0m/s^2$) is calculated by Equation (5).

$$\text{Vibration exposure limit time } T_L = \frac{200}{a^2} [\ \text{hours}\ ] \quad \cdots\cdots\cdots (5)$$

Where, a $[m/s^{2]}$ is the vibration total value of frequency-weighted r.m.s. acceleration.

Figure 7 shows the relationship between the vibration exposure limit time and the vibration total value of frequency-weighted r.m.s. acceleration compared to the daily vibration exposure A(8).

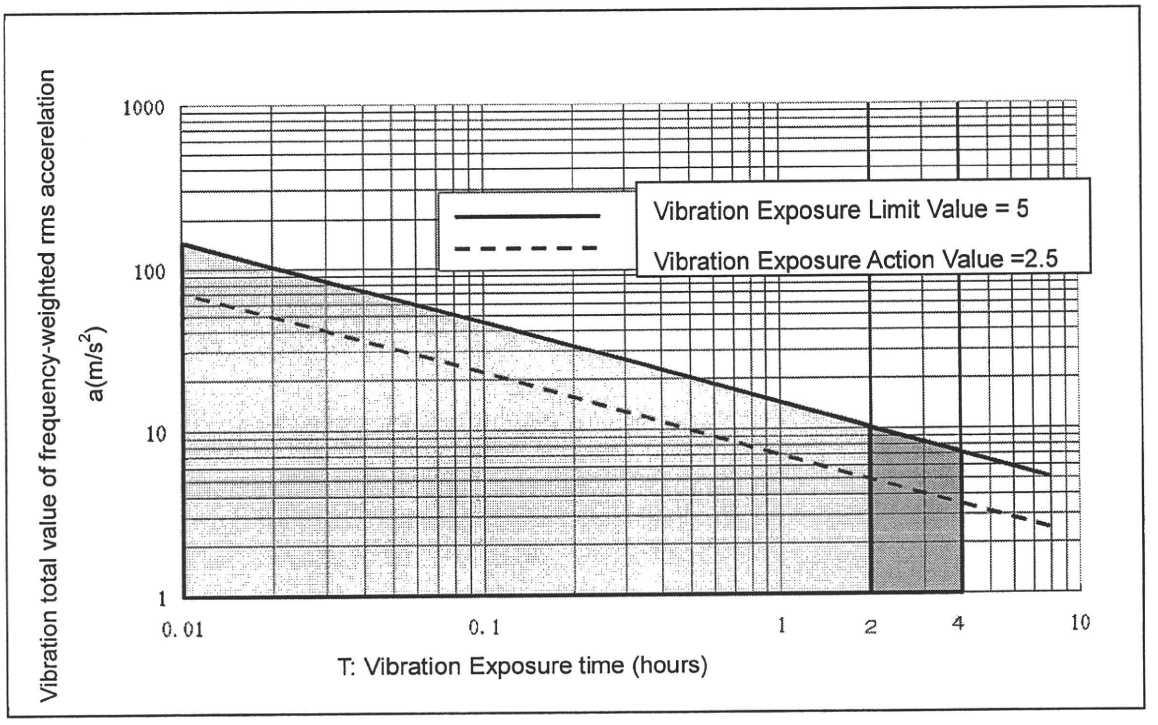

Figure 7 Relationship between the vibration exposure limit time and the vibration total value of frequency-weighted r.m.s. acceleration compared to the daily vibration exposure A(8)

Next, it is necessary to calculate the duration of exposure during a day using the "Vibration exposure time" using the methods found in ISO 5349-2 (method of a field measurement in the workplace). These results are used to estimate the amount of the vibration exposure in each vibration source and the vibration exposure time of a typical day that conform to A(8), the

international standards.

4. Conclusions

The MSD of the EU Directive and the PAD have had a great influence on Japan vibration safety standards. It is generally recognized that the introduction of the EU Directive to Japan has been very useful in helping decrease the 400 new cases of vibration injuries that have generally occurred in Japan each year. On March of 2006, the Ministry of Health, Labour Welfare appointed a special committee to investigate work management for the prevention of hand-arm vibration syndrome. This committee recommended adopting the EU Directive of MSD and PAD (Vibration) principles into the report of this committee in 2007.

This paper described the implementation of the new Japanese Guidelines for preventing Hand-Arm Vibration Syndrome that was published on 10th July 2009 by the Ministry of Health Labour and Welfare.

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