

**Hand – Arm – Vibration
Guideline for Employers**

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Implementation of the European Directive Physical Agents (Vibration) 2002/44/EC

The EC - Directive 2002/44/EG requests that employers carry out a risk assessment of the vibration exposure of their employees with the aim of reducing the health risks. This guideline gives a simplified method for this risk assessment. The method is based on a Technical Report of CEN/TC 231 and the essential content of the European Directive 2002/44/EC.

This guideline has been developed by those members of EUROMOT (European Association of Internal Combustion Engine Manufacturers) who are involved in the manufacture of handheld power tools.

It is intended that the guideline will improve the communication between employers and manufacturers of power tools with respect to the compliance with the Directive 2002/44/EC and shall assist the employers when they conduct the risk assessment.

This guideline refers solely to the determination of the daily exposure action value and the daily exposure limit value in Guideline 2002/44/EC. In case of diverging national laws or ordinances, this guideline cannot be applied.

The contents of this guideline represent is intended to inform employers on how to meet the requirements of the Directive, it is not intended that it should be used as a risk assessment for individual cases. Especially as variables peculiar to individual workplaces such as working methods, temperatures and other aspects have to be considered. EUROMOT cannot take any liability for the results achieved with this method or for any conclusion reached in each single application. Any questions should be addressed to the relevant Health and Safety Consultant. Manufacturers can supply further details of their products if required.

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1. What is new?

The EU Directive „Vibration“ refers directly to the Standards EN ISO 5349-1:2001 and EN ISO 5349-2:2001, which incorporate the state-of-the-art concerning the measurement and assessment of vibration at the workplace.

These standards and the requirements of the Vibration Directive provide several amendments and changes. Among others they require a risk assessment (Article 4), informing employees (Article 6) and the initiation of a program for the reduction of vibration exposure (if required, see, Article 5).

According to existing test standards, vibration is measured as frequency weighted acceleration on the handles of the power tool.

The assessment of the vibration exposure is calculated in relation to a standardised 8 h daily exposure level A(8). Advice on measurement is given in an Annex of the Directive. A simplified method is described in this brochure.

Depending on the daily exposure action value and the daily exposure limit value, the Directive requires different action by the employer. If an operators daily exposure to vibration is kept below the Exposure Action Level it should help him to avoid vibration related diseases.

If an operators daily exposure exceeds the Exposure Limit Value then there is a significant increase in the risk of developing vibration related diseases to the operator.

Whenever an employee is affected by a vibration exposure A(8) exceeding the daily exposure action level of 2,5 m/s². The employer has to carry out a risk assessment of the operation that the employee is carrying out and introduce control measures.

Hand-Arm Vibration Exposure Values:

Daily exposure limit value A(8) = 5 m/s²

Daily exposure action value A(8) = 2,5 m/s²

Vibration total value a_{hv} : For the determination of the daily exposure values of hand-arm vibration A(8) frequency weighted acceleration values are used, which combine all three measuring axis at each handle.

Equivalent vibration value $a_{hv,eq}$: Each operation normally includes several different modes, such as idling or cutting with full load. They may be combined in an equivalent vibration value $a_{hv,eq}$.

2. Measures

If the daily exposure action value of 2.5 m/s^2 is exceeded the employer shall implement a program of technical and organisational measures taking into account in particular

- the vibration risk is analysed adequately (Article 4)
- the choice of appropriate work equipment producing the least possible vibration (Article 5 (2)(b))
- suitable accessories and protective clothing provided such as handles with vibration damping features, heating handle system or protective gloves (Article 5 (2)(c)/(i)),
- appropriate maintenance programmes for the work equipment (Article 5 (2)(d))
- limitation of the duration and intensity of the vibration exposure (Article 5 (2)(g))
- adequate rest periods (Article 5 (2)(h))
- employees are informed and trained (Article 6)
- a medical surveillance program is installed (Article 8)

3. Necessary activities

Comparison values for typical vibration exposure values may be available in data base systems of Workers Compensation Boards such as VIBEX, in the data base KARLA (www.liaa.de/karla), in official publications and especially from information in the literature of manufacturers.

When using any of these data sources it is important you check that:

- the data was measured according to valid test standards
- The test standard uses the same reference data such as the equivalent vibration value
- whether the data source is honourable and reliable. The most reliable data are those from type approvals performed by an accredited test laboratory

If suitable values are unavailable or if the specific working conditions differ from those in the measuring standards significantly, specific measurements have to be conducted under representative working conditions at the work place .

4. Compliance and recommendations

Some hints for the compliance with the EU Directive „Vibration“, which should be considered already today

- the national implementation of the Directive will be implemented before 6 July 2005,
- a risk analysis shall be initiated as soon as possible, if necessary the required measurement shall be performed before this date,
- exposed employees shall be informed completely about risks associated with hand-arm vibration
- all equipment shall be maintained according to the instructions of the manufacturer in order to maintain the performance of the machine
- dull cutting tools shall be sharpened, repaired or taken out of service,
- vibration data shall be accumulated from technical literature
- when new equipment is purchased, machines with significantly lower vibration should be preferred if the purchase criteria and technical performance are equivalent or better
- vibration reduction programs , technical and organisational measures should be initiated immediately
- provision of personal protective equipment should be considered, including approved antivibration gloves, heated handles or gloves that will keep the operators hands warm and dry during work in cold weather

5. Simplified procedure for the determination of the operators daily vibration exposure

This section describes a simplified method for the determination of the daily vibration exposure $A(8)$. This method can be used where the test standard used to provide the vibration level quoted by the manufacturer reflects the work being undertaken by the operator.

Premises are:

- 1 the manufacturer provides data of the relevant machine(s) which correspond to the applicable standards (normally identified by a clear reference to the test code and technical data given as "Vibration Total Value a_{hv} or as "Equivalent Vibration Value $a_{hv,eq}$ ")
- 2 the working conditions are identical or similar to those used by the manufacturer (check the information of the manufacturer or contact the manufacturer if you have any doubts
- 3 the equipment used by the employee is in a good condition and conforms to the recommendations of the manufacturer
- 4 the machines and their accessories are similar to those used by the manufacturer when performing the vibration test.

For the determination of the daily vibration exposure not only the vibration data but also the actual daily exposure time is required.

The actual daily exposure time is the time period during which vibrations are transmitted from the machine into the hands of the operator. This time period has to be evaluated during a representative working day or can be taken from Table 1 as standard exposure time. This standard exposure time has been acquired under field conditions based on statistical principles such that the majority of all applications would fall into this range. If a specific machine is not listed, it may be appropriate to choose the exposure time from a similar machine.

The vibration data required is the equivalent vibration value $a_{hv,eq}$, which includes all typical operation modes of the machine. If the manufacturer has only given vibration data from each single operating mode, the various modes have to be weighted according to their percentage of the total exposure time. The European Technical Report CEN/TR 231064 gives a typical distribution of operating modes for some machines. See Table 2. Usually, only the risk class will be important for the employer since the class itself gives an indication what measures have to be taken.

In order to avoid complicated calculations, it may be sufficient to go directly to Table 3, which allows an immediate reading of vibration exposure points based on the exposure duration and the Equivalent Vibration Total value. This gives an indication to which vibration exposure class the machine belongs. Or if necessary the employer can convert exposure points directly into the daily vibration exposure $A(8)$ by using Figure 1.

Basically there are three alternatives:

- a. the exposure points P_E are not greater than 100: no measures have to be initiated by the employer
- b. the exposure points are above 100 and not greater than 400: the equipment may be used, however with the measures described above
- c. the exposure points are above 400: the use of the equipment is only permitted if the exposure time is reduced or other measures have been performed

If the employee uses several tools simultaneously on one working day, the exposure points can be determined separately and added into one single overall value. This overall value must then be compared with one of the three vibration exposure classes.

Table 1 – Typical exposure times of representative handheld power tools with combustion engines

Machine type	Application	Typical daily run time ^{exp}
Top handle chain saws	Tree service	2.4 h
Prof. saws < 80 cm ³	Logging, farming, landscaping	3.7 h
Prof. saws ≥ 80 cm ³	Heavy logging	3.7 h
Grass trimmers	Landscaping	4 h
Brushcutters	Road maintenance, landscaping	3.5 h
Hedge trimmers	Landscaping	3.5 h
Longshaft hedge trimmers	Landscaping, municipalities	2.0 h
Backpack blowers	Municipalities	3 h
Handheld blowers	Municipalities	1.5 h
Vacuum cleaner	Municipalities	1.0 h
Lawn edgers	Landscaping	3 h
Power pruner	Tree maintenance	0.5 h
Power broom	Landscaping, construction	2.0 h
Mist blowers	Agriculture	1.0 h
Fruit harvester (flap type)	Agriculture	3 h
Olive harvester (hook type)	Agriculture	3 h
Motor hoe	Agriculture	2 h
Hand drill (combustion)	Agriculture	1 h
Earth auger	Agriculture, municipalities	3 h
Cut-off machines (handheld)	Construction	1 h
Cut-off machines (carriage)	Construction	2.5 h
Electric hedge trimmer	Landscaping, municipalities	1.5 h
Electric blower	Landscaping, municipalities	1.0 h
Electric lawn trimmer	Landscaping, municipalities	1.0 h
Electric edger	Landscaping, municipalities	1.0 h
Electric pruner	Landscaping, municipalities	0.5 h
Electric longshaft hedge trimmer	Landscaping, municipalities	1.0 h
Electric chain saws	Construction	0.5 h
<p>Remark: The given exposure times were determined under representative conditions. It is estimated that 90% of all applications will have shorter exposure times, in the remaining 10% of all applications longer exposure times will occur. In those cases, a work-site specific analysis must be performed.</p>		

Table 2: Time sequences of the operating modes for chain saws and other power tools t_i

Machine type	Idling	Rated speed	Nominal max. speed	Reference
Tree service chain saws	1/3 T	1/3 T	1/3 T	EN ISO 22867
Prof. saws < 80 cm ³	1/3 T	1/3 T	1/3 T	EN ISO 22867
Prof. saws > 80 cm ³	1/2 T	1/2 T		EN ISO 22867
Grass trimmers	1/2 T		1/2 T	EN ISO 22867
Brushcutters	1/2 T		1/2 T	EN ISO 22867
Hedge trimmers	1/5 T		4/5 T	EN ISO 10517
Longshaft hedge trimmer	1/5 T		4/5 T	EN ISO 10517
Backpack blowers	1/7 T		6/7 T	
Handheld blowers	1/7 T		6/7 T	
Vacuum cleaners	1/7 T		6/7 T	
Mist blowers	1/7 T		6/7 T	
Lawn edgers	1/2 T		1/2 T	ISO 11789
Power pruner	1/2 T		1/2 T	EN ISO 11680
Power broom	1/7 T		6/7 T	
Fruit harvester (flap type)	1/7 T		6/7 T	
Olive harvester (hook type)	1/2 T	1/2 T		
Motor hoe	1/7 T		6/7 T	EN 709
Hand drill (combustion)	1/5 T		4/5 T	
Earth auger	1/5 T		4/5 T	
Cut-off machines (handheld)	1/7 T		6/7 T	EN ISO 19432
Cut-off machines (carriage)	1/7 T		6/7 T	
Electric hedge trimmer			*	EN 60745-2-15
Electric blower			*	IEC 60335-2-100
Electric lawn trimmer			*	
Electric Edger			*	
Electric pruner			*	EN 60745-1
Electric chain saw			*	EN 60745-2-13
Electric longshaft hedge trimmer			*	EN 60745-2-15

Table 3: Determination of vibration exposure points from the equivalent vibration total value and the associated exposure duration

Equivalent vibration total value $a_{hv,eq}$ [m/s ²]	[hours] [min]	Exposure duration									
		0.1	0.2	0.5	1	2	3	4	5	6	8
		6	12	30	60	120	180	240	300	360	480
2.5		1	3	6	13	25	38	50	63	75	100
3		2	4	9	18	36	54	72	90	108	144
3.5		2	5	12	25	49	74	98	123	147	196
4		3	6	16	32	64	96	128	160	192	256
4.5		4	8	20	41	81	122	162	203	243	324
5		5	10	25	50	100	150	200	250	300	400
5.5		6	12	30	61	121	182	242	303	363	484
6		7	14	36	72	144	216	288	360	432	576
6.5		8	17	42	85	169	254	338	423	507	676
7		10	20	49	98	196	294	392	490	588	784
7.5		11	23	56	113	225	338	450	563	675	900
8		13	26	64	128	256	384	512	640	768	1024
8.5		14	29	72	145	289	434	578	723	867	1156
9		16	32	81	162	324	486	648	810	972	1296
9.5		18	36	90	181	361	542	722	903	1083	1444
10		20	40	100	200	400	600	800	1000	1200	1600
10.5		22	44	110	221	441	662	882	1103	1323	1764
11		24	48	121	242	484	726	968	1210	1452	1936
11.5		26	53	132	265	529	794	1058	1323	1587	2116
12		29	58	144	288	576	864	1152	1440	1728	2304
12.5		31	63	156	313	625	938	1250	1563	1875	2500
13		34	68	169	338	676	1014	1352	1690	2028	2704
13.5		36	73	182	365	729	1094	1458	1823	2187	2916
14		39	78	196	392	784	1176	1568	1960	2352	3136
14.5		42	84	210	421	841	1262	1682	2103	2523	3364
15		45	90	225	450	900	1350	1800	2250	2700	3600
15.5		48	96	240	481	961	1442	1922	2403	2883	3844
16		51	102	256	512	1024	1536	2048	2560	3072	4096
16.5		54	109	272	545	1089	1634	2178	2723	3267	4356
17		58	116	289	578	1156	1734	2312	2890	3468	4624
17.5		61	123	306	613	1225	1838	2450	3063	3675	4900
18		65	130	324	648	1296	1944	2592	3240	3888	5184
18.5		68	137	342	685	1369	2054	2738	3423	4107	5476
19		72	144	361	722	1444	2166	2888	3610	4332	5776
19.5		76	152	380	761	1521	2282	3042	3803	4563	6084
20		80	160	400	800	1600	2400	3200	4000	4800	6400

Risk class:
 Exposure points <100: Daily exposure value < 2.5 m/s² , by this the action value is not exceeded
 Exposure points 100-400: Daily exposure value 2.5 - 5 m/s² , by this the action level is exceeded
 Exposure points >400: Daily exposure value > 5 m/s² , by this the limit value is exceeded

Advise for the usage of Table 3:

1. Uneven exposure times

If the equivalent vibration total value and the exposure duration is known go into the relevant lines and column, take the Exposure Points and compare these Exposure Points with the applicable Risk Class on the bottom of the table.

If the exposure duration is an uneven number, such as 3,7 h for the standard exposure time for chain saws, the precise Exposure Points can be determined by a simple addition of smaller fractions of the exposure time.

Example for a given equivalent vibration total value of 7.5 m/s :

3 h \Rightarrow EP = 338

0,5 h \Rightarrow EP = 56

0.1 h \Rightarrow EP = 11

0.1 h \Rightarrow EP = 11

SUM: 3.7 h EP = 416

These exposure points would indicate that the daily limit value is exceeded.

2. Unknown exposure time

Table 3 could be also used to determine a permitted exposure time. The equivalent vibration total value is known and the permitted exposure time shall be evaluated for the threshold value of the daily exposure limit value (EP = 400).

Example for a given equivalent vibration total value of 7.5 m/s :

EP= 338 \Rightarrow Exposure time is 3 hours

EP= 56 \Rightarrow Exposure time is 0.5 hours

Sum EP = 394, i.e. below 400, the permitted exposure time is 3.5 hours

3. Multiple used power tools on one working day

If multiple power tools are used on one working day one after the other, the risk class will be achieved by adding the exposure points of each application. For this task, each exposure duration and each equivalent vibration value has to be accumulated from existing literature. Again Table 3 delivers the exposure points for each application. The sum will be then compared with the vibration exposure class.

Example 1: 4 different power tools will be used on a typical working day

EP from Table 1:

	$a_{hv,eq}$	t	EP
Tool 1	12,0 m/s ²	6 min	29
Tool 2	8,0 m/s ²	12 min	26
Tool 3	6,0 m/s ²	12 min	14
Tool 4	5,0 m/s ²	30 min	25

Sum EP: 94

Result: the total vibration exposure points are not exceeding 100, by this the daily vibration action value of 2.5 m/s² is not exceeded. No further measures are required

Example 2: 4 different power tools will be used on a typical working day

EP from Table 1:

	$a_{hv,eq}$	t	EP
Tool 1	6,0 m/s ²	6 min	7
Tool 2	8,0 m/s ²	12 min	26
Tool 3	3,5 m/s ²	60 min	25
Tool 4	13,0 m/s ²	30 min	169

Sum EP: 227

Result: the total vibration exposure points are above 100, by this, the daily vibration action value is exceeded. Measures for the reduction of vibration exposure are necessary

Example 3: 3 different power tools will be used on a typical working day

EP from Table 1:

	$a_{hv,eq}$	t	EP
Tool 1	12.0 m/s ²	60 min	288
Tool 2	8.0 m/s ²	120 min	256
Tool 3	11.0 m/s ²	30 min	121
total RM:			665

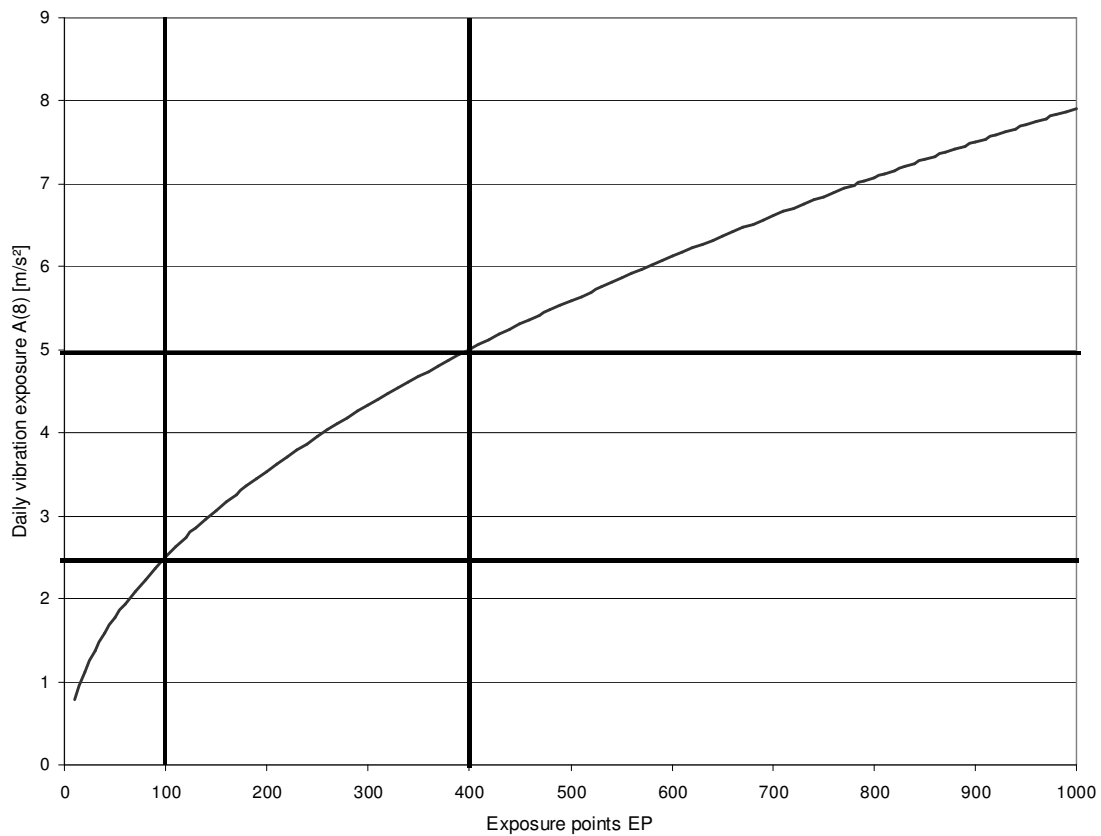
Result: the total exposure points are above 400, by this the daily vibration limit value is exceeded. The tools are not permitted under the given premises.

Conversion of the exposure points EP into the daily vibration exposure A(8)

Sometimes it may be appropriate to convert the abstract vibration exposure points EP into realistic daily vibration exposure values. This can be helpful if you want to compare the daily vibration exposure values with the given limits.

The vibration exposure points EP are marked on the horizontal line in Figure 1. Go from the known exposure points vertically to the curve and from the intersection with the curve to the left to the vertical line, which indicated the daily vibration exposure value A(8).

Figure 1 – Conversion of the exposure points EP into the daily vibration exposure A(8)



Additional information:

- [1] 2002/44/EC, Directive 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) (sixteenth individual Directive within the meaning of Article 16(1) of Directive 89/391/EEC)
http://europa.eu.int/eur-lex/pri/en/oj/dat/2002/l_177/l_17720020706en00130019.pdf
- [2] Übersicht Ermittlung und Bewertung von Vibrationsbelastungen (BIA-Report 2/2003, S. 224 – 233)
- [3] VDI 2057 *Human exposure to mechanical vibrations*
- [4] EN ISO 5349-1:2001 Mechanical vibration — Measurement and evaluation of human exposure to hand-transmitted vibration — Part 1: General requirements (ISO 5349-1:2001)
- [5] EN ISO 5349-2:2001 Mechanical vibration — Measurement and evaluation of human exposure to hand-transmitted vibration — Part 2: Practical guidance for measurement at the workplace (ISO 5349-2:2001)
- [6] Technical Report CEN/TR 231064 Guideline for the assessment of exposure to hand-transmitted vibration based on information provided by manufacturers of machinery
- [7] CR 1030-1:1995; CR 1030-2:1995 Hand-arm vibration — Guidelines for vibration hazards reduction — Part 1: Engineering methods by design of machinery; Part 2: Management measures at the workplace
- [8] Christ, E.: Vibrationseinwirkung am Arbeitsplatz – Gefährdungsbeurteilung und Prävention. In: „Die BG“, Heft 5/2002
- [9] Hand-arm vibration of chainsaws – comparison with vibration exposure, Health and Safety Laboratory Buxton, Draft May 2004
- [10] “Hand-arm vibration” HSG88, “Vibration Solutions” HSG 170, Leaflets INDG 126, INDG 175 and INDGD 338
- [11] Proposals for new Control of Vibration at Work Regulations Implementing the Physical Agents (Vibration) Directive 2002/44/EC, Hand-arm Vibration, Health & Safety Executive, Draft March 2004