Operation and Maintenance Manual
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Vibration Charts - and Example Calculations

SMCS - 7000

Equivalent vibration values of whole body vibration level for earthmoving equipment

Determining Exposure to Whole body vibration

If you are planning to determine a worker's vibration exposure values, the following pages will help you understand the process.

Use this assessment process in order to determine the Total Vibration Exposure Points (PE total) for a particular activity. The appropriate action will be shown by this process.

Find the vibration levels for a machine and activity in the Table 1. The X axis, the Y axis, and the Z axis are shown in the diagram below.

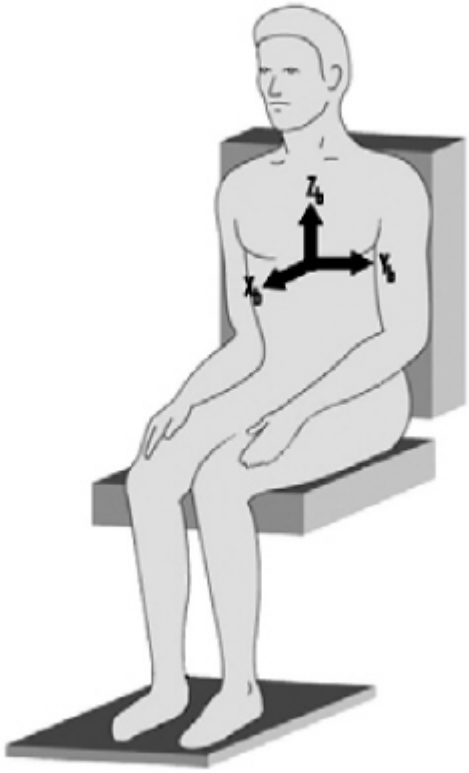

Illustration 1 g01223809

Table 1

"ISO Reference Table A - Equivalent vibration levels of whole body vibration emission for earthmoving equipment."								
Machine Family	**Machine Type**	**Typical Operating Activity**	**Vibration Levels**			**scenario factors**		
			X axis	**Y axis**	**Z axis**	**X axis**	**Y axis**	**Z axis**
Compactor	Single Drum Vibratory	compaction (boulder)	0,47	0,53	0,41	0,17	0,22	0,12
		compaction (silt)	0,29	0,28	0,28	0,08	0,17	0,11
	Vibratory Asphalt	asphalt with vibration	0,33	0,40	0,48	0,11	0,08	0,14
		asphalt without vibration	0,35	0,43	0,36	0,13	0,20	0,19
	Pneumatic-Tire Roller	Compacting	0,23	0,27	0,39	0,16	0,19	0,56
		Idling	0,03	0,04	0,04	0,01	0,01	0,01

	Landfill	work cycle	0,55	0,83	0,34	0,17	0,33	0,15
Excavator	Compact Track Excavator	excavating	0,33	0,21	0,19	0,19	0,12	0,10
		hydraulic breaker application	0,49	0,28	0,36	0,20	0,13	0,17
		transfer movement	0,45	0,39	0,62	0,17	0,18	0,28
	Track Type Excavator	excavating	0,44	0,27	0,30	0,24	0,16	0,17
		hydraulic breaker application	0,53	0,31	0,55	0,30	0,18	0,28
		mining application	0,65	0,42	0,61	0,21	0,15	0,32
		transfer movement	0,48	0,32	0,79	0,19	0,20	0,23
	Wheel Type Excavator	excavating	0,52	0,35	0,29	0,26	0,22	0,13
		transfer movement	0,41	0,53	0,61	0,12	0,20	0,19
Loader	Backhoe Loader	excavating	0,28	0,26	0,20	0,09	0,16	0,06
	Skid Steer Loader	load and carry motion	0,86	0,73	0,93	0,30	0,33	0,35
	Multi Terrain Loader	v-shape motion	1,21	1,00	0,82	0,30	0,84	0,32
	Track Loader	load and carry motion	0,89	0,67	0,52	0,12	0,16	0,10
		transfer movement	0,58	0,49	0,60	0,18	0,12	0,15
		v-shape motion	1,24	0,93	0,63	0,41	0,35	0,18
	Compact Wheel Loader	load and carry motion	0,94	0,86	0,65	0,27	0,29	0,13
	Wheel Loader	load and carry motion	0,84	0,81	0,52	0,23	0,20	0,14
		mining application	1,27	0,97	0,81	0,47	0,31	0,47
		transfer	0,76	0,91	0,49	0,33	0,35	0,17

		movement						
		v-shape motion	0,99	0,84	0,54	0,29	0,32	0,14
Motor Grader	Motor Grader	finish grading	0,41	0,48	0,38	0,22	0,26	0,14
		hard grading	0,61	0,64	0,78	0,21	0,21	0,30
		transfer movement	0,39	0,36	0,58	0,25	0,25	0,34
Paving Equipment	Asphalt Paver	transfer movement	0,75	0,40	1,08	0,30	0,12	0,37
		Work Cycle	0,11	0,15	0,34	0,04	0,06	0,17
Pipelayer	Pipelayer	work cycle	0,21	0,23	0,24	0,09	0,11	0,14
Planer	Cold Planer/Mill	Work Cycle	0,15	0,14	0,17	0,05	0,08	0,03
Road Reclaimers	Road Reclaimers	Cutting	0,15	0,10	0,17	0,06	0,03	0,02
		Roading	0,21	0,34	0,25	0,03	0,07	0,04
Scraper	Wheel Scraper	work cycle	1,05	1,18	1,12	0,34	0,40	0,42
Soil Stabilizer	Soil Stabilizer	Cutting	0,15	0,10	0,17	0,06	0,03	0,02
		Roading	0,21	0,34	0,25	0,03	0,07	0,04
Telehandler	Telehandler	Combination	0,79	0,54	0,68	0,04	0,02	0,10
Track-Type Tractor	Track-Type Tractor	dozing	0,74	0,58	0,70	0,31	0,25	0,31
		ripping	1,25	1,19	1,02	0,40	0,41	0,28
		transfer movement	0,87	0,80	0,97	0,43	0,40	0,34
		loading process	0,29	0,41	0,24	0,17	0,23	0,16
		travel with load	0,64	0,89	0,67	0,21	0,29	0,21

Truck	Articulated Truck	travel without load	0,82	1,02	0,81	0,26	0,26	0,28
		unloading	0,49	0,42	0,30	0,25	0,33	0,18
	Off-Highway Truck	loading process	0,20	0,22	0,21	0,19	0,17	0,19
		travel with load	0,61	0,63	0,82	0,21	0,24	0,34
		travel without load	0,73	0,73	0,87	0,20	0,25	0,33
		unloading	0,37	0,37	0,33	0,14	0,13	0,08

Table 2

Vibration Level	**Total Vibration Exposure Points**									
2.5	31	63	156	313	625	937	1250	1563	1875	2500
2.4	29	58	144	288	576	864	1152	1440	1728	2304
2.3	26	53	132	265	529	794	1058	1323	1587	2116
2.2	24	48	121	242	484	726	968	1210	1452	1936
2.1	22	44	110	221	441	662	882	1103	1323	1764
2.0	20	40	100	200	400	600	800	1000	1200	1600
1.9	18	36	90	181	361	542	722	903	1083	1444
1.8	16	32	81	162	324	486	648	810	972	1296
1.7	14	29	72	145	289	434	578	723	867	1156
1.6	13	26	64	128	256	384	512	640	768	1024
1.5	11	23	56	113	225	338	450	563	675	900

1.4	10	20	49	98	196	294	392	490	588	784
1.3	8	17	42	85	169	254	338	423	507	676
1.2	7	14	36	72	144	216	288	360	432	576
1.1	6	12	30	61	121	182	242	303	363	484
1.0	5	10	25	50	100	150	200	250	300	400
0.9	4	8	20	41	81	122	162	203	243	324
0.8	3	6	16	32	64	96	128	160	192	256
0.7	2	5	12	25	49	74	98	123	147	196
0.6	2	4	9	18	36	54	72	90	108	144
0.5	1	3	6	13	25	38	50	63	75	100
0.4	1	2	4	8	16	24	32	40	48	64
0.3	0	1	2	5	9	14	18	23	27	36
0.2	0	0	1	2	4	6	8	10	12	16
Hours	0.1	0.2	0.5	1	2	3	4	5	6	8
Minutes	6	12	30	60	120	180	240	300	360	480

Apply the Scenario Factors

When you have looked up the vibration levels in the table, you must apply the scenario factors to these vibration levels, when the factors are appropriate.

You will use these adjusted values in order to determine the Total Vibration Exposure Points (PE total).

The scenario factors are displayed in the three columns on the right side of the table. The factors are easy to apply.

If the task is similar to "Example 1", apply the following list:

- subtract the x axis scenario factor from the x axis vibration level reading.
- subtract the y axis scenario factor from the y axis vibration level reading.
- subtract the z axis scenario factor from the z axis vibration level reading.

Do not apply the scenario factors, if the task is average. An average task is described in "Example 2".

If the task is similar to "Example 3", apply the following list:

- add the x axis scenario factor from the x axis vibration level reading.
- add the y axis scenario factor from the y axis vibration level reading.
- add the z axis scenario factor from the z axis vibration level reading.

Three Axis

Use the adjusted values and the exposure duration for each axis. Look up values for PEx, PEy, and PEz on the table 1.

If the adjusted vibration level reading does not appear in the left hand column in the table, you must use the next highest value in the column in order to determine the P exposure.

For example if your adjusted vibration level reading is 0.67, you must use the next highest value of 0.7 in order to determine the P exposure.

The Total Vibration Exposure Points is the highest value of the three values (PEx, PEy, and PEz). The points are found in table 2.

The value for PE total will help you determine the vibration control actions.

White Area

The PE total value is less than 100. If the PE total value is in the white area, no action is needed. If the PE total value is close to the light gray area, you must take reasonable action in order to reduce vibration exposure. Provide the worker with information about reducing the vibration and with training about reducing the vibration.

Light Gray Area

The PE total value is between 100 and 529. If the PE total value is in the light gray area, you must take reasonable action in order to reduce vibration exposure. Provide health surveillance for exposed workers.

Dark Gray Area

The PE total value is greater than 529. If the PE total value is in the dark gray area, take immediate action in order to lower the Exposure Limit Value. If the exposure remains above the Exposure Action Value, you must take the following actions:

- Activate control measures.
- Activate a program of health surveillance.

The following three examples show PE total values for different machines and for different conditions.

Example 1

Compact Wheel loader - light vibration exposure

- good working conditions (smooth terrain)
- experienced operator
- typical operating conditions load and carry motion
- 4 hour duration

Find the vibration level values for x, y, and z axes for the compact wheel loader in the table. This is a light vibration exposure scenario. Subtract the appropriate scenario factor from each vibration level value.

Calculate the Total Vibration Exposure Point value. Use the exposure duration. Use the adjusted vibration levels in the table 1.

- 4 hour exposure duration
- PEx = 0.94 − 0.27 = 0.67 or 98 points
- PEy = 0.86 − 0.29 = 0.57 or 72 points
- PEz = 0.65 − 0.13 = 0.52 or 72 points

The highest PE value (98) represents the Total Vibration Exposure Points (PE total). This determines your action.

Since the Total Vibration Exposure Points (PE total) do not exceed 100, the Exposure Action Value is not exceeded. If the results are close to the light gray area, take the following action:

- reduce vibration exposure.
- provide information for the worker.
- provide training about reducing vibration.

Example 2

A Wheel Loader and A Track Type Excavator - average vibration exposure

Wheel loader

- normal working conditions (smooth terrain)
- experienced operator
- typical operating conditions
- v-shape motion
- 4 hour duration

Track type excavator

- typical operating conditions
- mining application
- 3 hour duration

Find the vibration level values for x, y, and z axes for the compact wheel loader in the table. This is an average vibration exposure scenario.

Calculate the vibration level values for the compact wheel loader. Use the exposure duration. Use the adjusted vibration levels in the table 1.

Wheel loader

- 4 hour exposure duration
- PEx = 0.99 or 200 points
- PEy = 0.84 or 162 points
- PEz = 0.54 or 72 points

Track type excavator

- 3 hour exposure duration
- PEx = 0.65 or 74 points
- PEy = 0.42 or 38 points
- PEz = 0.61 or 74 points

The total for each machine is added for the 7 hour exposure.

- PEx = 274 points
- PEy = 200 points
- PEz = 146 points

The highest PE value (274) represents the Total Vibration Exposure Points (PE total). This determines your action.

The Total Vibration Exposure Points (PE total) are between 100 and 529. The Exposure Action Value is exceeded, but the Exposure Limit Value is not exceeded.

Take action in order to lower the Exposure Limit Value. If the exposure remains above the Exposure Action Value, you must take the following actions:

- Activate control measures.

- Activate a program of health surveillance.

Example 3

Skid Steer Loader - heavy vibration exposure

- hard working conditions (severe terrain)
- operator with limited experience
- typical operating condition - load and carry motion
- 8 hour duration

Find the vibration level values for the x, y, and z axes for the skid steer loader in the table. This is a heavy vibration exposure scenario. Add the appropriate scenario factor from each vibration level value.

Calculate the vibration level values for the skid steer loader. Use the exposure duration. Use the adjusted vibration levels in the table 1.

- 8 hour exposure duration
- PEx = 0.86 + 0.30 = 1.16 or 576 points
- PEy = 0.73 + 0.33 = 1.06 or 484 points
- PEz = 0.93 + 0.35 = 1.28 or 676 points

The highest PE value (676) represents the Total Vibration Exposure Points (PE total). This determines your action.

Since the Total Vibration Exposure Points (PE total) are above 529, the Exposure Limit Value is exceeded.

Take immediate action in order to lower the Exposure Limit Value. If the exposure remains above the Exposure Action Value, you must take the following actions:

- Activate control measures.
- Activate a program of health surveillance.

Sources

The vibration information and calculation procedure is based on "ISO/TR 25398 Mechanical Vibration - Guideline for the assessment of exposure to whole body vibration of ride on operated earthmoving machines". harmonized data is measured by international institutes, organizations and manufacturers.

This literature provides information about assessing the whole body vibration exposure of operators of earthmoving equipment. The method is based on measured vibration emission under real working conditions for all machines.

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Consult your local Caterpillar dealer for more information about machine features that minimize vibration levels. Consult your local Caterpillar dealer about safe machine operation.

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