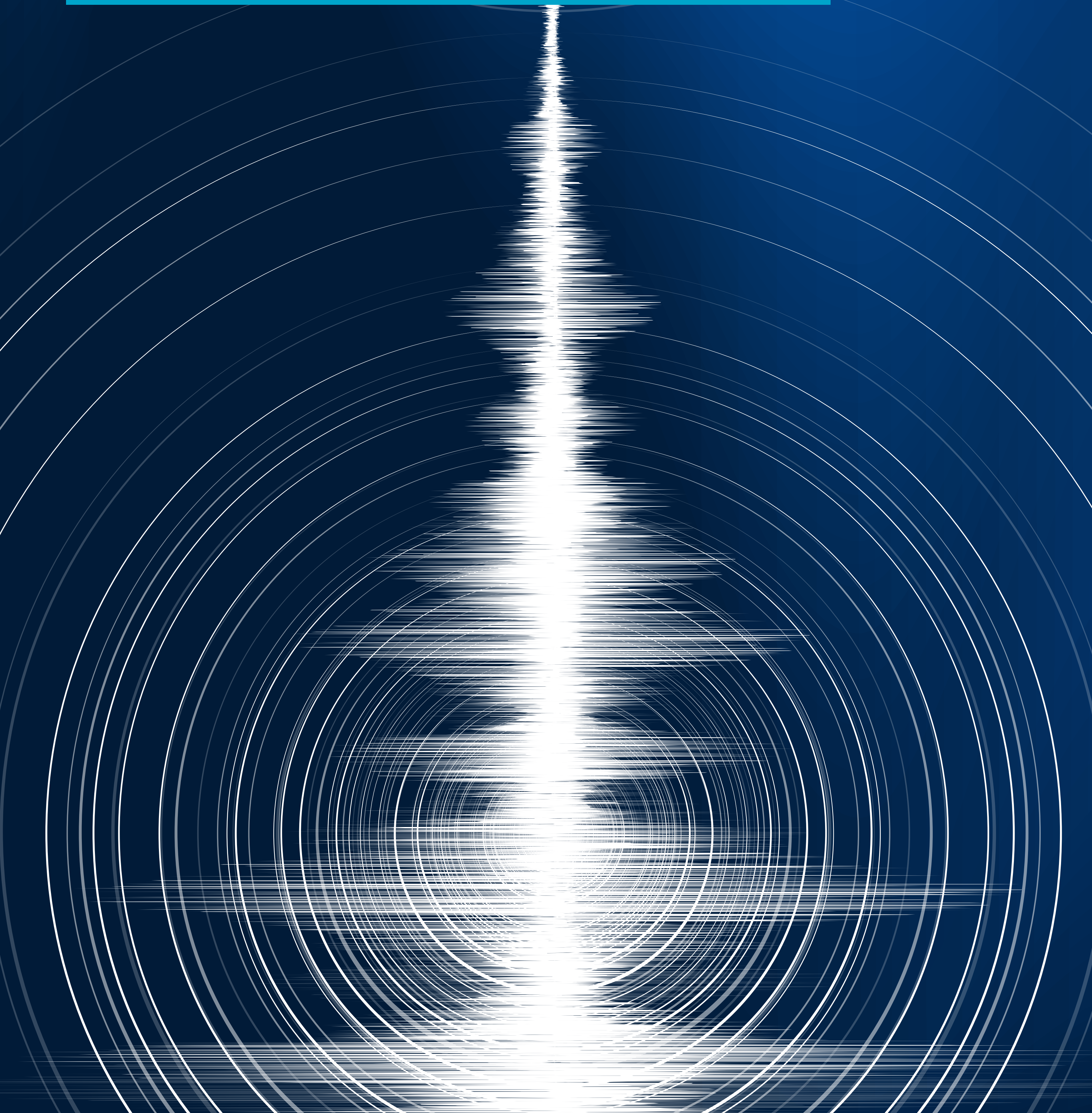
Measuring vibrations

Measuring and declaring vibration values

Atlas Copco



Measuring and declaring vibration value

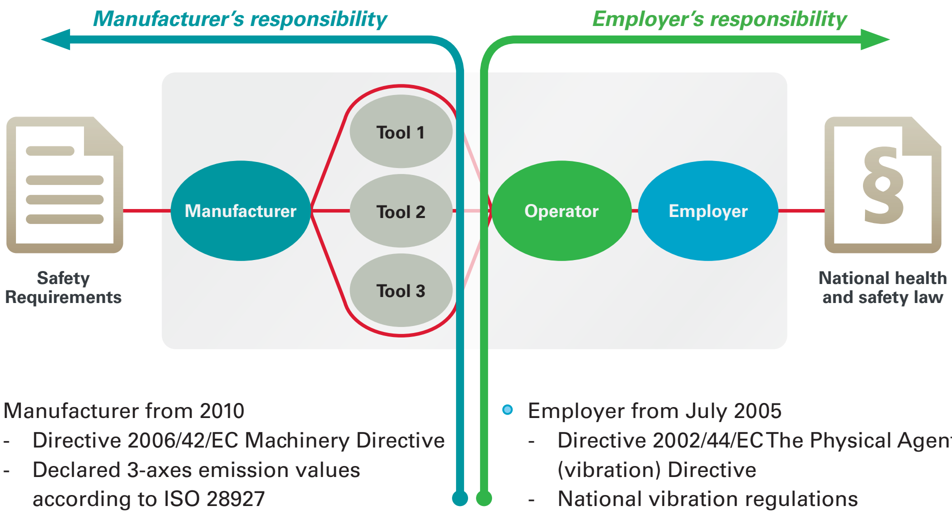
Everyone, from manufacturer to operator, is responsible to reduce the vibration exposure. Manufacturers supplying power tools within the European Union are responsible for measuring and declaring the vibration emission value for every machine model. To find out more on how we measure vibrations, continue reading. If you need to find a specific vibration value, check our product pages for information.

Everyone is responsible for reducing exposure

Unnecessary vibrations are a problem, primarily affecting the operator when being exposed. When it comes to minimizing exposure to vibration the manufacturer, employer and operator all have different responsibilities.

- The manufacturer of the power tools is responsible for developing and marketing tools and equipment that don't create unnecessary vibrations.
- The employer is responsible for the safety of his employees. As part of that, he should, whenever possible, choose tools that give low vibration exposure.
- The operator is responsible for using the tools according to the given instructions and to react when there is reason to believe that vibrations are unusually high.

Manufacturers are required to declare and supply the vibration value with every power tool sold within the European Union (part of the CE certification). The vibration value is based on measurements performed in accordance with the procedures described in emission standards. As of 2018, ISO 28927 series of standards and EN62841 are the valid emission standards for pneumatic and electric tools.



- Manufacturer from 2010
  - Directive 2006/42/EC Machinery Directive
  - Declared 3-axes emission values according to ISO 28927
- Employer from July 2005
  - Directive 2002/44/EC The Physical Agents (vibration) Directive
  - National vibration regulations

How we measure vibrations

Measuring three machines instead of one, will give a better estimate of the emission value.

The following section focuses on the ISO 28927 series of standards. These standards are in most cases similar to the standards in the EN 62841 series and the ISO standards can easily be found in most countries worldwide.

ISO 28927 consists of 13 parts, covering most machine types found in the market. If the machine type isn't covered in any part, ISO 20643 is used. The basic measurement technique, equipment and calculations are the same for all parts. The difference is related to the operating conditions of the different machine types.

It is important to remember that most parts in the ISO 28927 series are type tests, not actual in-use measurements. The type tests are intended to represent the average vibration magnitudes from real world use of the machines. The in-use vibration magnitude will vary from time to time and depend on many factors such as the process itself, the operators using the machines, inserted tools, consumables, etc. For manufacturers it isn't practically possible to cover all of these variations in a testing environment, as it would require thousands of measurements per machine model.

However, the declared values are measured under repeatable conditions so that they can be compared and checked. A power tool with a lower declared vibration value is likely to "vibrate less" in real world use, compared to a tool with a higher value.

Vibrations are measured in all three axes

Common requirements valid for all parts of ISO 28927

- Vibrations are measured in three axes
- New machine(s) must be used
- A minimum of one machine must be measured
- Three skilled operators operate the machine(s)
- Each operator performs five test runs per tool
- Vibration levels in all 3 axes are hand-arm weighted with filter specified in ISO 5349
- Testing according to the position of the transducer(s) – one or two positions depending on if the tool is intended for one or two hands
- Specifications presented of attached or inserted tools (i.e. drill bit, burr, socket, etc.)

Atlas Copco Industrial Technique chooses to use three machines for the declaration measurements. Measuring three machines instead of one, will give a better estimate of the emission value, as it also accounts for the differences between individual machines.

The outcome of the measurement gives two values

- The declared (vibration) emission value (a_{hd})
- The uncertainty of the measurement (K).

If the machine is intended for two hands, the highest value is declared. Both values are measured in m/s² (acceleration).

Correlation between vibrations and injuries. It is assumed that the development of injuries related to hand-arm vibrations are frequency dependent. The harmful frequencies ranges from 6.3 Hz to 1250 Hz and the frequency dependency outside this range is not yet agreed. The most harmful vibrations are in the range of 8 to 20 Hz, which typically corresponds to the impact frequencies of large chipping hammers and impact wrenches. (Source: ISO 5349-1).

Specific operating conditions. When applicable, the test also takes into consideration the requirements related to the specific operating conditions:

- The length of each test run (8-16 seconds)
- The required feed force (if applicable)
- The specifications of inserted tools or consumables
- The design and (material) properties of the work piece used

How to interpret and use the values a_{hd} and K. The outcome of the measurements are, as mentioned earlier, two values; the declared (vibration) emission value (DEV) and the uncertainty. These values represent the DEV and uncertainty of all machines of a specific model, regardless of when it is manufactured. New declaration measurements are performed if changes are made to the machine that may affect vibration emissions.

The DEV is the average vibration emission of a specific machine. This means that when you use a specific machine you can expect it to emit vibrations close to the DEV. However, the vibration magnitude depends on several factors such as operators, the individual machine, the work task, consumables etc. To account for that, the uncertainty value K is also provided. K takes into account parts of these variations but cannot, for practical reasons, cover all variations possible.

Hence, the vibration emission of a specific machine can be expected to be within the range:

$a_{hd} \pm K$

The DEV can be used to compare power tools to find the one with lowest vibrations and for risk assessments of the daily vibration exposure. When used for risk assessments the uncertainty shall always be, if deemed necessary (due to a particular rough process, low quality inserts or consumables etc), added to the DEV, not subtracted. Overestimating the risk will help protect the operator from injuries.

Measurement example: Angle grinder

The grinder is an angle grinder, model GTG25 F120-13, tool data in Table 1. The grinder is intended to be used with two hands. Three brand new tools are available and three skilled operators will perform the test. The tool is measured "out of the box" which means that the tool is tested in standard configuration.

Angle grinders are measured according to Part 1: Angle and vertical grinders. Since the grinder is intended for two-hand operation, two measurement positions are required; the throttle and the support handle.

Power	2.5 kW
Speed	12 000 rpm
Rated air pressure	6.3 bar
Wheel size and type	125 mm (5") type 27
Weight (incl. test wheel)	2.1 kg (~2.3 kg)

The feed force is measured by suspending the grinder in a scale.

Grinders are run under no-load conditions, equipped with an aluminum test wheel of the same size as the grinder is designed for. The test wheels have a pre-defined unbalance given in the standard. The size of the test wheel in this particular case is Ø125 mm (5").

The grinder is operated at its rated air pressure (6.3 bars). The applied feed force is related to the size of the wheel and is, in this case, 30 N. The feed force is measured by suspending the grinder in a scale. Note that the scale shows 5.3 kg (53 N). This is because the scale includes the weight of the grinder (23 + 30 N) so in order to achieve the required feed force the weight has to be compensated for.

For machines tested with type 27 test wheels, each operator shall carry out a series of five consecutive measurements, one in each orientation, by unfastening and refastening the test wheel. The sequence of measurements is 0°, 72°, 144°, 216° and 288°.

Each test run is carried out for 16 s. The vibrations are measured together with the average speed of the grinder.

Grinders are rated with a maximum (no-load) speed, which are not allowed to be exceeded for safety reasons. Therefore grinders are designed to run below the rated speed to allow for minor deviations in speed, but still not exceed the limit. The actual speed will also vary between individual machines and between different brands, even though the rated speed is the same.

However, the vibration magnitude is proportional to the speed of the wheel so lower speed means lower vibrations. To make the DEV comparable between different grinders and to account for the actual speed the value is corrected to the rated speed by a factor of:

$$\frac{\text{rated speed}}{\text{actual speed}}$$

Grinders equipped with technical means for automatically reducing unbalances may underestimate the vibrations in real world use. To account for that the declared vibration value is corrected with a correction factor of 1.3. The GTG25 F120-13 is equipped with such a device (auto balancer).

To complete the measurements, each operator performs five test runs per grinder. Between each run the test wheel is turned 72° as described above. The average vibration value, corrected to the rated speed, is calculated from the five runs. When the two other operators have completed their test runs the average vibration value of the grinder is calculated (see example in Table 2, measured speed is 11 000 rpm).

Vibration emission [m/s²]

	Actual vibration[1]	Rated speed correction
Operator 1	2.5	2.8
Operator 2	2.0	2.1
Operator 3	2.4	2.7
Average		**2.5**

[1] Average of five test runs

This sequence is then repeated for the other two grinders. The DEV is calculated as the average of all three grinders corrected with the factor 1.3 since the GTG25 is equipped with an auto balancer.

Grinder 1	1.6
Grinder 2	2.5
Grinder 3	3.0
Average	2.4
DEV[1]	**3.1**

[1] Corrected with the factor 1.3

The DEV of the GTG25 F120-13 is 3.1 m/s² and the uncertainty is 1.3 m/s².

Conclusion

The declared vibration value is measured according to ISO 28927 series of standards. The measurements are, except for a few machine types, type test measurements which are intended to represent the average real use vibrations. The outcome of the measurement is two values, the declared vibration emission value and the uncertainty, which can be used for risk assessments to prevent vibration injuries.