EMDC 5 (5541) P3
REV TZS 1471:2011

DRAFT TANZANIA STANDARD

Tolerance limits for environmental and occupational vibration

Tolerance limits for environmental vibration

0 Foreword

Any tool that vibrates is a potential cause for Vibration, especially when individual susceptibility is taken into account. Vibration can cause varying degrees of damage in buildings and affect vibration – sensitive machinery or equipment.

Its effects on people may be to cause disturbance or annoyance or, at higher levels, to affect a person ability to work. Constant exposure to vibration has been known to cause serious safety and health problems.

This Tanzania Standard is developed due to the requirements of the Law (EMA Cap 191, 2004) and due to the public outcry on vibration emanating from various locations. Therefore, the limit values provided by this Tanzania Standard will provide the basis for authorities to assess and manage environmental vibration.

In preparing this Tanzania Standard assistant was derived from:

a. Environmental guideline ground vibration and air blast limits for blasting in mines and quarries: Blasting limit guidelines v1.2: Minerals and petroleum Victoria 2001

b. HSE Hand-arm vibration. The control of vibration at work regulations 2005: Guidance and regulation (Ref made 25th October 2017)

1 Scope

This Tanzania Standard specifies limits for general environmental vibration including occupational environment and air overpressure. Tolerance limits in this Tanzania Standard are given with a view to protect people against risk to their health and safety, and to minimize annoyance to people in residential premises and other sensitive sites exposed to vibration.

2 Normative references

The following referenced documents are indispensable for the application of this Tanzania Standard:

EMDC 5 (5544) TZS 1399: 2011 (ISO 5349-1:2001), *Mechanical vibration – Measurement and evaluation of human exposure to hand transmitted vibration – General requirement*

EMDC 5 (5545) TZS 1400: 2011 (ISO 5349-2-2001), *Mechanical vibration - measurement and evaluation of human exposure to hand transmitted vibration – Practical Guidance for measurement at work place*

EMDC 5 (5543) TZS 1398: 2011 (ISO 2631-1-1997), *Mechanical vibration and shock – Evaluation of human exposure to whole body vibration*

TZS 1397: 2011, *Mechanical vibration and shock evaluation of human exposure to whole-body vibration. Method for evaluation containing multiple shocks*

EMDC 5 (5546) TZS 1401: 2011(ISO 2041:2009), *Mechanical vibration, shock and conditional monitoring – Vocabulary*

EMDC 5 (5547) TZS 1402: 2011(ISO 8041-2017), *Human response to vibration – Measuring Instrumentation*

EMDC 5 (5684)ISO 2631-2:2003: *Mechanical vibration and shock Evaluation of human exposure to wholebody vibration —Part 2:Vibration in buildings (1 Hz to 80 Hz)*

3 Terminology

For the purpose of this Tanzania Standard, the following terms and phrases shall have the meanings respectively ascribed to them by this section. Other definition can also be found in EMDC (3457)

3.1 Air Overpressure

Airborne pressure waves generated by blasting produced over a range of frequencies including those which are audible and those which are below the lower end of the audible spectrum.

3.2 Daily exposure limit period

The duration that is used as reference in defining daily exposure values

3.3 Exposure action value

The exposure action value (EAV) is the daily amount of vibration exposure value above which action must be taken to control exposure.

3.4 Exposure limit value

The exposure limit value (ELV) is the maximum permissible amount of vibration exposure value.

3.5 Exposure value, *a(8)*

Exposure value ***a(8)*** is the vibration magnitude that a person is exposed to in a day normalized to a period of 8 hours using the following formula:

$$a(8) = \boldsymbol{a}\sqrt{\frac{T}{8}}$$

where ***a*** is the vibration magnitude and *T* is the exposure period in hours

3.6 Ground vibration

Is the level of vibration (peak particle velocity) measured in mm/s in the ground anywhere on the sensitive site. The measurement point should be at least the longest dimension of the foundations of a building or structure away from the building or structure if possible.

3.7 Hand-arm vibration

Vibration which is transmitted into the hands and arms during a work activity.

3.8 Occupational Environment
Is a physical surrounding and social environment at workplace.

3.9 PPV

Peak Particle Velocity (V) – the maximum instantaneous sum of the velocity vectors of the ground movement measured in three orthogonal directions (expressed in millimeters per second).
The resultant PPV is calculated by producing a vector sum of the three (3) separate directional recordings:

$$\boldsymbol{V} = \sqrt{v_v^2 + v_l^2 + v_t^2}$$

where; v= vertical, l=longitudinal and t=transverse for every point of the recording.

3.10 Sensitive site

Any land within 10 meters of a residence, hospital, school, or other premises in which people could reasonably expect to be free from undue annoyance and nuisance caused by vibration. The 10 meters will be measured from the boundaries of the property.

3.11 Subsonic vibration

Repetitive motion of an object with frequency lower than 20 Hz that it can not be perceived by human ear but it can be felt.

3.12 Vibration

Is defined as mechanical oscillations or the repetitive motion of an object about an equilibrium point.

3.13 Vibration magnitude, ***a*** **for hand-arm vibration**

Vibration magnitude, ***a***, for hand-arm vibration is the root-mean-square weighted acceleration in m/s^2 evaluated from the measurements in three orthogonal directions at the vibrating surface in contact with the hand using the following formula.

$$\boldsymbol{a} = \sqrt{a_x^2 + a_y^2 + a_z^2}$$

where a_x, a_y and a_x are the root-mean-square weighted acceleration magnitudes in three orthogonal directions.

3.14 Vibration magnitude, A **for whole body vibration**

Vibration magnitude, A, for whole body vibration is the root-mean-square weighted acceleration in m/s^2 measured in one of the largest vibration of the three orthogonal directions at the supporting surface

3.15 Whole body vibration

Vibration which is transmitted into the body, when seated or standing, through the supporting surface.

3.16 dB(Z)decibels ‘z’ weighted z weighting is a flat frequency response between 10 hz and 20 khz ±1.5 db excluding microphone response replaces flat and linear.

4 Requirements

Tolerance limits to protect people against risk to their health and safety are given in tables 1.1 and 1.2, these limits do apply mostly to occupational environment. Table 1.3 and 1.4 gives tolerance limits to minimize annoyance to people from environmental vibration, the limits are applicable to residential premises and other sensitive sites.

Table 1.1 Tolerance limits for whole body vibration

Daily exposure limit period	Daily exposure limit value	Daily exposure action value	Test method
8 hours	1.15 m/s^2	0.5 m/s^2	EMDC 5 (5543) EMDC 5 (5542)

Table 1.2 Tolerance limits for hand arm vibration

Daily exposure limit period	Daily exposure limit value	Daily exposure action value	Test method
8 hours	5 m/s^2	2.5 m/s^2	EMDC 5 (5544) EMDC 5 (5545)

Table 1.3: Tolerance limit for ground vibration at sensitive sites

Limit on ground vibration	**Test method**
Transient vibration	
5 mm/s PPV at all times	Seismograph (see annex B)
Continuous vibration	
0,63 m/s^2 weighted r.m.s acceleration	EMDC 5 (5684)

Table 1.4: Tolerance limits for subsonic vibration/ air over pressure

Limit on sensitive sites	**Test method**
120 dBZ at all times	Seismograph (see annex B)

Annex A
Informative

Blasting practice

General information on vibration and air overpressure introduction

This document is intended to provide information to members of the public living close to blasting operations regarding the environmental impact of blast-induced ground vibration and air overpressure.

Basics on blasting

Each country has its own set of rules and regulation regarding the use of explosives. In each country blasting operations can only be undertaken by highly qualified personnel working under strict rules and guidelines.

1 Environmental Impact of Blasting

When explosives are detonated in a blast hole much of the energy is used to break up and move the rock or concrete. However, there is always some energy left over and this is converted into vibration that travels away from the blast area through both the ground and air. The vibration through the air is generally known as air overpressure. In the case of demolition vibration can be generated by the impact of the structure on the ground surface.

2 Information on Ground Vibration

As the ground vibration travels away from the blast area the level rapidly reduces. The level of vibration felt at any location is controlled by the design of the blast, the distance to the blast and the intervening geology. As the vibration travels through the ground it may arrive at a building and this structure will then also vibrate. If people are inside the building then they may feel that the structure has responded in such a fashion that damage must have occurred.
The level of blast vibration that causes damage to structures has been extensively investigated over many years by researchers worldwide. All of this research has shown that very high levels of vibration are required before damage is likely to occur.

3 Air Overpressure

The vibration that travels away from a blast area through the air is both audible and sub-audible.
Like ground vibration, levels of air overpressure decay rapidly with distance from the blast area.
However, in this case the level depends to a great extent on the weather conditions at the time of blasting as well as the blast design. Air overpressure travels through the air slower than vibration through the ground and it will therefore arrive at a location after the ground vibration. This time lag can be as much as several seconds at distances over 1 km.
As the air overpressure travels away from the blast area it may also interact with structures. When such air overpressure waves arrive at a structure it may cause rattling of windows, doors etc. The level of air overpressure likely to break windows is also very well researched and is incredibly high. Such levels are only likely to be exceeded close to blasting operations employing unconfined explosive charges. Like ground vibration it is common for air overpressure levels to be recorded as peak levels. In this case the units will be Pascals or decibels.

4 Human response

As has already been noted the human body is a very sensitive receptor for vibration. This response is enhanced if that person is inside of a structure due to the response of the structure to both the ground vibration and air overpressure. It is also known that structures will also response acoustically causing even greater concern amongst people inside the structure.

5 Environmental monitoring

It is good practice to measure the vibration emissions from the blast site at the nearest residence.

6 Key points

- Blasting is necessary in all aspects in our modern society.
- Blasting may cause some short-term environmental impact.
- Alternatives to blasting exist but usually cause more disturbance and inconvenience.
- Blasting is a highly controlled and regulated activity with an outstanding record of safety.

Annex B

Informative

Part I: General guidelines for ground vibration and air overpressure monitoring

Blasting seismographs are deployed in the field to record the levels of blast-induced ground vibration and air overpressure. Accuracy of the recordings is essential. These guidelines define the user's responsibilities when deploying blasting seismographs in the field and assume that the blasting seismographs conform to the ISEE "Performance Specifications for Blasting Seismographs".

1. Read the instruction manual and be familiar with the operation of the instrument. Every seismograph comes with an instruction manual. Users are responsible for reading the appropriate sections and understanding the proper operation of the instrument before monitoring a blast.
2. Seismograph calibration. Annual calibration of the seismograph is recommended.
3. Keep proper blasting seismograph records. A user's log should note: the user's name, date, time, place and other pertinent data.
4. Document the location of the seismograph. This includes the name of the structure and where the seismograph was placed on the property relative to the structure. Any person should be able to locate and identify the exact monitoring location at a future date.
5. Know and record the distance to the blast. The horizontal distance from the seismograph to the blast should be known to at least two significant digits. For example, a blast within 1000 meters or feet would be measured to the nearest tens of meters or feet respectively and a blast within 10,000 meters or feet would be measured to the nearest hundreds of feet or meters respectively. Where elevation changes exceed 2.5h:1v, slant distances or true distance should be used.
6. Record the blast. When seismographs are deployed in the field, the time spent deploying the unit justifies recording an event. As practical, set the trigger levels low enough to record each blast.
7. Record the full time history waveform. Summary or single peak value recording options available on many seismographs should not be used for monitoring blast-generated vibrations. Operating modes that report peak velocities over a specified time interval are not recommended when recording blast-induced vibrations.
8. Set the sampling rate. The blasting seismograph should be programmed to record the entire blast event in enough detail to accurately reproduce the vibration trace. In general, the sample rate should be at least 1000 samples per second.
9. Know the data processing time of the seismograph. Some units take up to 5 minutes to process and print data. If another blast occurs within this time the second blast may be missed.
10. Know the memory or record capacity of the seismograph. Enough memory must be available to store the event. The full waveform should be saved for future reference in either digital or analog form.
11. Know the nature of the report that is required. For example, provide a hard copy in the field; keep digital data as a permanent record or both. If an event is to be printed in the field, a printer with paper is needed.
12. Allow ample time for proper setup of the seismograph. Many errors occur when seismographs are hurriedly set-up. Generally, more than 15 minutes for set-up should be allowed from the time the user arrives at the monitoring location until the blast.
13. Know the temperature. Seismographs have varying manufacturer specified operating temperatures.
14. Secure cables. Suspended or freely moving cables from the wind or other extraneous sources can produce false triggers due to micro phonics.

Part II: Ground vibration monitoring

Placement and coupling of the vibration sensor are the two most important factors to ensure accurate ground vibration recordings.

A Sensor placement

The sensor should be placed on or in the ground on the side of the structure towards the blast. A structure can be a house, pipeline, telephone pole, etc. Measurements on driveways, walkways, and slabs are to be avoided where possible.

1. Location relative to the structure. Sensor placement should ensure that the data obtained adequately represents the ground-borne vibration levels received at the structure. The sensor should be placed within 3.05 meters (10 feet) of the structure or less than 10% of the distance from the blast, whichever is less.
2. Soil density evaluation. The soil should be undisturbed or compacted fill. Loose fill material, unconsolidated soils, flower-bed mulch or other unusual mediums may have an adverse influence on the recording accuracy.
3. The sensor must be nearly level.
4. The longitudinal channel should be pointing directly at the blast and the bearing should be recorded.
5. Where access to a structure and/or property is not available, the sensor should be placed closer to the blast in undisturbed soil.

B Sensor coupling

If the acceleration exceeds 1.96 m/s^2 (0.2 g), decoupling of the sensor may occur. Depending on the anticipated acceleration levels spiking, burial, or sandbagging of the geophone to the ground may be appropriate.

1. If the acceleration is expected to be:
   a. less than 1.96 m/s^2 (0.2 g), no burial or attachment is necessary
   b. between 1.96 m/s^2 (0.2 g), and 9.81 m/s^2 (1.0 g), burial or attachment is preferred. Spiking may be acceptable.
   c. greater than 9.81 m/s^2 (1.0 g) , burial or firm attachment is required (RI 8506).

The following table exemplifies the particle velocities and frequencies where accelerations are 1.96 m/s^2 (0.2 g) and 9.81 m/s^2 (1.0 g).

Frequency, Hz	4	10	15	20	25	30	40	50	100	200
Particle Velocity mm/s (in/s) at 1.96 m/s^2 (0.2 g)	78.0 (3.07)	31.2 (1.23)	20.8 (0.82)	15.6 (0.61)	12.5 (0.49)	10.4 (0.41	7.8 (0.31)	6.2 (0.25)	3.1 (0.12)	1.6 (0.06)
Particle Velocity mm/s (in/s) at 9.81 m/s^2 (1.0 g)	390 (15.4)	156 (6.14)	104 (4.10)	78.0 (3.07)	62.4 (2.46)	52.0 (2.05	39.0 (1.54)	31.2 (1.23)	15.6 (0.61)	7.8 (0.31)

2. Burial or attachment methods.
   a. The preferred burial method is excavating a hole that is no less than three times the height of the sensor (ANSI S2.47), spiking the sensor to the bottom of the hole, and firmly compacting soil around and over the sensor.
   b. Attachment to bedrock is achieved by bolting, clamping or adhering the sensor to the rock surface.

c. The sensor may be attached to the foundation of the structure if it is located within +/- 0.305 meters (1-foot) of ground level (RI 8969). This should only be used if burial, spiking or sandbagging is not practical.

3. Other sensor placement methods.

a. Shallow burial is anything less than described at 2a above.

b. Spiking entails removing the sod, with minimal disturbance of the soil and firmly pressing the sensor with the attached spike(s) into the ground.

c. Sand bagging requires removing the sod with minimal disturbance to the soil and placing the sensor on the bare spot with a sand bag over top. Sand bags should be large and loosely filled with about 4.55 kilograms (10 pounds) of sand. When placed over the sensor the sandbag profile should be as low and wide as possible with a maximum amount of firm contact with the ground.

d. A combination of both spiking and sandbagging gives even greater assurance that good coupling is obtained.

C Programming considerations

Site conditions dictate certain actions when programming the seismograph.

1. Ground vibration trigger level. The trigger level should be programmed low enough to trigger the unit from blast vibrations and high enough to minimize the occurrence of false events. The level should be slightly above the expected background vibrations for the area. A good starting level is 1.3 mm/s (0.05 in/s).
2. Dynamic range and resolution. If the seismograph is not equipped with an auto-range function, the user should estimate the expected vibration level and set the appropriate range. The resolution of the printed waveform should allow verification of whether or not the event was a blast.
3. Recording duration - Set the record time for 2 seconds longer than the blast duration plus 1 second for each 335 meters (1100 feet) from the blast.

Part III: Air overpressure monitoring

Placement of the microphone relative to the structure is the most important factor.

A Microphone placement

The microphone should be placed along the side of the structure, nearest the blast.

1. The microphone should be mounted near the geophone with the manufacturer's wind screen attached.
2. The microphone may be placed at any height above the ground. (ISEE 2005)
3. If practical, the microphone should not be shielded from the blast by nearby buildings, vehicles or other large barriers. If such shielding cannot be avoided, the horizontal distance between the microphone and shielding object should be greater than the height of the shielding object above the microphone.
4. If placed too close to a structure, the air blast may reflect from the house surface and record higher amplitudes. Structure response noise may also be recorded. Reflection can be minimized by placing the microphone near a corner of the structure. (RI 8508)
5. The orientation of the microphone is not critical for air overpressure frequencies below 1,000 Hz (RI 8508).

B Programming considerations

Site conditions dictate certain actions when programming the seismograph to record air overpressure.

1. Trigger level. When only an air overpressure measurement is desired, the trigger level should be low enough to trigger the unit from the air overpressure and high enough to minimize the

occurrence of false events. The level should be slightly above the expected background noise for the area. A good starting level is 20 Pa (0.20 millibars or 120 dB).

2. Recording duration. When only recording air overpressure, set the recording time for at least 2 seconds more than the blast duration. When ground vibrations and air overpressure measurements are desired on the same record, follow the guidelines for ground vibration programming (Part II C.3)