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Vibration — Tolerance limits

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In order to match with technological development and to keep continuous progress in industries, standards are subject to periodic review. Users shall ascertain that they are in possession of the latest edition

Rwanda Standards Board

P.O Box 7099 Kigali-Rwanda

KK 15 Rd, 49

Tel. +250 788303492

Toll Free: 3250

E-mail: info@rsb.gov.rw

Website: www.rsb.gov.rw

ePortal: www.portal.rsb.gov.rw

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Foreword

Rwanda Standards are prepared by Technical Committees and approved by Rwanda Standards Board (RSB) Board of Directors in accordance with the procedures of RSB, in compliance with Annex 3 of the WTO/TBT agreement on the preparation, adoption and application of standards.

The main task of technical committees is to prepare national standards.Final Draft Rwanda Standards adopted by Technical committees are ratified by members of RSB Board of Directors for publication and gazettment as Rwanda Standards.

DRS 237 was prepared by Technical Committee RSB/TC41, *Environment protection.*

In the preparation of this standard, reference was made to the following standard(s):

TZS 1471, Tolerance limits for environmental vibration

The assistance derived from the above source is hereby acknowledged with thanks.

This second edition cancels and replaces the first (RS 237:2014) been technically revised.

Committee membership

The following organizations were represented on the Technical Committee on *Environment Protection*(RSB/TC 41) in the preparation of this standard.

Appropriate Community Sanitation & Energy Service international (ACSE-1)

Biofuel Rwanda

Cimenterie du Rwanda (CIMERWA)

Compagnie pour l'environement et le Developement (COPED)

Energy water and Sanitation Authority (EWASA)

Kanombe Military Hospital.

Kinazi cassava plant

King Faisal Hospital

Pear Energy Company

Resources efficient and cleaner Production Center (RECP)

Rwanda Environnent Management Company (RWEMACO)

Rwanda Environnent Mangement Authority (REMA)

Rwanda Utility Regulatory Authority

Sulfo Industries

UMUTARA Polytechnic

University of Rwanda- College of Arts and Social Sciences (UR-CASS)

University of Rwanda- College of Science and Technology (UR-CST)

Rwanda Transport and Development Agency (RTDA)- co-secretariat

Rwanda Standards Board (RSB) – Secretariat

Vibration —Tolerance limits

1 Scope

This Draft Rwanda standard specifies limits for general vibration including occupational environmental and air overpressure.Tolerance limits in this 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 documents are referred to in the text in such a way that some or all of their content constitutes requirements of this document. For dated references, only the edition cited applies. For undated references, the latest edition of the referenced document (including any amendments) applies.

RS ISO 45001: 2018 Occupational health and safety management systems — Requirements with guidance for use

3 Terms and definitions

For the purposes of this standard, the following terms and definitions apply/

3.1

Air overpressure

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

3.2

Daily exposure limit period

Duration that is used as reference in defining daily exposure values

3.3

Exposure action value

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(ELV)

maximum permissible amount of vibration exposure value

3.5

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:

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

where

a vibration magnitude and ;

T exposure period in hours.

3.6

Ground vibration

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 foundations of 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

Physical surrounding and social environment at workplace

3.9

Peak Particle Velocity

The maximum instantaneous sum of the velocity vectors of the ground movement measured in three orthogonal directions (expressed in millimetres per second).

The resultant PPV is calculated by producing a vector sum of the three (3) separate directional recordings:

$$\boldsymbol{V} = \sqrt{\boldsymbol{v}_v^2} + \boldsymbol{v}_l^2 + \boldsymbol{v}_t^2$$

where

v vertical ;

l longitude; and

t transverse for every point of the recording

3.10

Sensitive site

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

3.11

Subsonic vibration

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

3.12

Vibration

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 acceleration magnitude in m/s^2 evaluated from the measurement in three orthogonal directions at the vibrating surface in contact with the hand using the following formula:

$$\boldsymbol{a} = \sqrt{\boldsymbol{a}_x^2 + \boldsymbol{a}_y^2 + \boldsymbol{a}_z^2}$$

where

a_x, a_y, a_z are the root-mean-square acceleration magnitude 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 acceleration magnitude 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.

4 Requirements

4.1 Tolerance limits to protect people against risk to their health and safety are given in Table 1 and Table 2; these limits do apply mostly to occupational environment. Table 3 and Table 4 gives tolerance limits to minimize annoyance to people from environmental vibration, the limits shall be applicable to residential premises and other sensitive sites.

Table 1 — Tolerance limits for whole body vibration

Daily exposure limit period	Daily exposure limit value	Daily exposure action value
8 h	1.15 m/s^2	0.5 m/s^2

Table 2 — Tolerance for limits for hand arm vibration

Daily exposure limit period	Daily exposure limit value	Daily exposure action value
8 h	5 m/s2	2..5 m/s2

Table 3 — Tolerance for limits for ground vibrationat sensitive sites

Limit on ground vibration	Test method
5 mm/s PPV at all times	Seismograph (See Annex B)

Table 4 — Tolerance for limits for subsonic vibration/air over pressure

Limit on sensitive sites	Test method
120 dBL at all times	S Seismograph (See Annex B)

Annex A
(Informative)

General information on vibration and air overpressure and Blasting practice

A.1 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

A.2 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.

A.2.1 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 to 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.

A.2.2. Information on Ground Vibration

A.2.2.1 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.

A.2.2.2 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.

A.2.3. Air overpressure

A.2.3.1. The vibration that travels away from a blast area through the air is both audible and sub audible.

A.2.3.2. Like ground vibration, levels of fair overpressure decay rapidly with distance from the blast area.

A.2.3.3. 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 1km.

A.2.3.3. 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 over pressure 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.

A.2.4. 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.

A.2.5. Human response

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

A.2.5. Environmental Monitoring

A.2.6.1. Blasting is necessary in all aspects in the modern society.

A.2.6.2. Blasting may cause some short-term environmental impact.

A.2.6.3. Alternatives to blasting exist but usually cause more disturbance and inconvenience.

Annex B
(informative)

General guidelines for ground vibration and air overpressure monitoring

B.1 Part 1— Ground Vibration monitoring

B.1.1 General

Blasting seismographs are deployed in the field to record the levels of blast-induced ground vibration and air overpressure.Accuracyoftherecordingsisessential.Theseguidelinesdefinetheuser'sresponsibilitieswhen deploying blasting seismographs in the field and assume that the blasting seismographs conform to the 'Performance Specifications for Blasting Seismographs".

B.1.2 Procedure

B.1.2.1. **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 operations of the instrument before monitoring a blast.

B.1.2.2 Seismograph calibration

Annual calibration of the seismograph is recommended

B.1.2.3. Keep proper blasting seismograph records;

a user's log should note, date, time, place and other pertinent data.

B.1.2.4. Document the location of the seismograph

This include the name of the structure and where these is mograph 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.

B.1.2.5 Knowandrecordthedistanceto theblast

The horizontal distance fromtheseismographtothe blast should be known to at least two significant digits. For examplea blast within 1 000 m or feet would be measured to the nearest tens of meters or feet respectively and a blast within 10 000 m or feet would be measured to the nearest hundreds of feet or meters respectively. Where elevation changes exceed 2.5 h: 1v,slant distances or true distance should be used.

B.1.2.6 Record the blast

When seismographsaredeployedinthefield, thetimespentdeployingtheunit justifiesrecordinganevent. As practical, set thetriggerlevelslowenoughtorecord a blast.

B.1.2.7 Record the full time history waveform

A paragraphsummary 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.

B.1.2.8 Set the sampling rate

The 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.

B.1.2.9 Know the data processing time of the seismograph

Some units take up to 5 min to process and print data. If another blast occurs within this time the second blast may be missed.

B.1.2.10 Know the memory or record capacity of the seismograph

Enough memory must be available to store the event. The full wave form should be saved for future reference neither digital or analogy form.

B.1.2.11. 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 inthe field, a printer with paper is needed.

B.1.2.12. Allow ample time for proper setup of the seismograph

A paramany errors occur when seismographs are hurriedly set-up. Generally, more than 15 min for set-up should be allowed from the time the user arrives at the monitoring location until the blast.

B.1.2.13. know the temperature

Seismographs have varying manufacturer specified operating temperatures.

B.1.2.14. Secure cables

Suspended or freely moving cables from the wind or other extraneous sources can produce false triggers due to micro phonics.

B.2 Part 2- Ground vibration monitoring

B.2.1 General

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

B.2.2Sensorplacement

B.2.2.1 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.

B.2.2 2 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 m (10 feet) of the structure or less than 10 % of the distance from the blast, whichever is less.

B.2.2.3 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.

B.2.2.4 The sensor must be nearly level

B.2.2.5. The longitudinal channel should be pointing directly at the blast and the bearing should be recorded.

B.2.2.6 Where access to a structure and/or property is not available, the sensor should be placed closer to the blast in undisturbed soil.

B.2.3 Sensorcoupling

B.2.3.1 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.

B.2.3.2 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; and

c) greater than 9.81 m/s^2 (1.0 g) , burial or firm attachment is required.

B.2.3.3 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 (1.0g).

Table B.1 — Particle velocities and frequencies for accelerations

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/s2 (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)

B.2.4 Burial or attachment methods

B.2.4.1 The preferred burial method is excavating a hole that is no less than three times the height of the sensor, spiking the sensor to the bottom of the hole, and firmly compacting soil around and over the sensor.

B.2.4.2 Attachment to bedrock is achieved by bolting, clamping or adhering the sensor to the rock surface

B.2.4.3 The sensor may be attached to the foundation of the structure if it is located within ± 0.305 m (1- foot) of ground level. This should only be used if burial, spiking or sandbaggingisnotpractical.

B.2.5 Other sensor placementmethods

B.2.5.1 Shallow burial is anything less than described inB.2.4.

B.2.5.2 Spiking entails removing the sod, with minimal disturbance of the soil and firmly pressing the sensor with the attached spike(s) into theground

B.2.5.3 Sand bagging requires removing the sod with minimal disturbance to the soil and placing the sensoronthebarespotwithasandbagovertop. Sandbagsshouldbelargeandlooselyfilledwithabout4.55 k (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.

B.2.5.4 A combination of both spiking and sandbagging gives even greater assurance that good coupling isobtained.

B.2.5.5 Programming considerations

B.2.5.6 Site conditions dictate certain actions when programming the seismograph.

B.2.5.6.1 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).

B.2.5.6.2 Dynamicrangeandresolution- If theseismographisnotequippedwithanauto-rangefunction, 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.

B.2.5.6.3 **Recording duration -** Set the record time for 2 sec longer than the blast duration plus 1 sec for each 335 m (1100 feet) from the blast.

B.3 Part 3— Air overpressure monitoring

B.3.1 general

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

B.3.2 Microphone placement

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

a) themicrophoneshouldbemountednearthegeophonewiththemanufacturer'swindscreenattached;

b) the microphone may be placed at any height above the ground;

c) 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 shieldingobjectshouldbegreaterthantheheightof theshieldingobjectabovethe microphone;

d) 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; and microphone may be placed at any height above the ground;

e) the orientation of the microphone is not critical for air overpressure frequencies below 1 000 Hz. should be mounted near the geophone with the manufacturer's wind screen attached.

B.3.3.1 Programmingconsiderations

B.3.3.1 Triggerlevel; whenonlyanairoverpressuremeasurementisdesired, thetriggerlevelshouldbe low enough to trigger the unit from the air overpressure and high enough to minimize the occurrence of false events. Thelevelshouldbeslightlyabovetheexpectedbackgroundnoisefor therea.Agoodstartinglevelis 20 Pa (0.20 mill barsor 120 dB)

B.3.3.2 Recording duration; whenonly 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 IIC).

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