TECHNICAL REPORT

ISO/TR 9953

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Earth-moving machinery — Warning devices for slow-moving machines — Ultrasonic and other systems

Engins de terrassement — Dispositifs avertisseurs des machines à déplacement lent — Systèmes à ultrasons et autres

Reference number
ISO/TR 9953:1996(E)

Foreword

ISO (the International Organization for Standardization) is a worldwide federation of national standards bodies (ISO member bodies). The work of preparing International Standards is normally carried out through ISO technical committees. Each member body interested in a subject for which a technical committee has been established has the right to be represented on that committee. International organizations, governmental and non-governmental, in liaison with ISO, also take part in the work. ISO collaborates closely with the International Electrotechnical Commission (IEC) on all matters of electrotechnical standardization.

The main task of technical committees is to prepare International Standards, but in exceptional circumstances a technical committee may propose the publication of a Technical Report of one of the following types:

— type 1, when the required support cannot be obtained for the publication of an International Standard, despite repeated efforts;

— type 2, when the subject is still under technical development or where for any other reason there is the future but not immediate possibility of an agreement on an International Standard;

— type 3, when a technical committee has collected data of a different kind from that which is normally published as an International Standard ("state of the art", for example).

Technical Reports of types 1 and 2 are subject to review within three years of publication, to decide whether they can be transformed into International Standards. Technical Reports of type 3 do not necessarily have to be reviewed until the data they provide are considered to be no longer valid or useful.

ISO/TR 9953, which is a Technical Report of type 2, was prepared by Technical Committee ISO/TC 127, *Earth-moving machinery*, Subcommittee SC 2, *Safety requirements and human factors*.

This document is being issued in the type 2 Technical Report series of publications (according to subclause G.3.2.2 of part 1 of the ISO/IEC Directives 1995) as a "prospective standard for provisional application" in

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the field of detection devices for reversing commercial vehicles because there is an urgent need for guidance on how standards in this field should be used to meet an identified need.

This document is not to be regarded as an "International Standard". It is proposed for provisional application so that information and experience of its use in practice may be gathered. Comments on the content of this document should be sent to the ISO Central Secretariat.

A review of this Technical Report (type 2) will be carried out not later than two years after its publication with the options of: extension for another three years; conversion into an International Standard; or withdrawal.

Annex A forms an integral part of this Technical Report.

Introduction

This Technical Report outlines the procedure and sets criteria necessary to qualify a machine-mounted detecting/warning device.

The purpose of this warning device is to prevent serious injury to persons caused by backward movement of machines where the direct view of the operator is restricted by parts or components of the machine (i.e. engine hood).

The system provides the operator with audible and additional optical warning of persons or objects in the path of the machine during self-propelled rearward movement.

After evaluating all currently available alternatives, experts and organizations responsible for occupational safety consider that the most effective reduction in accidents can be achieved by monitoring the area to the rear of the machine with ultrasonic sensors or similar systems which are linked to visual/acoustic warning devices in the cab.

Requirements and tests contained in this Technical Report for warning devices on reversing slow-moving machines have been devised by ISO/TC 127/SC 2, which includes equipment manufacturers, earth-moving machine manufacturers, and organizations representing operators and those responsible for occupational safety. Manufacturers and test houses are requested to present their experience with the requirements of this Technical Report. In this regard, the following should be observed.

a) In the opinion of the experts in the subcommittee, rearward detection devices cannot be implemented on their own. The accident-preventing function can only be tested in conjunction with the relevant machine model, by optimizing the monitoring range. A generally mandatory measuring plan is necessary for this.

b) As with these devices, the safety questions for reversing detection devices scarcely concern prevention of electrical contact or sharp mechanical edges, etc., but rather reliability of operation (possibly including self-monitoring). Requirements should focus primarily on this.

Earth-moving machinery — Warning devices for slow-moving machines — Ultrasonic and other systems

1 Scope

This Technical Report describes a method for evaluating the performance of a monitoring system, the minimum monitoring range behind the machine during rearward movement, the optical and audible information to the operator, and the self-testing properties of the system.

It is applicable to machines as defined in ISO 6165, with an operating speed of up to 5 km/h, and having visibility restrictions in accordance with ISO 5006-2, visibility category III at field of view (see 4.4.3 of ISO 5006-2:1993) and at visual field (see 4.5.3 of ISO 5006-2:1993).

2 Normative references

The following standards contain provisions which, through reference in this text, constitute provisions of this Technical Report. At the time of publication, the editions indicated were valid. All standards are subject to revision, and parties to agreements based on this Technical Report are encouraged to investigate the possibility of applying the most recent editions of the standards indicated below. Members of IEC and ISO maintain registers of currently valid International Standards.

ISO 5006-2:1993, *Earth-moving machinery — Operator's field of view — Part 2: Evaluation method.*

ISO 6165:— [1], *Earth-moving machinery — Basic types — Vocabulary.*

ISO 7731:1986, *Danger signals for work places — Auditory danger signals.*

ISO 9227:1990, *Corrosion tests in artificial atmospheres — Salt spray tests.*

ISO 13766:— [2], *Earth-moving machinery — Electromagnetic compatibility.*

IEC 529:1989, *Degrees of protection provided by enclosures (IP code).*

1) To be published. (Revision of ISO 6165:1987)

2) To be published.

3 Definitions

For the purposes of this Technical Report, the following definitions apply.

3.1 monitoring system: System which monitors an area at the rear of a machine during rearward movement to indicate an object in the monitoring range by optical and acoustical signals to the operator. The monitoring system contains components as defined in 3.1.1 to 3.1.3.

3.1.1 sensor: Component which detects objects in the monitoring range.

3.1.2 evaluation device: Component which analyses the signals from the sensors and the self-testing property and transmits a corresponding signal to the indication device.

3.1.3 indication device: Component which transmits to the operator audible/optical warning signals related to the respective distance or area.

3.2 monitoring range: Specific three-dimensional area behind the machine, which is divided into a pre-warning range, a main warning range and a collision range. (See figure 1.)

3.3 test body: A standard measuring unit to test the geometry and size of the warning area and its position relative to the machine. It can be made of metal or plastic, depending on the system used.

3.4 sensor location: The location where the sensors are fitted to the machine.

3.5 audible warning signals: Signals to warn the operator audibly in the event of persons or objects within the monitoring range.

3.6 optical warning signals: Signals to warn the operator visually in the event of persons or objects within the monitoring range.

3.7 slow-moving machine: Earth-moving machine which operates at a speed of up to 5 km/h during rearward movement at working and manoeuvring modes.

3.8 monitoring of operational reliability: A self-testing property of the system, with the minimum requirements as specified in 4.8.

3.9 evaluation time: Time from the first registration of an object within the monitoring range to the signal output.

4 Requirements

4.1 Monitoring range

The monitoring range shall be measured from the most rearward outline of the machine. The monitoring range is defined by the measuring points in figures 2 to 5.

4.2 Sensor location

The sensor(s) should be fitted to the rear of the machine and so arranged that the monitoring range as specified in 4.1 is covered. For excavators, the sensor(s) should be fitted to the rear of the upper structure so that the monitoring area is controlling rearward movement in relation to the operator's facing direction. The sensor location should not restrict any function or operation of the machine.

4.3 Activation of the system

The system shall be active only during rearward movement of the machine.

The activation shall start with shifting into reverse gear.

NOTE — For excavators, the monitoring function of the system should be given by any rearward movement in relation to the operator's facing direction. The warning device should not be active while the excavator is stationary.

4.4 Location of the indication device

The indication device shall be located in or within the operator's compartment.

4.5 Audible warning signals

4.5.1 The sound of the audible warning signals shall comply with ISO 7731.

4.5.2 At least three warning signals related to the monitoring range shall be available, as follows:

a) interval sound approx. 2 Hz: when an object is within the pre-warning area;

b) interval sound approx. 4 Hz: when an object is within the main warning area;

c) continuous sound: when an object is within the collision area.

4.5.3 An additional optical warning signal should be available. It should be located in the operator's direct view. The colours shall be as follows:

a) intermittent yellow warning light: when an object is within the pre-warning area;

b) yellow warning light: when an object is within the main warning area;

c) red warning light: when an object is within the collision area.

4.6 Location of the evaluation device

The location of the evaluation device shall be in accordance with the specification of the manufacturer of the system. No restriction to the operator or operating function of the machine shall be caused if the evaluation device is fitted within the operator's compartment.

4.7 Evaluation time

4.7.1 Measuring time of the system

The measuring time including all sensors in a monitoring system should not take longer than 200 ms before the indication appears. This time is calculated as the arithmetic mean of at least 50 measurements, in the course of which a test object [as specified in 5.1 a)] is moved at a speed of 1 ms from outside the main warning zone to the 1,0 m grid position, i.e. the trigger point for time measurement. The maximum measuring time until an indication is made should not be longer than 300 ms.

4.7.2 Activation time of the system

The first indication of an object in the monitoring range shall be made at the latest 600 ms after activation of the system, which is by engagement of reverse gear.

4.8 Monitoring of operational reliability

4.8.1 System check

The system check shall control the function of the whole system and be confirmed by a short audible signal of less than or equal to 10 ms, followed by a green operation control light. The system check shall be automatic after activation of the system.

4.8.2 Permanent self-checking

The monitoring system shall have a permanent monitoring function including at least the following:

a) an indication of sufficient power supply (voltage);

b) an operating indication light (green);

c) an optical/audible failure signal if the operation of the system is impaired, including at least the monitoring of each wire between the evaluation device and the sensor for

- wire break,
- short-circuit,
- time management,
- signal out- and input (pulse and echo),
- evaluation of the system.

4.9 Resistance to manipulation

It shall not be possible to disable the monitoring system by simply switching it off. The reversing detection device shall be so designed and installed that its reliable operation cannot easily be altered.

5 Tests and performance requirements

The test method shall be performed on a system which is fitted to the machine.

5.1 Test body

Geometry of the monitoring range is tested with the following test objects:

a) test object H for the horizontal test, consisting of a tube of 75 mm diameter, length 1 700 mm, and of grey colour;

b) test object V for the vertical test, consisting of a tube of 75 mm diameter, length 300 mm, and of grey colour.

5.2 Environmental conditions

The test shall be undertaken under the following environmental conditions:

- wind velocity (max.) of 5,4 m/s,
- temperature of (23 ± 5) °C,
- relative humidity of (60 ± 25) %.

The test shall not be affected by reflected sound from surrounding walls, auxiliary test equipment or other objects.

5.3 Static test of the monitoring range

The monitoring range as described in 4.1 shall be verified with a test body as specified in clause 5.1.

5.3.1 Horizontal test

Position test object H statically, with the longitudinal axis static in the monitoring range, standing perpendicular on the ground, in such a way that its longitudinal axis is in the grid positions of each measuring point shown in figure 2.

5.3.2 Vertical test

Position test object V statically, horizontally in the monitoring range, so that its three-dimensional centre is situated in the specified grid positions of each measuring point shown in figure 3 b) and at the height positions shown in figure 3 a).

5.4 Measuring procedure for field test checks

For a field compliance test, carry out the test at the measuring points indicated in figures 4 and 5. The static test procedure for the horizontal and vertical test is as specified in 5.3.1 and 5.3.2.

5.5 Valuation of the test results

Test object H and V shall be detected statically in all grid positions. Detection shall take place unambiguously with an uninterrupted sequence of the signal appropriate to the warning area. If the test object is not detected in one position, displace that position to the left and right by the width of the test object. The test object shall be detected perfectly in both positions.

5.6 Special environmental testing conditions

Beside the tests according to the environmental conditions specified in 5.2, the following tests should be performed.

5.6.1 Test at low temperature

Cool all components of the monitoring system down to – 20 °C and maintain this temperature for at least 0,5 h. Then carry out a function test within 3 min, using measuring points at 1,0 m (see 5.3 and figures 2 and 3).

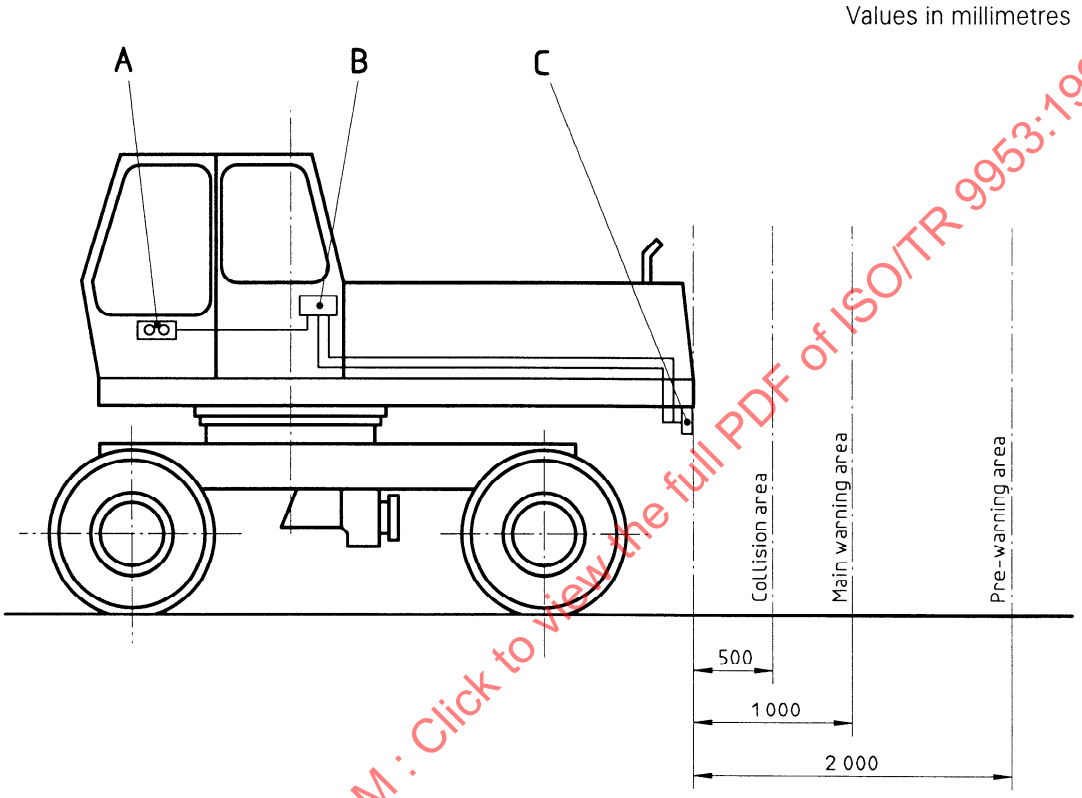
5.6.2 Test at high temperature

Heat all components of the monitoring system to a temperature of + 60 °C and maintain this temperature for at least 0,5 h. Then carry out a function test within 3 min, using one measuring point of the grid at 1,0 m (see 5.3 and figures 2 and 3).

NOTE — An alternative laboratory test is acceptable if its equivalence can be demonstrated.

6 Requirements and tests for components

All components of the monitoring system shall meet the requirements given in annex A.



A Warning control unit

B Electronical evaluation unit

C Sensor

Figure 1 — Monitoring range

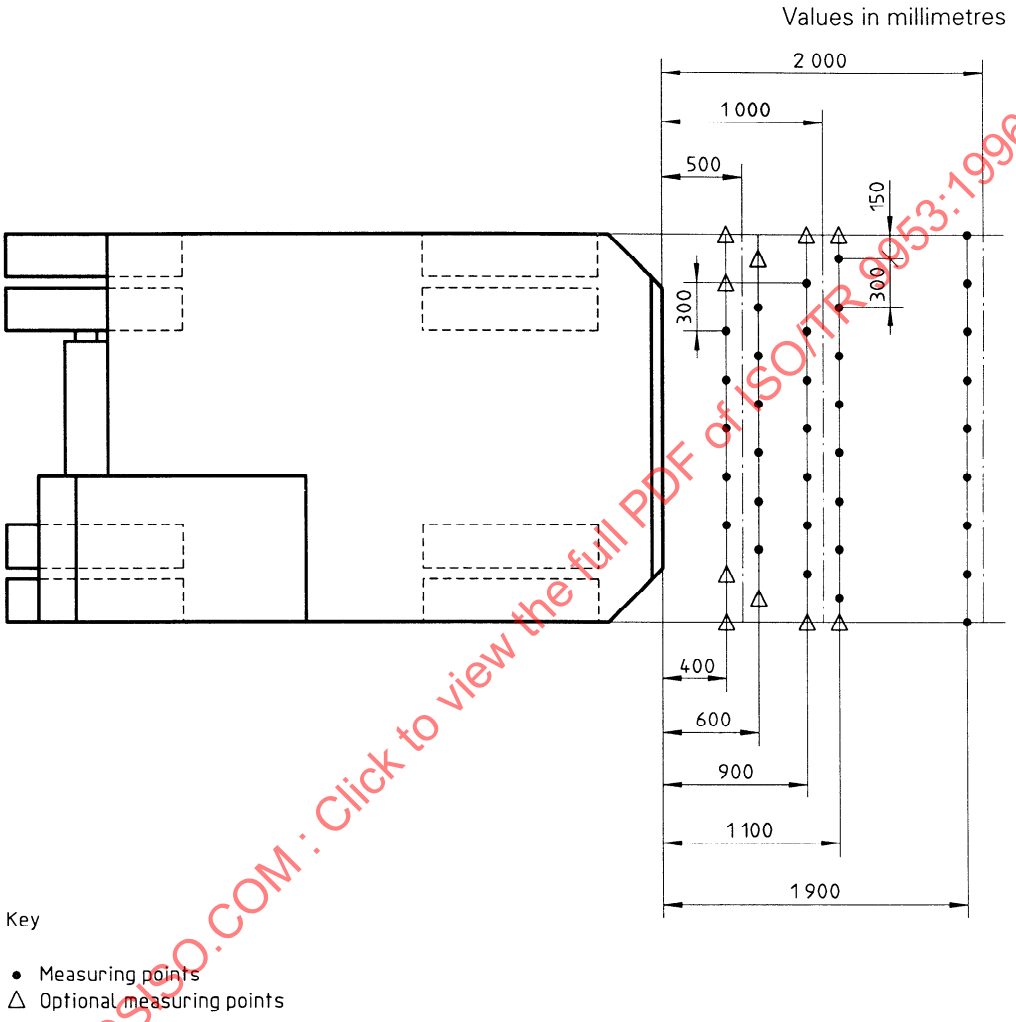
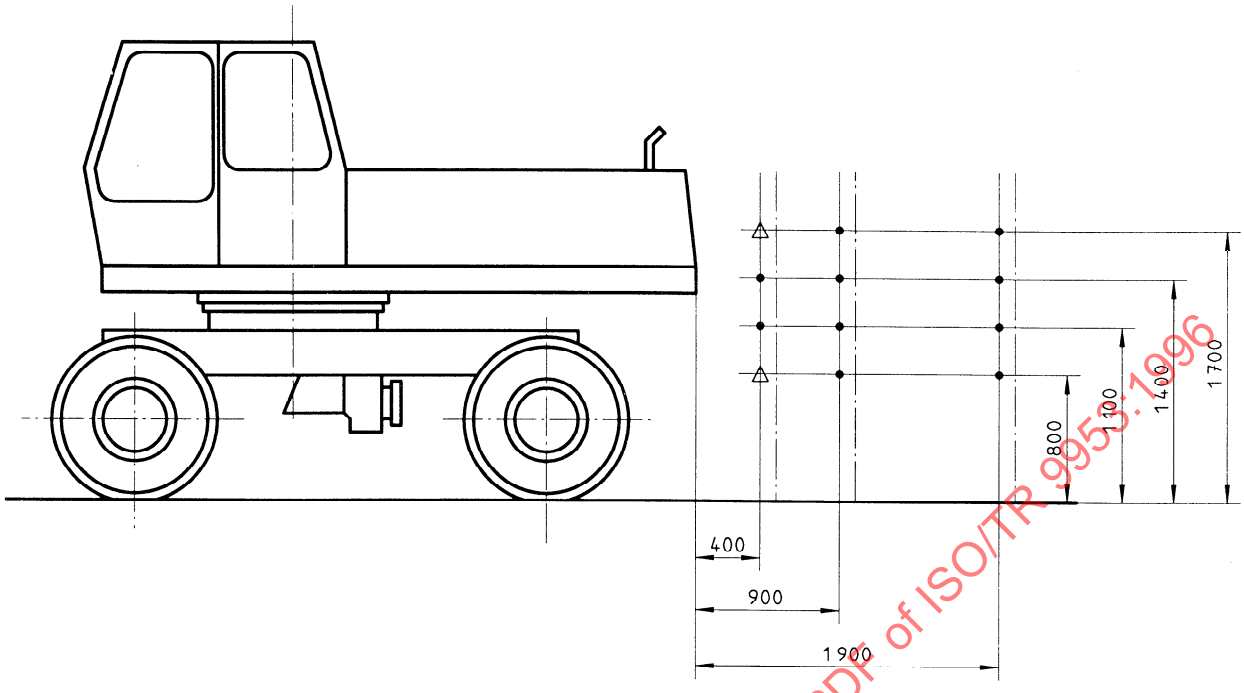
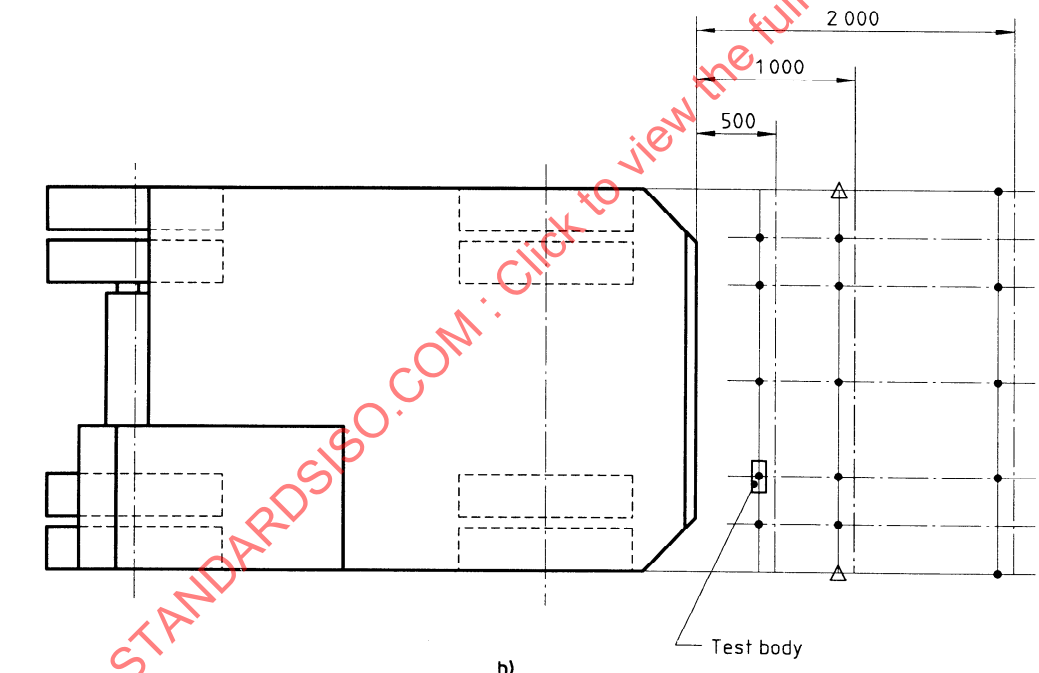


Figure 2 — Horizontal warning range and test grid for static test

Values in millimetres



a)



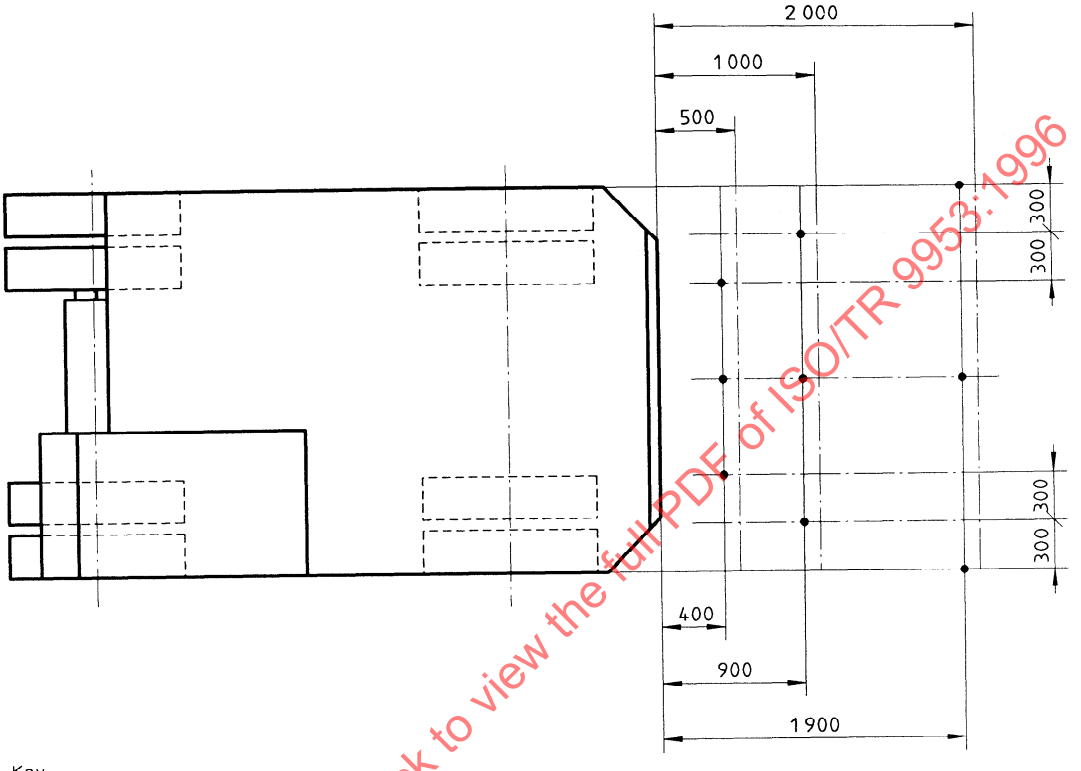
b)

Key

- Measuring points
△ Optional measuring points

Figure 3 — Vertical test grid for static test

Values in millimetres



Key

- Measuring points

Figure 4 — Horizontal test grid for field test

Values in millimetres

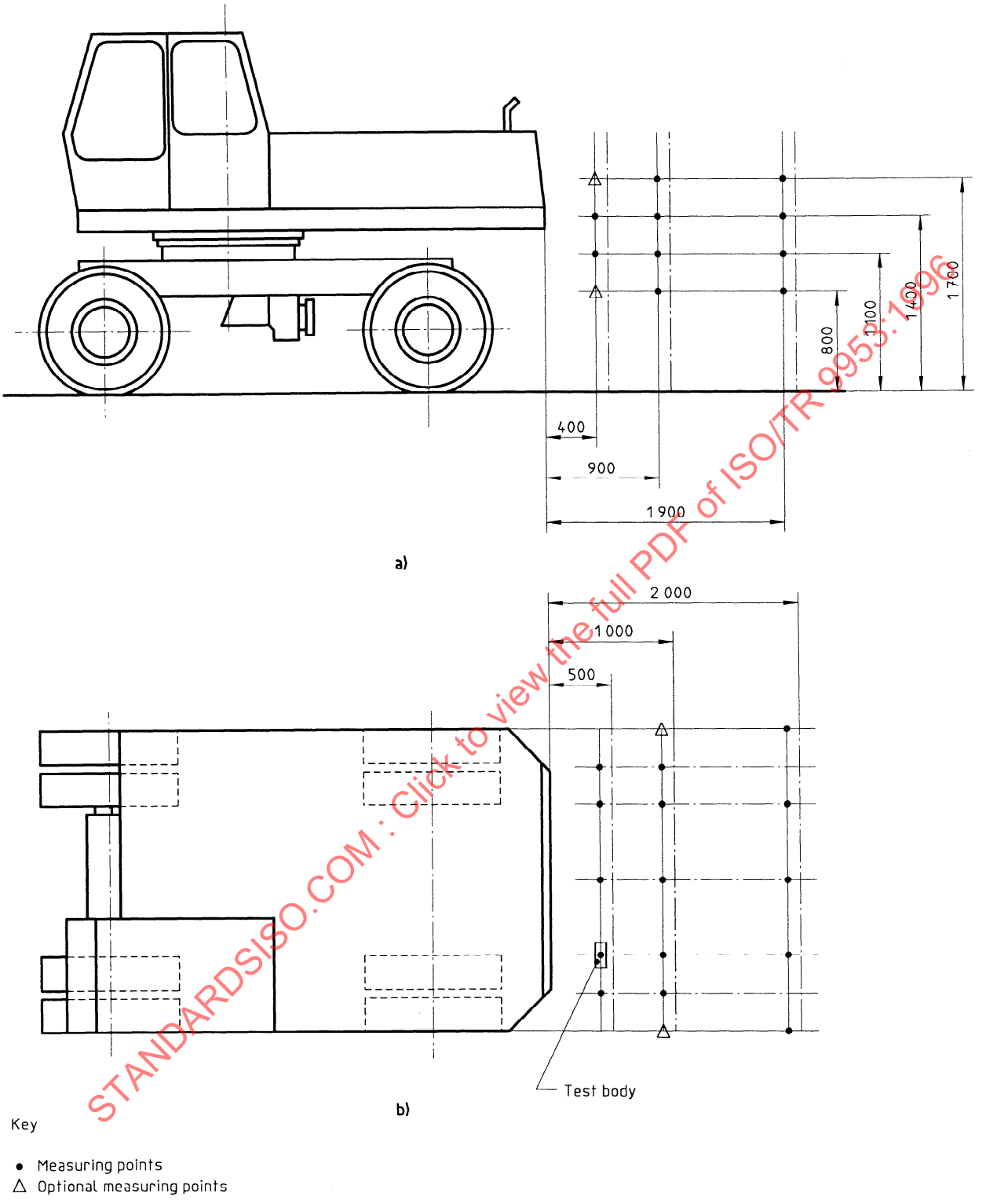


Figure 5 — Vertical test grid for field test

Annex A
(normative)

Requirements and tests for components

Unless specfied otherwise, the tests on the components shall be performed in the following sequence, and at an ambient temperature of (23 ± 5) °C with relative air humidity of (60 ± 25) %.

A.1 Mechanical vibration

A.1.1 Test

Fit the component on the test device in the same position and with the same fixings as in the machine. Subject the component to be tested to the following sinusoidal vibrations on a suitable vibration test device.

Frequency: 5 Hz to 200 Hz

Vibration amplitude: ± 15 mm

Acceleration: 49 m/s^2 (5g)

Transition frequency: about 8 Hz to 9 Hz

Number of frequency cycles: 50

Rate of change of frequency: 1 octave/min

The frequency cycles may be interrupted.

The test shall be performed for 16 h in each of three directions of vibration, perpendicular to one another, and one of which lies along the longitudinal axis of the machine.

A.1.2 Requirements

After the test, no cracks or changes shall be visible, and the component tested shall be capable of operation.

A.2 Climatic conditions

A.2.1 Test

NOTE — This test is related to storage conditions only.

Subject the components to be tested to five test cycles, each lasting 24 h, under the following climatic conditions.

a) Allow temperature equalization for 4 h at an ambient temperature of (23 ± 2) °C and relative humidity of between 45 % and 75 %.

b) Increase the temperature in the test chamber to (55 ± 2) °C and the relative humidity to between 95 % and 99 % within 0,5 h.

c) Maintain the temperature/humidity levels indicated in b) for 10 h.

d) Reduce the temperature in the test chamber to (– 40 ± 2) °C within 2,5 h.

e) Maintain the temperature indicated in d) for 2 h.

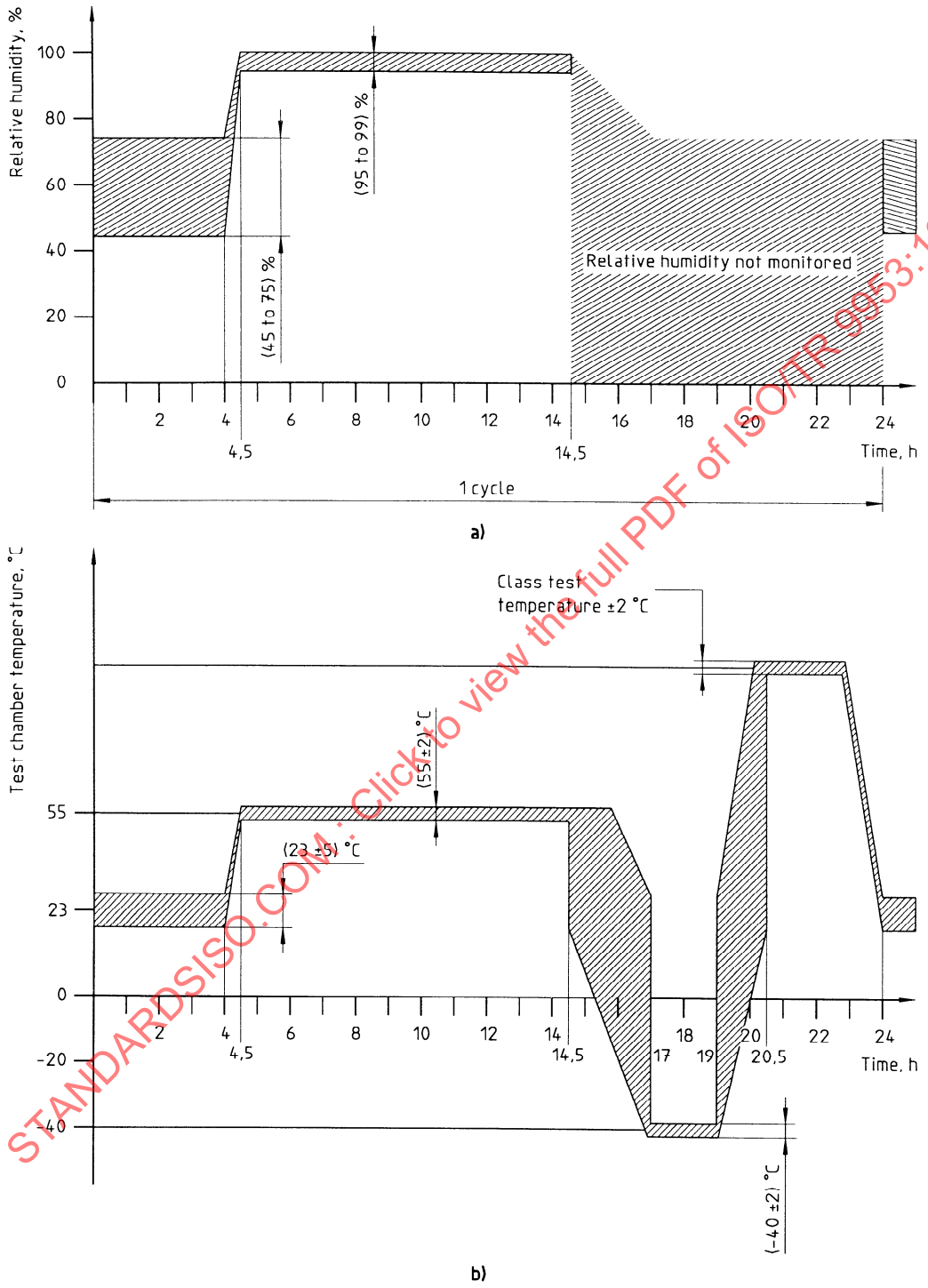
f) Increase the temperature of the specimen to (100 ± 2) °C within 1,5 h.

g) Maintain the temperature indicated in f) for 2 h.

h) Reduce the temperature in the test chamber to ambient temperature within 1,5 h.

During conditioning stages d), e), f), g) and h), the relative humidity is not monitored. During a break in the test procedure between two test cycles, the specimens shall be stored at ambient temperature.

The test cycle is shown diagrammatically in figure A.1.



NOTE — The hatched areas show (a) the acceptable changes in relative humidity and (b) the acceptable temperature changes of the test chamber(s) as a function of operating time.

Figure A.1 — Temperature/humidity cycling