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Earth-moving machinery — Wheeled or high-speed rubber-tracked machines — Performance requirements and test procedures for brake systems

Engins de terrassement — Engins sur pneumatiques ou sur chenilles en caoutchouc à grande vitesse — Exigences de performance et modes opératoires d'essai des systèmes de freinage

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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.

International Standards are drafted in accordance with the rules given in the ISO/IEC Directives, Part 2.

The main task of technical committees is to prepare International Standards. Draft International Standards adopted by the technical committees are circulated to the member bodies for voting. Publication as an International Standard requires approval by at least 75 % of the member bodies casting a vote.

Attention is drawn to the possibility that some of the elements of this document may be the subject of patent rights. ISO shall not be held responsible for identifying any or all such patent rights.

ISO 3450 was prepared by Technical Committee ISO/TC 127, *Earth-moving machinery*, Subcommittee SC 2, *Safety, ergonomics and general requirements*.

This fourth edition cancels and replaces the third edition (ISO 3450:1996), which has been technically revised.

Earth-moving machinery — Wheeled or high-speed rubber-tracked machines — Performance requirements and test procedures for brake systems

1 Scope

This International Standard specifies minimum performance requirements and test procedures for the service, secondary and parking brake systems of wheeled and high-speed rubber-tracked earth-moving machines, for the uniform assessment of those brake systems.

It is applicable to the following earth-moving machinery, operating on work sites or in mining, or travelling on public roads:

— self-propelled, rubber-tyred earth-moving machines, as defined in ISO 6165;

— self-propelled rollers and landfill compactors, as defined in ISO 6165 and ISO 8811;

— self-propelled scrapers, as defined in ISO 7133;

— remote-control machines, as defined in ISO 6165, wheeled or rubber-tracked;

— derivative earth-moving machines with rubber tyres;

— earth-moving machines with rubber tracks and a maximum machine speed ≥20 km/h.

It is not applicable to pedestrian-controlled earth-moving machinery (see ISO 17063) or crawler earth-moving machines with steel or rubber tracks that travel at <20 km/h (see ISO 10265). While purpose-built underground mining machines are not within the scope of this International Standard, its provisions can generally be applied to those machines with some braking performance modifications and additions (see Annex A).

NOTE At the time of publication, no International Standard dedicated to purpose-built underground mining machines had been developed.

2 Normative references

The following referenced documents are indispensable for the application 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.

ISO 6014, *Earth-moving machinery — Determination of ground speed*

ISO 6016, *Earth-moving machinery — Methods of measuring the masses of whole machines, their equipment and components*

ISO 6165, *Earth-moving machinery — Basic types — Identification and terms and definitions*

ISO 7133, *Earth-moving machinery — Tractor-scrapers — Terminology and commercial specifications*

ISO 8811, *Earth-moving machinery — Rollers and compactors — Terminology and commercial specifications*

ISO 9248, *Earth-moving machinery — Units for dimensions, performance and capacities, and their measurement accuracies*

ISO 10968, *Earth-moving machinery — Operator's controls*

ISO 15998, *Earth-moving machinery — Machine-control systems (MCS) using electronic components — Performance criteria and tests for functional safety*

3 Terms and definitions

For the purposes of this document, the following terms and definitions apply.

3.1
brake system
braking system
all components which combine together to stop and/or hold the machine, including the brake control(s), brake actuation system, the brake(s) themselves and, if the machine is so equipped, the retarder .

3.1.1
service brake system
primary system used for stopping and holding the machine

3.1.2
secondary brake system
system used to stop the machine in the event of any single failure in the service brake system

3.1.3
parking brake system
system used to hold a stopped machine in a stationary position and which, if applicable, may also be part of secondary brake system

3.1.4
hydrostatic brake system
hydrostatic or other similar propel drive system used to meet one or more of the brake system requirements

3.1.5 Braking system components

3.1.5.1
brake control
component directly activated by the operator to cause a force to be transmitted to the brake(s)

3.1.5.2
brake actuation system
all components between the brake control and the brake(s) which connect them functionally

3.1.5.3
brake
brakes
component which directly applies a force to oppose movement of the machine

NOTE The different types of brake include friction, mechanical, electrical, regenerative devices and hydrostatic or other fluid types.

3.1.5.4
common component
component that performs a function in two or more brake systems

EXAMPLE Pedal, valve.

3.1.5.5
retarder
energy-absorption device normally used to control machine speed

3.2
hydrostatic drive system
hydraulic system where hydraulic motors form a direct drive to the wheels or track to propel the machine and slow machine movement

3.3
machine test mass
operating mass of a machine which includes the heaviest combination of cab, canopy, operator protective structures (if required) with all their components and mountings, any combination of equipment approved by the manufacturer of the machine, including operator and full liquid systems in accordance with ISO 6016 (e.g. machine configuration and direction of travel having the most adverse effect on braking)

NOTE 1 For rollers, the sprinkler water reservoir(s) shall be full.

NOTE 2 For self-propelled scrapers with semi-trailed units, towed trailers and all types of dumpers, the machine test mass shall also include the maximum specified payload as per the machine manufacturer's specifications. For all other machines, the payload shall not be included.

3.4
stopping distance
s
distance travelled by the machine from the point on the test course at which the machine brake control actuation begins (e.g. operator actuates the brakes) to the point on the test course where the machine is fully stopped

NOTE 1 It is expressed in metres (m).

NOTE 2 It does not take into account the operator reaction time, unless stated, but does take into account the system reaction time.

3.5
mean deceleration
a

average rate of change in the velocity of the machine from the instant the brake control actuation begins until a full stop is achieved

NOTE It is expressed in metres per second squared (m/s^2), calculated from

$$a = \frac{v^2}{2s}$$

where

v is the velocity of the machine immediately prior to the brake control being activated, in metres per second (m/s);

s is the stopping distance, in metres (m).

3.6
burnishing
procedure used to condition the frictional surfaces of a brake

3.7
brake system pressure
fluid pressure available to the brake control

3.8
brake application pressure
measured fluid pressure used to actuate the brakes

3.9
modulated braking
ability to continuously and progressively increase and decrease the braking force by operation of the brake control

EXAMPLE A system allows the braking force to be increased and decreased over time, based on single or repeated movements of the brake control.

3.10
test course
surface upon which the test is carried out

NOTE See 5.3.

3.11
cold brakes
〈brake systems containing friction elements〉 condition of brakes where

— the brakes have not been actuated in the previous hour except in accordance with the applicable performance test (see Clause 6),

— the brakes have been cooled to 100 °C or less when measured on the brake disc or the outside of the brake drum, or

— in the case of totally enclosed brakes, including oil-immersed brakes, the temperature measured on the outside of the housing closest to the brake is below 50 °C or within the brake manufacturer's specifications

3.12
maximum machine speed
maximum speed determined in accordance with ISO 6014, or equivalent

3.13
back throttling
action of applying slight forward or reverse power to a hydrostatic or other similar drive system in order to hold the machine stationary

3.14
derivative earth-moving machine
machine with a combination of features from other earth-moving machines, thereby creating different configurations or arrangements

EXAMPLE Machine having the front-mounted equipment of a loader on a non-self-loading, rear-mounted dumper body.

3.15
safe state
condition in which, after a malfunction of the machine control system, the controlled equipment, process or system is automatically or manually stopped or switched into a mode that prevents unexpected performance or the potentially hazardous release of stored energy

3.16
dumper
self-propelled crawler or wheeled machine with an open body, which transports and dumps or spreads material, and where loading is performed by means other than the dumper

[ISO 6165]

NOTE For semi-trailed dumpers, see ISO 7132:2003, Figures 3, 16 and 20.

3.16.1
rigid-frame dumper
dumper having a rigid frame and wheel or crawler steering

[ISO 6165]

NOTE Rigid-frame and articulated-frame dumpers are illustrated in ISO 7132:2003, Figures 1 and 2, 8 and 9, 14 and 15, and 18 and 19.

3.16.2
articulated-frame dumper
⟨wheeled machine⟩ dumper with an articulated frame which accomplishes the steering of the dumper

[ISO 6165]

NOTE Rigid-frame and articulated-frame dumpers are illustrated in ISO 7132:2003, Figures 1 and 2, 8 and 9, 14 and 15, and 18 and 19.

3.17
trailer
transport machine with one or more axles which, according to its design, is suitable and intended for coupling to a self-propelled machine

3.18
fully developed deceleration rate
maximum continuous deceleration rate which the machine is capable of developing on a specified constant slope, with a specific machine test mass and surface condition and an initial (prior to deceleration) machine travel speed

3.19
purpose-built underground mining machine
specialized earthmoving machine designed for underground use which may have a lower height profile and trailer attached

EXAMPLE Underground dump trucks, tele-dumpers, load haul dumps, scoops, coal haulers, power trams, chock carriers, personnel carriers, loading machines.

3.20
machine control system
MCS
components needed to fulfil the function of the system, including sensors, signal processing unit, monitor, controls and actuators or several of these

NOTE The extent of the system is not limited to the electronic controls, but is defined by the machine-related function of the complete system. It therefore consists generally of electronic, non-electronic and connection devices. This can include mechanical, hydraulic, optical or pneumatic components/systems.

[ISO 15998]

4 General requirements

The requirements of this clause apply to all machines within the scope of this International Standard.

All brake systems shall be designed, constructed and installed such that contamination and/or its effects are minimized.

4.1 Required brake systems

4.1.1 All machines shall be equipped with

a) a service brake system,

b) a secondary brake system, and

c) a parking brake system.

Service, secondary and parking brake systems may share common components or functions and do not have to be three independent and separate systems.

4.1.2 No brake system (including hydrostatic systems) shall contain a disconnecting device such as a clutch or shiftable gear-box which allows disabling of the brake, except for systems in accordance with a) and/or b), as follows:

a) any device designed to disconnect the service or secondary brake power source for cold weather starting shall require application of the parking brake before disconnection can take place;

b) a parking brake disconnect (release) designed to allow movement of disabled machines shall be located outside the operator's station unless it can be reapplied immediately.

4.1.3 All machines shall have service brakes of an equal nominal capacity rating applicable to each of the wheels (or equivalent) of at least one axle. Dumpers and self-propelled scrapers with semi-trailed unit(s) shall have service brakes applicable to at least one axle of the towing machine and one axle of each semi-trailed unit.

4.1.4 For rollers, the service and secondary brakes shall apply to all power-driven drums and wheels. Each drum of a split drum shall have the same nominal brake torque. The brake of a single-drum roller and a combined roller shall apply to all wheels and to the drum.

4.1.5 If the parking brake is intended to stop creep movement, the parking brake system shall permit actuation of the parking brake during travel.

4.2 Common components

Service, secondary and parking brake systems can share common components. Where common components are used, the machine's braking performance shall meet the requirements for secondary brake systems given in 4.5 and 4.7, as applicable. If there is a failure in any single component within the brake system — except for tyres, drum or track — braking performance shall be in accordance with Table 3.

Acceptable performance is achieved for common brake control failure as follows. If there is a failure with a common brake control (lever, pedal, etc.) used to actuate the combined service and secondary brake systems, and there is another dynamic braking capability provided with the machine (e.g. parking brake with dynamic braking capability), the dynamic braking capability shall stop the machine after the failure within 120 % of the stopping distance for secondary brakes (under secondary test conditions) in accordance with Table 3. This dynamic braking capability may be applied automatically and without modulation. An indication should be given to the operator simultaneous with, or before, application of the brake system, if applied automatically.

4.3 Brake control systems

All brake system controls shall be capable of being applied by an operator from the operating position. Parking brake system controls shall be arranged so that, unless immediately reapplied, they cannot be released once applied.

Unintended brake control activation can be avoided through compliance with ISO 10968.

Brake control systems should be designed to avoid any unintended application or release of brakes during normal operation. This does not preclude the automatic application of a brake system due to intended design conditions that also meet the requirements of this International Standard.

The arrangement of the brake system controls should be in accordance with ISO 10968. If not, an instructional sign shall be provided (e.g. using symbols) explaining the control arrangement. Brake pedals and hydrostatic brake system controls are obvious and may not require machine instructions.

A brake control system shall prevent or minimize any uncontrolled braking performance (random brake applications, releases or sporadic braking performance, etc.) during normal operation (start, stop or normal travel operation of the machine, etc.).

Electric, electronic and electronic machine control systems (MCS) for service, secondary or parking brakes shall comply with ISO 15998.

The operator should be able to apply the service or secondary brake while retaining control of the steering device on the machine with at least one hand.

4.4 Service brake systems

All machines shall meet the service brake performance requirements given in Clause 6, as applicable. The service brake system shall have modulated braking for machines designed for maximum machine speeds greater than 6 km/h. If a travel mode that limit the maximum machine speed to 6 km/h or less can be selected, modulation is not required in this mode.

If other systems receive power from the service brake system, any failure in those systems that reduces service brake system performance shall be considered as a failure in the service brake system.

4.5 Secondary brake systems

All machines shall meet the secondary brake performance requirements given in Clause 6, as applicable. The secondary brake system shall have modulated braking for maximum machine speeds greater than 20 km/h.

4.6 Parking brake systems

All machines shall meet the parking brake requirements of Clause 6, as applicable.

After application of the parking brake, the parking brake system shall not depend on an exhaustible energy source or continuous operator action (e.g. hand or foot effort). The parking brake system may use common components, provided the requirements of 6.4 and Table 2 are met. The parking brake, operating according to the manufacturer's specifications, shall be in accordance with Table 2, regardless of any contraction of the brake parts or leakage of any kind.

NOTE Mechanical springs are not considered to be an exhaustible energy source. Back throttling by a hydrostatic drive system does not meet the parking brake requirements, as back throttling requires continuous operator action.

The parking brake shall require an action by the operator prior to release of the parking brake control. The parking brake shall not automatically release during normal start up or upon loss of power to the parking brake system or parking brake MCS.

A parking brake may be applied automatically (e.g. spring- or control-system-activated), in which case it shall be applied or remain applied after the machine is in a stopped condition and the engine shut down.

Machines with the capability for a self test of the parking brake shall include design provisions that the machine does not propel unless there is a propel activation by the operator during the self test.

4.7 Hydrostatic brake systems

For a machine fitted with a hydrostatic brake system, the service and secondary brakes shall be in accordance with 4.4 and 4.5, respectively.

Typical hydrostatic brake systems have an exhaustible power supply and would not be able to meet the requirements for parking brakes given in 4.6.

Service brake application shall be obtained by one of the following means:

— operation of a single control;

— moving the foot from the drive pedal to the brake pedal;

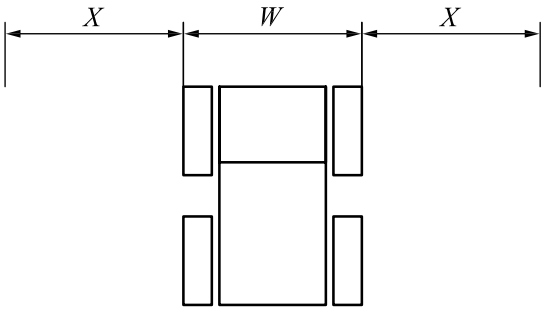
— at the start of the braking sequence, releasing the drive control(s) and moving to the neutral or reverse propel position using hand or foot.

A brake system additional to the service brake may be used to hold the machine when there is creep movement. A machine may be held stationary, regardless of the grade, using the throttle of the hydrostatic or similar propel drive system (back throttling).

4.8 Systems with combined brake and steer function

If the braking system has a combined brake and steer function and is used as the secondary brake system, the machine shall maintain controllability during secondary brake stopping distance testing in accordance with Clause 6.

While remaining within the applicable secondary brake stopping distance specified in Table 3, the machine shall not veer outside a boundary lane, X, on either side of the machine, in accordance with Figure 1.



For $W \leq 2$, X shall be 1,25W.

For $W > 2$, X shall be 2 m. This is intended to limit the machine veering outside the required public road traffic lane width.

Key

W width of machine over wheels or tracks, m

X width of boundary lane, m

Figure 1 — Boundary conditions for secondary braking

4.9 Performance and warning devices for stored energy sources

If stored energy (e.g. reservoirs, accumulators) is used for the service brake system, the stored energy system shall be equipped with a low-energy warning device. The remaining pressure on the third service brake application after the warning signal shall have sufficient energy to provide secondary brake performance in accordance with Table 3, as applicable to the machine.

The warning device shall readily attract the operator's attention by providing a continuous (e.g. steady or pulsating) visible and/or audible warning. Gauges indicating pressure or vacuum do not meet this requirement.

4.10 Braking systems with electronic MCS

The electronic control system for a braking system shall meet safe state requirements as determined by the manufacturer using a risk assessment methodology. An electronic MCS complying with ISO 15998 meets such safe state requirements.

If the maximum machine speed is limited by design to less than 6 km/h, these safe state requirements are fulfilled when any of the braking systems can bring the machine to a stop within the brake stopping distances given Table 3.

Braking systems on machines that meet the requirements of this International Standard also achieve the safety concept of ISO 15998 for earth-moving machinery braking systems. A risk assessment of the brake MCS needs to be carried out to determine if functional braking after any single failure involving an electrical and/or electronic MCS meets the braking performance requirements of this International Standard.

NOTE ISO 15998 also requires additional testing of the MCS to verify its performance and modes of failure.