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Earth-moving machinery — Operator's controls

Engins de terrassement — Commandes de l'opérateur

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Foreword

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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.

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ISO 10968 was prepared by Technical Committee ISO/TC 127, *Earth-moving machinery*, Subcommittee SC 2, *Safety requirements and human factors*.

This second edition cancels and replaces the first edition (ISO 10968:1995), which has been technically revised.

Earth-moving machinery — Operator's controls

1 Scope

This International Standard specifies requirements and guidelines for the operator's primary controls on earth-moving machinery (as defined in ISO 6165) in as far as those controls relate to the ride-on operator (for remote operator-controlled machines, see ISO 15817). Its provisions for finger-, hand- and foot-operated controls are not intended to prevent usage of other types of controls, control locations or control movements. Nevertheless, it does recommend that the general requirements and principles of arrangement be followed for those others, taking into account operator safety and ergonomics.

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 3411, *Earth-moving machinery — Human physical dimensions of operators and minimum operator space envelope*

ISO 3450, *Earth-moving machinery — Braking systems of rubber-tyred machines — Systems and performance requirements and test procedures*

ISO 5010, *Earth-moving machinery — Rubber-tyred machines — Steering requirements*

ISO 6165, *Earth-moving machinery — Basic types — Vocabulary*

ISO 6405-1, *Earth-moving machinery — Symbols for operator controls and other displays — Part 1: Common symbols*

ISO 6405-2, *Earth-moving machinery — Symbols for operator controls and other displays — Part 2: Specific symbols for machines, equipment and accessories*

ISO 6682, *Earth-moving machinery — Zones of comfort and reach for controls*

ISO 10264, *Earth-moving machinery — Key-locked starting systems*

ISO 10265, *Earth-moving machinery — Crawler machines — Performance requirements and test procedures for braking systems*

ISO 13766, *Earth-moving machinery — Electromagnetic compatibility*

ISO 15817, *Earth-moving machinery — Safety requirements for remote operator control*[1)]

ISO 15998, *Earth-moving machinery — Machine-control systems (MCS) using electronic components — Performance criteria and tests*[1)]

1) To be published.

3 Terms and definitions

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

3.1
primary control
control that is used frequently or continuously by the operator (see ISO 6682)

NOTE The primary controls are the following.

a) For the base machine:

1) steering;

2) clutch or inch pedal;

3) gear selection;

4) speed;

5) travel direction;

6) brakes;

7) rotary/slewing motion.

b) For equipment:

1) raising/lowering operations (e.g. loader arm, dozer equipment, excavator boom, side boom winch, rope excavator winch);

2) boom extending, retracting or articulating operations;

3) backward-/forward motion (e.g. backhoe-arm);

4) attachment operations (e.g. bucket, attachment bracket shovel, clamshell, forges, dump body);

5) rotary/slewing operations.

3.2
secondary control
control that is infrequently used by the operator but is needed for the proper functioning of the machine (e.g. control for parking brake, for lighting)

3.3
machine response
movement of base machine or equipment or attachment in response to activation of a control

EXAMPLE Raising of the bucket when the bucket lift control is moved to the raise position, closing of a clamshell when the clamshell close control is moved to the close position.

3.4
control actuating force
force exerted at the centre of the control contact surface, in the direction of movement of the surface, in order to achieve a control function

NOTE This force does not necessarily represent the force typically applied by the operator.

3.5
remote operator control
operation of an earth-moving machine by an operator at a distance from the machine by means of wired control or wireless control, including the control of an autonomous machine when operating in remote-control mode

4 Control location

4.1 Control locations

The location of controls shall be in accordance with ISO 3411 and should also take into account the guidelines given in ISO 6682.

4.2 Distance between primary controls

4.2.1 The distance between adjacent controls and between controls and other machine parts shall be sufficient to allow operation without unintentional activation of adjacent controls. The overlapping of controls is permissible to provide independent and simultaneous control application.

4.2.2 The distance between finger, hand- and foot-operated controls, or between those types of controls and any adjacent parts, shall be as follows.

NOTE The distance between two adjacent finger-operated controls is related to the width of the controls. Therefore, a distance between the centre lines of two adjacent controls is specified, depending on whether a device is located between two controls.

— For finger-operated controls, the distance between the centre lines of two adjacent controls (excluding key or touch pads intended for fingertip activation):

  1) 25 mm, without divider;

  2) 18 mm, with divider.

— For hand-operated (with fingers around the control): 40 mm.

— For foot-operated controls: 50 mm.

4.2.3 If two adjacent finger-, hand- or foot-operated controls are intended to be used simultaneously, a smaller distance is acceptable.

The location of secondary controls should follow the same principle.

4.3 Measures against movement or damage by external forces

Controls, control linkage and their power supply shall be arranged such that they cannot be damaged or moved into an undesirable position by foreseeable external forces, e.g. hand or foot force or shaking (vibration) of the machine.

4.4 Non-slip pedals

The surface of pedals shall be slip-resistant.

5 Movement of controls

5.1 General

5.1.1 The movement of the controls in relation to their neutral position shall be in the same general direction as the machine response, unless the combining of controls or customary usage dictates otherwise (e.g. driving control of machines where the operator's position is located on a slewable part of the machine, such as the upper structure of an excavator).

5.1.2 If a machine is equipped with an alternative operator's position, with duplicated control arrangements, both sets of controls shall operate in the same manner. When one set of controls is active, the other set shall be inactive. The active set shall be clearly identified with a visual indicator.

Machines shall maintain the same correspondence between action on steering controls and direction of travel, whatever the position of the reversible drive.

5.1.3 All controls shall return to their neutral position when the operator releases the control, unless the control has a detent or hold position or continuously activated position.

5.1.4 There shall be no hazardous movement during or following start-up or stoppage of the power supply or engine.

Starting systems shall be in accordance with ISO 10264.

5.1.5 If control signals are electrically transmitted, the control system shall be in accordance with ISO 13766 and ISO 15998.

5.1.6 The controls shall be so arranged or deactivated or guarded that they cannot be activated unintentionally — in particular when the operator is getting into or out of the operator's station according to the manufacturer's instructions.

5.1.7 The type, location and method of operation of typical primary controls are specified in Annex A for the base machine and in Annex B for equipment. Controls for equipment not otherwise specified (e.g. on the backhoe portion of a backhoe loader) should follow the same principles as given by Annex B.

5.1.8 The identification symbols shall be on the controls or next to them. If space limitations dictate, a diagram showing the primary controls is acceptable: it shall be easily visible to the operator.

Graphical symbols shall be in accordance with ISO 6405-1 and ISO 6405-2.

5.2 Multifunctional controls

5.2.1 General

In the case of a multifunctional control used to control the operations of the base machine and/or equipment or attachments, the following applies *in addition* to 5.1.

5.2.2 Basic movement of multifunctional controls

The basic movements of multifunctional controls consist of the following control movements (or combination of them):

— to the front/rear;

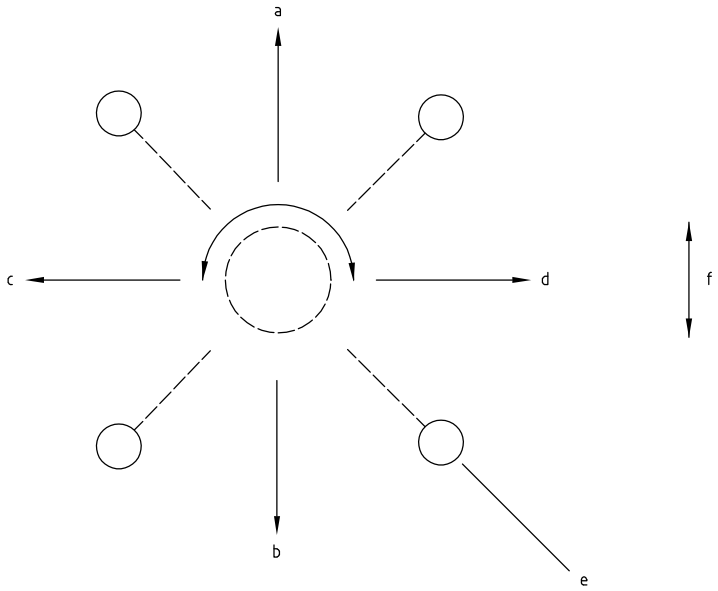
— to the left/right;

— slewing/rotation(e.g. gear selection up and down);

— upward/downward (lifting/lowering).

The combined movement of operational functions (e.g. to front left or to front right, to rear left or to rear right) is permitted.

See Figure 1.



a Front.
b Rear.
c Left.
d Right.
e Combined control.
f Upward and downward (lifting/lowering).

Figure 1 — Basic functions of a multifunctional control

5.2.3 Machine responses to control change-over

Changing the machine response to a multifunctional control movement to another primary function (see Annexes A and B) is permissible if a control mechanism label or visual indicator is provided to inform the operator of the control movements and the machine responses in the basic and change-over positions.

5.2.4 Additional controls located at a multifunctional control

Additional control mechanisms, such as knobs or switches, may be located on a multifunctional control to actuate either primary or secondary controls. However, no more than four additional control mechanisms should be located on the control (e.g. grab turned right/hold/left, driving forward/neutral/rearward, oscillation axle lock/unlock, stabilizer up/hold/down).

The control device for the additional control mechanisms and the response shall be indicated by a control mechanism label or visual indicator.

Fingertip-activated controls such as key or touch pads are excluded from these requirements.

6 Control-actuating forces

6.1 The maximum control actuating forces given in Table 1 shall not be exceeded for normal operation, but may be exceeded on a control for an emergency.

6.2 The minimum control actuating force shall be such that unintentional movement of the control can be avoided (see Table 1 and 5.1.6).

6.3 The control actuating forces given in Table 1 do not apply to braking and steering systems. For the maximum control actuating forces for these systems, see ISO 3450, ISO 10265 and ISO 5010.

6.4 The minimum mechanical strength of the control shall be at least five times the normal control actuating force, in accordance with Table 1.

6.5 The direction of the control actuating force is in respect of the position of the operator when actuating the control.

Table 1 — Control actuating forces

Control operation	Control-actuating force N		
	Max.	**Normal (frequent operation)**	**Min.**[a]
Hand			
lever, forward/backward	230	80	20
lever, sideways	100	60	15
brake lever, upwards	400	60	15
Foot			
pedal	450	120 [b]	30
tread, centre-pivoted	230	50	30
Toe			
pedal	90	50	12
Fingertip			
lever or switch	20	10	2

[a] For information only. Since the actuating force can be variable along the travel of the control lever, the indicated values are intended to be achieved during the movement and, in particular, before any engagement into a detent position.

[b] With back support: 150 N.

Annex A
(normative)

Earth-moving machinery — Primary common controls for base machine

	Control	Location	Operation requirement(s)
A.1	**Steering**		
A.1.1	Steering-wheel	Forward of the operator (see, also, 4.1)	A clockwise rotation shall effect a right turn, and a counter-clockwise rotation shall effect a left turn.
A.1.2	Hand-operated: one-lever control	See 4.1	Moving the lever to the left shall effect a left turn and moving the lever to the right shall effect a right turn.
A.1.3	Hand-operated: two-lever control	See 4.1	Moving the left lever forward and/or the right lever rearward shall effect a right turn. Moving the left lever rearward and/or the right lever forward shall effect a left turn.
A.2	**Clutch and inch pedals**		
	Foot-operated	Accessible to the operator's left foot (see also 4.1)	Pushing the pedal forward and/or downward shall effect disengagement.
A.3	**Gear selection/gear shifting**		
A.3.1	Hand-operated	See 4.1	The shifting pattern shall be simple and clearly marked. In particular, the neutral position shall be clearly identified and easy to select.
A.3.2	Finger-operated	Accessible to the operator (see, also, 4.1)	Pushing the upper/ right button shall effect up-shift and pushing the lower/ left button shall effect down-shift.
A.4	**Speed — Engine and/or ground speed**		
A.4.1	Foot-operated acceleration/deceleration	Accessible to the operator's right foot (see, also, 4.1)	Acceleration: Forward and/or downward motion shall increase speed. Deceleration: Rearward and/or upward motion shall decrease speed.
	— Foot-operated decelerator	Accessible to the operator's right foot (see, also, 4.1)	Forward and/ or downward motion shall decrease speed.
A.4.2	Hand-operated lever control	See 4.1	Acceleration: Forward and/or downward motion shall increase speed. Deceleration: Rearward and/or upward motion shall decrease speed.
A.4.3	Finger-operated	Accessible to the operator's hand (see, also, 4.1)	Acceleration: Pushing the acceleration button/switch shall increase speed. Deceleration: Pushing deceleration button/ switch shall decrease speed. Acceleration: Turning the lever, knob or dial, to the right shall increase speed. Deceleration: Turning the lever, knob or dial, to the left shall decrease speed.

	Control	Location	Operation requirement(s)
A.5	**Machine travelling**		
A.5.1	**Direction control: forward-reverse non-variable speed**		
A.5.1.1	Hand-operated or hand-/finger-operated	Accessible to the operator (see, also, 4.1)	Moving the control or lever forward/upward or to the right shall effect forward motion and moving the control or lever rearward/down or to the left shall effect rearward motion.
A.5.1.2	Finger-operated	Accessible to the operator (see, also, 4.1)	Pushing the upper button shall effect forward motion and pushing the lower button shall effect. rearward motion.
A.5.2	**Combination ground speed and direction — Continuously variable combined control**		
A.5.2.1	Hand-operated	Accessible to the operator (see, also, 4.1)	Moving the control from neutral position forward and/or upward shall effect forward motion and increase forward speed. Moving the control from the neutral position rearward and/or downward shall effect rearward motion and increase rearward speed.
A.5.2.2	Foot-operated: one-pedal control	Accessible to the operator's right foot (see, also, 4.1)	The pedal shall pivot under the operator's foot and shall come to rest in the neutral position. Forward and/or downward motion of the front of the pedal shall effect forward motion and increase forward speed. Downward motion on the rear of the pedal shall effect rearward motion and increase rearward speed.
A.5.2.3	Foot-operated: two-pedal control	Accessible to the operator's feet (see, also, 4.1)	Forward and/or downward motion of the right pedal shall effect forward motion and increase forward speed. Downward motion on the left pedal shall effect rearward motion and increase rearward speed.
A.5.3	**Combination ground speed, direction and steering — Continuously variable combined control**		
A.5.3.1	Hand-operated: one-lever control	Accessible to the operator (see, also, 4.1)	Forward motion of the lever shall effect forward motion and increase speed. Reverse motion of the lever shall effect reverse motion and increase speed. Moving the lever to the left shall effect a left turn and moving the lever to the right shall effect a right turn.
A.5.3.2	Hand-operated: two-lever control	Accessible to the operator (see, also, 4.1)	Forward motion of both levers shall effect forward motion and increase speed. Reverse motion of both levers shall effect reverse motion and increase speed. Moving the left lever forward and/or the right lever rearward shall effect a right turn. Moving the left lever rearward and/or the right lever forward shall effect a left turn.

	Control	Location	Operation requirement(s)
A.5.3.3	Foot-operated: two-pedal control	Accessible forward of the operator (see, also, 4.1)	The pedals shall pivot under the operator's foot and remain at rest in the neutral position. Downward motion of the front of both pedals shall effect forward motion and increase speed. Downward motion of the rear of both pedals shall effect reverse motion and increase speed. Downward motion of the front of the left pedal and/or downward motion of the rear of the right pedal shall effect a right turn. Downward motion of the front of the right pedal and/or downward motion of the rear of the left pedal shall effect a left turn.
A.6	**Brakes**		
A.6.1	**Service brake**		
A.6.1.1	Foot-operated	See 4.1	The direction of motion shall be generally forward and/or downward for engagement.
A.6.1.2	Hand-operated	See 4.1	Pull motion to apply is preferred.
A.6.2	Parking brake		
A.6.2.1	Foot-operated	See 4.1	The direction of motion shall be generally forward and/or downward for engagement.
A.6.2.2	Hand-operated	See 4.1	Pull motion to apply is preferred
A.6.3	**Combination steering and brake**		
A.6.3.1	Foot-operated: two pedal control with overlapping	See 4.1	Moving the right pedal downward shall effect a right turn. Moving the left pedal downward shall effect a left turn. Moving the "overlap" pedal downward shall effect a stop.
A.6.3.2	Foot-operated: three-pedal control	See 4.1	Moving the right pedal downward shall effect a right turn. Moving the left pedal downward shall effect a left turn. Moving the centre pedal downward shall effect a stop.
A.6.3.3	Hand- or finger operated	Accessible to the operator's hand (see also 4.1)	Moving the right lever rearward shall effect a right turn. Moving the left lever rearward shall effect a left turn. Pulling both levers shall effect a stop.
A.6.4	**Rotary/slewing brake**		
	— Foot-operated	Accessible to the operator's left foot (see, also, 4.1)	Direction of motion shall be downward for engagement.
A.7	**Rotary/slewing motion**		
A.7.1	**Hand-operated — Turnable lever control**	Accessible to the operator (see, also, 4.1)	Clockwise movement shall effect clockwise rotation.
A.7.2	**Upper structure slewing/rotating**		
A.7.2.1	Hand-operated: single lever control	Accessible to the operator's left hand (see, also, 4.1)	Moving the lever forward shall effect clockwise rotation.
A.7.2.2	Hand-operated multipurpose lever control	Accessible to the operator's left hand (see, also, 4.1)	Moving the lever to the right shall effect clockwise rotation.

Annex B
(normative)

Earth-moving machinery — Primary equipment controls

	Control	Location	Operation requirements[a]
B.1	**Raising/lowering**		
B.1.1	Hand-operated	Accessible to the operator's right hand (see, also, 4.1)	Moving the lever rearward shall raise, and moving the lever forward shall lower, the equipment.
B.1.2	Foot-operated: one-pedal control	Accessible to the operator's foot (see, also, 4.1)	The pedal shall pivot under the operator's foot and remain at rest in the neutral position. Moving the rear of the pedal downward shall raise the equipment. Moving the front of the pedal downward shall lower the equipment.
B.1.3	Foot-operated: two-pedal control	Accessible to the operator's feet (see also 4.1)	Moving the right pedal downward shall raise the equipment. Moving the left pedal downward shall lower the equipment.
B.1.4	Dumper body raising/ lowering Hand-operated	Accessible to the operators hand (see, also, 4.1)	Moving the lever rearward or upward shall raise, and moving the lever forward or downward shall lower, the body. For front dump type dumpers, moving the lever forward shall raise, and moving the lever rearward shall lower, the dump body.
B.1.5	Ripper raising/ lowering Hand-/finger-operated	Accessible to the operator's right hand (see, also, 4.1)	Moving the lever rearward or to the left shall raise, and moving the lever forward or to the right shall lower, the equipment.
B.2	**Extension/retraction**		
B.2.1	Hand-operated	Accessible to the operator's left hand (see, also, 4.1)	Moving the lever forward or to the left shall extend the equipment. Moving the lever rearward or to the right shall retract the equipment.
B.2.2	Finger-operated	Accessible to the operator's left hand (see, also, 4.1)	Pushing the upper/left button shall extend the equipment. Pushing the lower/right button shall retract the equipment.
B.2.3	Foot-operated: one-pedal control	Accessible to the operator's right fool (see, also, 4.1)	The pedal shall pivot under the operator's foot and remain at rest in the neutral position. Moving the front of the pedal downward shall extend the equipment. Moving the rear of the pedal downward shall retract the equipment.
B.2.4	Foot-operated: two-pedal control	Accessible to the operator's feet (see, also, 4.1)	Moving the right pedal downward shall extend the equipment. Moving the left pedal downward shall retract the equipment.

	Control	Location	Operation requirements[a]
B.3	**Rear/forward motion**		
B.3.1	Hand-operated	Accessible to the operator's left hand (see, also, 4.1)	Moving the lever rearward shall effect rearward motion. Moving the lever forward shall effect forward motion.
B.3.2	Finger-operated	Accessible to the operator's left hand (see, also, 4.1)	Pushing the upper/left button/lever shall effect forward motion. Pushing the lower/right button/lever shall effect rearward motion.
B.3.3	Foot-operated: one-pedal control	Accessible to the operator's left foot (see, also, 4.1)	The pedal shall pivot under the operator's foot and remain at rest in the neutral position. Moving the front of the pedal downward shall effect forward motion. Moving the rear of the pedal downward shall effect rearward motion.
B.3.4	Foot-operated: two-pedal control	Accessible to the operator's feet (see, also, 4.1)	Moving the right pedal downward shall effect forward motion. Moving the left pedal downward shall effect rearward motion.
B.4	**Equipment/attachment response** (see 3.3)		
B.4.1	Hand-operated: single lever control	Accessible to the operator's right hand (see, also, 4.1)	Moving the lever rearward shall effect active operation.
B.4.2	Hand-operated: multipurpose lever control	Accessible to the operator's right hand (see, also, 4.1)	Moving the lever to the left shall effect active operation.
B.4.3	Finger-operated	Accessible to the operator's right hand (see, also, 4.1)	Moving the lever rearward shall effect active operation.
B.4.4	Foot-operated: one-pedal control	Accessible to the operator's right foot (see, also, 4.1)	The pedal shall pivot under the operator's foot and remain at rest in the neutral position. Moving the rear of the pedal downward shall effect active operation.
B.4.5	Foot-operated: two-pedal control	Accessible to the operator's right foot (see, also, 4.1)	Moving the right/ left pedal downward shall effect active operation.
B.4.6	Foot-operated: one pedal control for pivot-attachment	Accessible to the operator's right foot	The pedal shall pivot under the operator's foot and remain at rest in the neutral position. Downward motion of the front/right of the pedal shall effect clockwise rotation. Downward motion of the rear/left of the pedal shall effect anticlockwise rotation.
B.5	**Rotary/slewing operation**		
B.5.1	Hand-operated: single lever control	Accessible to the operator's left hand (see, also, 4.1)	Moving the lever forward or to the right shall effect clockwise rotation.
B.5.2	Hand-operated: multipurpose lever control	Accessible to the operator's left hand (see, also, 4.1)	Moving the lever to the right shall effect clockwise rotation. Moving the lever to the left shall effect anticlockwise rotation.
B.5.3	Hand-operated: turnable lever control	Accessible to the operator (see, also, 4.1)	Clockwise movement shall effect clockwise rotation.
B.5.4	Finger-operated	Accessible to the operator's left hand	Pushing the right button shall effect clockwise rotation

	Control	Location	Operation requirements[a]
B.5.5	Foot-operated: one pedal control	Accessible to the operator's left foot (see, also, 4.1)	The pedal shall pivot under the operator's foot and shall remain at rest in the neutral position. Downward motion of the front of the pedal shall effect clockwise rotation. Downward motion to rearward of the pedal shall effect anticlockwise rotation.
B.5.6	Foot-operated: two-pedal control	Accessible to the operator's left foot (see, also, 4.1)	Forward and/or downward motion of the right pedal shall effect clockwise rotation. Forward and/or downward motion of the left pedal shall effect anticlockwise rotation.

[a] On many types of earth-moving machines, the direction of motion of the equipment depends on the height of the equipment above ground and the position of the attachment. Therefore, a middle height and position are used in defining the operations.

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