
**Earth-moving machinery —
Operator's controls**

Engins de terrassement — Commandes de l'opérateur





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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.

The procedures used to develop this document and those intended for its further maintenance are described in the ISO/IEC Directives, Part 1. In particular, the different approval criteria needed for the different types of ISO documents should be noted. This document was drafted in accordance with the editorial rules of the ISO/IEC Directives, Part 2 (see www.iso.org/directives).

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. Details of any patent rights identified during the development of the document will be in the Introduction and/or on the ISO list of patent declarations received (see www.iso.org/patents).

Any trade name used in this document is information given for the convenience of users and does not constitute an endorsement.

For an explanation of the voluntary nature of standards, the meaning of ISO specific terms and expressions related to conformity assessment, as well as information about ISO's adherence to the World Trade Organization (WTO) principles in the Technical Barriers to Trade (TBT) see www.iso.org/iso/foreword.html.

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

This third edition cancels and replaces the second edition (ISO 10968:2004), which has been technically revised. The main changes compared to the previous edition are as follows:

- the document has been reorganized for easier interpretation;
- minimum and normal actuating forces have been removed;
- state-of-the-art solutions have been taken into account.

Any feedback or questions on this document should be directed to the user's national standards body. A complete listing of these bodies can be found at www.iso.org/members.html.

Introduction

This document specifies design criteria for operator's controls on earth-moving machinery. As machines have gone through significant developments since the first edition of this document in 1995, this document covers both legacy machines and state-of-the-art solutions. This is important to take into account when reading the annexes.

As attachments and controls are becoming more advanced, it was considered important to reorganize the document for easier interpretation whereby base machine, equipment and attachments were separated in different annexes. As graders and dozers often have unique operator's controls, it was also decided to separate these two machine types into separate annexes.

Other important changes made in the third edition include the removal of minimum and normal actuating forces for operator's controls. It was considered that as there is a large variation in actuating forces for different types of controls, providing standardized actuating forces was not feasible. Instead, it is the manufacturer's responsibility that minimum actuating forces are enough to prevent inadvertent activation of the operator's controls caused by machine operation (e.g. machine acceleration/deceleration, vibration).

While preparing this document, it was noted that levers are developing rapidly and there are large differences even within a given machine family, for example excavators. The document therefore tries to also account for the most advanced excavators, whereby more controls are added to levers in order to allow for more functionality. It is recognized that new technologies and new technical measures will be developed as the state-of-the-art changes in order to improve the operation of earth-moving machinery.

Earth-moving machinery — Operator's controls

1 Scope

This document specifies requirements and guidelines for the operator's controls on earth-moving machinery as defined in ISO 6165, in as far as those controls relate to any direct-control machine. The recommendations given for finger-, hand- and foot-operated controls are not intended to prevent usage of other types of controls, control locations or control movements. This document is not applicable to devices which are not directly related to machine control.

NOTE For remote operator control of machines, see ISO 15817.

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.

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

ISO 3450, *Earth-moving machinery — Wheeled or high-speed rubber-tracked machines — Performance requirements and test procedures for brake systems*

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

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: Symbols for specific machines, equipment and accessories*

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

ISO 17063, *Earth-moving machinery — Braking systems of pedestrian-controlled machines — Performance requirements and test procedures*

3 Terms and definitions

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

ISO and IEC maintain terminological databases for use in standardization at the following addresses:

- ISO Online browsing platform: available at <https://www.iso.org/obp>
- IEC Electropedia: available at <http://www.electropedia.org/>

3.1

control

device actuated by an operator to execute a *machine response* (3.4)

3.2

primary control

control (3.1) that is used frequently or continuously by the operator

Note 1 to entry: The primary controls are the following:

- a) For the *base machine* (3.5):
 - steering;
 - clutch or inch pedal;
 - gear selection;
 - speed (engine or ground speed);
 - travel direction;
 - brakes;
 - swing of upper structure.
- b) For equipment (3.6):
 - swing operation;
 - raising/lowering operation (e.g. loader lift arm, dozer blade or ripper, excavator boom, side boom winch, rope excavator winch);
 - boom/arm extending/retracting;
 - rearward/forward motion;
 - boom side shift (e.g. side shift carriage of the backhoe linkage);
 - boom fold/unfold;
 - boom offset.
- c) For *attachments* (3.7):
 - attachment operation (e.g. bucket, tiltrotator, clamshell, forks);
 - rotation operation (e.g. tiltrotator where the position of the attachment is changed as opposed to the functional rotation of a tool as in an auger);
 - tilting operation;
 - dump/curl operation.

3.3

secondary control

control (3.1) that is infrequently used by the operator but is needed for the proper functioning of the machine

EXAMPLE Control for parking brake, lighting, mode selection, quick coupler and stabilizers.

3.4

machine response

described function of the *base machine* (3.5) or *equipment* (3.6) or *attachment* (3.7) resulting from the activation of a *control* (3.1)

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.

3.5**base machine**

machine with a cab or canopy and operator protective structures if required, without *equipment* (3.6) or *attachments* (3.7) but possessing the necessary mountings for such equipment and attachments

[SOURCE: ISO 6746-2:2003, 3.3]

3.6**equipment**

set of components mounted onto the *base machine* (3.5) which allows an *attachment* (3.7) to perform the primary design function of the machine

[SOURCE: ISO 6746-2:2003, 3.4]

3.7**attachment**

assembly of components that can be mounted onto the *base machine* (3.5) or *equipment* (3.6) for specific use

[SOURCE: ISO 6746-2:2003, 3.5]

3.8**proportional control**

control (3.1) that allows continuously variable or modulated *machine response* (3.4)

3.9**remote operator control**

operator *control* (3.1) of a machine by wireless or wired transmission of signals from a remote control box not located on the machine to a receiving unit located on the machine

[SOURCE: ISO 15817:2012, 3.7, modified — The accepted term "remote control" has been deleted.]

3.10**control actuating force**

force required at the centre of the *control* (3.1) contact surface, in the direction of the intended movement of the control, in order to activate a control function

Note 1 to entry: This force does not necessarily represent the force typically applied by the operator.

3.11**lever**

arm or handle that is moved by the operator's hand to control a function or functions of a machine

3.12**single lever control**

lever (3.11) movable in one axis that controls the described function

3.13**two lever control**

two *single lever controls* (3.12) that, in combination, control the described function

3.14**two-axis multifunction control**

lever (3.11) movable in axes a-b + c-d that controls the described functions

Note 1 to entry: See [Figure 3](#).

3.15**four-axis multifunction control**

lever (3.11) movable in axes a-b + c-d + e-f + g-h that controls the described functions

Note 1 to entry: See [Figure 3](#).

3.16

button

control (3.1) that is pressed to release or activate a function

3.17

dial

control (3.1) that is rotated in order to operate a function

3.18

pedal

control (3.1) that is exclusively foot-operated

3.19

single pedal control

pedal (3.18) movable in one axis, that controls the described function

3.20

two pedal control

two *pedals* (3.18) that, in combination, control the described function

4 Requirements for controls

4.1 General

This document recommends that the general requirements and principles of arrangement be followed for other types of controls apart from the one's listed below, taking into account operator safety and ergonomics.

4.2 Control locations

The location of primary controls shall be within the minimum operator space envelope as given in ISO 3411. Primary and secondary controls should also take into account the guidelines given in ISO 6682.

4.3 Distance between controls

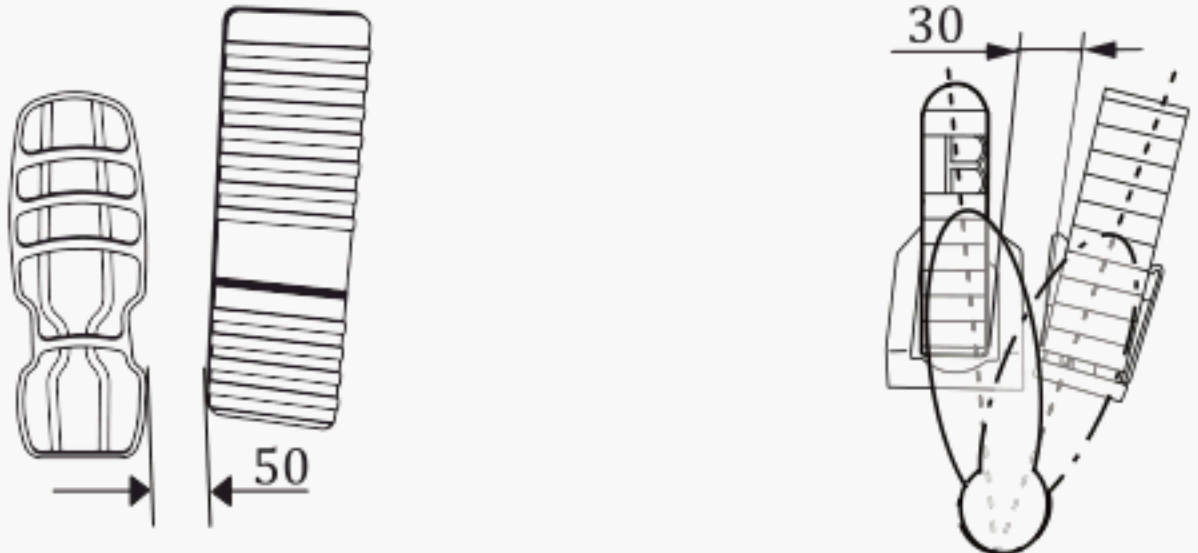
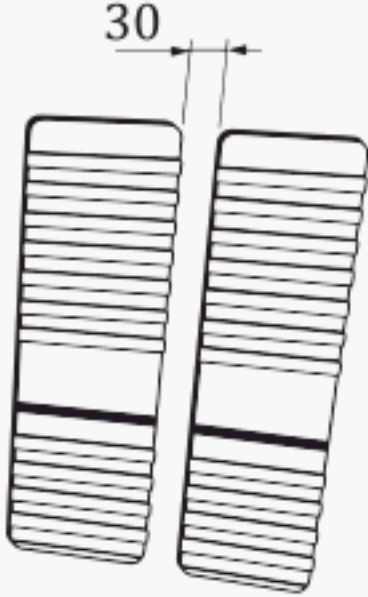
4.3.1 The distance between adjacent controls and between controls and other machine parts shall be sufficient to allow operation without unintentional activation of adjacent controls. The overlapping of controls is permissible to provide independent and simultaneous control application.

4.3.2 The minimum distance between finger-, hand- and foot-operated controls, or between these types of controls and other machine parts, shall be in accordance with [Table 1](#):

Table 1 — Distance between controls

Type of control	Minimum distance between two adjacent controls
Finger-operated controls	23 mm, without divider (distance between centre line of adjacent controls) 18 mm, with divider (distance between centre line of adjacent controls) For keys located on a touch screen or buttons on a lever: 14 mm (distance between centre line of adjacent controls)
Hand-operated controls	40 mm (clearance between two adjacent controls)

Table 1 (continued)

Type of control	Minimum distance between two adjacent controls
Foot-operated controls	<p>For pedals not intended to be used simultaneously:</p> <p>50 mm (clearance between two adjacent controls) for controls intended to be operated with separate feet or same foot but different heel positions (Figure 1 a).</p> <p>30 mm (clearance between two adjacent controls) for controls intended to be operated with the same foot and from the same heel position. These controls shall not be parallel to each other (Figure 1 b).</p> <p>Exception: adjacent controls may be parallel to each other provided there is a minimum 30 mm distance between the planes of the operating surfaces. These types of controls are not intended to be used simultaneously.</p> <div style="text-align: right;">Dimensions in millimetres</div> <div style="text-align: center;">  </div> <div style="display: flex; justify-content: space-around;"> <p>a) Controls operated by separate feet or different heel positions</p> <p>b) Controls operated by same foot from same heel position</p> </div> <p style="text-align: center;">Figure 1 — Distance between controls</p>
Foot-operated controls	<p>For pedals intended to be used simultaneously:</p> <p>Maximum 30 mm (clearance between two adjacent controls) for controls intended to be operated with the same foot and from the same heel position (e.g. the throttle controls on a self-propelled scraper with two separate engines) (Figure 2). The pedals may be parallel.</p> <div style="text-align: right;">Dimensions in millimetres</div> <div style="text-align: center;">  </div> <p style="text-align: center;">Figure 2 — Distance between parallel pedals</p> <p>Exceptions: For adjacent controls that can both be used by a single foot or used simultaneously (e.g. parallel excavator travel pedals) distances between 30 and 50 mm are also allowed.</p>

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

4.4 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.

4.5 Pedals

The surface of pedals shall be slip-resistant.

5 Movement of controls

5.1 General

5.1.1 The type, location and method of operation of typical primary controls shall be according to [Annex A](#) for base machine movements, according to [Annex B](#) for equipment movements, and according to [Annex C](#) for attachment movements. Specific requirements for graders are found in [Annex D](#). Specific requirements for dozers are found in [Annex E](#). Primary controls for equipment not otherwise specified shall follow the same principles as given by [Annex B](#). Primary controls for attachment not otherwise specified shall follow the same principles as given by [Annex C](#).

5.1.2 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 the part of the machine that can swing, such as the upper structure of an excavator).

5.1.3 If a machine is equipped with an alternative operator's position with duplicated control arrangements, then 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. An exception would be for mechanically connected dual controls (e.g. duplicate steering wheels, duplicated propulsion controls) where all controls are continuously active.

5.1.4 All controls shall return to their neutral position when the operator releases the control, unless the control has a detent or hold position for continuous activation.

5.1.5 For foot-operated controls where the pedal is operated in two directions (treadle pedal), for example, downward motion of the front of the pedal and downward motion of the rear of the pedal, the pedal shall pivot under the operator's foot and shall remain at rest in the neutral position.

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

5.1.7 The controls shall be arranged so as not to create a tripping hazard when the operator is getting into or out of the operator's station according to the manufacturer's instructions.

5.1.8 For gear/drive/speed selection controls the shifting pattern shall be clearly marked. In particular, the neutral position shall be clearly identified.

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

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

5.2 Multifunction controls

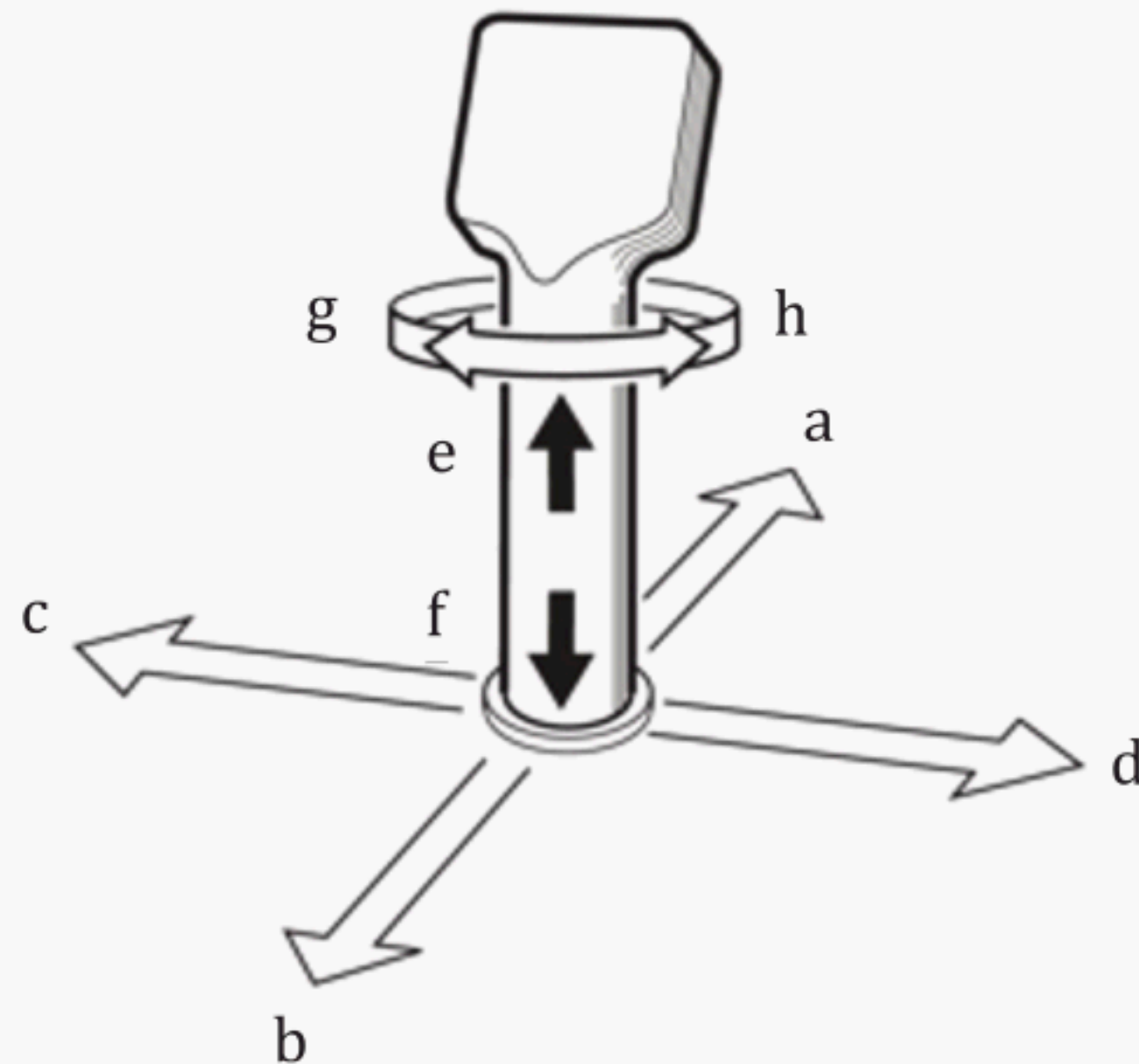
5.2.1 General

In the case of a multifunction control used to control the operations of the base machine, equipment or attachments, either separately or in combination, the following applies in addition to [5.1](#).

5.2.2 Basic movement of multifunction controls

The basic movements of multifunction controls consist of the control movements illustrated in [Figure 3](#).

Combined movements to provide simultaneous operation of functions are permitted.



Key

a	front	e	upward
b	rear	f	downward
c	left	g	clockwise
d	right	h	counter-clockwise

Figure 3 — Basic movement of a multifunction control

5.2.3 Machine responses to control change-over

Changing the machine response to a multifunction control movement to another primary function (see [Annexes A, B and C](#)) 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. There shall be no hazardous movements during control change-over.

5.2.4 Additional controls located at a multifunction control

Additional control mechanisms (e.g. dials, switches) may be located on a multifunction control to actuate either primary or secondary controls. The control device for the additional control mechanisms and the response shall be indicated by a label or visual indicator.

6 Control actuating forces

6.1 The maximum control actuating force required to actuate a control shall not exceed the forces specified in [Table 2](#).

6.2 The minimum control actuating force shall prevent activation of the control due to inertial forces on the control caused by machine operation (e.g. machine acceleration/deceleration, vibration) when used as intended.

6.3 The control actuating forces given in [Table 2](#) do not apply to braking. The maximum control actuating forces for brake systems shall be in accordance with ISO 3450, ISO 10265 and ISO 17063, as applicable.

6.4 The control actuating forces given in [Table 2](#) do not apply to steering wheels. Control actuating forces for steering wheels shall be in accordance with ISO 5010.

6.5 The minimum strength of the control shall be sufficient to withstand at least five times the control actuating force that the control was designed for without sustaining permanent damage (e.g. deformation, fracture) or having its primary function impeded.

Table 2 — Control actuating forces

Control operation	Maximum control actuating force N
Hand	
— lever, forward/backward	230
— lever, sideways	100
— lever, upward	400
Foot	
— pedal	450
— treadle, centre-pivoted	230
Toe	
— pedal	90
Finger tip	
— lever or switch	20
NOTE The direction of the control actuating force is in respect of the position of the operator when actuating the control.	

Annex A (normative)

Earth-moving machinery — Base machine

[Table A.1](#) to [A.9](#) specify the control type, location, operation requirements and examples for base machine movements (see [Figure A.1](#)).

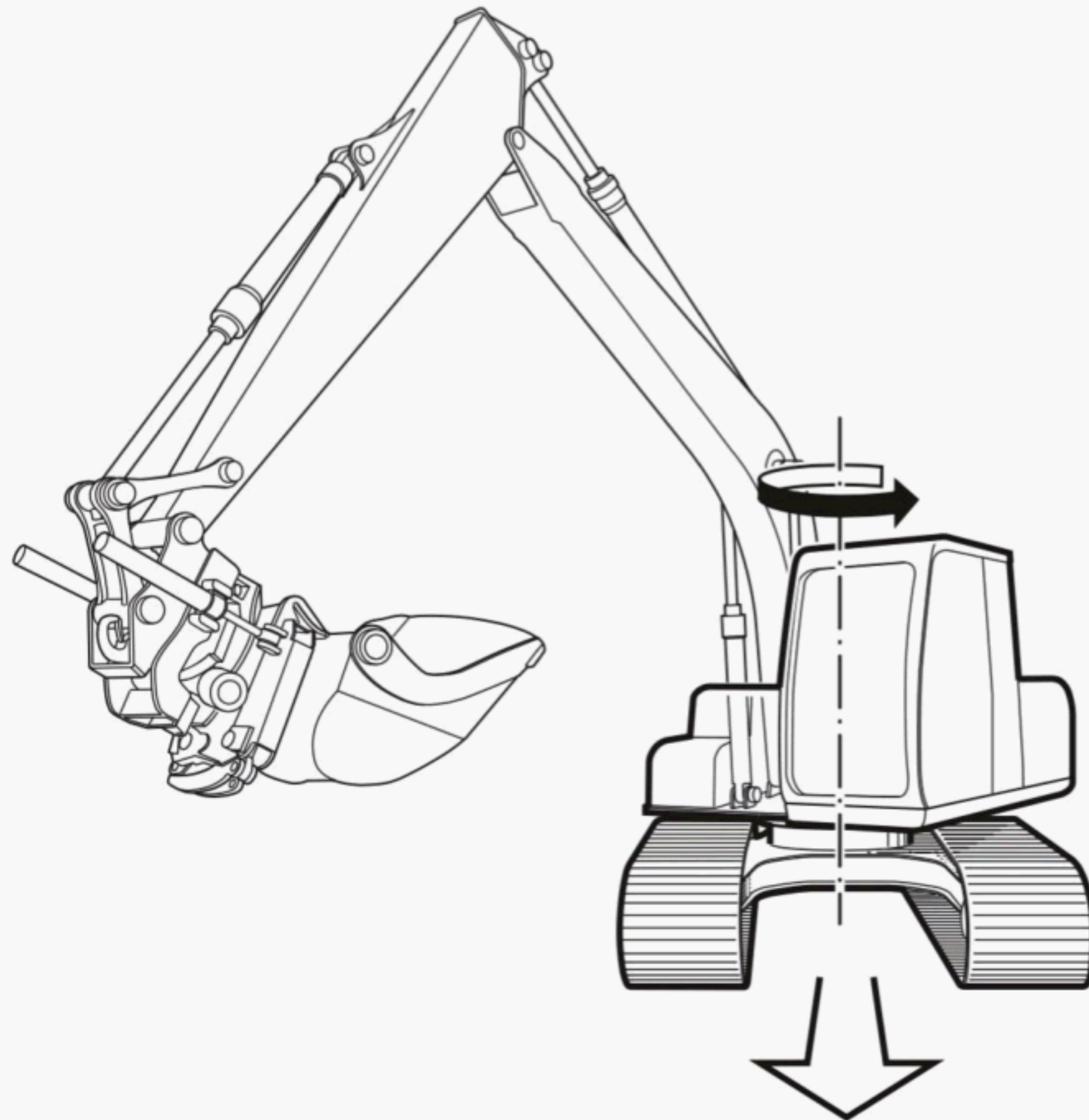


Figure A.1 — Base machine

Table A.1 — Steering only

Control type	Location	Operation requirements and examples
Hand-operated steering wheel	Forward of the operator	A clockwise rotation shall execute a right turn. A counter-clockwise rotation shall execute a left turn.
Hand-operated single lever control	Manufacturer's choice	Moving the lever to the left shall execute a left turn. Moving the lever to the right shall execute a right turn.
Hand-operated two lever control ^a	Manufacturer's choice	Moving the right lever rearward shall execute a right turn. Moving the left lever rearward shall execute a left turn.
Hand-operated four-axis multifunction control	Accessible to the operator's left hand	A clockwise rotation shall execute a right turn. A counter-clockwise rotation shall execute a left turn.
Foot-operated two pedal control ^b	Manufacturer's choice	Forward or downward motion of the right pedal shall execute a right turn. Forward or downward motion of the left pedal shall execute a left turn.
Finger-operated proportional control	Accessible to the operator's left hand	A clockwise rotation shall execute a right turn. A counter-clockwise rotation shall execute a left turn.
Finger-operated buttons	Manufacturer's choice	Pushing the left button shall execute a left turn. Pushing the right button shall execute a right turn.
NOTE 1 Operation requirements are related to forward motion.		
NOTE 2 For combination ground speed, direction and steering controls see Table A.6 .		
^a Typical for a clutch/brake crawler dozer.		
^b Typical for a clutch/brake or hydrostatic crawler loader.		

Table A.2 — Clutch and gear selection

Control type	Location	Operation requirements and examples
Finger-operated buttons	Accessible to the operator's right hand	Pushing the upper or right button shall execute a gear up-shift. Pushing the lower or left button shall execute a gear down-shift.
	Accessible to the operator's left hand	Pushing the upper or left button shall execute a gear up-shift. Pushing the lower or right button shall execute a gear down-shift.
Finger-operated lever	Manufacturer's choice	Pushing the lever forward or upward shall execute a gear up-shift. Pushing the lever rearward or downward shall execute a gear down-shift.
Hand-operated single lever control	Manufacturer's choice	Gear selection shall follow the indicated gear selection pattern.
Foot-operated single pedal control	Accessible to the operator's left foot	Downward or forward motion shall execute clutch disengagement. Upward or rearward motion shall execute clutch engagement.

Table A.3 — Speed — Engine or ground speed

Control type	Location	Operation requirements and examples
Hand-operated single lever control	Manufacturer's choice	Moving the lever forward or downward shall increase speed. Moving the lever rearward or upward shall decrease speed.
Finger-operated buttons or switches	Manufacturer's choice	Pushing the acceleration button or switch shall increase speed. Pushing the deceleration button or switch shall decrease speed.
Finger-operated dial	Manufacturer's choice	Turning the dial clockwise shall increase speed. Turning the dial counter-clockwise shall decrease speed.
Foot-operated single pedal control	Accessible to the operator's right foot	Downward or forward motion shall increase speed. Upward or rearward motion shall decrease speed.
	Accessible to the operator's right foot	For crawler dozers downward or forward motion shall decrease speed.

Table A.4 — Machine travelling: direction control — Forward/reverse

Control type	Location	Operation requirements and examples
Hand-operated single lever control	Manufacturer's choice	Moving the lever forward or upward or to the right shall execute forward motion. Moving the lever rearward or downward or to the left shall execute rearward motion.
Finger-operated buttons	Manufacturer's choice	Pushing the upper or front button shall execute forward motion. Pushing the lower or back button shall execute rearward motion.
Hand operated four-axis multifunction control	Accessible to the operator's left hand	Moving the control forward shall execute forward motion. Moving the control rearward shall execute rearward motion.

Table A.5 — Machine travelling: combination ground speed and direction — Variable speed

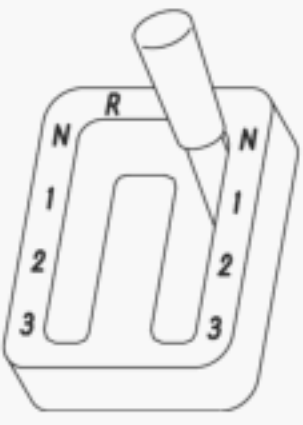
Control type	Location	Operation requirements and examples
Hand-operated single lever control	Manufacturer's choice	Moving the lever from the neutral position forward or upward shall execute forward motion and increase forward speed. Moving the lever from the neutral position rearward or downward shall execute rearward motion and increase reverse speed.
Hand-operated other	Manufacturer's choice	<p>Single lever control inverted V- or U-shaped gate, see Figure A.2:</p>  <p>Figure A.2 — Example of an inverted U-shaped control pattern</p> <p>Moving the control from the neutral position to the right and to the rear of an inverted V- or U-shaped gate shall execute forward motion and increase forward speed.</p> <p>Moving the control from the neutral position to the left and to the rear of an inverted V- or U-shaped gate shall execute rearward motion and increase reverse speed.</p>
Foot-operated single pedal control	Accessible to the operator's right foot	Downward or forward motion of the front of the pedal shall execute forward motion and increase forward speed. Downward or rearward motion of the rear of the pedal shall execute rearward motion and increase reverse speed.
Foot-operated two pedal control	Manufacturer's choice	Forward or downward motion of the right pedal shall execute forward motion and increase forward speed. Forward or downward motion of the left pedal shall execute rearward motion and increase reverse speed.

Table A.6 — Machine travelling: combination ground speed, direction and steering — Variable speed

Control type	Location	Operation requirements and examples
Hand-operated two-axis multifunction control	Manufacturer's choice	<p>Moving the control forward shall execute forward motion and increase forward speed.</p> <p>Moving the control rearward shall execute rearward motion and increase rearward speed.</p> <p>Moving the control to the left shall execute a counter-clockwise rotation.</p> <p>Moving the control to the right shall execute a clockwise rotation.</p> <p>In forward motion, moving the control to the left shall execute a left turn.</p> <p>In forward motion, moving the control to the right shall execute a right turn.</p> <p>For rearward motion the control pattern shall be indicated.</p>
Hand-operated two lever control	Manufacturer's choice	<p>Moving both levers forward shall execute forward motion and increase forward speed.</p> <p>Moving both levers rearward shall execute rearward motion and increase reverse speed.</p> <p>During forward motion, moving the left lever forward relative to the right lever shall execute a right turn.</p> <p>During forward motion, moving the right lever forward relative to the left lever shall execute a left turn.</p> <p>During rearward motion, moving the right lever rearward relative to the left lever shall execute a left turn.</p> <p>During rearward motion, moving the left lever rearward relative to the right lever shall execute a right turn.</p>
Finger-operated proportional control	Accessible to the operator's left hand	<p>Moving the proportional control to the right shall execute a right turn.</p> <p>Moving the proportional control to the left shall execute a left turn.</p>
	Accessible to the operator's right hand	<p>Moving the proportional control to the right shall increase forward speed.</p> <p>Moving the proportional control to the left shall increase reverse speed.</p>
Foot-operated two pedal control	Manufacturer's choice	<p>Downward motion of the front of both pedals shall execute forward motion and increase forward speed.</p> <p>Downward motion of the rear of both pedals shall execute reverse motion and increase reverse speed.</p> <p>During forward motion, downward motion of the front of the left pedal relative to the right pedal shall execute a right turn.</p> <p>During forward motion, downward motion of the front of the right pedal relative to the left pedal shall execute a left turn.</p> <p>During rearward motion, downward motion of the rear of the right pedal relative to the left pedal shall execute a left turn.</p> <p>During rearward motion, downward motion of the rear of the left pedal relative to the right pedal shall execute a right turn.</p>
NOTE Operation requirements are related to forward motion. See 5.1.2 .		

Table A.7 — Brakes

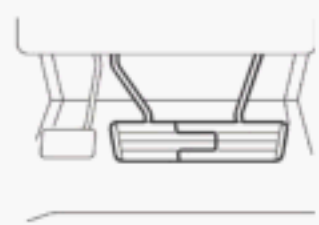
Control type	Location	Operation requirements and examples
Hand-operated single lever control	Manufacturer's choice	Pull motion shall engage brake (applicable for both service and parking brake).
Foot-operated single pedal control	Manufacturer's choice	Downward or forward motion shall engage brake (applicable for both service and parking brake).
Foot-operated two pedal control	Manufacturer's choice	For foot operated controls whereby steering and brakes are combined (overlapping), see Figure A.3. 
<p>Figure A.3 — Example of steering and brakes combined Downward motion of the overlap^a (both left and right pedal) pedal shall engage brake.</p>		
NOTE Operation requirements are related to forward motion. See 5.1.2 .		
^a The overlap can be replaced by a separate pedal in the centre.		

Table A.8 — Braking: combination ground speed and direction — Variable speed

Control type	Location	Operation requirements and examples
Hand-operated single lever control	Manufacturer's choice	During forward motion of the machine, moving the levers rearward towards the neutral position shall execute braking. During rearward motion of the machine, moving the levers forward towards the neutral position shall execute braking.
Hand-operated two lever control	Manufacturer's choice	During forward motion of the machine, moving the levers rearward towards the neutral position shall execute braking. During rearward motion of the machine, moving the levers forward towards the neutral position shall execute braking.

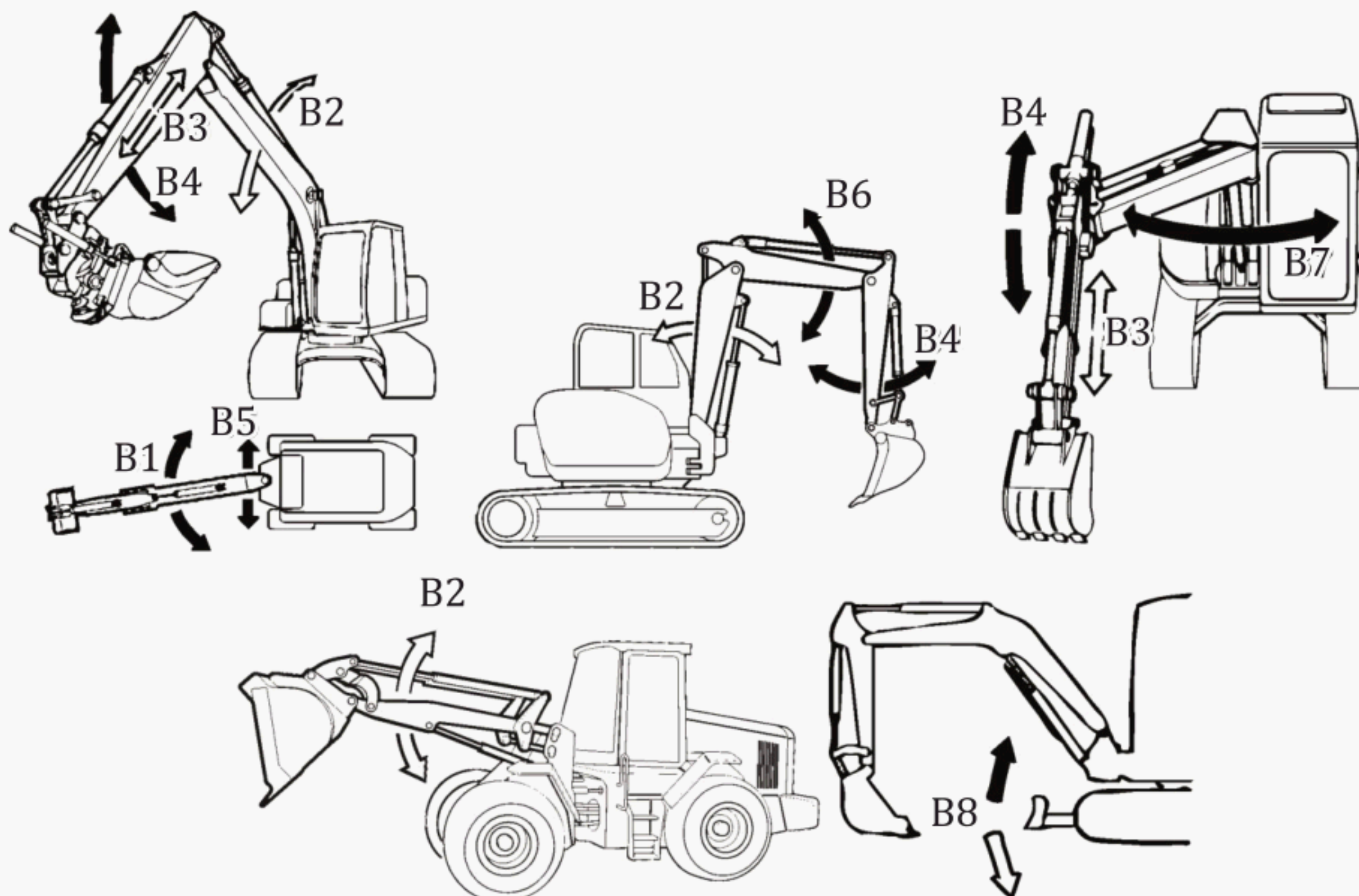
Table A.9 — Swing of upper structure

Control type	Location	Operation requirements and examples
Hand-operated single lever control	Accessible to the operator's left hand	Moving the lever forward or right shall execute clockwise rotation. Moving the lever backward or left shall execute counter-clockwise rotation.
Hand-operated two-axis multifunction control	Accessible to the operator's left hand	Moving the control to the right shall execute clockwise rotation. Moving the control to the left shall execute counter-clockwise rotation.
Hand-operated four-axis multifunction control	Accessible to the operator's left hand	Moving the control to the right shall execute clockwise rotation. Moving the lever to the left shall execute counter-clockwise rotation.

Annex B (normative)

Earth-moving machinery — Equipment

Table B.1 to B.8 specify the control type, location, operation requirements and examples for equipment movements (see Figure B.1).



Key

- | | |
|---|-------------------------------------|
| B1 swing of boom and arm (see Table B.1) | B5 boom side shift (see Table B.5) |
| B2 raising/lowering (see Table B.2) | B6 boom fold/unfold (see Table B.6) |
| B3 telescopic/linear extension/retraction (see Table B.3) | B7 boom offset (see Table B.7) |
| B4 rearward/forward (see Table B.4) | B8 blade control (see Table B.8) |

Figure B.1 — Equipment

Table B.1 — Swing of boom and arm

Control type	Location	Operation requirements and examples
Finger-operated proportional control	Manufacturer's choice	<p>Moving the proportional control to the right shall move the boom or arm to the right.</p> <p>Moving the proportional control to the left shall move the boom or arm to the left.</p> <p>Moving the proportional control forward shall move the boom or arm to the right.</p> <p>Moving the proportional control rearward shall move the boom or arm to the left.</p>
Hand-operated two-axis multifunction control	Accessible to the operator's left hand	<p>Moving the control to the right shall move the boom or arm to the right whereby a button is pressed simultaneously or with a toggle function.</p> <p>Moving the control to the left shall move the boom or arm to the left whereby a button is pressed simultaneously or with a toggle function.</p>
Foot-operated single pedal control	Manufacturer's choice	<p>Downward motion of the left side of the pedal shall swing the boom or arm to the left.</p> <p>Downward motion of the right side of the pedal shall swing the boom or arm to the right.</p> <p>For a pedal that is longitudinal in orientation, it is up to the manufacturer's choice.</p>

Table B.2 — Raising/lowering

Control type	Location	Operation requirements and examples
Hand-operated single lever control	Manufacturer's choice	<p>Moving the lever rearward shall raise the equipment. Moving the lever forward shall lower the equipment.</p> <p>For rear dumper body raising/lowering:</p> <p>Moving the lever rearward or upward shall raise the dumper body. Moving the lever forward or downward shall lower the dumper body.</p> <p>For front dump type dumpers raising/lowering:</p> <p>For front dump type dumpers, moving the lever forward shall raise the dumper body. Moving the lever rearward shall lower the dumper body.</p>
Hand-operated two-axis multifunction control	Accessible to the operator's right hand	<p>Moving the control forward shall execute a downward movement. Moving the control rearward shall execute an upward movement.</p>
Hand-operated four-axis multifunction control	Accessible to the operator's left hand	<p>Moving the control upward shall execute an upward movement. Moving the control downward shall execute a downward movement.</p>
Foot-operated single pedal control	Manufacturer's choice	<p>Downward motion of the front of the pedal shall lower the equipment. Downward motion of the rear of the pedal shall raise the equipment.</p> <p>For rear dumper body raising/lowering:</p> <p>Downward motion of the front of the pedal shall lower the dumper body. Downward motion of the rear of the pedal shall raise the dumper body.</p> <p>For front dump type dumpers raising/lowering:</p> <p>Downward motion of the front of the pedal shall raise the dumper body. Downward motion of the rear of the pedal shall lower the dumper body.</p>

Table B.3 — Telescopic/linear extension/retraction

Control type	Location	Operation requirements and examples
Hand-operated single lever control	Manufacturer's choice	Moving the lever forward or to the left shall extend the equipment. Moving the lever rearward or to the right shall retract the equipment.
Finger-operated buttons	Accessible to the operator's left hand	Pushing the upper/left button shall extend the equipment. Pushing the lower/right button shall retract the equipment.
Finger-operated proportional control	Accessible to the operator's left hand	Moving the proportional control forward or to the left shall extend the equipment. Moving the proportional control rearward or to the right shall retract the equipment.
	Accessible to the operator's right hand	Moving the proportional control forward or to the right shall extend the equipment. Moving the proportional control rearward or to the left shall retract the equipment.
Foot-operated single pedal control	Manufacturer's choice	Moving the front of the pedal downward shall extend the equipment. Moving the rear of the pedal downward shall retract the equipment.

Table B.4 — Rearward/forward

Control type	Location	Operation requirements and examples
Hand-operated single lever control	Accessible to the operator's left hand	Moving the lever forward shall execute forward motion. Moving the lever rearward shall execute rearward motion.
Hand-operated two-axis multifunction control	Accessible to the operator's left hand	Moving the control forward shall execute a forward movement. Moving the control rearward shall execute a rearward movement.
Hand-operated four-axis multifunction control	Accessible to the operator's left hand	Moving the control forward shall execute a forward movement. Moving the control rearward shall execute a rearward movement.

Table B.5 — Boom side shift

Control type	Location	Operation requirements and examples
Foot-operated single pedal control	Manufacturer's choice	Downward motion of the front or right of the pedal shall execute offset to the right. Downward motion of the rear or left of the pedal shall execute offset to the left.
Finger-operated proportional control	Manufacturer's choice	Moving the proportional control to the right shall move the boom to the right. Moving the proportional control to the left shall move the boom to the left.

Table B.6 — Boom fold/unfold

Control type	Location	Operation requirements and examples
Foot-operated single pedal control	Manufacturer's choice	Downward motion of the front of the pedal shall unfold the two-piece boom. Downward motion of the rear of the pedal shall fold the two-piece boom.
Finger-operated proportional control	Accessible to the operator's right hand	Moving the proportional control forward shall unfold the two-piece boom. Moving the proportional control rearward shall fold the two-piece boom.

Table B.7 — Boom offset

Control type	Location	Operation requirements and examples
Finger-operated proportional control	Manufacturer's choice	Moving the proportional control to the right shall execute offset to the right. Moving the proportional control to the left shall execute offset to the left.
Finger-operated buttons	Manufacturer's choice	Pushing the right button shall execute offset to the right. Pushing the left button shall execute offset to the left.
Foot-operated single pedal control	Manufacturer's choice	Downward motion of the front or right of the pedal shall execute offset to the right. Downward motion of the rear or left of the pedal shall execute offset to the left.

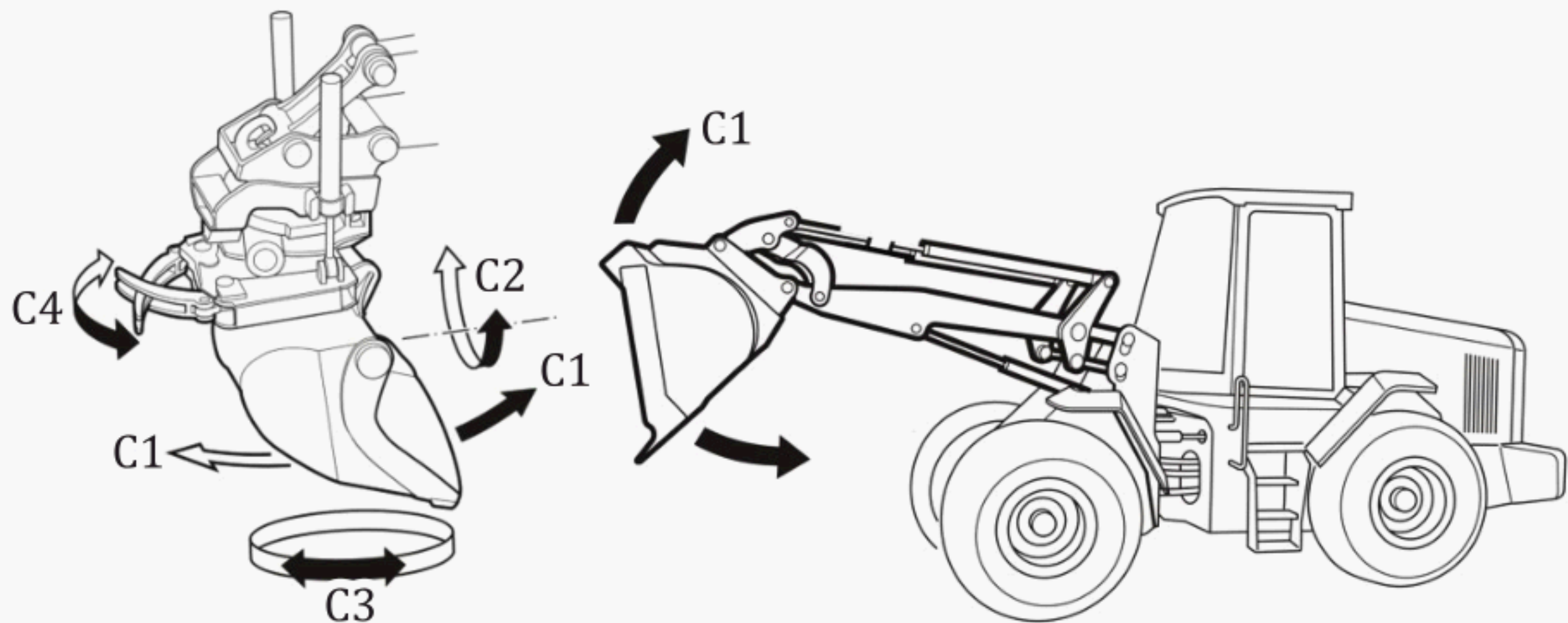
Table B.8 — Blade control

Control type	Location	Operation requirements and examples
Hand-operated single lever control	Manufacturer's choice	Moving the lever forward shall lower the blade. Moving the lever rearward shall raise the blade. Pushing the lever to the most forward position shall float the blade. The blade moves freely under an external force.
Hand-operated two-axis multifunction control	Manufacturer's choice	Moving the control forward shall lower the blade. Moving the control rearward shall raise the blade. Moving the control to the right shall lower the right-hand side of the blade. Moving the control to the left shall lower the left-hand side of the blade. Pushing the control to the most forward position shall float the blade. The blade moves freely under an external force.
Finger-operated buttons	Manufacturer's choice	Pushing the button shall float the blade. The blade moves freely under an external force.
Finger-operated proportional control	Manufacturer's choice	Horizontal proportional control: Moving the proportional control to the right shall angle the blade to the right. Moving the proportional control to the left shall angle the blade to the left.
Foot-operated single pedal control	Manufacturer's choice	Downward motion of the front of the pedal shall lower the blade. Downward motion of the rear of the pedal shall raise the blade.
Finger-operated buttons	Manufacturer's choice	Pushing the upper button shall angle the blade to the right. Pushing the lower button shall angle the blade to the left. Pushing the right button shall lower the right-hand side of the blade. Pushing the left button shall lower the left-hand side of the blade.

Annex C (normative)

Earth-moving machinery — Attachment

[Table C.1](#) to [C.4](#) specify the control type, location, operation requirements and examples for attachment movements (see [Figure C.1](#)).



Key

- C1 dump/curl of bucket or attachment (see [Table C.1](#))
- C2 tilting of bucket or attachment (see [Table C.2](#))
- C3 rotation of bucket or attachment (see [Table C.3](#))
- C4 open/close of grippers (see [Table C.4](#))

Figure C.1 — Examples of attachments

Table C.1 — Dump/curl of bucket or attachment

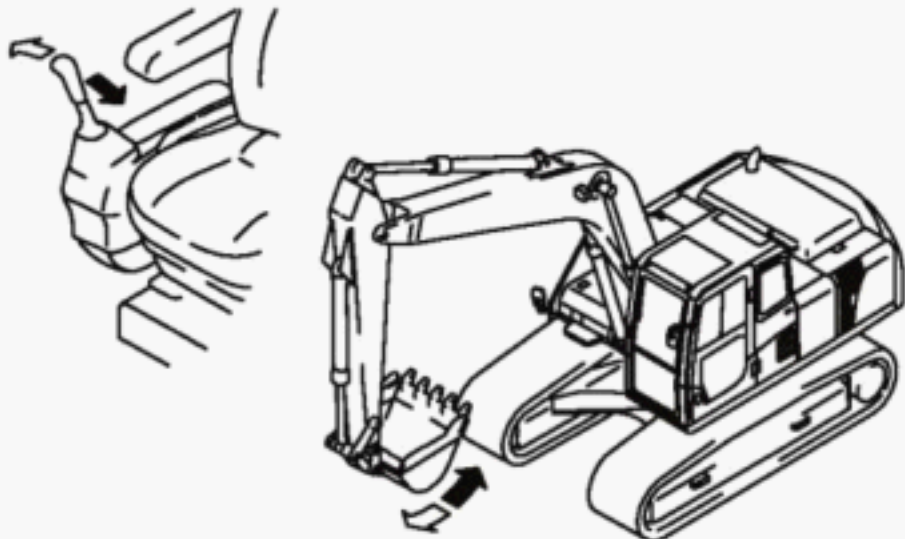
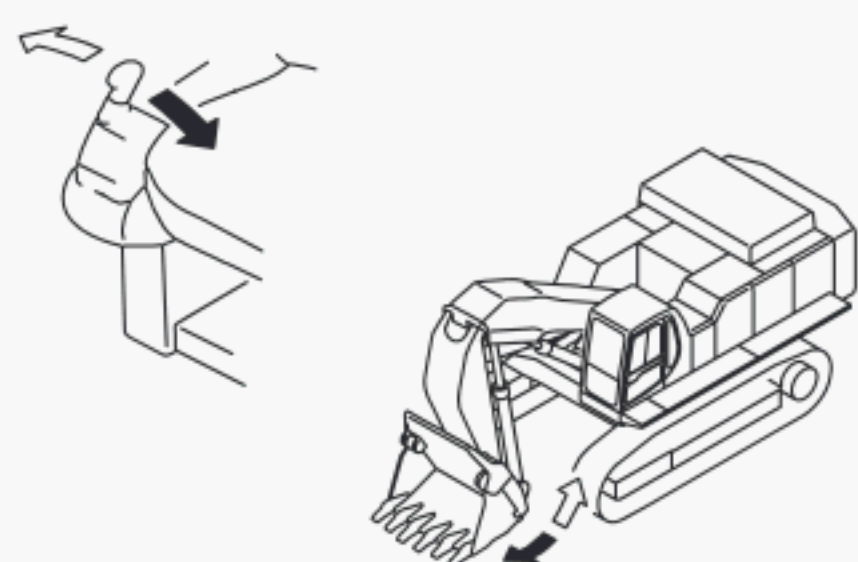
Control type	Location	Operation requirements and examples
Hand-operated single lever control	Accessible to the operator's right hand	Moving the lever rearward shall curl the attachment or bucket. Moving the lever forward shall dump the attachment or bucket.
Hand-operated two-axis multifunction control	Accessible to the operator's right hand	<p>For hoe-type attachments or buckets (Figure C.2):</p> <p>Moving the control to the left shall curl the attachment or bucket.</p> <p>Moving the control to the right shall dump the attachment or bucket.</p>  <p>Figure C.2 — Control of hoe-type attachments or buckets</p> <p>For front loaded attachments or buckets (Figure C.3):</p> <p>Moving the control to the left shall curl the attachment or bucket.</p> <p>Moving the control to the right shall dump the attachment or bucket.</p>  <p>Figure C.3 — Control of front loaded attachments or buckets</p>
Hand-operated four-axis multifunction control	Accessible to the operator's right hand	Moving the control rearward shall dump the attachment or bucket. Moving the control forward shall curl the attachment or bucket.
Finger-operated proportional control	Accessible to the operator's right hand	Moving the proportional control rearward shall curl the attachment or bucket. Moving the proportional control forward shall dump the attachment or bucket.
Foot-operated single pedal control	Accessible to the operator's right foot	Moving the front of the pedal downward shall dump the attachment or bucket. Moving the rear of the pedal downward shall curl the attachment or bucket.
NOTE For loader applications, the term tilt is commonly used as a synonym for the curl function described in this table.		

Table C.2 — Tilting of bucket or attachment

Control type	Location	Operation requirements and examples
Hand-operated four-axis multifunction control	Accessible to the operator's right hand	Moving the control to the right shall lower right hand side of attachment. Moving the control to the left shall lower left hand side of attachment.
Finger-operated proportional control	Accessible to the operator's right hand (thumb)	Horizontal proportional control: Moving the proportional control to the right shall lower right hand side of attachment. Moving the proportional control to the left shall lower left hand side of attachment. Vertical proportional control: Moving the proportional control forward or up shall lower right hand side of attachment. Moving the proportional control rearward or down shall lower left hand side of attachment.
NOTE In case where tilt and gripper are used simultaneously without rotation, then tilt can be moved to the location accessible to the operators left-hand.		

Table C.3 — Rotation of bucket or attachment

Control type	Location	Operation requirements and examples
Foot-operated single pedal control	Manufacturer's choice	Moving the front of the pedal downward shall execute a clockwise rotation. Moving the rear of the pedal downward shall execute a counter-clockwise rotation.
Hand-operated four-axis multifunction control	Accessible to the operator's right hand	Turning the control clockwise shall execute a clockwise rotation. Turning the control counter-clockwise shall execute a counter-clockwise rotation.
Hand-operated other	Manufacturer's choice	One lever - rotatable lever control: Rotating the control clockwise shall execute a clockwise rotation. Rotating the control counter-clockwise shall execute a counter-clockwise rotation.
Finger-operated proportional control	Accessible to the operator's left hand (thumb)	Horizontal proportional control: Moving the proportional control to the right shall execute a counter-clockwise rotation. Moving the proportional control to the left shall execute a clockwise rotation. Vertical proportional control: Moving the proportional control upward shall execute a counter-clockwise rotation. Moving the proportional control downward shall execute a clockwise rotation.
Finger-operated buttons	Buttons on separate levers	Pushing the button on the right lever shall execute a clockwise rotation. Pushing the button on the left lever shall execute a counter-clockwise rotation.

Table C.4 — Open/close of grippers

Control type	Location	Operation requirements and examples
Finger-operated proportional control	Accessible to the operator's right hand	<p>Horizontal proportional control:</p> <p>Moving the proportional control to the right shall open the gripper.</p> <p>Moving the proportional control to the left shall close the gripper.</p> <p>Vertical proportional control:</p> <p>Moving the proportional control upward shall open the gripper.</p> <p>Moving the proportional control downward shall close the gripper.</p>
Foot-operated single pedal control	Manufacturer's choice	<p>Downward motion of the front of the pedal shall close the gripper.</p> <p>Downward motion of the rear of the pedal shall open the gripper.</p>

Annex D (informative)

Graders

Table D.1 to D.8 specify the control type, location, operation requirements and examples for grader movements.

Table D.1 — Circle turn, rotation

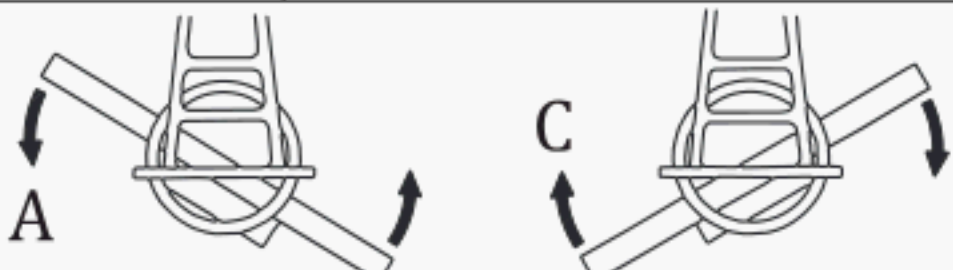
Control type	Location	Operation requirements and examples
Hand-operated single lever control	Accessible to the operator's left hand	Moving the lever forward shall rotate the blade counter-clockwise (A movement in Figure D.1). Moving the lever rearward shall rotate the blade clockwise (C movement in Figure D.1).
Hand-operated four-axis multifunction control	Manufacturer's choice	Rotating the control clockwise shall rotate the blade clockwise (C movement in Figure D.1). Rotating the control counter-clockwise shall rotate the blade counter-clockwise (A movement in Figure D.1).
 <p>Figure D.1 — Circle turn, rotation</p>		

Table D.2 — Blade lift


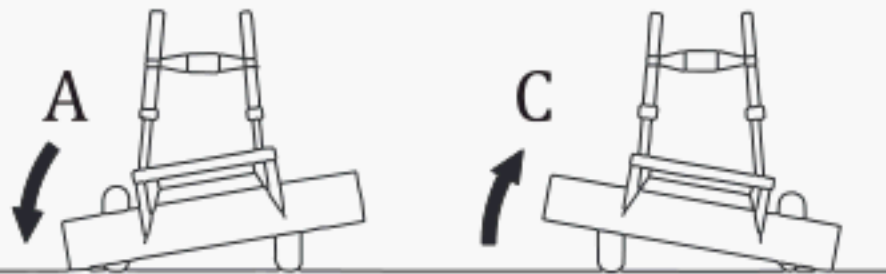
Control type	Location	Operation requirements and examples
Hand-operated single lever control	Accessible to the operator's right hand	<p>Moving the lever forward shall lower the right side of blade (A movement in Figure D.2).</p> <p>Moving the lever rearward shall raise the right side of blade (C movement in Figure D.2).</p>  <p>Figure D.2 — Blade lift for control with right hand</p>
	Accessible to the operator's left hand	<p>Moving the lever forward shall lower the left side of blade (A movement in Figure D.3).</p> <p>Moving the lever rearward shall raise the left side of blade (C movement in Figure D.3).</p>  <p>Figure D.3 — Blade lift for control with left hand</p>
	Manufacturer's choice	Pushing the lever to the most forward position shall float the blade. The blade moves freely under an external force.
Hand-operated two-axis multifunction control	Manufacturer's choice	<p>Moving the control forward shall lower the blade.</p> <p>Moving the control rearward shall raise the blade.</p>

Table D.3 — Circle side shift, centre shift

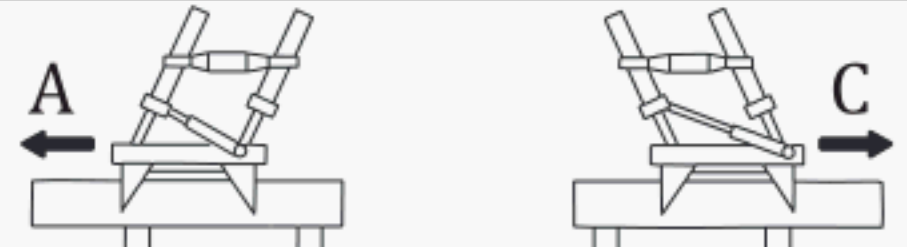
Control type	Location	Operation requirements and examples
Hand-operated single lever control	Manufacturer's choice	Moving the lever forward shall shift the circle or drawbar to the left (A movement in Figure D.4). Moving the lever rearward shall shift the circle or drawbar to the right (C movement in Figure D.4).
Hand-operated two-axis multifunction control	Manufacturer's choice	Moving the control forward or to the left shall shift the circle or drawbar to the left (A movement in Figure D.4). Moving the control rearward or to the right shall shift the circle or drawbar to the right (C movement in Figure D.4).
 <p>Figure D.4 — Circle side shift, centre shift</p>		

Table D.4 — Wheel lean


Control type	Location	Operation requirements and examples
Hand-operated single lever control	Manufacturer's choice	Moving the lever forward shall cause the wheels to lean to the left (A movement in Figure D.5). Moving the lever rearward shall cause the wheels to lean to the right (C movement in Figure D.5).
Hand-operated two-axis multifunction control	Manufacturer's choice	Moving the control forward or to the left shall cause the wheels to lean to the left (A movement in Figure D.5). Moving the control rearward or to the right shall cause the wheels to lean to the right (C movement in Figure D.5).
 <p>Figure D.5 — Wheel lean</p>		

Table D.5 — Blade side shift, slide

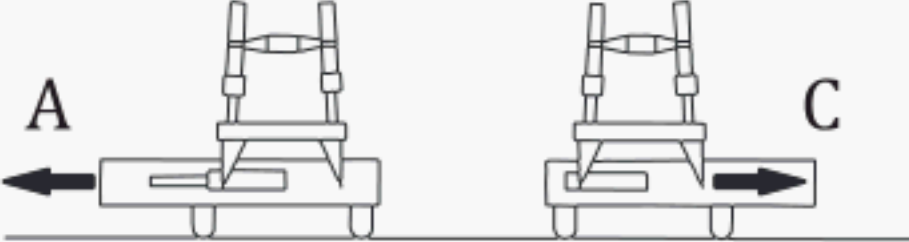
Control type	Location	Operation requirements and examples
Hand-operated single lever control	Manufacturer's choice	Moving the lever forward shall shift the blade to the left (A movement in Figure D.6). Moving the lever rearward shall shift the blade to the right (C movement in Figure D.6).
Hand-operated two-axis multifunction control	Manufacturer's choice	Moving the control forward or to the left shall shift the blade to the left (A movement in Figure D.6). Moving the control rearward or to the right shift the blade to the right (C movement in Figure D.6).
 <p>Figure D.6 — Blade side shift, slide</p>		

Table D.6 — Blade tilt, pitch

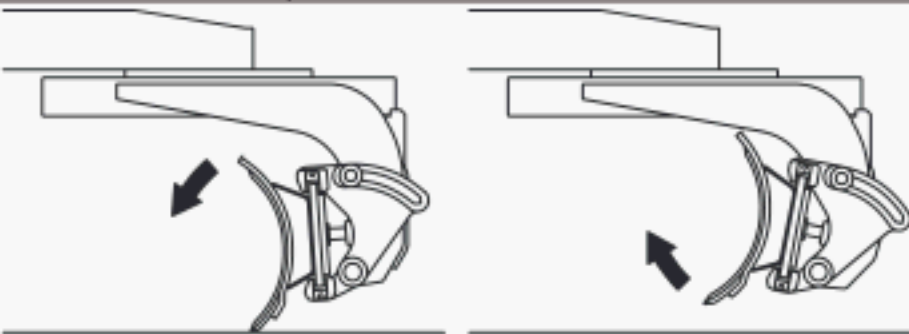
Control type	Location	Operation requirements and examples
Hand-operated single lever control	Manufacturer's choice	Moving the lever forward shall move the top edge of the blade forward (A movement in Figure D.7). Moving the lever rearward shall move the top edge of the blade rearward (C movement in Figure D.7).
Hand-operated four-axis multifunction control	Manufacturer's choice	Moving the control forward shall move the top edge of the blade forward (A movement in Figure D.7). Moving the control rearward shall move the top edge of the blade rearward (C movement in Figure D.7).
 <p>Figure D.7 — Blade tilt, pitch</p>		

Table D.7 — Scarifier, ripper raise/lower



Control type	Location	Operation requirements and examples
Hand-operated single lever control	Manufacturer's choice	Moving the lever forward shall lower the attachment (A movement in Figure D.8). Moving the lever rearward shall raise the attachment (C movement in Figure D.8).
Hand-operated two-axis multifunction control	Manufacturer's choice	Moving the control downward or forward shall lower the attachment (A movement in Figure D.8). Moving the control upward or rearward shall raise the attachment (C movement in Figure D.8).
 <p>Figure D.8 — Scarifier, ripper raise/lower</p>		

Table D.8 — Articulation

Control type	Location	Operation requirements and examples
Hand-operated single lever control	Accessible to the operator's left hand	Moving the lever forward shall move the front of the machine to the right (A movement in Figure D.9). Moving the lever rearward shall move the front of the machine to the left (C movement in Figure D.9).
	Accessible to the operator's right hand	Moving the lever forward shall move the front of the machine to the left (C movement in Figure D.9). Moving the lever rearward shall move the front of the machine to the right (A movement in Figure D.9).
Hand-operated four-axis multifunction control	Accessible to the operator's left hand	Rotating the control clockwise shall move the front of the machine to the right (A movement in Figure D.9). Rotating the control counter clockwise shall move the front of the machine to the left (C movement in Figure D.9).
 <p>Figure D.9 — Articulation</p>		

Annex E
(informative)

Dozers

Table E.1 to E.6 specify the control type, location, operation requirements and examples for dozer movements.

Table E.1 — Blade lift

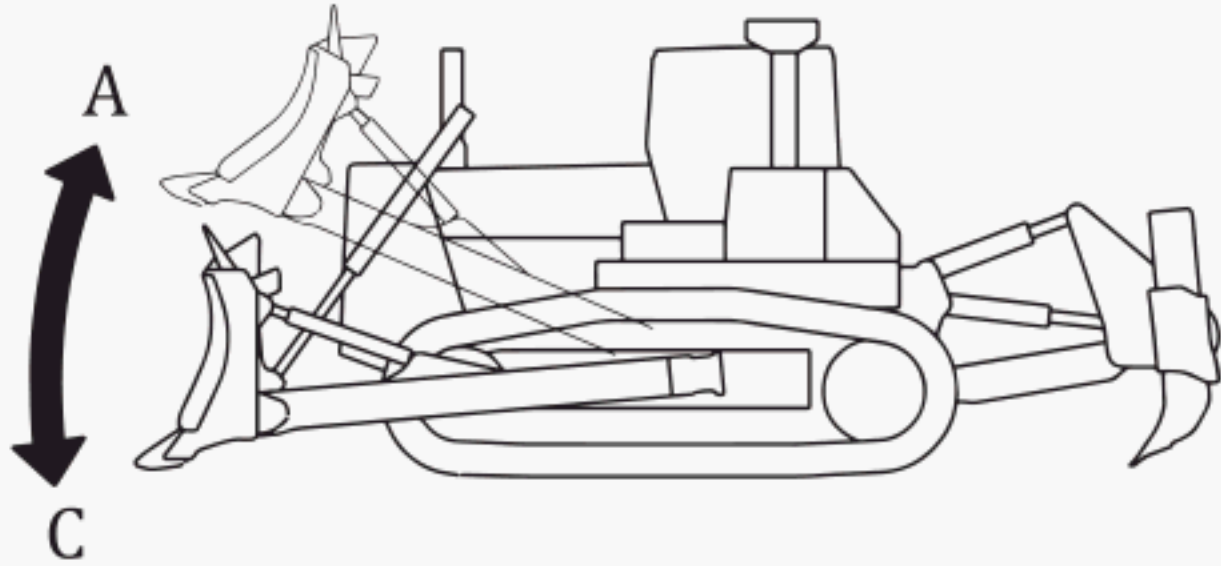
Control type	Location	Operation requirements and examples
Hand-operated four-axis multifunction control	Accessible to the operator's right hand	Moving the control forward shall lower the blade (C movement in Figure E.1). Moving the control rearward shall raise the blade (A movement in Figure E.1). Pushing the control to the most forward position shall float the blade. The blade moves freely under an external force.
		

Figure E.1 — Blade lift

Table E.2 — Blade angle

Control type	Location	Operation requirements and examples
Hand-operated four-axis multifunction control	Accessible to the operator's right hand	Rotating the control clockwise shall rotate the blade clockwise (H movement in Figure E.2). Rotating the control counter-clockwise shall rotate the blade counter-clockwise (G movement in Figure E.2).
Finger-operated proportional control	Accessible to the operator's right hand	Horizontal proportional control: Moving the proportional control forward or to the left shall rotate the blade clockwise (H movement in Figure E.2). Moving the proportional control rearward or to the right shall rotate the blade counter-clockwise (G movement in Figure E.2).

The diagram shows a side view of a bulldozer blade. Two curved arrows above the blade indicate rotation: arrow 'G' points counter-clockwise and arrow 'H' points clockwise. The blade is shown in its current position and two dashed outlines show its range of motion.

Figure E.2 — Blade angle

Table E.3 — Blade tilt

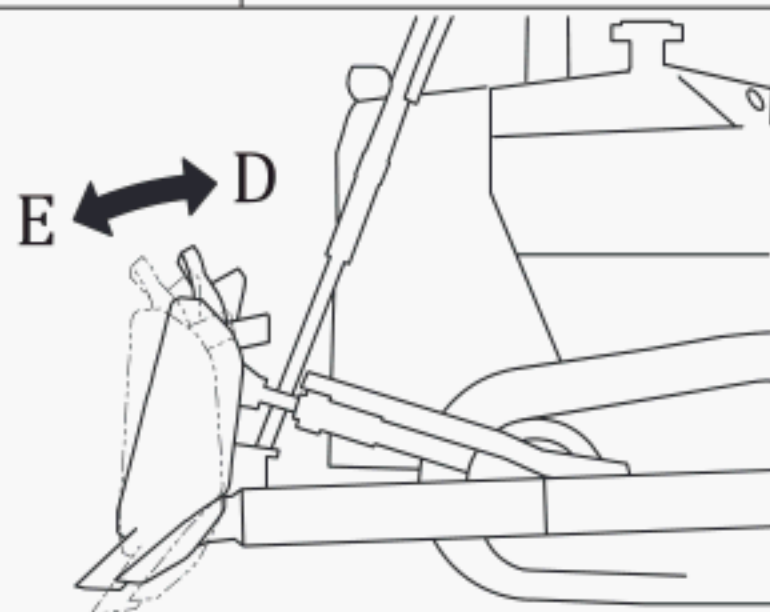
Control type	Location	Operation requirements and examples
Hand-operated four-axis multifunction control	Accessible to the operator's right hand	Moving the control to the right shall lower the right-hand side of the blade (A movement in Figure E.3). Moving the control to the left shall lower the left-hand side of the blade (B movement in Figure E.3).

The diagram shows a front view of a bulldozer blade. Two vertical arrows to the right of the blade indicate tilting: arrow 'A' points upwards and arrow 'B' points downwards. The blade is shown in its current position and two dashed outlines show its range of motion.

Figure E.3 — Blade tilt

Table E.4 — Blade pitch

Control type	Location	Operation requirements and examples
Hand-operated four-axis multifunction control	Accessible to the operator's right hand	Moving the control to the right while pressing the pitch button shall forward pitch the blade (E movement in Figure E.4). Moving the control to the left while pressing the pitch button shall backward pitch the blade (D movement in Figure E.4).
Finger-operated proportional control	Accessible to the operator's right hand	Horizontal proportional control: Moving the proportional control forward or to the right shall forward pitch the blade (E movement in Figure E.4). Moving the proportional control rearward or to the left shall backward pitch the blade (D movement in Figure E.4).
Finger-operated buttons	Accessible to the operator's right hand	Pushing the upper or right button shall forward pitch the blade (E movement in Figure E.4). Pushing the lower or left button shall backward pitch the blade (D movement in Figure E.4).

**Figure E.4 — Blade pitch****Table E.5 — Ripper raise/lower**

Control type	Location	Operation requirements and examples
Hand-operated two-axis multifunction control	Accessible to the operator's right hand	Moving the control to the right or rearward shall lower the ripper (C movement in Figure E.5). Moving the control to the left or forward shall raise the ripper (A movement in Figure E.5).

**Figure E.5 — Ripper raise/lower**

Table E.6 — Ripper tilt

Control type	Location	Operation requirements and examples
Hand-operated two-axis multifunction control	Accessible to the operator's right hand	Moving the control forward shall tilt in the ripper (A movement in Figure E.6). Moving the control rearward shall tilt back the ripper (B movement in Figure E.6).
Finger-operated proportional control	Accessible to the operator's right hand	Horizontal proportional control: Moving the proportional control forward or rotating the control counter-clockwise shall tilt in the ripper (A movement in Figure E.6). Moving the proportional control rearward or rotating the control clockwise shall tilt back the ripper (B movement in Figure E.6).

The diagram shows a hand holding a control lever. The lever is shown in two positions: position A (forward) and position B (rearward). Arrows indicate the movement from the neutral position to A and B.

Figure E.6 — Ripper tilt

Bibliography

- [1] ISO 6165, *Earth-moving machinery — Basic types — Identification and terms and definitions*
- [2] ISO 6682, *Earth-moving machinery — Zones of comfort and reach for controls*
- [3] ISO 6746-2:2003, *Earth-moving machinery — Definitions of dimensions and codes — Part 2: Equipment and attachments*
- [4] ISO 15817:2012, *Earth-moving machinery — Safety requirements for remote operator control systems*
- [5] MIL-STD-1472G, *Department of Defense Design Criteria Standard: Human Engineering (11-JAN-2012)*

