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Earth-moving machinery — Safety —

Part 5: Requirements for hydraulic excavators

Engins de terrassement — Sécurité —

Partie 5: Exigences applicables aux pelles hydrauliques

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ISO copyright office
Ch. de Blandonnet 8 • CP 401
CH-1214 Vernier, Geneva, Switzerland
Tel. +41 22 749 01 11
Fax +41 22 749 09 47
copyright@iso.org
www.iso.org

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Foreword

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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).

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For an explanation on 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 the following URL: 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 second edition cancels and replaces the first edition (ISO 20474-5:2008), which has been technically revised with the following changes:

— normative references have been updated;

— references to national and regional provisions in the withdrawn ISO/TS 20474-14 have been deleted;

— new safety requirements and protective measures have been added, including requirements for load safety devices and the normative annex, *Requirements for excavator swing brakes*.

It is intended to be used in conjunction with ISO 20474-1.

A list of all parts in the ISO 20474 series, published under the general title, *Earth-moving machinery — Safety,* can be found on the ISO website.

Introduction

This document is a type-C standard as stated in ISO 12100.

The machinery concerned and the extent to which hazards, hazardous situations or hazardous events are covered are indicated in the Scope of this document.

When requirements of this type-C standard are different from those which are stated in type-A or B standards, the requirements of this type-C standard take precedence over the requirements of the other standards for machines that have been designed and built according to the requirements of this type-C standard.

ISO 20474 provides acceptable safety requirements for earth-moving machinery. This standard does not necessarily provide requirements to meet all national and regional regulatory provisions, e.g. Japan does not allow object handling with earth-moving machinery.

Earth-moving machinery — Safety —

Part 5: Requirements for hydraulic excavators

1 Scope

This document gives the safety requirements specific to hydraulic excavators as defined in ISO 6165. It is intended to be used in conjunction with ISO 20474-1, which specifies general safety requirements common to two or more earth-moving machine families. The specific requirements given in this document take precedence over the general requirements of ISO 20474-1.

This document deals with all significant hazards, hazardous situations and events relevant to the earth-moving machinery within its scope (see ISO 20474-1:2017, Annex A) when used as intended or under conditions of misuse reasonably foreseeable by the manufacturer. It specifies the appropriate technical measures for eliminating or reducing risks arising from relevant hazards, hazardous situations or events during commissioning, operation and maintenance.

This document is not applicable to machines manufactured before the date of its publication.

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 3449:2005, *Earth-moving machinery — Falling-object protective structures — Laboratory tests and performance requirements*

ISO 3471, *Earth-moving machinery — Roll-over protective structures — Laboratory tests and performance requirements*

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

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

ISO 6683, *Earth-moving machinery — Seat belts and seat belt anchorages — Performance requirements and tests*

ISO 7096, *Earth-moving machinery — Laboratory evaluation of operator seat vibration*

ISO 7135, *Earth-moving machinery — Hydraulic excavators — Terminology and commercial specifications*

ISO 7451, *Earth-moving machinery — Volumetric ratings for hoe-type and grab-type buckets of hydraulic excavators and backhoe loaders*

ISO 7546, *Earth-moving machinery — Loader and front loading excavator buckets — Volumetric ratings*

ISO 8643, *Earth-moving machinery — Hydraulic excavator and backhoe loader lowering control device — Requirements and tests*

ISO 10262, *Earth-moving machinery — Hydraulic excavators — Laboratory tests and performance requirements for operator protective guards*

ISO 10567, *Earth-moving machinery — Hydraulic excavators — Lift capacity*

ISO 12117, *Earth-moving machinery — Tip-over protection structure (TOPS) for compact excavators — Laboratory tests and performance requirements*

ISO 12117-2:2008, *Earth-moving machinery — Laboratory tests and performance requirements for protective structures of excavators — Part 2: Roll-over protective structures (ROPS) for excavators of over 6 t.* Amended by ISO 12117-2:2008/Amd 1:2016

ISO 20474-1:2017, *Earth-moving machinery — Safety — Part 1: General requirements*

3 Terms and definitions

For the purposes of this document, the terms and definitions given in ISO 20474-1, ISO 6165 and ISO 7135, and the following apply.

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

— ISO Online browsing platform: available at http://www.iso.org/obp

— IEC Electropedia: available at http://www.electropedia.org/

3.1
excavator
hydraulic excavator
self-propelled machine on crawlers, wheels or legs, having an upper structure normally capable of a 360° swing with mounted *equipment* (3.3), primarily designed for excavating with bucket, without moving the undercarriage during the work cycle

Note 1 to entry: An excavator work cycle normally comprises excavating, elevating, swinging and the discharging of material.

Note 2 to entry: An excavator can also be used for object or material handling/transportation.

Note 3 to entry: Unless specifically identified as a *cable excavator*, an excavator is commonly referred to as a *hydraulic excavator*.

Note 4 to entry: See Annex B for illustrations.

[SOURCE: ISO 6165:2012, 4.4, modified — By adding Note 4.]

3.1.1
compact excavator
excavator (3.1) with an operating mass 6 000 kg or less

Note 1 to entry: See Annex B for illustrations.

[SOURCE: ISO 6165:2012, 4.4.4, modified — By adding Note 1.]

3.1.2
walking excavator
excavator (3.1) with three or more supporting legs which can be articulated, telescopic or both and which can be fitted with wheels

Note 1 to entry: See Annex B for an illustration.

[SOURCE: ISO 6165:2012, 4.4.2, modified — By adding Note 1.]

3.2
extra-long reach equipment application
application of *hydraulic excavator* (3.1) equipped with extra-long reach equipment

Note 1 to entry: Extra-long reach equipment application includes the following:

— extra-long front equipment application consisting of an extra-long boom and an extra-long arm with lighter duty bucket for extra wide working range purpose;

— telescopic arm application;

— telescopic arm with clamshell bucket application;

— extra-long front equipment demolition application consisting of an extra-long boom (multi-booms), extra-long arm and demolition attachment.

3.3
material handling
moving of scrap and loose bulk material, e.g. scrap iron, demolition debris and mulch

3.4
material handling excavator
hydraulic excavator (3.1) purpose-built for material handling and typically equipped with an elevated (fixed or movable) operator station

3.5
demolition application
demolishing by pushing or pulling, or fragmenting by crushing or shearing, buildings or other civil engineering structures and their component parts

3.6
swing
rotation of the upper structure of an excavator in relation to a fixed reference frame on the ground

3.7
working swing revolution speed
turntable-swing speed, reached in a 180° revolution of the upper structure with maximum rotation command input starting from a still position

Note 1 to entry: It is expressed in revolutions per minute (r/m).

3.8
deceleration swing angle
angle measured in degrees of swing while the swing motion is decelerated from working swing revolution speed to a complete stop (halt)

3.9
swing torque
torque which propels the upper structure relative to the undercarriage

Note 1 to entry: It is expressed in newton metres (N · m).

3.10
swing service brake
device or system to decelerate the rotation of the upper structure and to bring it to a stop in any position

EXAMPLE Frictional brake, electrically operated brake, hydrostatically or other hydraulically operated brake.

Note 1 to entry: See Annex A.

3.11
swing parking brake
device or system to hold the stopped upper structure in a stationary position

Note 1 to entry: See Annex A.

3.12
swing lock
mechanically engaged device designed to block the upper structure in a fixed position with respect to the undercarriage

Note 1 to entry: See Annex A.

4 Safety requirements and protective measures

4.1 General

Hydraulic excavators shall comply with the safety requirements and protective measures of ISO 20474-1, in as far as those are not modified by the specific requirements of this clause.

4.2 Operator station

4.2.1 Operator protection

4.2.1.1 Operator protective guard

Excavators with an operating mass greater than 1 500 kg shall be designed so that an operator protective guard can be fitted. The manufacturer, according to the intended use of the machine, shall offer a protective guard. The protective guard shall be in accordance with ISO 10262.

NOTE For excavators used in demolition applications, additional requirements exist.

4.2.1.2 Roll-over protective structures (ROPS) and tip-over protective structures (TOPS)

4.2.1.2.1 General

Except for walking excavators (see 4.6.3), ISO 20474-1:2017, 4.3.3 does not apply.

Hydraulic excavators with an operating mass of 1 000 kg up to 6 000 kg shall be equipped with a TOPS in accordance with ISO 12117. If the structure is compliant with the performance requirements given in both ISO 12117 (TOPS) and ISO 12117-2 (ROPS), the manufacturer may identify both standards (TOPS and ROPS) on the label.

Hydraulic excavators with an operating mass greater than 6 000 kg and less than 50 000 kg shall be provided with a ROPS in accordance with ISO 12117-2.

Material-handling excavators with fixed cab risers and with an operating mass greater than 1 000 kg and less than 50 000 kg shall be fitted with a TOPS.

For evaluation of the performance of the TOPS, ISO 12117-2 shall be used in respect of lateral loading only and with the following lateral load energy, U_S:

$$U_S = 6{,}500 \times (M/10\,000)^{1{,}25}$$

The TOPS shall be labelled in accordance with ISO 12117-2:2008, Clause 9, as amended by ISO 12117-2:2008/Amd 1:2016, except that the reference shall be made to ISO 20474-5.

Alternatively, in fulfilling this requirement a manufacturer may provide a ROPS in accordance with ISO 12117-2. In such cases, the labelling may either be in accordance with ISO 12117-2 for ROPS or modified as specified above for TOPS. Where a structure complies with both ROPS and TOPS

performance requirements, a manufacturer may optionally identify both standards (ROPS and TOPS) on the label.

NOTE ISO 12117 is intended to be applied to compact excavators having a swing type boom and an operating mass of between 1 000 kg and 6 000 kg. This does not preclude the possibility of establishing a reproducible means of evaluating the load-carrying characteristics of TOPS under static loading, and prescription of performance requirements of a representative specimen under such loading for excavators with an operating mass over 6 000 kg. In this case, the test is carried out in accordance with ISO 12117-2.

4.2.1.3 Operator's seat

If a suspension seat is provided for excavators, the seat shall comply with spectral class EM 6 as given in ISO 7096:2008.

4.2.2 Rear window defrosting system

ISO 20474-1:2017, 4.3.2.7, shall only apply for rear window defrosting if visibility through the rear window is required according to ISO 20474-1, 4.8.1.

4.3 Controls for driving and steering

ISO 20474-1:2017, 4.5.1 and 4.6.1 shall apply with the following addition/exception: the movements of the controls for driving and steering do not need to correspond to the intended direction of movement if the upper structure is not in the normal driving direction.

4.4 Swing brakes

Swing brakes shall comply with the requirements given in Annex A.

NOTE Requirements can differ for excavators with extra-long reach equipment.

4.5 Stability and safety devices

4.5.1 General

ISO 20474-1:2017, 4.11 shall apply with the additions given in 4.5.2 to 4.5.4 below.

NOTE All rated capacities as defined hereafter are based on tests, calculations, or both, of machines on a level and firm supporting surface.

The mass of the load, its density and the location of its centre of gravity, as well as the mass of the attachment and the quick coupler, if fitted, shall be included in the determination of the rated operating load and the size/capacity of the attachment.

In order to provide sufficient stability, the rated operating load in intended operations shall be determined as specified in 4.5.2 and 4.5.3.

4.5.2 Bucket and shovel applications

The rated lift capacity of an excavator used in a bucket or shovel application shall be determined according to ISO 10567.

The volumetric rating of the bucket or shovel shall be determined according to ISO 7451 or ISO 7546.

4.5.3 Object-handling applications

4.5.3.1 General

The capacity of excavators shall be determined in accordance with 4.5.3.2 and 4.5.3.3.

4.5.3.2 Rated lift capacity in object handling

The rated lift capacity in object handling shall be defined by its rated lift capacity according to ISO 10567.

4.5.3.3 Rated lift capacity table in object handling

A table of the rated lift capacity in object handling, established by the manufacturer, shall be provided in accordance ISO 10567. The tables shall be available at the operator's station for each object-handling configuration specified in the operator's manual.

4.5.3.4 Load safety devices

Excavators used in object-handling operations with a maximum rated lift capacity of ≥ 1 000 kg, according to ISO 10567 or an overturning moment of ≥ 40 000 N · m shall have provisions for the following.

a) An acoustic or visual warning device which indicates to the operator when the rated lift capacity/corresponding load moment is reached and continues as long as the lift capacity or load moment is exceeded. The rated lift capacity is defined in 4.5.3.2.

   This device may be deactivated while the excavator is performing operations other than object handling. The activation shall be clearly indicated. The control device for activation and deactivation shall be within the operator's zone of comfort according to ISO 6682. A warning sign shall be placed close to the control device indicating the need for activation during object handling.

b) A lowering control device on each raising boom and arm cylinder to prevent uncontrolled movement in the case of a hydraulic line failure or rupture. For each arm cylinder the device shall be installed at the end which is pressurized to raise the arm away from the base machine. The lowering control device for each boom and arm cylinder shall be tested in accordance with ISO 8643.

4.5.3.5 Other applications

The rated lift capacity of material-handling excavators and derivative machinery shall be determined by the manufacturer according to the load specification given in 4.5.3.2 and 4.5.3.3 and considering the comparable hazard.

4.6 Specific requirements for walking excavators

4.6.1 Operator station

4.6.1.1 Steering system

ISO 20474-1:2017, 4.6.1, is not applicable.

4.6.1.2 Visibility

ISO 20474-1:2017, 4.8.1, is not applicable.

The ground contacting part of each leg in all possible positions shall be visible from the operator's station in order to ensure that the operator can place the legs on firm ground.

4.6.2 Wheel brake system

ISO 20474-1:2017, 4.7, is not applicable to walking excavators having a maximum of two wheels.

4.6.3 Operator protection

4.6.3.1 Roll-over protective structures (ROPS)

Walking excavators shall be fitted with ROPS in accordance with ISO 3471, as applicable in that International Standard to backhoe loaders of equivalent mass.

4.6.3.2 Restraint systems

All walking excavators fitted with a cab shall be equipped with an operator restraint system in accordance with ISO 6683.

4.6.3.3 Falling-object protective structure (FOPS)

Walking excavators shall be designed so that a FOPS in accordance with ISO 3449:2005, level II, can be fitted (see also ISO 20474-1:2017, 4.3.4).

4.6.3.4 Legs, hydraulic circuit

All leg cylinders shall be fitted with lock valves to prevent the machine from becoming unstable in the case of a hydraulic system failure.

4.6.4 Stability

4.6.4.1 Test conditions

The stability shall be determined under the following test conditions:

a) on a level and firm supporting test surface;

b) with stabilizer and wheels (at maximum spread position) extended as specified by the manufacturer;

c) with the lower side of the undercarriage at a levelled position of approximately 350 mm above the test surface;

d) with tipping lines as shown in Figure 1;

e) at maximum reach with/without telescopic arm to the front/rear, as shown in Figure 2, and to the side as shown in Figure 3.

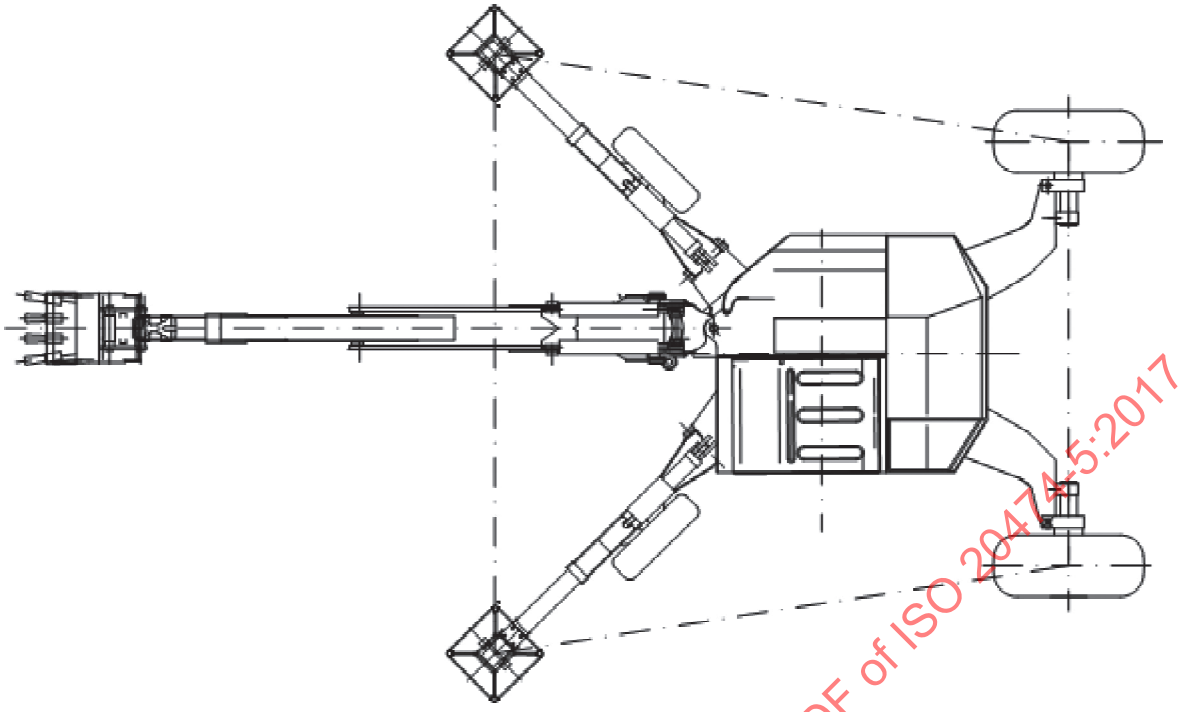
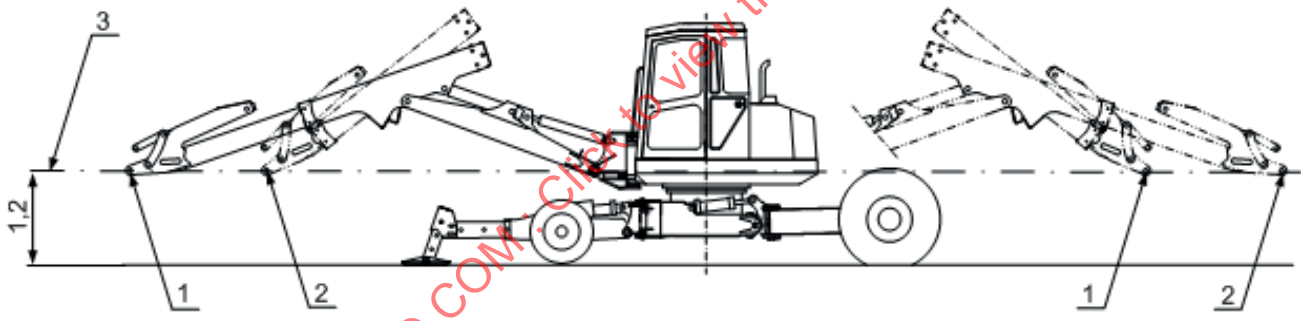


Figure 1 — Tipping lines of walking excavators

Dimensions in metres

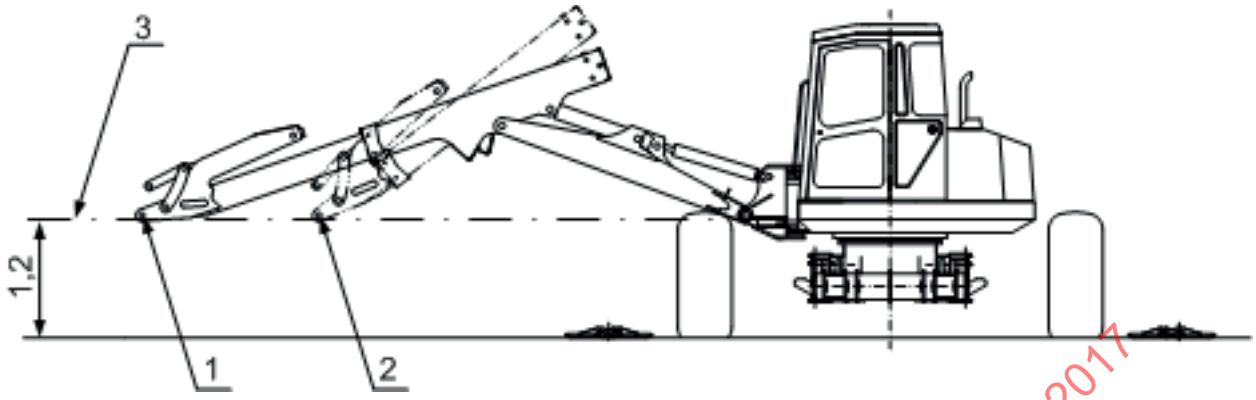


Key

1 fully extended
2 fully retracted
3 measuring line

Figure 2 — Measurement of rated tipping load to front/rear

Dimensions in metres



Key

1 fully extended
2 fully retracted
3 measuring line

Figure 3 — Measurement of rated tipping load to the side

4.6.4.2 Bucket applications

The capacity of walking excavator in bucket applications shall be determined according to ISO 10567.

The volumetric rating of the bucket shall be determined in accordance with ISO 7451.

4.6.4.3 Object-handling applications

The rated lift capacity in object handling shall be determined according to ISO 10567.

4.6.5 Retrieval and towing

ISO 20474-1:2017, 4.15, shall apply, except for ISO 20474-1:2017, 4.15.2 and 4.15.5.

5 Information for use

ISO 20474-1:2017, 6.2, shall apply with the following additions:

— a description of the excavator configuration required if intended to be used for object handling;

— a description of excavator stability in different applications;

— a description of special precautions for walking excavators;

— instructions for operation of the load safety devices, if fitted;

— where applicable, a table of the rated lift capacity in object handling;

— instructions for the selection and use of operator protective guards, e.g. top guard, front guard (see 4.2.1.1), appropriate for the application.

Annex A
(normative)

Requirements for excavator swing brakes

A.1 General

Annex A specifies minimum performance criteria and test methods for the swing service brake, swing parking brake and swing lock of hydraulic excavators.

A.2 Minimum performance

A.2.1 Swing movement

A.2.1.1 Test-swing revolution speed

The test-swing revolution speed shall be the working swing revolution speed.

A.2.1.2 Deceleration swing angle, β_B

The deceleration swing angle, β_B, shall be less than the higher of the following values:

$$\beta_B = 90°$$

or

$$\beta_B = \frac{n^2 \cdot 360}{2 \cdot n'_B} + \beta_{B0}$$

where

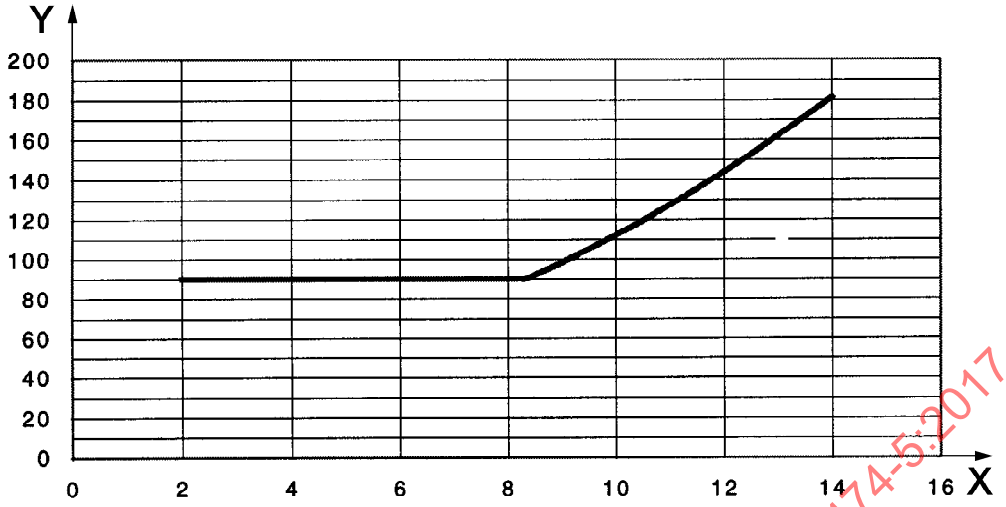
n is the test-swing revolution speed (min^{-1});

n'_B = 250 (min^{-2});

β_{B0} = 40°.

A.2.2 Swing service brake

The swing service brake shall be capable of decelerating the upper structure to a complete stop from the test swing revolution speed as specified in A.2.1.1. A disconnection of the swing service brake shall not be possible. See Figure A.1.



Key

X upperstructure revolutions, r/min^{-1}

Y deceleration swing angle, °

Figure A.1 — Swing service brake

During no less than 10 tests the deceleration swing angle shall not exceed by more than 20 % the deceleration swing angle β_B (see A.2.1.2). These tests shall be made at a sequence rate as rapid as the swing acceleration and deceleration will allow.

A.2.3 Swing parking brake

The swing parking brake shall be capable of holding the upper structure for 30 min in the maximum slope and in the most unfavourable position of the upper structure, as specified by the manufacturer. The working equipment shall be extended to maximum radii with the empty bucket in rollout position.

The swing parking brake shall apply automatically in case of engine stop or shall be capable of being manually applied, with and without the engine running.

The swing parking brake shall remain effective when the source of energy fails.

The swing parking brake on excavators with an operating mass ≥6 000 kg shall be fully mechanical, e.g. spring friction brake. On excavators with an operating mass <6 000 kg the swing parking brake may be a hydraulic lock valve applied directly to the swing motor and if so a separate swing lock according to A.2.4 shall be provided.

NOTE 1 The above requirement of a fully mechanical swing parking brake is not intended to prevent future development of other types of technology providing equivalent safety.

NOTE 2 A swing parking brake could perform as an emergency brake in case of hose failure.

Excavators with an operating mass <1 000 kg do not require a swing parking brake.

A.2.4 Swing lock

The swing lock shall be capable of withstanding without permanent deformation the maximum swing motor torque.

A swing lock is not required if its function is provided by the swing parking brake.

A.3 Test conditions

The tests shall be made with the standard equipment specified by the manufacturer.

Outriggers and blade, if present, shall be placed on the ground in their working position as specified by the manufacturer.

All fluid system shall be filled as specified by the manufacturer. The fuel tank shall be at least half full. The swing system pressures shall be adjusted and function as specified by the manufacturer.

The test for the swing service brake to define the test swing revolution speed according to A.2.1.1 and deceleration swing angle according to A.2.1.2 shall be made with the working equipment extended to maximum radii with the empty bucket in rollout position.

The measurement starts with the actuation of the braking at test swing revolution speed.

For the test of the service swing brake and the swing lock, the machine shall be positioned on a flat surface with a maximum gradient slope of ± 1 %.

A.4 Test report

The test report shall contain the following information:

— machine manufacturer;

— model and serial-number;

— machine specification;

— result of test.

Annex B
(informative)

Illustrations

See Figures B.1 to B.5.

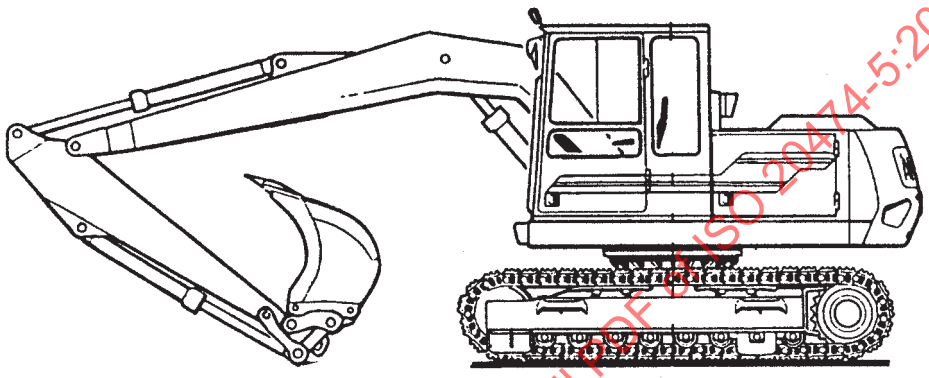


Figure B.1 — Crawler excavator

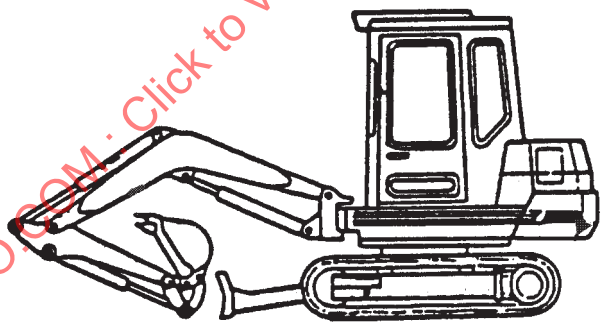


Figure B.2 — Compact crawler excavator