BRITISH STANDARD

BS 6912-9: 1992
ISO 10567: 1992

Safety of earth-moving machinery —

Part 9: Methods for the calculation and verification of the lift capacity of hydraulic excavators

UDC 621.879.3.016

Committees responsible for this British Standard

The preparation of this British Standard was entrusted by Technical Committee B/513, Construction equipment and plant, and site safety, to Subcommittee B/513/1, Earth-moving machinery upon which the following bodies were represented:

Associated Offices Technical Committee
British Coal Corporation
Construction Plant (Hire Association)
Federation of Civil Engineering Contractors
Federation of Manufacturers of Construction Equipment and Cranes
Health and Safety Executive
Institution of Civil Engineers
Institution of Highways and Transportation
Silsoe Research Institute

This British Standard, having been prepared under the direction of Technical Committee B/513, was published under the authority of the Standards Board and comes into effect on 15 December 1992

The following BSI references relate to the work on this standard:
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Contents

National foreword

This Part of BS 6912 has been prepared under the direction of Technical Committee B/513 construction equipment and plant, and site safety. It is identical with ISO 10567:1992 *Earth-moving machinery — Hydraulic excavators — Lift capacity,* published by the International Organization for Standardization (ISO).

ISO 10567 was prepared by Subcommittee 2, Safety requirements and human factors, of ISO Technical Committee 127, Earth-moving machinery, with the active participation and approval of the UK.

Annex A forms an integral part of this British Standard. Annex B is for information only.

Cross-references

International Standard	Corresponding British Standard
Normative	
ISO 6015:1989	BS 6911 *Testing earth-moving machinery* Part 3:1990 *Measurement of tool forces of hydraulic excavators* (Identical)
ISO 7135	BS 6914 *Terminology (including definitions of dimensions and symbols) for earth-moving machinery* A Part standard is in preparation. See clause **2** of the text of the International Standard.
Informative	
ISO 6016:1982	BS 6300:1982 *Methods of measuring the masses of whole machines, their equipment and components of earth-moving machinery* (Identical) BS 6914 *Terminology (including definitions of dimensions and symbols) for earth-moving machinery*
ISO 6165:1987	Part 1:1988 *Glossary of terms for basic types of earth-moving machinery* (Identical)
ISO 6746-1:1987	Part 2:1988 *Glossary of terms for base machine* (Identical)
ISO 6746-2:1987	Part 3:1988 *Glossary of terms for equipment* (Identical)

Textual error. When adopting the text of the International Standard, the textual error given below was discovered. It has been indicated by asterisk in the text and has been reported to ISO in a proposal to amend the text of the International Standard.

An important dimensional error concerning lift point height occurs in Figure 1b) of the ISO standard and a corrected version is shown in national Annex A.

A British Standard does not purport to include all the necessary provisions of a contract. Users of British Standards are responsible for their correct application.

Compliance with a British Standard does not of itself confer immunity from legal obligations.

Summary of pages

This document comprises a front cover, an inside front cover, pages i and ii, pages 1 to 10, an inside back cover and a back cover.

This standard has been updated (see copyright date) and may have had amendments incorporated. This will be indicated in the amendment table on the inside front cover.

1 Scope

This International Standard provides a uniform method to calculate hydraulic excavator lift capacity and a test procedure for verifying the calculations. It covers both hydraulic lift capacity limits and machine tipping limits and establishes the rated lift capacity for hydraulic excavators as defined in ISO 7135.

2 Normative references

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

ISO 6015:1989, *Earth-moving machinery — Hydraulic excavators — Methods of measuring tool forces.*

ISO 7135:—, *Earth-moving machinery — Hydraulic excavators — Terminology and commercial specifications*[1)].

3 Definitions

For the purposes of this International Standard, the following definitions apply.

3.1
load

external force, including the weight of the attached equipment, applied at the lift point

3.2
lift point

location on the bucket or the bucket mounting bracket, specified by the manufacturer, to which a load may be attached, or the centre-line of the bucket pivot mounting pin on the arm. For bucket or bucket mounting bracket load attachment, the bucket cylinder is fully extended. See Figure 1

3.3
lift point height

vertical distance from the ground reference plane to the lift point. See Figure 1

3.4
lift point radius

horizontal distance from the axis of rotation to the vertical hoist line or tackle. See Figure 1

3.5
balance point

moment acting to overturn the machine with a specific load and point lift radius which is equal to the moment of the machine available to resist overturning

3.6
tipping load

static load at the balance point

3.7 rated tipping load

75 % of the static tipping load

3.8 Hydraulic pressures

3.8.1
working circuit pressure

that nominal pressure applied to the specific circuit by the pump(s)

3.8.2
holding circuit pressure

maximum static pressure in a specific circuit, limited by a relief valve at a flow no greater than 10 % of rated circuit flow

3.9 hydraulic lift capacity

Load that can be lifted from the lift point by the boom cylinders with the bucket in rated lift bucket position and the excavator physically restrained from tipping.

3.9.1
boom hydraulic lift capacity

load that can be lifted by applying working circuit pressure to the boom cylinder(s) without exceeding holding circuit pressure in any other circuit

3.9.2
arm hydraulic lift capacity

load that can be lifted by applying working circuit pressure to the arm cylinder(s) without exceeding the working circuit pressure in the boom cylinders or the holding circuit pressure in any other circuit

3.10
rated hydraulic lift capacity

87 % of the smaller of boom or arm hydraulic, lift capacity at specific lift point positions

3.11
rated lift capacity

smaller of either rated tipping load (**3.7**) or rated hydraulic lift capacity (**3.10**)

[1)] To be published.

4 Calculations

4.1 Tipping load calculations

A series of calculations at various lift radii is made to determine the load required to achieve the balance point as defined in **3.5**. Sufficient lift radii shall be considered to develop the rated lift capacity chart (see Annex A). Lift point positions shall be included above and below the ground reference plane, over the ends and the sides of the machine, and with the machine in the configuration that results in the lowest moment available to resist overturning.

4.1.1 *Machine configuration for calculations*

4.1.1.1 Because of the large number of attachment options and machine variations available, the manufacturer shall publish revised load rating charts if these variations would decrease the machine rated lift capacity by more than 5 %.

4.1.1.2 Lift capacities shall be calculated with the machine on a firm level supporting surface.

4.1.2 *Calculations for balance point for end tipping line*

4.1.2.1 The tipping line to be used for balance point calculations over the front/rear of machines with track-type undercarriage shall be a line connecting the centre-line of support idlers or sprockets (see Figure 2). The linkage shall be positioned over the front/rear in the least stable position for these calculations.

4.1.2.2 The tipping line to be used for calculations over the front/rear of machines with rubber-tyred undercarriage shall be the axle centre-line, the bogie axle centre-line, or a line connecting the outrigger pads as shown in Figure 3.

4.1.2.3 The tipping line for pivoted outrigger pads shall be a line at the ground reference plane, connecting the point on the pads directly below the centre-line of the pivot. For rigid outrigger pads, the tipping line shall be a line connecting the centroid of the contact area between the pads and the ground reference plane.

4.1.2.4 A backfill blade, properly attached to the machine and capable of supporting the machine as an outrigger, may be considered an outrigger.

4.1.2.5 For machines equipped with outriggers, calculations shall be made both without the outriggers applied and with the outriggers applied in their most favourable position.

4.1.3 *Calculations for balance point for side tipping line*

4.1.3.1 The tipping line to be used for side tipping balance point calculations on machines with track-type undercarriages shall be defined by the pivot points between support rollers and track elements (such as links or guides) as shown in Figure 4.

4.1.3.2 The tipping line to be used for calculations for the balance point of machines with rubber-tyred undercarriage with blocked or non-oscillating axles shall be a line connecting the centre of contact of the tyres (midpoint between dual tyres) on the same side of the machine, at the ground reference plane (see Figure 3 and Figure 4).

4.1.3.3 The tipping line for an excavator with an oscillating axle shall be a line through the axle pivot point and one other rigid support point (see Figure 3).

4.1.3.4 If ratings are based upon a blocked or non-oscillating axle, this condition shall be clearly defined on the load rating charts and diagrams.

4.1.3.5 When outriggers are used, the position of the tipping line shall be as specified in **4.1.2.3**.

4.2 Hydraulic lift capacity calculations

A series of calculations at various lift points is made to determine the load that can be lifted with the force generated by the boom or the arm hydraulic lift capacity (as defined in **3.9.1** and **3.9.2**). Sufficient excavator linkage position calculations shall be made, including lift points above and below the ground reference plane, to develop the rated lift capacity chart shown in Annex A.

5 Verification testing

5.1 Test site

5.1.1 *Dead weight test site (immovable weight)*

A dead weight test site shall consist of a firm and level horizontal surface arranged so that a load cell can be connected between the lift point and the dead weight. The dead weight may be either a horizontal rail with a movable attachment device or a fixed point dead weight with the excavator moving to obtain the various lift points (see Figure 5 and Figure 6).

5.1.2 ***Live weight test site (movable weight)***

A live weight test site shall consist of a firm and level horizontal surface arranged so that a weight attached to the lift point can be moved without obstructing the limit of the excavator's tipping load or hydraulic capacity. See Figure 7 for a typical test arrangement. The live weight should be kept within 0,5 m of the surface from which it was raised to minimize the possibility of the machine overturning.

5.2 Test equipment

Instrumentation accuracy shall be as defined in ISO 6015.

5.2.1 A load cell of sufficient capacity (if a dead weight test site is used).

5.2.2 Weights of known mass (if a live weight test site is used).

5.2.3 A means of measuring the lift point position relative to the axis of rotation of the excavator.

5.2.4 A means of measuring perpendicularity between the load line and the ground reference plane when using the dead weight test site.

5.2.5 A means to monitor the pressure in all hydraulic circuits which will be under pressure during the actual lift capacity verification tests.

5.3 Test procedure

5.3.1 The excavator shall be thoroughly cleaned and in normal working condition with fuel tanks filled to capacity and all other fluids at their prescribed levels and at normal operating temperature.

5.3.2 The excavator shall be fitted with working equipment and counterweight as specified by the manufacturer for the calculated lift capacity chart being verified.

5.3.3 Tyres on rubber-tyred undercarriage machines shall be inflated to the manufacturer's recommended values.

5.3.4 Track tension on machines with track-type undercarriage shall be adjusted to the manufacturer's recommendations.

5.3.5 The hydraulic pressure shall be checked. This will include the working circuit pressure and the holding circuit pressure to ensure that the system is set at the manufacturer's recommended nominal published value.

5.3.6 The test personnel shall conduct the tests in a safe manner and follow the operating instructions, operator's manuals, safety rules, etc., furnished by the manufacturer of the excavator and of the test equipment.

5.3.7 A means shall be provided for preventing the excavator from overturning during the test procedure.

5.4 Tests

5.4.1 Tipping load measurements shall be carried out at lift specific radii to determine the force that achieves the balance point defined in **3.5**.

Tests for machines with outriggers shall be conducted both without the outriggers applied and with the outriggers applied in their most favourable position.

5.4.2 Hydraulic lift capacity measurements shall be carried out at specific lift points to verify hydraulic lift capacity calculations. These measurements are made without exceeding the working circuit pressure in the boom cylinders or the holding circuit pressure in any other circuit.

5.4.3 The number of verifying points obtained shall include at least the following four points:

a) tipping over the end and side: position the linkage over the end and the side to obtain tipping load;

b) hydraulic limited lift capacity above and below the ground reference plane.

5.5 Test results

Measured lift forces, lift point heights and lift point radii for tipping loads and hydraulic lift capacities shall be recorded.

6 Validation of calculated values

The measured values should be within 95 % of the calculated values. If not, the lift capacity chart shall be adjusted based on the correction factor determined by the measured values.

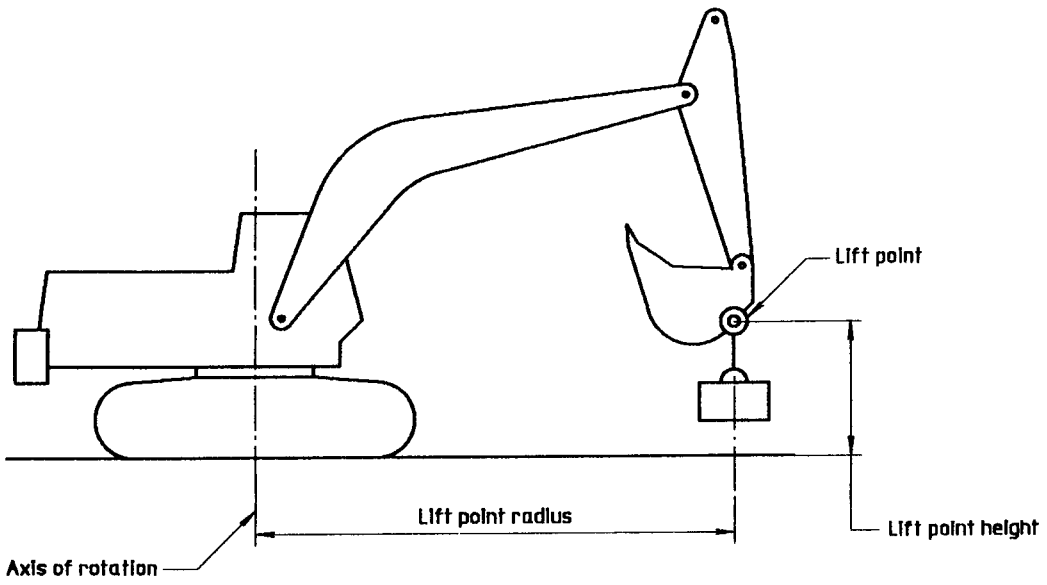
7 Rated lift capacity chart

7.1 The format for the rated lift capacity chart is presented in Annex A.

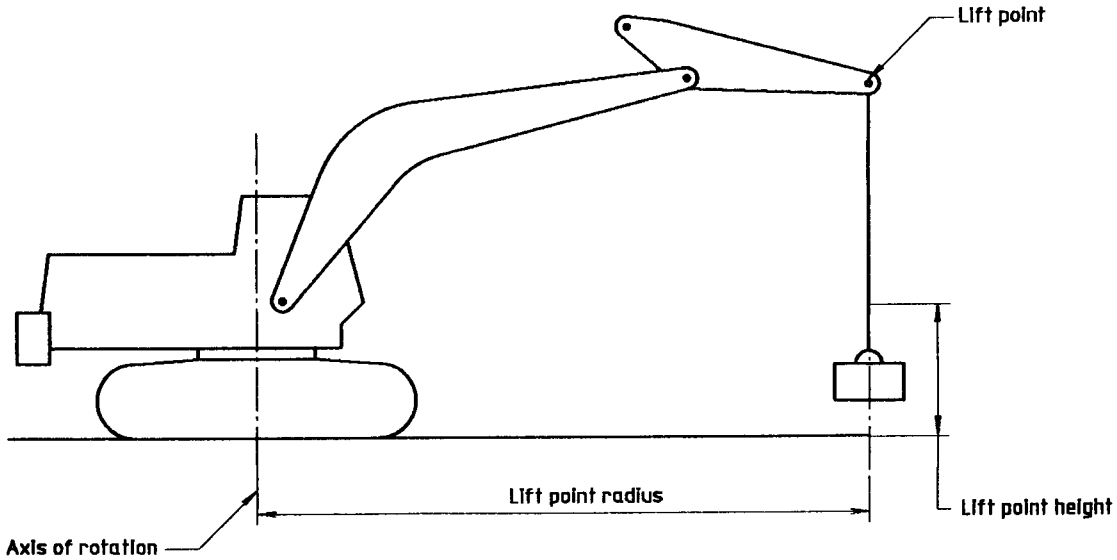
7.2 The rated lift capacity chart shall show the lift capacity (see **3.11**) at specific lift point radii. The chart shall note if the values are limited by hydraulic lift capacity.

7.3 Rated lift capacity values shall be tabulated for intersections of the lift point with a 0,5 m, 1 m, or 2 m vertically and horizontally spaced grid placed over the excavator's working range with bucket attitude maintained in the rated lift bucket position. The maximum and minimum lift radii shall also be included. The origin of the grid shall be at the intersection of the ground reference plane and axis of rotation.

7.4 A rated lift capacity chart shall be mounted inside the excavator cab and be legible from the control position.



a) Condition 1



b) Condition 2

[a] See national foreword for details of textual error.

Figure 1 — Lift point

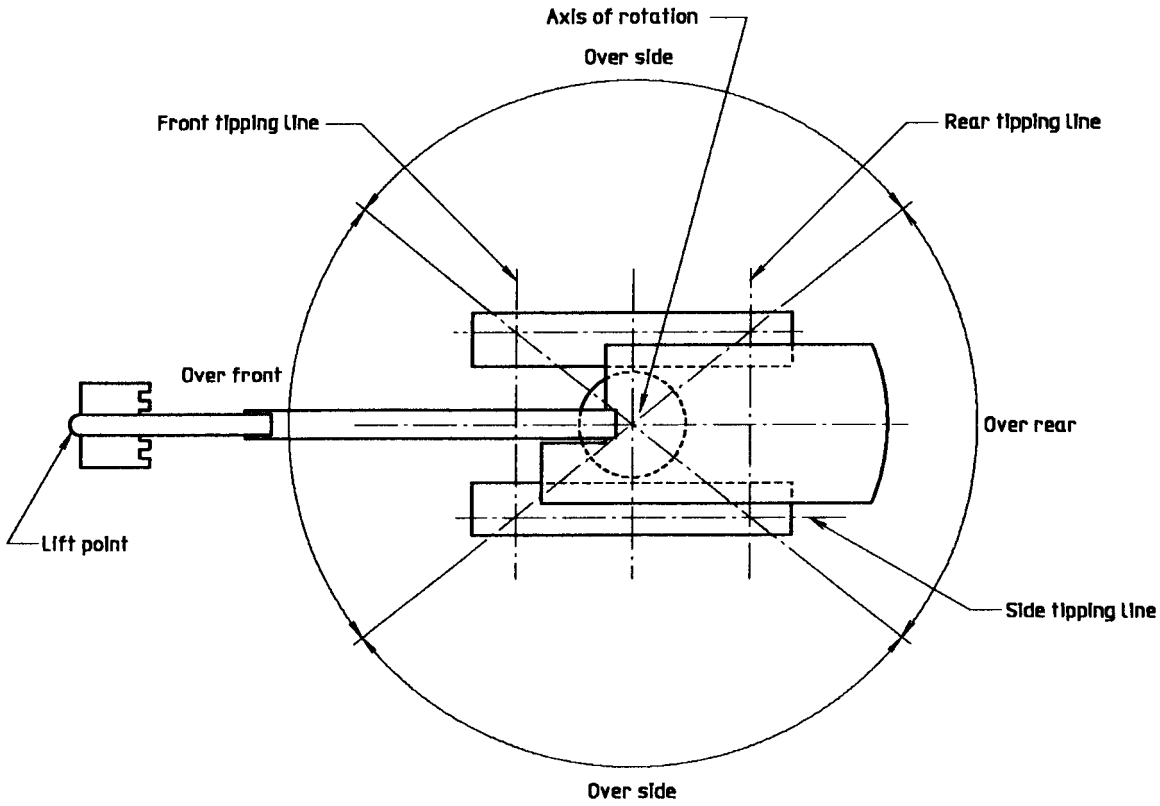


Figure 2 — Track-type undercarriage

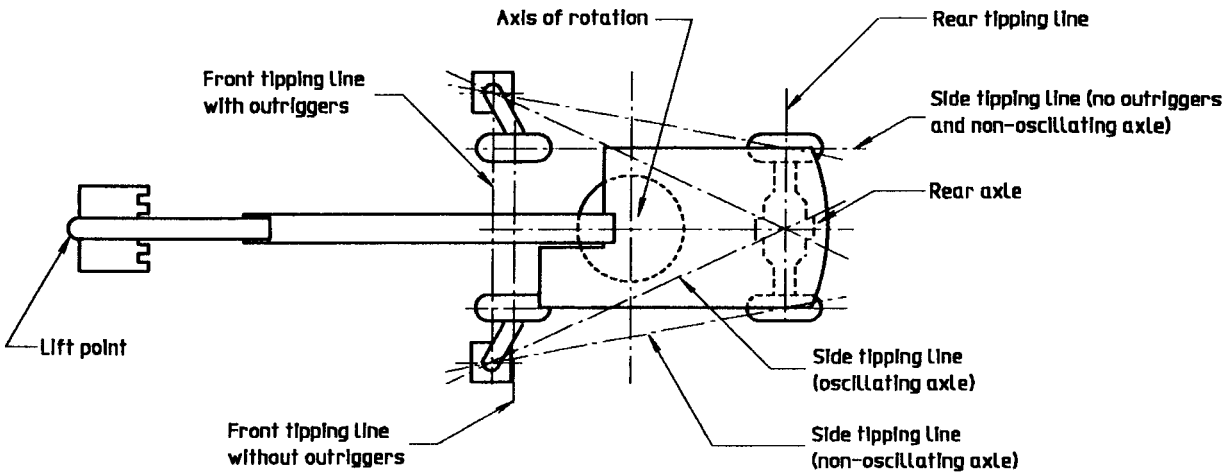


Figure 3 — Rubber-tyred undercarriage

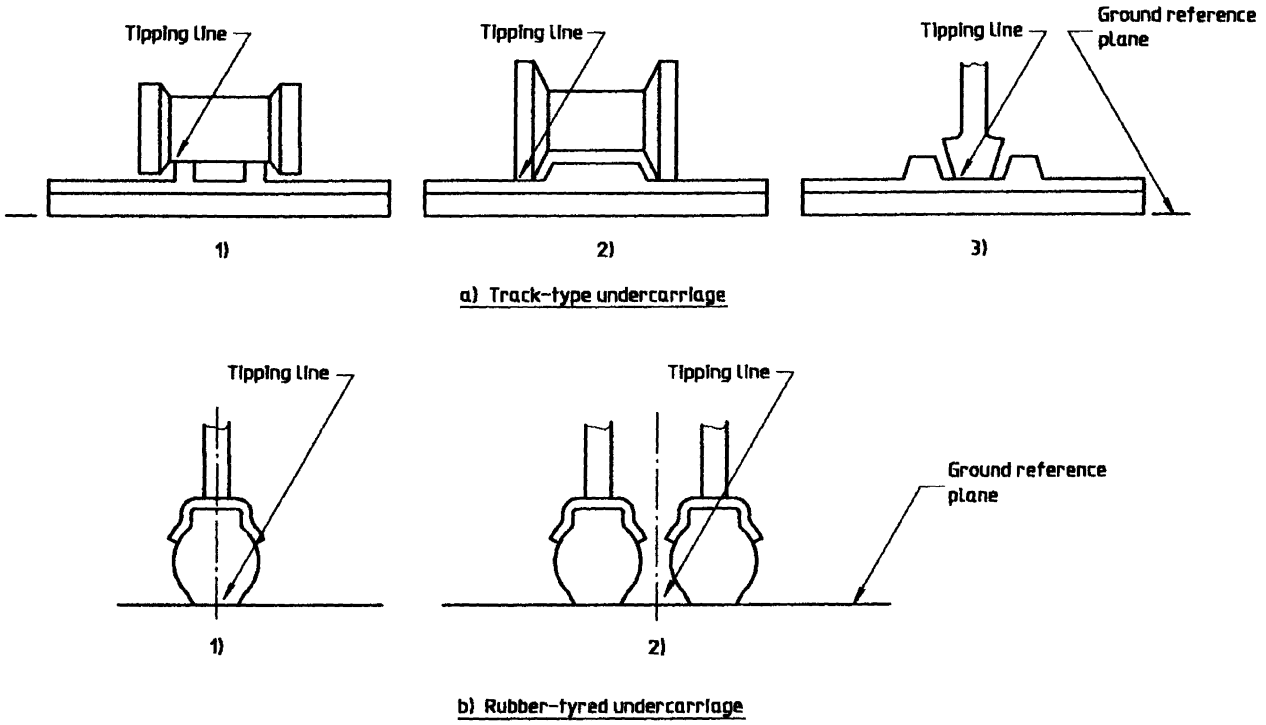


Figure 4 — Tipping lines

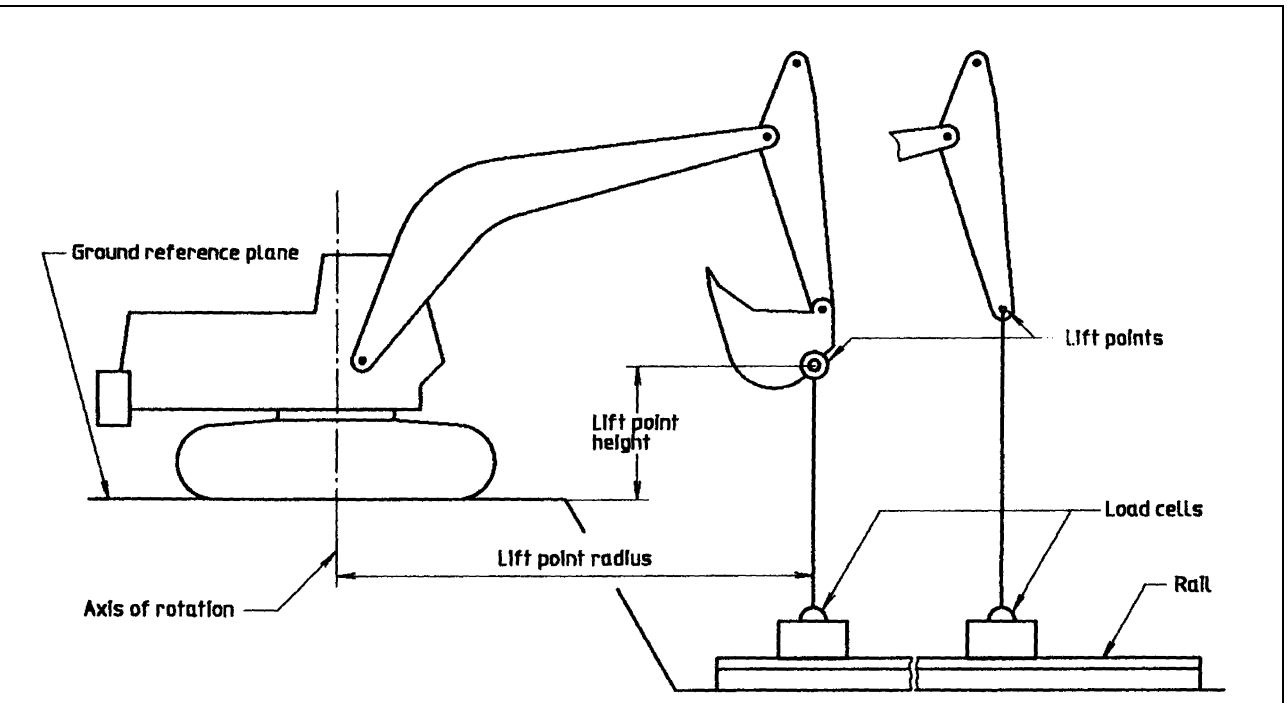


Figure 5 — Self-aligning dead weight

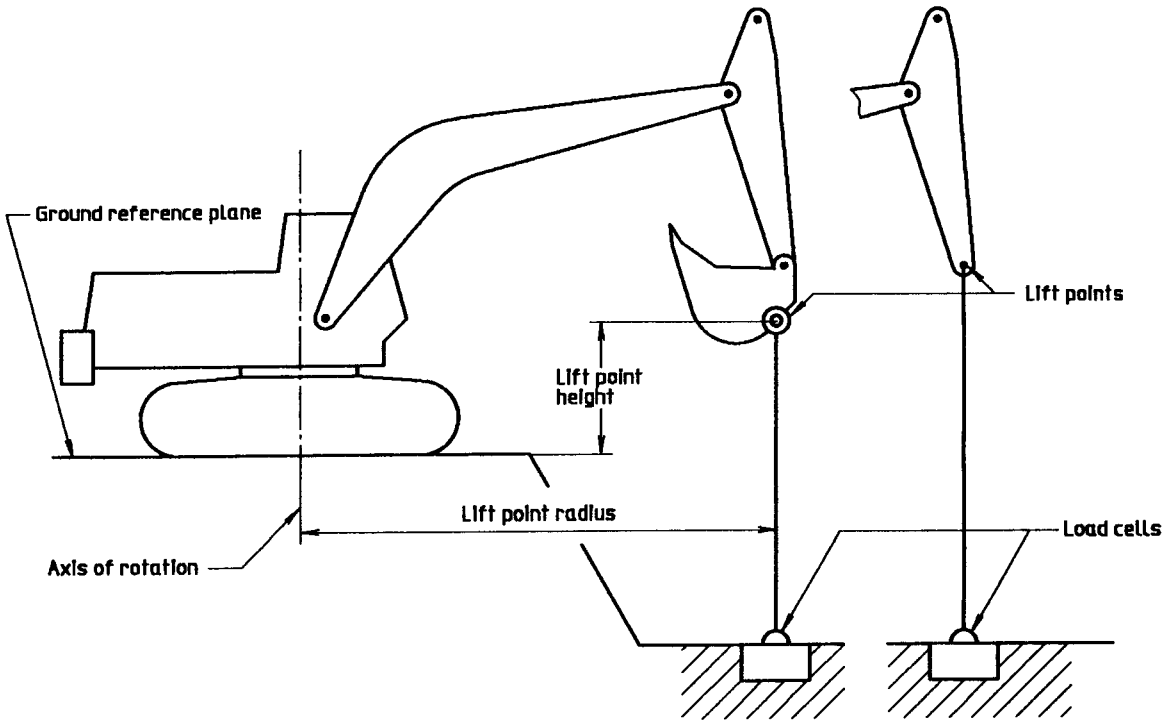


Figure 6 — Fixed dead weight

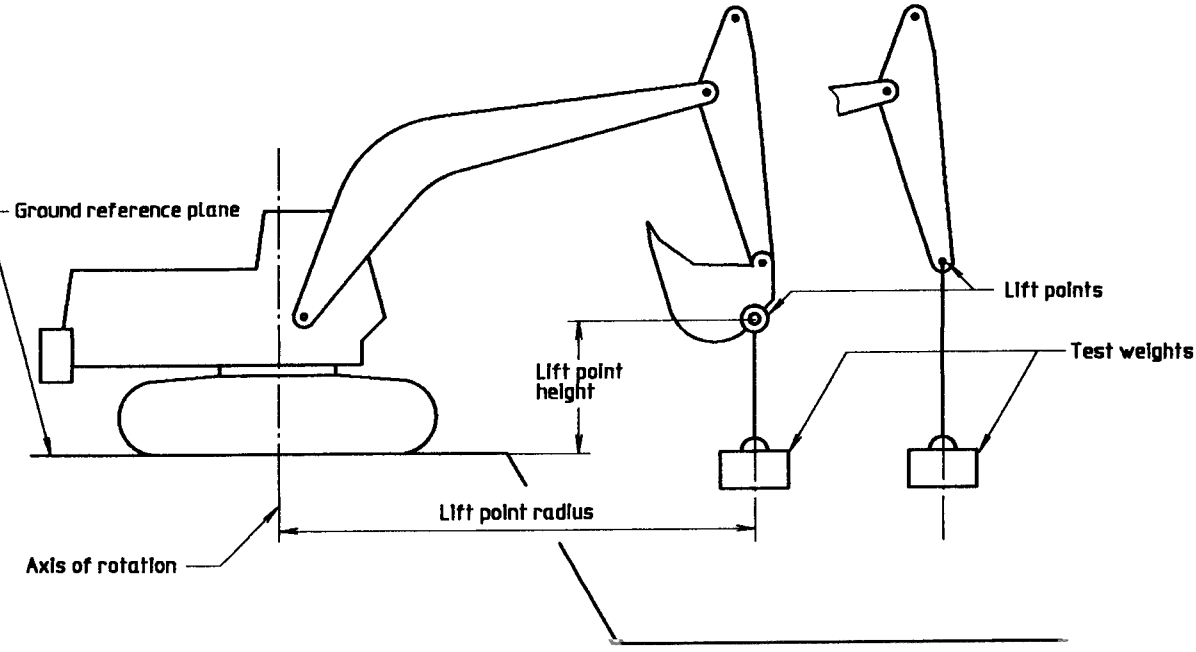


Figure 7 — Live weight

Annex A (normative)
Rated lift capacity chart (typical)

Manufacturer's identification: .....

Model No.: ..... Serial number: .....

Mass with bucket: ..... kg Mass without bucket: ..... kg

Bucket No. or identification: ..... Bucket mass: ..... kg

DO NOT attempt to lift or hold any load that is greater than these rated values at their specified load radii and height.

The mass of slings and any auxiliary lifting devices shall be deducted from the rated load to determine the net load that may be lifted.

The lift point is located on the : .....

NOTE 1 The following tables are not exhaustive; they are to be adapted to test conditions (see **7.3**). Indicate by an asterisk (*) the rated lift capacity values limited by rated hydraulic lift capacity.

Rated lift capacity over ends, in newtons						
Lift point height to GRP mm	**Lift point radius** mm					
	r_{min}	r_1	r_2	r_3	r_4	r_{max}
$+ h$						
0						
$- h$						

Rated lift capacity over sides, in newtons						
Lift point height to GRP mm	**Lift point radius** mm					
	r_{min}	r_1	r_2	r_3	r_4	r_{max}
$+ h$						
0						
$- h$						

CAUTION — All rated lift capacities are based on the machine being level and on a firm supporting surface. For safe working loads, the user is expected to make due allowance for the particular job conditions such as soft or uneven ground, non-level conditions, side loads, hazardous conditions, experience of personnel, etc. The operator and other personnel should fully acquaint themselves with the operator's manual furnished by the manufacturer before operating this machine, and rules for safe operation of equipment shall be adhered to at all times.

The above loads are in compliance with ISO 10567.

Annex B (informative)
Bibliography

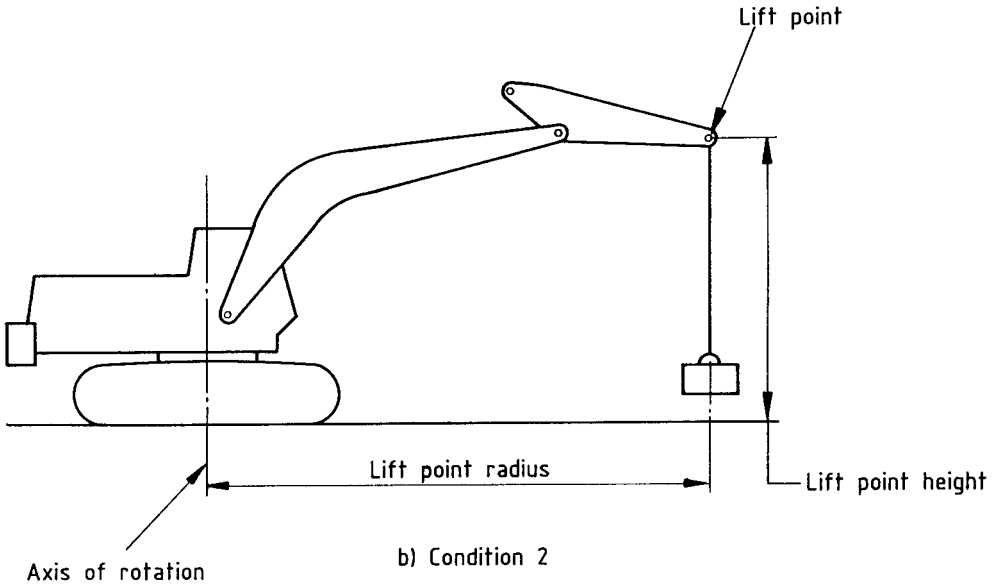
[1] ISO 6016:1982, *Earth-moving machinery — Methods of measuring the masses of whole machines, their equipment and components.*

[2] ISO 6165:1987, *Earth-moving machinery — Basic types — Vocabulary.*

[3] IS0 6746-1:1987, *Earth-moving machinery — Definitions of dimensions and symbols — Part 1: Base machine.*

[4] ISO 6746-2:1987, *Earth-moving machinery — Definitions of dimensions and symbols — Part 2: Equipment.*

National annex A (normative)
Correction to Figure 1



b) Condition 2

List of references

See national foreword.

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