INTERNATIONAL STANDARD

ISO 14397-1

First edition
2002-03-15

Earth-moving machinery — Loaders and backhoe loaders —

Part 1: Calculation of rated operating capacity and test method for verifying calculated tipping load

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Engins de terrassement — Chargeuses et chargeuses-pelleteuses —

Partie 1: Calcul de la charge utile nominale et méthode d'essai pour vérifier la charge de basculement calculée

ISO 14397-1:2002
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Reference number
ISO 14397-1:2002(E)

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Case postale 56 • CH-1211 Geneva 20
Tel. + 41 22 749 01 11
Fax + 41 22 749 09 47
E-mail copyright@iso.ch
Web www.iso.ch

Printed in Switzerland

Foreword

ISO (the International Organization for Standardization) is a worldwide federation of national standards bodies (ISO member bodies). The work of preparing International Standards is normally carried out through ISO technical committees. Each member body interested in a subject for which a technical committee has been established has the right to be represented on that committee. International organizations, governmental and non-governmental, in liaison with ISO, also take part in the work. ISO collaborates closely with the International Electrotechnical Commission (IEC) on all matters of electrotechnical standardization.

International Standards are drafted in accordance with the rules given in the ISO/IEC Directives, Part 3.

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

Attention is drawn to the possibility that some of the elements of this part of ISO 14397 may be the subject of patent rights. ISO shall not be held responsible for identifying any or all such patent rights.

ISO 14397-1 was prepared by Technical Committee ISO/TC 127, *Earth-moving machinery*, Subcommittee SC 1, *Test methods relating to machine performance*.

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ISO 14397 consists of the following parts, under the general title *Earth-moving machinery — Loaders and backhoe loaders*:

— *Part 1: Calculation of rated operating capacity and test method for verifying calculated tipping load*

— *Part 2: Test method for measuring breakout forces and lift capacity to maximum lift height*

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Earth-moving machinery — Loaders and backhoe loaders —

Part 1: Calculation of rated operating capacity and test method for verifying calculated tipping load

1 Scope

This part of ISO 14397 specifies the means for determining the rated operating capacity of wheel and crawler loaders and of the loader portion of backhoe loaders, as these machine types are defined in ISO 6165, including standard methods for calculation and test verification of the tipping load.

2 Normative references

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The following normative documents contain provisions which, through reference in this text, constitute provisions of this part of ISO 14397. For dated references, subsequent amendments to, or revisions of, any of these publications do not apply. However, parties to agreements based on this part of ISO 14397 are encouraged to investigate the possibility of applying the most recent editions of the normative documents indicated below. For undated references, the latest edition of the normative document referred to applies. Members of ISO and IEC maintain registers of currently valid International Standards.

ISO 6016:1998, *Earth-moving machinery — Methods of measuring the masses of whole machines, their equipment and components*

ISO 6165:2001, *Earth-moving machinery — Basic types — Vocabulary*

ISO 6746-1:1987, *Earth-moving machinery — Definitions of dimensions and symbols — Part 1: Base machine*

ISO 7546:1983, *Earth-moving machinery — Loader and front loading excavator buckets — Volumetric ratings*

ISO 9248:1992, *Earth-moving machinery — Units for dimensions, performance and capacities, and their measurement accuracies*

ISO 14397-2, *Earth-moving machinery — Loaders and backhoe loaders — Part 2: Test method for measuring breakout forces and lift capacity to maximum lift height*

3 Terms, definitions and symbols

For the purposes of this part of ISO 14397, the terms, definitions and symbols given in ISO 6165 and ISO 6746-1 and the following apply.

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3.1 Terms and definitions

3.1.1
rated operating capacity
N
calculated value, in kilograms, representing normal loading under typical operating conditions

3.1.2
minimum calculated tipping load
m_{tip}
minimum mass, in kilograms, which, when placed in the loader bucket, will cause the loader to achieve the tipping limit condition in its least stable configuration, with the loader placed on a hard, level surface and the resultant force acting vertically through the centroid of the rated bucket volume as specified in ISO 7546

3.1.3
lift capacity to maximum height
m_{lift}
mass, in kilograms, which can be lifted from the ground to maximum height using the lift cylinder or cylinders at hydraulic circuit working pressure, with the bucket positioned to hold the maximum load and the resultant force acting vertically through the centroid of the rated bucket volume as specified in ISO 7546

3.1.4
maximum moment arm
n
maximum horizontal distance between the load centre of gravity and the tipping line when the bucket is retracted to achieve a horizontal strike plane

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NOTE The maximum moment arm, n, of each type of loader is shown in Figures 1 to 6.

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3.1.5
tipping limit condition
⟨wheel loaders⟩ condition in which at least one of the wheels farthest from the tipping line no longer touches the ground

3.1.6
tipping limit condition
⟨crawlers⟩ condition in which the rear track roller or rollers no longer touch the track rail link surface

NOTE For other types of suspension, the tipping limiting condition is that specified by the manufacturer.

3.1.7
tipping line
line about which the loader tips

NOTE See Figures 1 to 6.

3.1.8
operating mass
mass of the base machine with equipment and empty attachment as specified by the manufacturer, and with the operator (75 kg), full fuel tank and all fluid systems at the levels specified by the manufacturer

[ISO 6016:1998]

3.1.9
hydraulic circuit working pressure
pressure applied to the specific hydraulic lifting circuit by the hydraulic pump or pumps

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3.1.10
swing loader
loader having a swing type lift arm which can rotate to the left and right of the straight position

3.2 Symbols

$A1$	articulation angle, as defined in ISO 6746-1	°
G_1	measured load on the front wheel at the opposite side of the tipping line (without load in bucket)	kg
G_2	measured load on the rear wheel at the opposite side of the tipping line (without load in bucket)	kg
G_H	measured load on the rear axle (without load in bucket)	kg
$L2$	crawler base, as defined in ISO 6746-1	m
$L3$	wheel-base, as defined in ISO 6746-1	m
$L5$	rear axle to hinge (pivot of the articulated steering), as defined in ISO 6746-1	m
m_{lift}	lift capacity to maximum height (see 3.1.3)	kg
m_{tip}	minimum calculated tipping load (see 3.1.2)	kg
N	rated operating capacity (see 3.1.1)	kg
n	maximum moment arm (see 3.1.4)	m
n_1	moment arm of load G_1 (horizontal distance between centre of action of G_1 and side tipping line)	m
n_2	moment arm of load G_2 (horizontal distance between centre of action of G_2 and side tipping line)	m
$W1$	maximum width, as defined in ISO 6746-1 (see ISO 14397-2)	m
$W2$	track gauge, as defined in ISO 6746-1 (see ISO 14397-2)	m
$W3$	tread (wheel track), as defined in ISO 6746-1	m
$W4$	track shoe width, as defined in ISO 6746-1 (see ISO 14397-2)	m

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4 Calculation of rated operating capacity

4.1 Principle

For each type of loader, the configurations in which the loader is most likely to tip over are assessed and the corresponding tipping line determined. The rated operating capacity, N, is then given by:

$$N = k \times m_{tip} \quad (1)$$

or

$$N = m_{lift}$$

(whichever is less)

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where

k is a factor accounting for the effects of the operating surface and of the dynamic forces caused by travel speed, tyre deflection, etc., equal to

0,5 for wheel loaders and backhoe loaders, and

0,35 for crawler loaders and crawler backhoes;

m_{tip} is the minimum calculated tipping load, equal to the sum of the moments opposing the tipping over of the loader divided by the maximum moment arm:

$$m_{\text{tip}} = \sum_i \frac{G_i \times n_i}{n} \tag{2}$$

where

G_i is a partial load that opposes the tipping over of the loader, and

n_i is its corresponding moment arm with respect to the tipping line;

m_{lift} is the lift capacity to maximum height, determined in accordance with ISO 14397-2.

4.2 Loader configurations

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4.2.1 General

The loader shall be the standard version specified by the manufacturer.

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If the tipping load is determined under specific conditions, as is the case with additional counterweights, ripper, backhoe or tyre ballast, then these conditions shall be specified in the operator's manual and advertizing literature so that the stable operating conditions are clearly defined.

The backhoe portion of backhoe loaders shall be in the transport position specified by the manufacturer.

4.2.2 Rigid frame type

Rigid frame wheel loaders and backhoe loaders with steered wheels shall be in the straight-ahead position (see Figures 1 and 3).

4.2.3 Articulated frame type

Articulated frame wheel loaders and backhoe loaders shall be positioned with the frames both straight and fully articulated to the right and left (see Figure 2).

4.2.4 Swing-arm type

Swing-arm type wheel loaders shall be turned in the most unstable position, as defined by the manufacturer (see Figures 4 and 5).

4.2.5 Bucket

The bucket shall be positioned to provide the maximum moment arm, as defined in 3.1.4 and shown in Figures 1 to 6.

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4.3 Procedure

4.3.1 Wheel loaders and backhoe loaders — Articulated or Ackermann steering

4.3.1.1 General

Measure the load, G_H, in kilograms, on the rear axle, with the empty bucket positioned as shown in Figures 1, 2 and 3 and with full articulation in the case of articulated machines.

For compact loaders, the calculation method given for articulated or straight-frame machines may only be used if

$$A1 \leqslant 45° \text{ and } \frac{W3}{L3} \leqslant 0{,}7 \quad (3)$$

4.3.1.2 Wheel loaders and backhoe loaders — Articulated steering at maximum articulation

With the steering system at maximum articulation, right and left, calculate the rated operating capacity, in kilograms, using the following formula:

$$N = k \times m_{\text{tip}} = 0{,}5 \times \frac{G_H \left(L3 - L5 + L5 \times \cos A_1 \right)}{n} \quad (4)$$

4.3.1.3 Straight-frame wheel loaders and backhoe loaders — Ackermann steering

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With the steering system in the straight-ahead position, calculate the rated operating capacity, in kilograms, using the following formula:

$$N = k \times m_{\text{tip}} = 0{,}5 \times \frac{G_H \times L3}{n} \quad (5)$$

ISO 14397-1:2002
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4.3.2 Swing-arm type wheel loaders — Articulated or Ackermann steering

4.3.2.1 Swing-arm type wheel loaders — Swing arm in straight position — Articulated steering

See Figures 4 and 5. Use Equation (4).

4.3.2.2 Swing-arm type wheel loaders — Swing arm in straight position — Ackermann steering

Use Equation (5).

4.3.2.3 Swing-arm type wheel loaders — Swing arm perpendicular to tipping line — Articulated steering at maximum articulation and to most critical side

See Figure 6. Measure the loads, G_1 and G_2, in kilograms, on the two wheels (front and rear) opposite the bucket position, with the empty bucket and the swing arm perpendicular to the tipping line, at maximum steering articulation and to the most critical side, as defined by the manufacturer.

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Calculate the rated operating capacity, N, in kilograms, using the following formula:

$$N = k \times m_{tip} = 0{,}5 \times \frac{G_1 n_1 + G_2 n_2}{n} \tag{6}$$

where

$$n_1 = W3 \times \cos\left[\operatorname{arccot}\left(\frac{L3 - L5 + L5 \times \cos A1 - 0{,}5 \times W3 \times \sin A1}{L5 \times \sin A1 + 0{,}5 \times W3 \times \cos A1 - 0{,}5 \times W3}\right)\right], \text{ in metres} \tag{7}$$

$$n_2 = W3 \times \cos\left[A1 - \operatorname{arccot}\left(\frac{L3 - L5 + L5 \times \cos A1 - 0{,}5 \times W3 \times \sin A1}{L5 \times \sin A1 + 0{,}5 \times W3 \times \cos A1 - 0{,}5 \times W3}\right)\right], \text{ in metres} \tag{8}$$

4.3.2.4 Swing-arm type wheel loaders — Swing arm perpendicular to tipping line — Ackermann steering at maximum steering angle

Measure the loads G_1 and G_2, in kilograms, on the two wheels (front and rear) opposite the bucket position, with the bucket empty, the swing arm perpendicular to the tipping line, and at the maximum steering angle.

Calculate the rated operating capacity, N, in kilograms, using the following formula:

$$N = 0{,}5 \times \frac{(G_1 + G_2) \times W3}{n} \tag{9}$$

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4.3.3 Crawler loader

Measure the load G_H on the sprocket centreline, with the empty bucket positioned as shown in Figure 7.

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Calculate the rated operating capacity, N, in kilograms, using the following formula:

$$N = 0{,}35 \times \frac{G_H \times L2}{n} \tag{10}$$

5 Tipping load verification test

5.1 General

A variability exists between the calculated and the test values. This is because dynamic forces acting on wheel loaders and backhoe loaders (caused by travel speed, tyre deflection, the suspension system and tyre penetration of the operating surface under test conditions) will result in values lower than those determined by calculation. The loader test results may be influenced by dynamic factors associated with ground contact and tyre and suspension design.

5.2 Test equipment

The test equipment shall be in accordance with ISO 14397-2.

Maximum travel speed at rated operating capacity is assumed to be less than the maximum travel speed. The travel speed with the bucket in the normal carry position shall not exceed

— 15 km/h for wheel loaders and backhoe loaders, and

— 6 km/h for crawler loaders and crawler backhoe loaders.

It is recommended that the load be reduced if the speed exceeds the stated values.

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5.3 Operating surface and loader configuration

The operating surface shall be

— hard, substantially smooth and level for wheel loaders and wheel backhoe loaders, and

— softer, and not as smooth or level for crawler loaders and crawler backhoe loaders.

The machine configuration shall be in accordance with 4.2.

5.4 Test measurement of minimum tipping load

Using a hydraulic cylinder or mechanical winch, apply a vertical downward force acting through the bucket volume centroid to find the tipping condition.

For a wheel loader, wheel backhoe loader or wheel swing loader, record the force when the rear tyre or tyres leave the ground in the straight-ahead position, and convert the force to the equivalent tipping load, in kilograms. In the case of an articulated configuration, test with the oscillating axle unblocked and the force measurement taken when one wheel opposite the tipping line leaves the ground.

For a crawler loader, take the force measurement when the rear rollers leave the track link surface. The oscillating axle shall be unlocked, except in the case of swing loaders, where an automatic activation of the oscillating axle occurs during lift arm swinging.

5.5 Verification

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The calculated values shall be within 2 % of the test results, in accordance with ISO 9248.

5.6 Test report

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The following information shall be included in the test report on the verification of the calculated tipping load:

a) manufacturer;

b) model;

c) type;

d) test machine product identification number;

e) machine operating mass for test (see ISO 6016), in kilograms;

f) mass and location of additional counterweights, in kilograms ;

g) steering, comprising

  — maximum articulated steering angle for articulated frame loaders, in degrees, and

  — maximum swing angle of swing loader arms, in degrees;

h) tyre type and size(s);

i) tyre pressure(s), in kilopascals;

j) type and width of track shoes, crawler loaders (see ISO 6746-1);

k) lift capacity to maximum height, in kilograms;

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