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

*Engins de terrassement — Méthodes de mesure des masses des  
engins de terrassement complets, de leurs équipements et de leurs  
organes constitutifs*

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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.

International Standards are drafted in accordance with the rules given in the ISO/IEC Directives, Part 2.

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 document may be the subject of patent rights. ISO shall not be held responsible for identifying any or all such patent rights.

ISO 6016 was prepared by Technical Committee ISO/TC 127, *Earth-moving machinery*, Subcommittee SC 1, *Test methods relating to safety and machine performance*.

This third edition cancels and replaces the second edition (ISO 6016:1998), which has been technically revised.

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# Earth-moving machinery — Methods of measuring the masses of whole machines, their equipment and components

## 1 Scope

This International Standard specifies methods for measuring the masses of whole earth-moving machines, their equipment, attachments or components, using weighbridges or force transducers. It also defines the terms related to these masses.

It is applicable to earth-moving machinery as defined in ISO 6165.

## 2 Normative references

The following referenced documents are indispensable for the application of this document. For dated references, only the edition cited applies. For undated references, the latest edition of the referenced document (including any amendments) applies

ISO 6165:2006, *Earth-moving machinery — Basic types — Identification and terms and definitions*

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

## 3 Terms and definitions

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

### 3.1 General definitions

#### 3.1.1

##### **base machine**

machine with a cab or canopy and operator-protective structures if required, without equipment or attachments but possessing the necessary mounting for such equipment and attachments

NOTE For an example, see Figure 1.

#### 3.1.2

##### **equipment**

set of components mounted onto the base machine that allows an attachment to perform the primary design function of the machine

NOTE For examples, see Figure 1.

#### 3.1.3

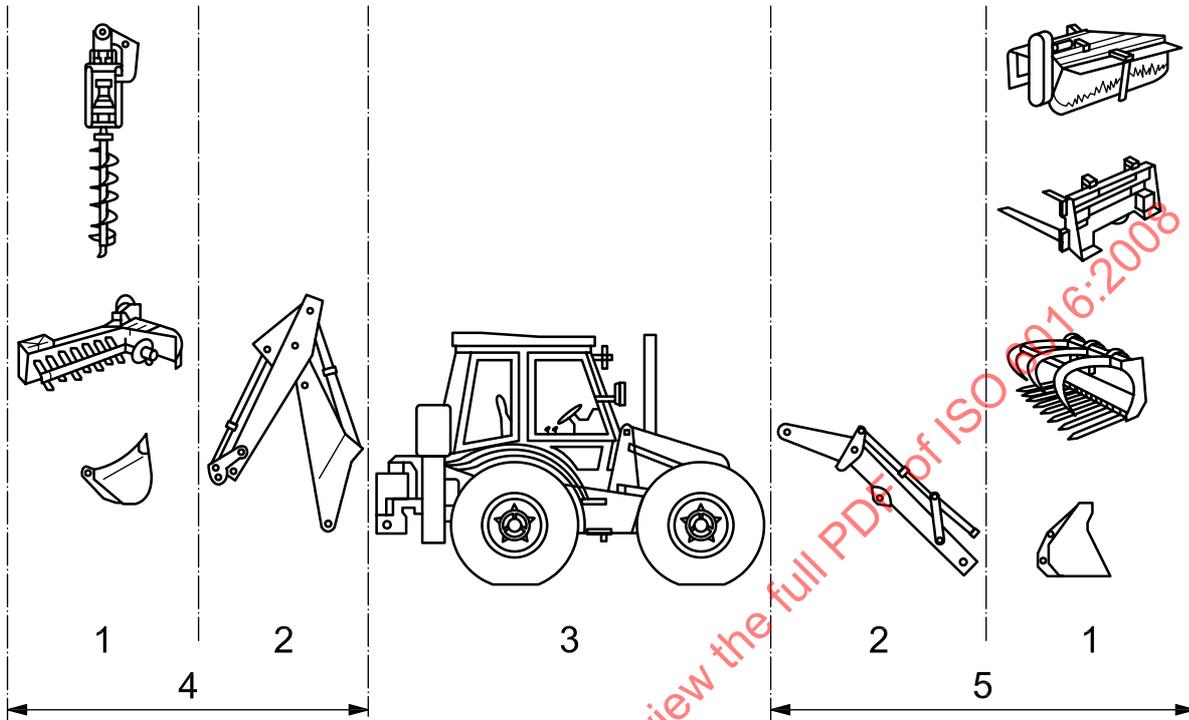
##### **optional equipment**

optional components mounted onto the base machine or equipment to increase, for example, capacity, flexibility, or enhance comfort

**3.1.4 attachment**

assembly of components that can be mounted onto the base machine or equipment for specific use

NOTE For examples, see Figure 1.



**Key**

- 1 attachment
- 2 equipment
- 3 base machine
- 4 backhoe portion
- 5 loader portion

NOTE This illustration of a loader, its equipment and attachments, is given by way of example only. Equipment and attachments can differ from one machine to another and between machine types. Some base machines can be fitted directly with an attachment (e.g. a grader with a dozer blade).

**Figure 1 — Base machine, equipment and attachments**

**3.1.5 component**

part, or assembly of parts, of a base machine, equipment or attachment

**3.1.6 ballast**

removable weight added to the base machine or equipment as specified by the manufacturer, which is used to increase machine performance, e.g. stability, traction or compaction

NOTE Ballast can be added through the use of weights on wheels, frames or axles, counterweights, liquid-filled tyres, or compartments to be filled with water, sand or iron parts.

**3.1.7 left-hand [right-hand] side**

side defined when the machine is oriented towards its primary direction of travel

**3.1.8****front axle [rear axle] of machine**

axle defined for the primary direction of travel

**3.2 Masses****3.2.1****operating mass****OM**

mass of the base machine, with equipment and empty attachment in the most usual configuration as specified by the manufacturer, and with the operator (75 kg), full fuel tank and all fluid systems (i.e. hydraulic oil, transmission oil, engine oil, engine coolant) at the levels specified by the manufacturer and, when applicable, with sprinkler water tank(s) half full

NOTE 1 The mass of an operator is not included for non-riding machines.

NOTE 2 Ballast mass at delivery can be included if specified by the manufacturer.

**3.2.2****rated payload****PL****paymass**

mass that can be carried by the machine, as specified by the manufacturer

**3.2.3****rated ballast mass****BM**

maximum mass of ballast that can be added to the machine, as specified by the manufacturer

**3.2.4****gross machinery mass****GMM**

maximum machine mass as approved by the manufacturer, which combines the operating mass (OM) of the machine with the heaviest combination of equipment and attachments, the heaviest combination of optional equipment, the rated payload (PL), as specified by the manufacturer, the rated ballast mass (BM) and, when applicable, full sprinkler water tank(s)

**3.2.5 Axle distribution of masses of wheeled machines****3.2.5.1****axle load**

mass on each axle at the **operating mass** (3.2.1)

**3.2.5.2****maximum axle load**

maximum mass allowable on each axle, as specified by the manufacturer

**3.2.6****shipping mass****SM**

mass of the base machine without an operator, with the fuel level at 10 % of tank capacity or with the minimum fuel level needed for machine shipping purposes as specified by the manufacturer, whichever is higher, with all fluid systems at the levels specified by the manufacturer and with empty sprinkler tank(s), when applicable, and with or without equipment, ballast, attachment, cab, canopy, operator-protective structures, wheels and counterweights as stated by the manufacturer

NOTE If the manufacturer intends that the machine be partially disassembled for shipping purposes, the masses of the disassembled items will also be stated.

### 3.3 Measurements

#### 3.3.1

##### **single measurement**

measurement whose result is obtained as the indication of one measuring device or as a sum of the indications of several measuring devices acting simultaneously

#### 3.3.2

##### **cumulative measurement**

measurement whose result is obtained as a sum of the indications of a single measuring device or that of several measuring devices acting successively

#### 3.3.3

##### **axis of support**

line(s) through the centerline(s) of the axles or the centre of the left-hand-side and right-hand-side wheels or track about which the machine rotates

### 3.4 Apparatus

#### 3.4.1

##### **general**

complete set of equipment and devices required to determine the mass of a machine or its equipment or attachment or component

#### 3.4.2

##### **weighbridge**

device with a platform, normally flush with the adjacent surfaces, used to determine mass

NOTE Force transducers can be used within the weighbridge to determine the mass.

#### 3.4.3

##### **force transducer**

device used to determine mass by measuring the force applied either by tension or pressure

#### 3.4.4

##### **knife edge**

device with an angled edge used to support and transfer the load at the axis of support of the machine

#### 3.4.5

##### **decking**

material of suitable size and strength for distributing machine mass over weighbridges

## 4 Preparation for testing

The machine shall be clean and equipped according to the manufacturer's specifications.

In the case of a cumulative measurement, the same fixed position of the equipment and attachment in relation to the base machine shall be ensured for all measurements.

Articulated machines should normally be tested in a straight line.

Wheeled machines shall be tested with the brakes released. Where necessary, crawler machines shall be manoeuvred until the contact-grousers are level on each side.

**IMPORTANT — It is essential to ensure that the ground reactions in the horizontal plane are zero.**

## 5 Methods for measuring mass

### 5.1 General

The single measurement method should be used whenever possible. The cumulative measurement method may be used when the mass or the physical size of the base machine, equipment and attachment exceeds the capabilities of the measurement apparatus available.

### 5.2 Precision of measurement apparatus

The precision of apparatus used to determine masses of whole earth-moving machinery, equipment or attachments shall be such that the total measurement procedure provides a result of an accuracy within the tolerances specified in ISO 9248. It is recommended that weighbridges, force transducers and other measurement equipment used be subjected to a calibration procedure.

### 5.3 Single-measurement method

#### 5.3.1 Principle

This method involves measuring the ground reaction forces acting simultaneously on the machine at its axes of support as in Figure 2 and Figure 3 a) or 3 b), or, alternatively, the force acting on a tensile force transducer or transducers when the machine is suspended over the ground as in Figure 4.

#### 5.3.2 Procedure

When a single weighbridge or force transducer is used, the machine shall be placed centrally on it, as shown in Figure 2.

When several weighbridges or a pressure force transducer or transducers are used, the wheels or tracks of the machine shall be placed as close as possible to the centre of the platforms of these weighbridges or force transducer(s), as shown in Figure 3 a). Decking and knife edges shall be used for crawler machines to ensure the correct transfer of load exerted by machine mass to the weighbridges or force transducer(s), as shown in Figure 3 b).

When one or more tensile force transducers are used, one end of the slinging apparatus (steel cables, chains, ropes, etc.) shall be attached to the lifting points on the machine, with the machine in the manufacturer's recommended position for lifting, and the other end shall be attached to the suspended force transducer(s). The machine shall then be lifted or the machine supports lowered as shown in Figure 4. If more than one force transducer is used, the vertical position for each transducer shall be ensured.

#### 5.3.3 Measurement results

The result of each measurement shall be reduced by the mass of any decking, knife edge or slinging apparatus used.

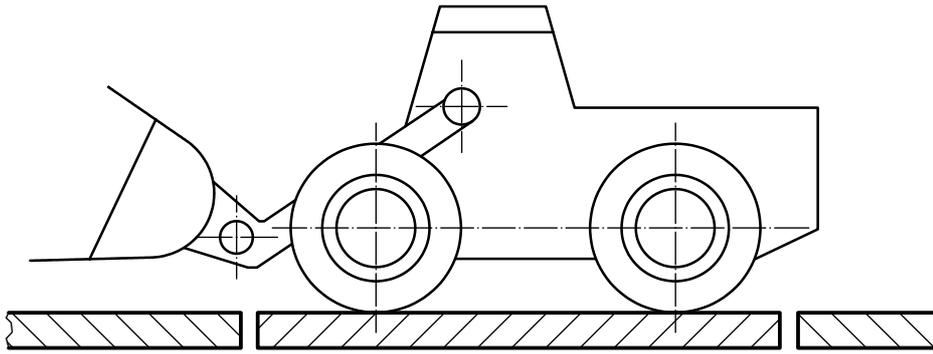
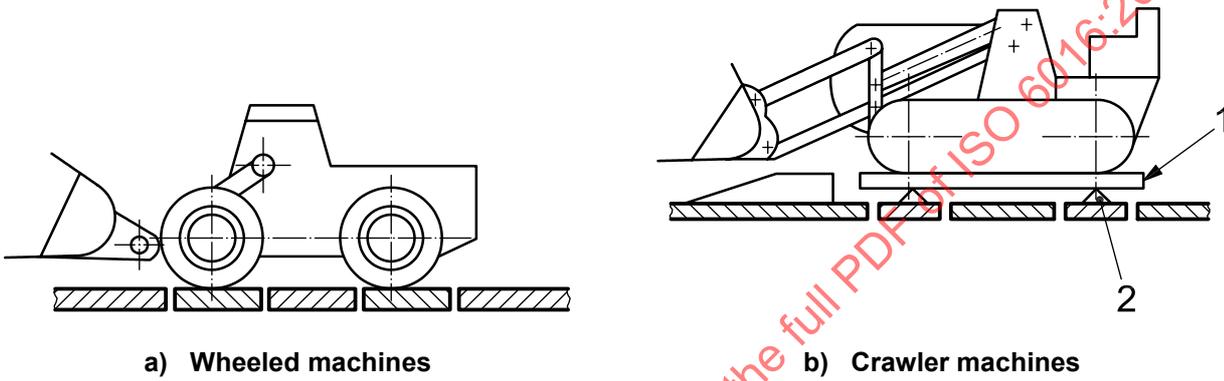


Figure 2 — Weighbridge



a) Wheeled machines

b) Crawler machines

Key

- 1 decking
- 2 knife edge

Figure 3 — Weighbridges or force transducers

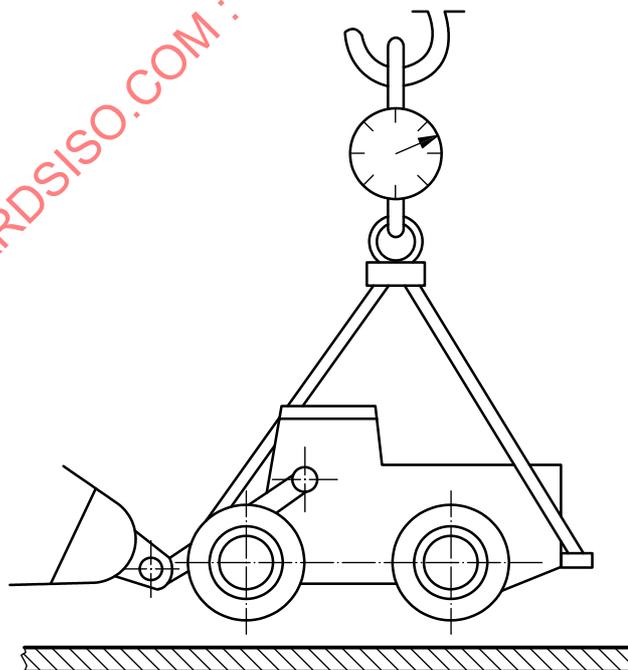


Figure 4 — Crane hook — Force transducer

## 5.4 Cumulative measurement method

### 5.4.1 Principle

This method involves successive measuring of the ground reaction forces acting on the machine at its axes of support when it is placed as shown in Figure 5 and 6.

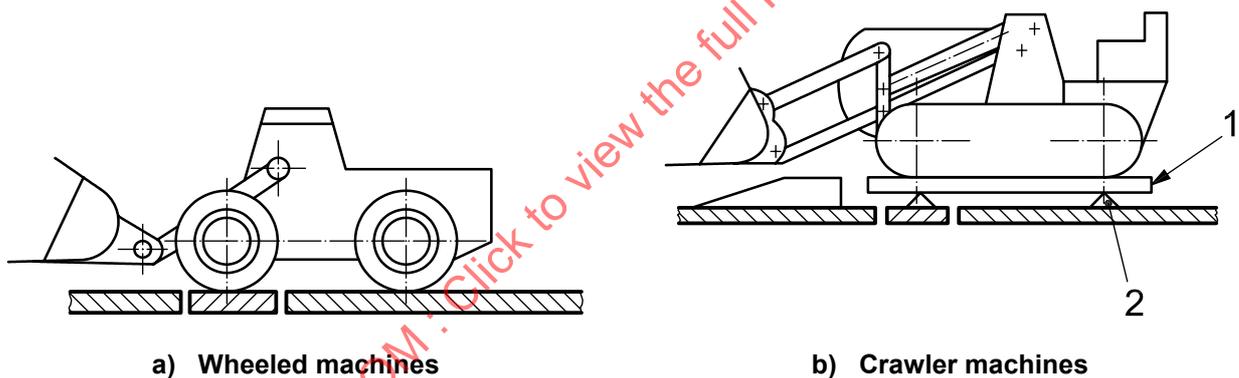
### 5.4.2 Procedure

When a single weighbridge or force transducer is used, the machine shall be placed with one wheel or one axis of support (as shown in Figures 5 and 6) on the platform, while the other axis is supported on a hard surface adjacent to the weighbridge. The partial mass shall be measured with the machine always in a level position. The machine shall then be placed with the other axis of support on the single weighbridge or force transducer. If measuring each wheel individually, the partial mass of each wheel shall be measured. The partial masses shall be combined to determine the total mass.

When several weighbridges or pressure force transducers are used, they shall be placed successively under each axis of support while keeping the machine in a level position.

### 5.4.3 Measurement results

The result of each measurement shall be reduced by the mass of any decking or knife edges used.



#### Key

- 1 decking
- 2 knife edge

Figure 5 — Weighbridge or force transducer — Axes of support — Front and rear axles of machine