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Powered industrial trucks and tractors — Brake performance and component strength

Chariots de manutention et tracteurs industriels automoteurs — Performance de freinage et résistance des éléments de frein

Reference number
ISO 6292:2008(E)

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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 6292 was prepared by Technical Committee ISO/TC 110, *Industrial trucks*, Subcommittee SC 2, *Safety of powered industrial trucks*.

This second edition cancels and replaces the first edition (ISO 6292:1996) and includes some of the contents of ISO 6292:1996 but has some major changes in approach to brake requirements for powered industrial trucks and tractors.

The major changes in approach are:

— stopping distance methodology has been included. Braking reaction time, but not human reaction time, is included in the determination of the stopping distance. See ISO/TR 29944;

— addition of assessment of brake fade;

— groups A1 and A2 (see Table 2) to be categorised by truck rated capacity or laden mass.

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Introduction

Industrial trucks, tractors and burden carriers, generally referred to as trucks throughout, can satisfy the braking requirements of this International Standard by complying with either the stopping distance requirements or the drawbar drag requirements. Based on the requirements for brakes of rubber-tyred earthmoving machinery (ISO 3450), the stopping distance as a measurement value has been established. The brake performance is limited by consideration of the load. For further reference as to how the measurement of stopping distance and measurement of brake reaction time were derived, see ISO/TR 29944.

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Powered industrial trucks and tractors — Brake performance and component strength

1 Scope

This International Standard specifies performance, test methods, controls, control forces and component strength for brake systems fitted to

— powered industrial trucks of all capacities,

— industrial tractors with rated capacities up to and including 20 000 N drawbar pull,

— burden carriers, and

— industrial trucks handling freight containers,

as defined in ISO 5053.

Loss of electrical power and loss of any other form of power assistance is not covered by this International Standard. Braking used in emergency situations (e.g. activating the emergency switch or control system shut down) is not covered in this International Standard.

This International Standard only includes requirements for newly manufactured trucks.

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 3691-1:—[1)], *Industrial Trucks — Safety requirements and verification — Part 1: Self-propelled industrial trucks, other than driverless, variable-reach trucks and burden-carrier trucks*

ISO 5053, *Powered industrial trucks — Terminology*

1) To be published. (Revision of ISO 3691:1980)

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3 Terms and definitions

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

3.1
actual truck velocity
v
actual measured velocity of the truck, just prior to the service brake being applied

3.2
brake fade
decrease of braking torque as a function of temperature and/or speed at constant application force

3.3
braking force
force at the contact surface between a wheel and the ground, produced by the effect of a braking system, which opposes the velocity or the tendency to movement of the vehicle

[ISO 611:2003, definition 9.11.3]

3.4
braking performance
performance of a braking system as measured by the braking distance in relation to the initial speed of the truck and/or by braking force and the capability to hold the truck at a standstill on a gradient

3.5
braking system
combination of parts which fulfil one or more of the following functions:

— control (usually to reduce) a vehicle's speed,

— bring the vehicle to a halt or hold it stationary

[ISO 611:2003, definition 3.2]

3.6
cold brakes
brake that meets one of the following conditions:

a) the temperature measured at the periphery of the disc or on the outside of the drum is below 100 °C;

b) in the case of totally enclosed brakes including oil-immersed brakes, the temperature on the outside of the housing is below 50 °C or within the manufacturer's specification;

c) the brake has not been operated in the previous 1 h.

3.7
control device
part of the braking system which initiates its operation

NOTE Control devices of industrial trucks are defined in ISO 3691-1:—, 5.4.2.2, 5.4.2.3 and 5.4.2.4.

3.8
fade test
〈lining effectiveness〉 test procedure consisting of one or more brake applications or the continuous dragging of the brake to generate heat with the effect that differences in braking performance, if any, can be observed

[ISO 611:2003, definition 8.4]

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3.9
lining bedding
lining burnishing
pre-test conditioning procedure for obtaining a specified degree of geometric, physical and chemical adaptation between the brake lining surface and the drum

3.10
laden mass
foreseen maximum laden truck mass likely to occur in the intended use of the truck, taking into account various combinations of optional equipment and the actual capacity applicable at the lift height specified for the tests (where relevant)

3.11
parking braking system
braking system allowing a vehicle to be held stationary mechanically, even on an inclined surface, particularly in the absence of the operator

3.12
service braking system
braking system allowing the operator to control, directly or indirectly, the speed of the truck or to bring the truck to a halt

3.13
stopping distance
s_0
distance travelled by the truck during the total braking time, i.e. distance travelled by the truck from the instant when the driver begins to actuate the control device until the instant when the truck stops

3.14
test velocity
velocity greater than 90 % of the maximum designed truck velocity

NOTE If the truck velocity is automatically reduced in certain load conditions or load positions (i.e. lift height dependent), this reduced velocity is the maximum travel velocity for that load condition/position.

3.15
unladen mass
foreseen minimum unladen truck mass is likely to occur in the intended use of the truck, taking into account various combinations of optional equipment

4 Requirements

4.1 General

The following requirements for brake systems apply.

4.2 Required brake systems

The truck shall have the following brake systems:

— a service brake system;

— a parking brake system.

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4.3 Operating means

The service and parking brakes shall be operated by means of independent systems. Both braking systems may utilize the same brakes; i.e. brake shoes, brake drums and related actuating items. The exceptions to this requirement are brake systems fitted to stand-on and pedestrian controlled trucks as defined in ISO 3691-1.

4.4 Service brake system

All trucks shall meet the service brake requirements of 6.2 and 6.4.

4.5 Parking brake system

The parking brake system shall meet the requirements of 6.1.

4.6 Brake control forces

The control forces to meet the required brake performances for the systems, as specified in 6.1 and either 6.2.1 or 6.2.2, shall not exceed the values given in 4.6.1 to 4.6.5 and summarised in Table 1.

4.6.1 For brakes applied by depressing a pedal, the required service brake performance and parking brake performance shall be attained with a pedal force not greater than 450 N.

4.6.2 For brakes applied by an upward movement of a brake pedal (releasing the brake pedal), the required service brake performance and parking brake performance specified shall be attained with the pedal fully released. The force required to release the brakes and to hold the pedal fully depressed whilst travelling shall not be greater than 200 N.

4.6.3 For parking brakes applied by means of a handlever, the required brake performance shall be attained when a force not greater than 300 N is applied to the handlever at the gripping point.

4.6.4 For service brakes applied by squeezing a handgrip, the required brake performance shall be attained when a force not greater than 150 N is applied to the handlever at the gripping point.

4.6.5 For brakes applied by means of a tiller which is biased, e.g. spring loaded, to the upright position (as on pedestrian controlled trucks), the required service brake performance shall be attained at the maximum depressed stroke position of the tiller when a force not greater than 150 N is applied at the mid-point of the handgrip.

4.7 Brake component strength

The strength of brake components shall not be lower than the values given in 4.7.1 to 4.7.5 and summarised in Table 1.

4.7.1 For trucks having a downward movement of a brake pedal (depressing the brake pedal) to apply the service or parking brake(s), the system shall be capable of withstanding a brake pedal force of at least 1 200 N without any failure, cracking or deformation which affects the brake performance or function.

4.7.2 For trucks having an upward movement of a brake pedal (releasing the brake pedal) to apply the service or parking brake(s), the system shall be capable of withstanding a force of 200 % of the maximum possible setting of the spring which applies the brake(s), without any failure or cracking or any deformation which affects the brake performance or function.

The pedal when fully depressed, and its associated mechanical stop shall be capable of withstanding a force of 1 800 N applied at the centre of the brake pedal actuating surface without any failure, cracking or deformation which affects the brake performance or function.

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4.7.3 For trucks having a handlever to apply the parking brake(s), the system shall be capable of withstanding a force of at least 600 N applied at the gripping point of the lever, without any failure, cracking or deformation which affects the brake performance or function.

4.7.4 For trucks having a handgrip which is squeezed to apply the service brake(s), the system shall be capable of withstanding a force of at least 300 N applied to the handgrip, without any failure, cracking or deformation which affects the brake performance or function.

4.7.5 For trucks having a tiller which is depressed or released to apply the service or parking brake(s), the system and associated mechanical stops shall be capable of withstanding a force of at least 900 N when applied at the mid point of the handgrip, without any failure, cracking or deformation which affects the brake performance or function.

Table 1 — Brake control forces and component strengths

Brake type	Service brake		Parking brake	
	Maximum control force	Minimum component strength	Maximum control force	Minimum component strength
Depressed pedal	450 N	1 200 N	450 N	1 200 N
Released pedal	200 N	Up-stop 200 % maximum spring setting and Down stop 1 800 N [a]	200 N	Up-stop 200 % maximum spring setting and Down stop 1 800 N [a]
Handlever	—	—	300 N [b]	600 N
Squeeze grip	150 N	300 N	—	—
Tiller	150 N	900 N	—	900 N

[a] See 4.7.2.

[b] See 6.1.2, last paragraph.

4.8 Stored energy system

4.8.1 Service brake recovery capacity

If an air operated service braking system employing stored energy is used, then, with the truck stationary, the service braking system shall have the capability of delivering 70 % of maximum system pressure measured at the brakes when the brakes are fully applied 20 times at the rate of six applications per minute with the engine running at the optimum speed for braking energy recovery.

4.8.2 Warning device for stored energy system

A service braking system employing stored energy shall be equipped with a warning device, which actuates before the stored energy drops below 50 % of the manufacturer's specified maximum operating energy level. The device shall be readily visible and/or audible to the operator, and shall provide a continuous warning. Gauges indicating pressure or vacuum do not meet these requirements.

4.9 Additional requirements

In some markets, the additional requirements listed in the normative Annex A apply.

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5 Test conditions

5.1 General

5.1.1 Manufacturer's precautions shall be observed while carrying out performance tests.

5.1.2 The test course shall consist of a hard dry surface made of concrete, asphalt or an equivalent surface.

The test course shall have no more than 2 % slope at right angles to the direction of travel. Slope in the direction of travel shall be level ± 0,5 %.

5.1.3 For the laden condition, the truck shall be tested with rated capacity in a position recommended by the manufacturer. The mast or the forks shall be tilted fully rearward and fully retracted, if it is provided by the design of the truck.

NOTE The load may be secured to the truck during testing.

5.1.4 Tractors shall be tested without load or trailers.

5.1.5 The truck mass and axle load distribution shall be measured and recorded.

5.1.6 All parameters relating to braking systems shall be within the manufacturer's specifications, i.e. tyre size and pressure, brake adjustment. No manual adjustments shall be made to the braking system in the course of each performance test.

5.1.7 If the truck is fitted with a power boost system (brake servo-assistance), the system shall be operating.

5.1.8 Burnishing or conditioning of brakes before testing is permissible.

5.1.9 Immediately prior to a test, the truck shall be operated until the truck fluids, i.e. engine and transmission oils are at normal operating temperature as specified by the manufacturer.

5.1.10 At the commencement of the parking brake performance tests (6.1) and the service brake performance tests (6.2) the brakes shall be cold.

5.2 Stopping distance test

5.2.1 The approach to the test course shall be of sufficient length, smoothness and uniformity to ensure the test velocity is reached before the brakes are actuated.

5.2.2 When the truck transmission provides a selection of gear ratios, the tests shall be conducted with the transmission in the gear corresponding to the test velocity specified.

The drive system may be disengaged prior to completing the stop.

5.2.3 The truck test velocity shall be at that velocity measured immediately prior to the brake control being applied.

5.3 Drawbar drag test

5.3.1 Drawbar drag test shall not be conducted on trucks where the braking force is directly related to truck velocity, e.g. electronic regenerative braking systems.

5.3.2 When measuring the drawbar drag the truck velocity shall not be greater than 1,6 km/h. The drawbar shall be essentially horizontal and attached to a point recommended by the manufacturer.

5.3.3 Travel controls shall be in neutral and the parking brake shall be fully disengaged except when service and parking brake are the same device.

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6 Performance tests

The performance test requirements shall be met for all truck configurations/conditions: laden, unladen, different battery mass, etc.

6.1 Parking brake performance

6.1.1 The parking brake performance shall be tested in each direction of travel of the truck.

6.1.2 The parking brake, without the assistance of the operator, shall be capable of holding the truck either on the following gradient or on the gradient specified by the manufacturer, whichever is the greater.

a) Trucks with elevating operating position above 1 200 mm and trucks specifically designed to travel with elevated loads: 5 %.

   NOTE This does not include industrial trucks handling freight containers.

b) Platform and stillage trucks, pallet trucks, platform-lift trucks, pallet-stacking trucks, low lift order picking trucks, straddle trucks, reach trucks, bi-directional lift trucks, multi-directional lift trucks, pedestrian-controlled trucks and pedestrian controlled tractors: 10 %.

c) Any other sit-on and stand-on industrial truck or tractor: 15 %.

If the specified gradient is more than 15 % the maximum control force for handlever parking brake application may exceed 300 N but shall not exceed 500 N.

6.2 Service brake performance

6.2.1 Stopping distance

The service brake system shall bring the truck to a complete stop within the stopping distance s_0 measured from the point of brake control application given in Table 2 under the test conditions as specified in Clause 5.

The stopping distance measurement is to start when the brake control means is actuated.

The brake system stopping test shall be conducted twice while travelling forward, once in each direction of the course and similarly twice while travelling in reverse. Cold brakes shall be used for each test run.

The forward stopping distance and truck velocity results shall be the average of the test measurements taken in each direction of the course. The same average calculations shall be made for the rearward direction.

6.2.2 Drawbar drag test

The brake system shall meet the requirements of Table 3 under the test conditions as specified in Clause 5.

The service brake performance shall be tested in both forward and reverse direction.

6.2.3 Alternative test procedures

Other test procedures which give equivalent accuracy may be used such as accelerometers, gradients etc. These procedures shall be verified by a reference measurement to the stopping distance.

Modelling/calculations, reinforced by actual test data on like trucks, may be used to show compliance for the service and parking brake performance.

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6.3 Warning device testing (for stored energy system)

A test shall be conducted to ensure the warning device (see 4.8.2) shall activate before the system energy drops below 50 % of the manufacturer's specified maximum operating energy level.

6.4 Heat fade test

6.4.1 The heat fade test shall be carried out after the truck has been tested as required in 6.2.1 and 6.2.2.

6.4.2 The service brake shall be applied and released to complete four consecutive stops at or as near as possible to the maximum deceleration of the truck without sliding the tyres. After each stop, the initial velocity shall be regained as quickly as possible using maximum acceleration. A fifth consecutive stop shall be measured and shall not exceed 125 % of the stopping distance previously reported in 6.2.1.

6.4.3 As an alternative to 6.4.2, the brake system shall complete four consecutive drawbar-drag tests. A fifth consecutive drawbar-drag test shall be measured and shall not be less than 75 % of the braking force reported in 6.2.2.

6.4.4 A heat fade test shall be conducted on trucks if alternative test procedures as defined in 6.2.3 are used.

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Table 2 — Stopping distance, s_0 [m], in consideration of velocity, v [km/h]

Group	Types of truck	Stopping distance s_0 m		
a) For truck velocity v km/h		$v \leqslant 5$	$5 < v \leqslant 13{,}4$	$v > 13{,}4$
A1	All industrial trucks except groups A2, B1, B2, C and D < 16 000 kg rated capacity or 35 000 kg laden mass, whichever is greater	$s_0 < 0{,}15\ v + \frac{v^2}{23{,}6}$	$s_0 < 0{,}15\ v + \frac{v}{4{,}7}$	$s_0 < 0{,}15\ v + \frac{v^2}{63{,}6}$
A2	All industrial trucks except groups B1, B2, C and D ⩾ 16 000 kg rated capacity or ⩾ 35 000 kg laden mass	$s_0 < 0{,}15\ v + \frac{v^2}{19{,}1}$	$s_0 < 0{,}15\ v + \frac{v}{3{,}8}$	$s_0 < 0{,}15\ v + \frac{v^2}{50{,}9}$
B1	Industrial tractors with 1 or 2 braked wheels	$s_0 < 0{,}15\ v + \frac{v^2}{33{,}1}$	$s_0 < 0{,}15\ v + \frac{v}{6{,}6}$	$s_0 < 0{,}15\ v + \frac{v^2}{89{,}0}$
B2	Industrial tractors with 3 or 4 braked wheels	$s_0 < 0{,}15\ v + \frac{v^2}{47{,}3}$	$s_0 < 0{,}15\ v + \frac{v}{9{,}5}$	$s_0 < 0{,}15\ v + \frac{v^2}{127{,}1}$
b) For truck velocity v km/h		$v \leqslant 4$	$4 < v \leqslant 13{,}4$	$v > 13{,}4$
C	Trucks with elevating operating position above 1 200 mm and trucks specifically designed to travel with elevated loads	$s_0 < 0{,}15\ v + \frac{v^2}{11{,}4}$	$s_0 < 0{,}15\ v + \frac{v}{2{,}8}$	$s_0 < 0{,}15\ v + \frac{v^2}{38{,}1}$
c) For truck velocity v km/h		All velocities		
D	Rough-terrain truck	$s_0 < 0{,}15\ v + \frac{v^2}{63{,}5}$		

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Table 3 — Calculation of braking force, F [N], in consideration of velocity, v [km/h], and mass, m [kg], of the laden truck

Group	Types of truck	Braking force F N		
a) For truck velocity v km/h		$v \leqslant 5$	$5 < v \leqslant 13{,}4$	$v > 13{,}4$
A1	All industrial trucks except groups A2, B1, B2, C and D < 16 000 kg rated capacity or 35 000 kg laden mass, whichever is greater	$F > 0{,}91\ m$	$F > 0{,}182\ v\ m$	$F > 2{,}45\ m$
A2	All industrial trucks except groups A1, B1, B2, C and D ⩾ 16 000 kg rated capacity or ⩾ 35 000 kg laden mass	$F > 0{,}73\ m$	$F > 0{,}146\ v\ m$	$F > 1{,}96\ m$
B1	Industrial tractors with 1 or 2 braked wheels	$F > 1{,}28\ m$	$F > 0{,}255\ v\ m$	$F > 3{,}43\ m$
B2	Industrial tractors with 3 or 4 braked wheels	$F > 1{,}82\ m$	$F > 0{,}365\ v\ m$	$F > 4{,}91\ m$
b) For truck velocity v km/h		$v \leqslant 4$	$4 < v \leqslant 13{,}4$	$v > 13{,}4$
C	Trucks with elevating operating position above 1 200 mm and trucks specifically designed to travel with elevated loads	$F > 0{,}44\ m$	$F > 0{,}110\ v\ m$	$F > 1{,}47\ m$
c) For truck velocity v km/h		All velocities		
D	Rough-terrain truck	$F > 2{,}45\ m$		

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Annex A
(normative)

Additional requirements

Japanese law requires industrial trucks operating in Japan to meet the following additional requirements.

— The stopping distance of an unladen truck travelling at a velocity of 20 km/h, or if the maximum velocity of the truck is less than 20 km/h at the maximum velocity of the truck, shall not exceed 5 m.

— The stopping distance of a laden truck travelling at a velocity of 10 km/h, or if the maximum velocity of the truck is less than 10 km/h at the maximum velocity of the truck, shall not exceed 2,5 m.

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