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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

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Foreword

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

Any feedback or questions on this document should be directed to the user's national standards body. A complete listing of these bodies can be found at www.iso.org/members.html.

This third edition cancels and replaces the second edition (ISO 6292:2008), which has been technically revised.

The main changes compared to the previous edition are as follows:

— the definition for drawbar drag has been added as 3.13;

— Subclause 4.7 (previously 4.8) has been technically revised;

— for service brake systems, the heat fade test is now compulsory in all test methods.

— the scope has been extended to industrial tractors with 66 750 N drawbar pull.

Introduction

Industrial trucks, generally referred to as trucks, can satisfy the braking system requirements of this document 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.

Powered industrial trucks and tractors — Brake performance and component strength

1 Scope

This document specifies performance, test methods, controls, control forces and component strength for brake systems fitted to the following, as defined in ISO 5053-1:

— powered industrial trucks of all capacities;

— towing and pushing tractors up to and including 66 750 N drawbar pull (hereafter referred to as industrial tractors);

— burden carriers; and

— industrial trucks handling freight containers.

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

This document only includes requirements for newly manufactured trucks.

2 Normative references

There are no normative references in this document.

3 Terms and definitions

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

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

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

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

3.1
braking force
force at the contact surface between a wheel and the ground, produced by the effect of a *braking system* (3.3), which opposes the speed or the tendency to movement of the truck

[SOURCE: ISO 611:2003, 9.11.3]

3.2
braking performance
performance of a *braking system* (3.3) as measured by the braking distance in relation to the initial speed of the truck and/or by *braking force* (3.1) and the capability to hold the truck at a standstill on a gradient

3.3
braking system
combination of parts which fulfil one or more of the following functions:

— control (usually to reduce) a truck's speed;

— bring the truck to a halt or hold it stationary

[SOURCE: ISO 611:2003, 3.2, modified — In the definition, the word "vehicle" has been changed to "truck".]

3.4
cold brake
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

3.5
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* (3.2), if any, can be observed

[SOURCE: ISO 611:2003, 8.4]

3.6
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 or disc

3.7
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)

3.8
parking braking system
braking system (3.3) allowing a truck to be held stationary mechanically, even on an inclined surface, particularly in the absence of the operator

3.9
service braking system
braking system (3.3) allowing the operator to control, directly or indirectly, the speed of the truck or to bring the truck to a halt

3.10
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

Note 1 to entry: Control device is part of the *braking system* (3.3) which initiates its operation. Control devices of industrial trucks are defined in ISO 3691-1:2011, 4.4.2.2, 4.4.2.3 and 4.4.2.4.

3.11
test speed
speed greater than 90 % of the maximum designed truck speed

Note 1 to entry: If the truck speed is automatically reduced in certain load conditions or load positions (i.e. lift height dependent), this reduced speed is the maximum travel speed for that load condition/position.

3.12
unladen mass
foreseen minimum unladen truck mass likely to occur in the intended use of the truck, taking into account various combinations of optional equipment

3.13
drawbar drag
steady state *braking force* (3.1) that can be applied to the ground by a mechanical *braking system* (3.3) at a given speed

4 Requirements

4.1 Required brake systems

The truck shall have the following brake systems:

— a service brake system;

— a parking brake system.

4.2 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. Independent brake systems are not required to be fitted to stand-on and pedestrian controlled trucks as defined in ISO 3691-1.

4.3 Service braking system

All trucks shall meet the service brake requirements for:

— stopping distance (6.3.1) and heat fade test (6.5.2);

— drawbar drag test (6.3.2) and heat fade test (6.5.3); or

— alternative test procedure (6.3.3), e.g. calculation, and heat fade test simulation (6.5).

4.4 Parking braking system

The parking braking system shall meet the requirements of 6.2.

4.5 Brake control forces

4.5.1 The control forces to meet the required brake performances for the systems, as specified in 6.2 and either 6.3.1 or 6.3.2, shall not exceed the values given in 4.5.2 to 4.5.6 and summarized in Table 1.

NOTE Other types of brake actuations are possible.

4.5.2 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.

4.5.3 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 while travelling shall not be greater than 200 N.

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

4.5.5 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 handgrip at the gripping point.

4.5.6 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.

4.6 Brake component strength

4.6.1 The strength of brake components shall not be lower than the values given in 4.6.2 to 4.6.6 and summarized in Table 1.

4.6.2 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.

4.6.3 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.

4.6.4 For trucks having a hand lever 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.

4.6.5 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.

4.6.6 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 applied at the midpoint of the handgrip, without any failure, cracking or deformation which affects the brake performance or function.

Table 1 — Brake control forces and component strengths (in Newtons)

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

[a] See 4.6.3.

[b] See 6.2.2, last paragraph.

4.7 Stored energy systems

4.7.1 Service brake recovery capacity

4.7.1.1 Air operating service braking system employing stored energy

The air operating service braking system shall have the capability of delivering 70 % of maximum system pressure measured at the brakes when the service brake is fully applied 20 times at the rate of 6 applications per minute with the truck stationary and the engine running at the optimum speed for braking energy recovery.

4.7.1.2 Braking systems with hydraulic accumulator

The capacity of hydraulic accumulator charging system shall be designed so that the pressure in the accumulator is not less than that required to meet the braking performance of either 6.3.1 or 6.3.2, when the service brake is fully applied with a frequency of one brake application every 5 seconds. For internal combustion engine trucks (IC), the test shall be performed at idle speed with the truck stationary. The test duration shall be at least 2 minutes.

4.7.2 Warning device for loss of stored energy

A service brake system employing stored energy shall be equipped with a warning device, which is activated before the stored energy reaches the level at which the truck cannot meet the required braking performance as specified in 6.3. The device shall be clearly visible or audible to the operator and provide a continuous warning when activated. Gauges indicating pressure or vacuum do not meet these requirements.

The warning device pressure level shall be set for activation at a pressure level such that the truck meets the requirements of either 6.3.1 or 6.3.2. This requirement is not applicable for hydraulic service braking systems which are redundant by other means, e.g. dual circuit braking systems.

The truck shall have enough stored energy to meet the requirements of 6.3.1 after the alarm occurs.

Truck speed can be automatically restricted while the alarm is triggered.

4.8 Additional requirements

In some countries, the additional requirements listed in Annex A can apply.

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.

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 Lining burnishing or conditioning of brakes before testing is permissible.

5.1.9 Immediately before 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 The brakes shall be cold at the beginning of the parking brake performance tests (see 6.2) and service brake performance tests (see 6.3).

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 speed 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 speed specified.

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

5.2.3 The truck test speed (see 3.11) shall be that speed measured immediately prior to the brake control being applied.

5.3 Drawbar drag test

5.3.1 The drawbar drag test is only applicable when the braking components being tested are exclusively a mechanical brake (e.g. disc or drum) and when the brake reaction time is equal to or less than 0,54 s.

NOTE See ISO/TR 29944 for details of brake reaction time

5.3.2 The drawbar drag method shall meet the following requirements:

a) measure drawbar drag in both forward and reverse direction while pulling at no more than 1,6 km/h in both directions;

b) the drawbar shall be essentially horizontal and attached to a point recommended by the manufacturer.

For trucks up to and including 16 000 kg capacity the drawbar shall be attached at the approximate vertical centre of gravity of the truck/load combination but not to exceed 900 mm above the test surface.

For trucks above 16 000 kg capacity the drawbar shall be attached at the approximate vertical centre of gravity of the truck/load combination.

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

6 Performance tests

6.1 General

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

6.2 Parking braking system performance

6.2.1 The parking braking system performance shall be tested in each direction of travel of the truck.

6.2.2 The parking braking system, 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 greater.

a) Trucks with elevating operating position above 500 mm and trucks specifically designed to travel with elevated loads: 5 %.

NOTE This does not include trucks handling freight containers.

b) Platform and stillage trucks, pallet trucks, platform-lift trucks, pallet-stacking trucks, low lift order picking trucks with a lift height of less than 500 mm, straddle trucks, reach trucks, bi-directional lift trucks, multi-directional lift trucks and industrial pedestrian-controlled trucks and pedestrian-controlled tractors: 10 %.

c) Any other sit-on or stand-on trucks or tractors: 15 %.

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

The parking braking system shall be capable of maintaining the specified performance requirement despite any contraction of the brake parts, depletion of the source of energy, or leakage of any kind.

6.3 Service braking system performance

6.3.1 Stopping distance test

The service braking 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 shall start when the brake control means is actuated.

The stopping distance 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 speed 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.

6.3.2 Drawbar drag test

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

6.3.3 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.

6.4 Test of warning device for loss of stored energy

A test shall be conducted to ensure the warning device activates as required by 4.7.2.

6.5 Heat fade test

6.5.1 The heat fade test shall be carried out after the truck has been tested as required in 6.3.1 or 6.3.2.

6.5.2 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 speed 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 6.3.1.

6.5.3 As an alternative to 6.5.2, the braking 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 6.3.2.

6.5.4 A heat fade test shall be conducted on trucks if alternative test procedures as defined in 6.3.3 are used.

Table 2 — Stopping distance, s_0, in consideration of speed, v

Group	Types of truck	Stopping distance s_0 m		
a) For truck speed, v (km/h)		**$v \leq 5$**	**$5 < v \leq 13{,}4$**	**$v > 13{,}4$**
A1	All industrial trucks except groups A2, B1, B2, C and D <16 000 kg rated capacity and <35 000 kg laden mass	$s_0 < 0{,}15\ v + \frac{v^2}{23{,}6}$	$s_0 < 0{,}15\ v + \frac{v}{4{,}7}$	$s_0 < 0{,}15\ v + \frac{v^2}{63{,}6}$
A2	All industrial trucks except groups B1, B2, C and D ≥16 000 kg rated capacity or ≥35 000 kg laden mass	$s_0 < 0{,}15\ v + \frac{v^2}{19{,}1}$	$s_0 < 0{,}15\ v + \frac{v}{3{,}8}$	$s_0 < 0{,}15\ v + \frac{v^2}{50{,}9}$
	Counterbalanced trucks specifically designed to handle freight containers 6 m length and above			
B1	Industrial tractors and Burden carriers 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 and Burden carriers 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 speed, v (km/h)		**$v \leq 4$**	**$4 < v \leq 13{,}4$**	**$v > 13{,}4$**
C	Trucks with elevating operating position above 500 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 speed, v (km/h)		**All speeds**		
D	Rough-terrain truck	$s_0 < 0{,}15\ v + \frac{v^2}{63{,}5}$		

Table 3 — Calculation of braking force, *F*, in consideration of speed, *v*, and mass, *m*, of the laden truck

Group	Types of truck	Braking force *F* N		
a) For truck speed, *v* (km/h)		**$v \leq 5$**	**$5 < v \leq 13{,}4$**	**$v > 13{,}4$**
A1	All industrial trucks except groups A2, B1, B2, C and D <16 000 kg rated capacity and <35 000 kg laden mass	$F > 0{,}91\ m$	$F > 0{,}182\ v\ m$	$F > 2{,}45\ m$
A2	All industrial trucks except groups B1, B2, C and D ≥16 000 kg rated capacity or ≥35 000 kg laden mass	$F > 0{,}73\ m$	$F > 0{,}146\ v\ m$	$F > 1{,}96\ m$
	Counterbalanced trucks specifically designed to handle freight containers 6 m length and above			
B1	Industrial tractors, and Burden carriers with 1 or 2 braked wheels	$F > 1{,}28\ m$	$F > 0{,}255\ v\ m$	$F > 3{,}43\ m$
B2	Industrial tractors, and Burden carriers with 3 or 4 braked wheels	$F > 1{,}82\ m$	$F > 0{,}365\ v\ m$	$F > 4{,}91\ m$
b) For truck speed, *v* (km/h)		**$v \leq 4$**	**$4 < v \leq 13{,}4$**	**$v > 13{,}4$**
C	Trucks with elevating operating position above 500 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 speed, *v* (km/h)		**All speeds**		
D	Rough-terrain truck	$F > 2{,}45\ m$		