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# British Standard Specification for **Steering capability of rubber tyred earth-moving machines**

[ISO title: Earth-moving machinery — Rubber-tyred machines — Steering capability]

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Systèmes de direction pour engins de terrassement équipés de pneumatiques — Spécification

Lenkfähigkeit von gummibereiften Erdbaumaschinen

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National foreword

This British Standard has been prepared under the direction of the Road Engineering Standards Committee and is identical with ISO 5010-1984 'Earth-moving machinery — Rubber-tyred machines — Steering capability' published by the International Organization for Standardization (ISO).

**Terminology and conventions.** The text of the international standard has been approved as suitable for publication as a British Standard without deviation. Some terminology and certain conventions are not identical with those used in British Standards; attention is drawn especially to the following.

The comma has been used as a decimal marker. In British Standards it is current practice to use a full point on the baseline as the decimal marker.

Wherever the words 'International Standard' appear, referring to this standard, they should be read as 'British Standard'.

Cross-references

| International standards | Corresponding British Standards                                                                          |
|-------------------------|----------------------------------------------------------------------------------------------------------|
| ISO 6165-1978           | BS 5718 : 1979 Glossary of terms for basic types of earth-moving machinery (Identical)                   |
| ISO 7457-1983           | BS 6486 : 1984 Method for measurement of turning dimensions of wheeled earthmoving machinery (Identical) |

The Technical Committee has reviewed the provisions of ISO 3450\*, to which reference is made in the text, and has decided that they are acceptable for use in conjunction with this standard.

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

\*Currently being revised.

British Standard Specification for

# Steering capability of rubber tyred earth-moving machines

## 1 Scope

This International Standard specifies steering system test and performance criteria which allow uniform evaluation of the steering capability of earth-moving machines operating on work sites or that will travel on public roads.

## 2 Field of application

This International Standard applies to self-propelled, rubber-tyred earth-moving machines having speed capability exceeding 20 km/h.

**2.1** Earth-moving machines are considered to be of the following basic types, as defined in ISO 6165 :

- tractor;
- loader;
- dumper;
- tractor-scraper;
- excavator;
- grader.

**2.2** Applicable steering systems include the following means of providing power for steering :

- manual steering;
- power-assisted steering;
- full-power steering.

## 3 References

ISO 3450, *Earth-moving machinery — Wheeled machines — Braking system — Performance requirements and test procedures*.<sup>1)</sup>

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

ISO 7457, *Earth-moving machinery — Measurement of turning dimensions of wheeled machines*.

## 4 Terms and definitions

**4.1 steering system** : A system including all machine elements between the operator and the ground contacting wheels participating in steering the machine.

**4.2 Ackermann steering system** : A system using the typical automotive vehicle steering geometry in which a pair of wheels at one axle location is mounted on the machine through substantially vertical steering axes at, or adjacent to, each of those wheels; the angular relationships of the wheels about those vertical axes being coordinated such that in any turn, the horizontal wheel axes, when extended, tend to meet at a common point.

**4.3 articulated steering system** : A system incorporating a substantially vertical steering axis to connect two portions of the machine; for example, the front and rear chassis sections or frames. Steering is accomplished by articulation between the two machine portions about the steering axis.

**4.4 wagon steering system** : A form of articulated steering system in which the vertical steering axis is located at a wheel axle position.

**4.5 skid steering system** : A system using variation of speed and/or direction of rotation between wheels on opposite sides of the machine as the means of changing or controlling the course of the machine.

**4.6 manual steering system** : A system depending exclusively on the muscular power of the operator to effect normal steering of the machine.

**4.7 power-assisted steering system** : A system employing auxiliary power source(s) to supplement the muscular power of the operator to effect steering of the machine. Without steering auxiliary power source(s), the machine can be steered with muscle power only. (See 7.2.1.)

1) At present at the stage of draft. (Revision of ISO 3450-1975.)

**4.8 full-power steering system** : A system in which steering is provided by steering power source(s). Without the power source(s), the machine cannot reasonably be steered with muscle power only. (See 7.2.1.)

**4.9 emergency steering system** : The system used to steer the machine in the event of a failure of the normal steering power source(s) or engine stoppage.

**4.10 steering power source** :

**4.10.1 normal steering power source** : The means for providing power to effect steering in either power-assisted or fully powered steering systems; for example, hydraulic pump, air compressor, electric generator.

**4.10.2 emergency steering power source** : The means for providing power to the emergency steering system; for example, hydraulic pump, air compressor, accumulator, battery.

**4.11 failures of the normal steering power source** : The complete and instantaneous loss of a normal steering power source output. It is assumed that not more than one failure will occur at the same time.

**4.12 steering control element** : Manual control means by which the operator provides muscular power inputs to the steering system to effect the desired steering of the machine, including the typical steering wheel or any equivalent manual control means.

**4.13 steering effort** : The necessary force exerted by the operator on the steering control element in order to steer the machine.

**4.14 steering angle** : The total displacement angle between the front wheels and the rear wheels as they move about one or more vertical steering axes from their normal straight-ahead condition to a turned condition.

**4.14.1** The steering angle for multiple axle machines is determined between the wheels at the farthest forward and the farthest rearward axle.

**4.14.2** Ackermann steering inherently has a greater steering angle on the side of the machine toward the inside of the turn as compared to the wheels on the outside of the turn. Therefore, where Ackermann steering is involved, location of steering angle measurement shall also be specified.

**4.14.3** A steering angle accomplished by a combination of geometries incorporating Ackermann steering is included in 4.14 and requires specifying location of measurement in accordance with 4.14.2.

**4.15 tyre circle** : The outer type clearance diameter determined in accordance with 10.1.

## 5 General requirements

The following requirements apply to all steering systems within the scope of this International Standard.

**5.1** The normal steering control element provided for the operator shall continue in all circumstances to be the steering control means of the operator.

**5.2** All steering systems shall be designed and installed on the machine to withstand, without functional damage, anticipated force inputs from the operator under panic conditions. (See 11.1.1.)

**5.3** The normal steering system sensitivity, modulation, and response shall be adequate to allow the skilled operator to maintain the machine consistently within the intended operating path of each operation for which the machine was designed. This shall be verified by meeting the requirements of 11.2.

**5.3.1** Machines with rear axle steering shall also meet the steering stability requirements of 11.2.2.

**5.3.2** Machines that have maximum rated speeds in excess of 20,0 km/h in reverse shall have similar steering system force, rate, and duration capability in both forward and reverse. This shall be verified by system schematics or calculations. A test in reverse is not required.

**5.4** Steering hydraulic circuits shall, if used, incorporate the following features :

**5.4.1** Pressure control devices as required to avoid excessive pressures in the hydraulic circuit.

**5.4.2** Hydraulic hoses, fittings, and tubings with test bursting pressures at least four times the highest pressure limits established by the power source pressure control device(s) for the normal and emergency steering systems.

**5.4.3** Plumbing arrangements which avoid excessively tight hose bends, torsion in the installed hoses, or scrubbing and chafing of hoses.

**5.5** Steering system reliability shall be enhanced by the selection and design of components arranged so that inspection and maintenance can be readily performed.

**5.6** Steering system disturbances shall meet the following conditions.

**5.6.1** Steering system disturbances due to other machine functions shall be minimized by appropriate arrangement and geometry. Flexure or travel of suspension elements, machine side inclinations or axle oscillations and steering variations due to driving and braking torques at the wheels are among the influences which shall be minimized by suitable system arrangement and geometry.

**5.6.2** Steering system disturbances due to the influences of external forces on the machine within the applications for which the machine is designed shall not significantly affect steering control.

**5.7** Power-assisted and full-power steering systems shall meet the following conditions.

**5.7.1** These systems should preferably be separate from other power systems and circuits. Where this is not the case, the power-assisted and full-power systems shall have priority over other systems or circuits except an emergency steering system and emergency stopping system which shall be maintained at the level of performance specified in ISO 3450.

**5.7.2** If other systems (consumers) are provided with power from the normal steering power source, any failure in these systems (consumers) shall be considered the same as a failure in the normal steering power source.

**5.7.3** A change in ratio between the steering control element and steered wheels is permissible after failure of the normal steering power source, provided the requirements of 11.3, 11.4 or 11.5 are met.

**5.8** An emergency steering system shall be provided on full-power steering machines.

This system should preferably be separate from other power systems and circuits. Where this is not the case, the emergency steering devices and circuits shall have priority over all other systems or circuits except the emergency stopping system, which shall be maintained at the level of performance specified in ISO 3450.

**5.9** The operator's manual for machines equipped with an emergency steering system shall include the following information :

- a) an indication that the machine is equipped with an emergency steering system;
- b) the emergency steering capability limitations;
- c) the field testing procedure for verifying that the emergency steering system is functional.

## 6 Ergonomic requirements

The following requirements apply to all steering systems within the scope of this International Standard.

**6.1** The machine shall steer in the direction that corresponds to the direction of movement of the steering control element; i.e. steering wheel rotation shall be such that clockwise rotation will tend to turn the machine to the right; counterclockwise rotation will tend to turn the machine to the left.

**6.2** Steering effort as defined in 4.13 shall be as low as practical and shall not exceed the following values :

**6.2.1** Steering effort for normal steering systems shall not exceed 115 N when specified for the steering tests described in clause 11.

**6.2.2** Steering effort for emergency steering systems shall not exceed 350 N when specified for the steering tests described in clause 11.

**6.3** Steering control element movement to produce a given result shall not vary more than 25 % between right and left turns up to a 30 ° steering angle. This may be shown by calculations. For Ackermann steering, this angle applies to the wheels toward the inside of the turn.

**6.4** When continued moving of the steering control element is required to continue changing the steering angle, it is desirable to make steering control movement for a given steering angle change greater in the vicinity of the straight-ahead position, such as is commonly achieved with variable rate worm steering gears.

## 7 Performance requirements

### 7.1 Normal steering

Steering effort (see 4.13) for normally operating systems, whether manual, power-assisted, or full-power, shall not exceed 115 N when negotiating the test courses outlined in 11.2.3 and 11.4.3.

### 7.2 Emergency steering; power-assisted systems

**7.2.1** Steering effort (see 4.13) shall not exceed 350 N during the emergency steering tests outlined in 11.3.5, 11.3.6 and 11.4.4. If this requirement is not met, the steering system shall be classified and tested as a full-power steering system.

**7.2.2** A warning device indicating a normal steering power source failure is required. This warning device shall be auditive or visual and shall be activated by failure of the normal steering power source. However, no emergency steering power source or warning device is required, provided that the emergency steering capability remains within the limits of 7.2.1, regardless of time or number of steering applications, and that either a significant increase in steering effort or a significant increase in steering wheel movement for a given amount of steering gives a definite indication to the operator of normal steering power source failure.

**7.2.3** This emergency steering system shall also function with reverse machine movement if the maximum rated speed in reverse exceeds 20 km/h.

### 7.3 Emergency steering; full-power systems

**7.3.1** Full-power steering systems shall be provided with an emergency steering power source as defined in 4.10.2.