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Earth-moving machinery — Rubber-tyred machines — Steering requirements

Engins de terrassement — Engins équipés de pneumatiques — Systèmes de direction

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Contents

Page

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 5010 was prepared by Technical Committee ISO/TC 127, *Earth-moving machinery*, Subcommittee SC 2, *Safety requirements and human factors*.

This third edition cancels and replaces the second edition (ISO 5010:1992), which has been technically revised.

Earth-moving machinery — Rubber-tyred machines — Steering requirements

1 Scope

This International Standard specifies steering system tests and performance criteria for evaluating the steering capability of rubber-tyred, self-propelled earth-moving machines having a machine speed, determined in accordance with ISO 6014, greater than 20 km/h.

It is applicable to dozers, loaders, back-hoe loaders, excavators, dumpers, scrapers and graders equipped with either manual steering, power-assisted steering or fully powered steering systems as defined in ISO 6165.

It is not applicable to rollers, compactors or pipelayers.

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 3450, *Earth-moving machinery — Braking systems of rubber-tyred machines — Systems and performance requirements and test procedures*

ISO 6014, *Earth-moving machinery — Determination of ground speed*

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

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

ISO 10968, *Earth-moving machinery — Operator's controls*

ISO 13849 (all parts), *Safety of machinery — Safety-related parts of control systems*

ISO 15998,[1)] *Earth-moving machinery — Machine-control systems (MCS) using electronic components — Performance criteria and tests for functional safety*

IEC 62061, *Safety of machinery — Functional safety of safety-related electrical, electronic and programmable electronic control systems*

1) Under preparation.

3 Terms and definitions

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

3.1
steering system
system including all machine elements between the operator and the ground-contacting wheels participating in steering the machine

3.1.1
manual steering system
system depending exclusively on the muscular power of the operator to effect normal steering of the machine

3.1.2
power-assisted steering system
system employing auxiliary power source(s) to supplement the muscular power of the operator to effect steering of the machine

NOTE 1 Without steering auxiliary power source(s), the machine can be steered with muscular power only.

NOTE 2 See 6.2.1.

3.1.3
full power-assisted steering system
fully powered steering system
system in which the steering is performed by one (or several) source(s) of power

NOTE A fully powered steering system can be described as one that would require 115 N or more muscle power to steer without the power assist.

3.1.4
emergency steering system
system used to steer the machine in the event of a failure of the normal steering power source(s) or engine stoppage

3.2 Steering power sources

3.2.1
normal steering power source
means for providing power to effect steering in either power-assisted or fully powered steering systems

EXAMPLE Hydraulic pump, air compressor, electric generator.

3.2.2
emergency steering power source
means for providing power to the emergency steering system

EXAMPLE Hydraulic pump, air compressor, accumulator, battery.

3.2.3
failure of normal steering power source
complete and instantaneous loss of a normal steering power source output

NOTE It is assumed that not more than one failure will occur at the same time.

3.3
steering control element
control element used by the operator to transmit the desired direction of steering of the machine

3.3.1
steering wheel
operating element, circular shaped or shaped as a segment of a circle, used to generate a steering angle to the steered wheels

3.3.2
lever control
operating element consisting of two independent levers that generate control of the relative speed of the left-hand and right-hand sides of the drive system

3.3.3
joystick control
operating element(s), used to apply either a steering angle to the steered wheels, or to generate a relative speed of the drive systems on the left-hand and right-hand side, by actuating the operating element to the left-hand or right-hand side

3.3.4
pushbutton control
operating element consisting of two separate pushbuttons which can generate a steering angle to the steered wheels or generate control of the relative speed of the left-hand and right-hand sides of the drive system

3.3.5
foot pedal control
operating element used to apply either a steering angle to the steered wheels, or to generate a relative speed of the drive systems on the left-hand and right-hand sides, by pressing two separate foot pedals

3.4
steering effort
necessary force exerted by the operator on the steering control element in order to steer the machine

3.5
steering angle
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

NOTE 1 The steering angle for multiple-axle machines is determined between the wheels at the farthest forward and farthest rearward axles.

NOTE 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, the location of the steering angle measurement also needs to be specified.

A steering angle accomplished by a combination of geometries incorporating Ackermann steering is included, and also requires the location of the steering angle measurement to be specified.

3.6
tyre circle
outer tyre clearance diameter determined in accordance with Clause 9

3.7
working circuit pressure
nominal pressure applied to the specific circuit by the pump(s)

3.8
transfer device
parts of the **steering system** (3.1) being used to transfer forces (actuation forces and steering forces) and/or steering commands between the **steering control element** (3.3), and if applicable, the **steering power source** (3.2)

NOTE The steering forces and/or steering commands can be transferred

— mechanically,

— hydraulically,

— electrically,

— electronically,

or as a combination of these.

3.9
steered wheels
wheels whose direction of movement can be directly or indirectly modified in order to determine the machine's direction of travel

3.10
safe state
state applied automatically or manually, after a malfunction of the steering-control system whereby the controlled equipment, process or system is stopped or switched to a safe mode in order to prevent unexpected movements or potentially hazardous release of stored energy

NOTE Safe state is a function of many factors, including operating conditions, the technologies involved, fault-detection capabilities and the safety concept. For electro-hydraulic steering control systems, disabling the electronic portions during a fault and relying on the hydraulic steering system is just one of several ways to reach a safe state.

4 General requirements

4.1 All steering systems

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

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

4.1.1.1 When the steering control element is released, the selected turning circle of tyres (see 3.6) shall remain identical or become larger during travel in the forward direction.

4.1.1.2 The steering system shall be designed so that the movement of the steering control element is consistent with its effect. If control operation is not obvious, an operational sign shall be provided (e.g. using symbols).

4.1.1.3 During machine operation, no uncontrolled steering movement shall occur due to the normal operation of the electronic steering control system.

4.1.1.4 The steering control element shall permit the rate of steering to be gradually adjusted. If the steering speed cannot be gradually adjusted, the maximum machine speed shall be limited to 10 km/h.

4.1.2 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 10.1.1.)

4.1.3 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 10.2. If a steering control does not permit modulated steering speed, the machine speed shall be reduced to $\leqslant$ 10 km/h.

4.1.3.1 Machines with rear axle steering shall also meet the steering stability requirements of 10.2.2.

4.1.3.2 Machines capable of speeds in excess of 20 km/h in reverse shall have similar steering system forces, rates and duration capability in both forward and reverse. This shall be verified by system schematics or calculations. A test in reverse is not required.

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

a) pressure control devices as required to avoid excessive pressures in the hydraulic circuit;

b) hydraulic hoses, fittings and tubing with test burst pressures at least four times the working circuit pressure control device(s) for normal and emergency steering systems;

c) plumbing arrangements which avoid excessively tight hose bends, torsion in the installed hoses, or scrubbing and chafing of hoses.

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

4.1.6 Steering system disturbances shall meet the conditions given in 4.1.6.1 and 4.1.6.2.

4.1.6.1 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.

4.1.6.2 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.

4.1.7 Power-assisted and fully powered steering systems shall meet the conditions given in 4.1.7.1 and 4.1.7.3.

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

4.1.7.2 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.

4.1.7.3 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 10.3 are met.

4.1.8 For machines equipped with an emergency steering system, the 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 for the emergency stopping system, which shall be maintained at the level of performance specified in ISO 3450.

4.1.9 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 test procedure for verifying that the emergency steering system is functional.