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Mobile elevating work platforms — Design, calculations, safety requirements and test methods

Plates-formes élévatrices mobiles de personnel — Conception, calculs, exigences de sécurité et méthodes d'essai

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ISO copyright office
CP 401 • Ch. de Blandonnet 8
CH-1214 Vernier, Geneva
Phone: +41 22 749 01 11
Email: copyright@iso.org
Website: www.iso.org

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Foreword

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The procedures used to develop this document and those intended for its further maintenance are described in the ISO/IEC Directives, Part 1. In particular, the different approval criteria needed for the different types of ISO document should be noted. This document was drafted in accordance with the editorial rules of the ISO/IEC Directives, Part 2 (see www.iso.org/directives).

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For an explanation of the voluntary nature of standards, the meaning of ISO specific terms and expressions related to conformity assessment, as well as information about ISO's adherence to the World Trade Organization (WTO) principles in the Technical Barriers to Trade (TBT), see www.iso.org/iso/foreword.html.

This document was prepared by Technical Committee ISO/TC 214, *Elevating work platforms*.

This third edition cancels and replaces the second edition (ISO 16368:2010), which has been technically revised.

The main changes are as follows:

— all requirements from ISO 16653-1 have been integrated into this document;

— in the Scope, additional details have been added included intended use and objectives;

— the normative references have been updated;

— in Clause 3, seven new definitions have been added to support their use in the text;

— Clause 4 has been updated to include a new figure for the rated load of tools and materials; Table 1 and Figure 3 have been revised to show load-sensing and enhanced stability examples separately and to include more working configurations; verification methods have been removed from each clause and placed in new Table 7 in Clause 5; access system requirements have been revised to include Table 4 and Table 5;

— in Clause 6, the contents of Annex F have been merged into 6.2.1 and the previous Annex F has been deleted.

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.

Introduction

This document is a type-C standard as stated in ISO 12100:2010.

This document is of relevance, in particular, for the following stakeholder groups representing the market players with regard to machinery safety:

— machine manufacturers (small, medium and large enterprises);

— health and safety bodies (regulators, accident prevention organisations, market surveillance, etc.).

Others can be affected by the level of machinery safety achieved with the means of the document by the above-mentioned stakeholder groups:

— machine users/employers (small, medium and large enterprises);

— machine users/employees (e.g. trade unions, organizations for people with disabilities);

— service providers, e.g. for maintenance (small, medium and large enterprises);

— consumers (in the case of machinery intended for use by consumers).

The above-mentioned stakeholder groups have been given the possibility to participate at the drafting process of this document.

The machinery concerned and the extent to which hazards, hazardous situations or hazardous events are covered, are indicated in the Scope of this document.

When requirements of this type-C standard are different from those which are stated in type-A or type-B standards, the requirements of this type-C standard take precedence over the requirements of the other standards for machines that have been designed and built according to the requirements of this type-C standard.

The objective of this document is to establish rules for safeguarding persons and objects against the risk of an accident associated with the operation of mobile elevating work platforms (MEWPs). MEWPs are assemblies of one or more sub-assemblies produced by one or more manufacturers. A MEWP is the product of activities that include design, production, and testing, as well as the provision of information on the MEWP itself.

This document does not repeat all the general technical rules applicable to every electrical, mechanical, or structural component. Its safety requirements have been developed on the basis that MEWPs are periodically maintained according to given instructions, working conditions, frequency of use and national or other regulations. It is assumed that MEWPs are checked for function before start of work, whether used daily or seldom used, and are not put into operation unless all the required control and safety devices are available and in working order. Where, for clarity, an example of a safety measure is given in the text, it is not intended as the only possible solution. Any other solution leading to the same risk reduction is permissible if an equivalent level of safety is achieved.

Annex A explains the choice of Beaufort Scale 6 as the maximum wind speed.

Annex B specifies additional requirements for wireless controls and control systems.

Annex C provides, in addition to those found in the body of this document, appropriate extracts from DIN 15020 (all parts) to avoid the unexplained inconsistencies in coefficients of utilization for wire ropes found in other standards for lifting devices.

Annex D provides a worked example of the provisions given in Annex C.

Annex E gives kerb test calculations.

Annex F presents the list of significant hazards dealt with by this document.

Mobile elevating work platforms — Design, calculations, safety requirements and test methods

1 Scope

This document specifies safety requirements and protective/risk reduction measures, and the means for their verification, for all types and sizes of mobile elevating work platforms (MEWPs) intended for moving a person(s) along with their necessary tools and materials at an elevated work location.

This document also applies to MEWPs designed for applications requiring special access to specific work areas. These MEWPs can be either self-propelled or manually propelled and are used to elevate personnel to a level at which they can place, install, or retrieve objects or material on a routine basis. To facilitate operator access to the work area, the retraction of a portion of the MEWP's work platform guardrail system(s) can be necessary.

This document is intended to serve as a guide for manufacturers and remanufacturers of MEWPs to achieve the following objectives:

— elimination or reduction of accidents and personal injuries;

— establishment of criteria for design, manufacture, remanufacture, rebuild/recondition, testing and performance;

— establishment and understanding by manufacturers and remanufacturers of their responsibilities.

The design and manufacturing requirements of this document apply to all MEWPs manufactured or remanufactured on or after the effective date, but it is not applicable to rebuilt or reconditioned MEWPs.

It identifies the hazards arising from the use of MEWPs and describes methods for the elimination or reduction of these hazards.

This document is not applicable to

a) permanently installed personnel-lifting appliances serving defined levels,

b) firefighting and fire rescue appliances (see for example, EN 1777),

c) unguided work cages suspended from lifting appliances (see for example, EN 1808),

d) elevating operator position on rail-dependent storage and retrieval equipment (see for example, EN 528),

e) tail lifts (see for example, EN 1756-1:2001+A1:2008, EN 1756-2:2004+A1:2009),

f) mast-climbing work platforms (see ISO 16369),

g) fairground equipment,

h) lifting tables with a lifting height of less than 2 m (see for example, EN 1570-1:2011+A1:2014),

i) builder's hoists for persons and materials,

j) aircraft ground-support equipment (see for example, EN-1915-1:2013, EN-1915-2:2001+A1:2009),

k) digger derricks,

l) elevating operator positions on industrial trucks (see for example, ISO 3691-3),

m) elevating operator positions on cranes,

n) certain requirements for insulating aerial devices on a chassis for use in live work on electrical installations (see Note 1),

o) multi-purpose elevating platform powered industrial trucks (MPEPs) controlled by a single stand-up riding operator and intended to be used for manually picking and transporting small items at height,

p) powered industrial trucks used to pick and place stock or inventory.

NOTE 1 For requirements for use near live electrical installations, see ISO 16653-2. For requirements for use on live electrical installations, see IEC 61057.

It does not cover hazards arising from:

— use in potentially explosive atmospheres,

— use of compressed gases for load-bearing components,

— derailment and runaway of rail-mounted MEWPs,

— work on live electrical systems (see Note 2 and Note 3).

NOTE 2 Hazards arising from work on live electrical systems are addressed in IEC 61057.

NOTE 3 For MEWPs that employ aerial devices used for live working, this document is to be used in conjunction with IEC 61057, taking into consideration the potential exceptions from this document that are specified in IEC 61057.

2 Normative references

The following documents are referred to in the text in such a way that some or all of their content constitutes requirements 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 3864 (all parts), *Graphical symbols — Safety colours and safety signs*

ISO 4305, *Mobile cranes — Determination of stability*

ISO 7000, *Graphical symbols for use on equipment — Registered symbols*

ISO 12100, *Safety of machinery — General principles for design — Risk assessment and risk reduction*

ISO 13849-1, *Safety of machinery — Safety-related parts of control systems — Part 1: General principles for design*

ISO 13850, *Safety of machinery — Emergency stop function — Principles for design*

ISO 13854, *Safety of machinery — Minimum gaps to avoid crushing of parts of the human body*

ISO 18893:—[1], *Mobile elevating work platforms — Safety principles, inspection, maintenance, and operation*

ISO 20332, *Cranes — Proof of competence of steel structures*

ISO 21455, *Mobile elevating work platforms — Operator's controls — Actuation, displacement, location and method of operation*

IEC 60068-2-64, *Environmental testing — Part 2-64: Tests — Test Fh: Vibration, broadband random and guidance*

IEC 60204-1, *Safety of machinery — Electrical equipment of machines — Part 1: General requirements*

IEC 60204-32:2023, *Safety of machinery — Electrical equipment of machines — Part 32: Requirements for hoisting machines*

1) Under preparation. Stage at the time of publication: ISO/FDIS 18893:2024.

IEC 60529, *Degrees of protection provided by enclosures (IP Code)*

IEC 61310-1, *Safety of machinery — Indication, marking and actuation — Part 1: Requirements for visual, acoustic and tactile signals*

3 Terms and definitions

For the purposes of this document, the terms and definitions given in ISO 12100 and the following apply.

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

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

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

3.1
access position
position(s) to provide access to and from the *work platform* (3.58)

Note 1 to entry: The access position, *lowered travel position* (3.21), *stowed position* (3.51) and *transport position* (3.52) can be identical.

3.2
aerial device
device, extensible, articulating or both, which is primarily designed and used to position personnel

Note 1 to entry: This does not include the *chassis* (3.5). When an aerial device is mounted on a mobile *chassis* (3.5) it becomes a component of a MEWP. This device can also be used to handle material, if designed and equipped for that purpose.

3.3
anchorage
designated point of attachment utilized with a personal fall protection system

3.4
chain drive system
system that comprises one or more chains running on chain sprockets or over chain pulleys, as well as any associated chain sprockets, chain pulleys and compensating pulleys

3.5
chassis
base of a MEWP

Note 1 to entry: See Figure 1.

Note 2 to entry: The chassis can be pulled, pushed, self-propelled, etc.

3.6
ductile materials
materials that have a minimum elongation at fracture of 10 % in a gauge length of 51 mm of a standard tensile test specimen

3.7
elevated travel position
configuration(s) of the MEWP for travel outside of the *lowered travel position* (3.21)

3.8
extending structure
structure which is connected to the *chassis* (3.5) and supports the *work platform* (3.58) and which allows movement of the *work platform* (3.58) to its required position

Note 1 to entry: See Figure 1.

3.9
fall arrest system
personal fall protection system designed to arrest the fall of an *operator* (3.36) or *occupant(s)* (3.35)

3.10
fall restraint system
personal fall protection system that restrains or prevents an *operator* (3.36) or *occupant(s)* (3.35) from reaching a fall hazard

3.11
finite element analysis
FEA
computerized method of idealizing a real model for the purposes of performing structural analysis

3.12
folding guardrails
guardrails capable of being reduced in height

Note 1 to entry: For facilitating MEWP movement under obstructions and ease of transport.

3.13
handhold
device for single hand placement that aids body support and balance

3.14
handrail
device for hand placement that aids body support and balance and permits hand movement on the device

Note 1 to entry: A handrail can be part of a guardrail.

3.15
indoor use
operation in areas shielded from wind so that there is no wind force acting on the MEWP being operated

3.16
instability
condition of a MEWP in which the sum of the moments which tend to overturn the MEWP exceeds the sum of the moments which tend to resist overturning

3.17
installer
entity that installs an *aerial device* (3.2) on a *chassis* (3.5)

Note 1 to entry: The installer can also be the *responsible entity* (3.43).

3.18
load cycle
cycle starting from an *access position* (3.1) and completed by the carrying out of work and return to the same *access position* (3.1)

3.19
load-sensing system
system of monitoring the vertical load and vertical forces on the *work platform* (3.58)

3.20
lowering, noun
operations, other than travelling, for moving the *work platform* (3.58) to a lower level

Note 1 to entry: See Figure 1.

3.21
lowered travel position
configuration(s) of the MEWP, as defined by the *responsible entity* (3.43), for travel up to maximum travel speed

Note 1 to entry: The lowered travel position, *access position* (3.1), *stowed position* (3.51), and *transport position* (3.52) can be identical.

3.22
mobile elevating work platform
MEWP
machine/device intended for moving a person(s), along with their necessary tools and material to an elevated work location, consisting of at least a *work platform* (3.58) with controls, an *extending structure* (3.8) and a *chassis* (3.5)

3.23
group A MEWP
MEWPs on which the vertical projection of the centre of the *work platform* (3.58) area, in all work platform configurations at the maximum chassis inclination specified by the manufacturer, is always inside the tipping lines

3.24
group B MEWP
MEWPs not in group A

3.25
type 1 MEWP
MEWP for which travelling is only allowed when in the *stowed position* (3.51)

3.26
type 2 MEWP
MEWP for which travelling with the *work platform* (3.58) in the *elevated travel position* (3.7) is controlled from a point on the *chassis* (3.5)

Note 1 to entry: Type 2 MEWPs and type 3 MEWPs can be combined.

3.27
type 3 MEWP
MEWP for which travelling with the *work platform* (3.58) in the *elevated travel position* (3.7) is controlled from a point on the *work platform* (3.58)

Note 1 to entry: Type 2 MEWPs and type 3 MEWPs can be combined.

3.28
pedestrian-controlled MEWP
MEWP whose controls for powered travel can be operated by a person walking close to the MEWP

3.29
rail-mounted MEWP
MEWP whose travel is guided by rails

3.30
self-propelled MEWP
MEWP whose travel is powered by an internal power source

3.31
totally manually operated MEWP
MEWP whose movement is powered only by manual effort

3.32
vehicle-mounted MEWP
MEWP whose *aerial device* (3.2) is designed for and installed on a vehicle *chassis* (3.5)

3.33
moment-sensing system
system monitoring the moment acting about the tipping line tending to overturn the MEWP

3.34
non-ductile materials
brittle materials
materials that are not classified as *ductile materials* (3.6)

3.35
occupant(s)
person(s) in the *work platform* (3.58) other than *operator* (3.36)

3.36
operator
person who controls the operation of a MEWP

3.37
oscillating axle
supporting structure which allows mainly vertical movement of the end wheel assemblies independently or in relation to each other

3.38
outdoor use
use of a MEWP in an environment that can be exposed to wind

3.39
raising, noun
operation, other than travelling, that moves the *work platform* (3.58) to a higher level

Note 1 to entry: See Figure 1.

3.40
rated load
load for which the MEWP has been designed in normal operation, comprising persons, tools and materials, acting vertically on the *work platform* (3.58)

Note 1 to entry: A MEWP can have more than one rated load.

3.41
rebuild/recondition
overhaul or repair of a MEWP, accomplishing work beyond the scope of maintenance, utilizing replacement parts and components, in order to restore the MEWP to the original standard(s)

3.42
remanufacture
modification of a MEWP, either by the original manufacturer or *responsible entity* (3.43), so that the MEWP will comply with one or more standards in effect on the date the remanufacture is completed

3.43
responsible entity
person or entity with responsibility for the design, specification, procurement, fabrication, manufacture, assembly, provision of information and testing of a MEWP sub-assembly or ready-for-use MEWP

Note 1 to entry: Depending on national regulations or local practice, this term can refer to one or more of the following entities: manufacturer, installer, custodian, dealer, or entity placing the product on the market.

3.44
retractable guardrail
guardrail where a portion is capable of being locked in a retracted position without reducing overall height

Note 1 to entry: For accessing a work area.

3.45
rotation
circular movement of the *work platform* (3.58) about a vertical axis local to the *work platform* (3.58)

Note 1 to entry: See Figure 1.

3.46
secondary work platform
additional platform attached to the *work platform* (3.58) or the *extending structure* (3.8), and able to be moved separately

3.47
slab
substantially level surface of asphalt, concrete, or equivalent supporting material

3.48
slewing, noun
circular movement of the *extending structure* (3.8) about a vertical axis

Note 1 to entry: See Figure 1.

3.49
stability
condition of a MEWP in which the sum of the moments which tend to overturn the unit is less than or equal to the sum of the moments tending to resist overturning

3.50
stabilising device
device or system used to stabilise a MEWP by supporting and/or levelling the complete MEWP or the *extending structure* (3.8)

Note 1 to entry: See Figure 1.

EXAMPLE Outrigger, jack, suspension-locking device, extending axle, torsion bar.

3.51
stowed position
configuration of the MEWP as defined by the *responsible entity* (3.43), in which the *extending structure* (3.8) is lowered and retracted, and *stabilising devices* (3.50) are retracted

Note 1 to entry: The stowed position, *access position* (3.1), *lowered travel position* (3.21) and *transport position* (3.52) can be identical.

3.52
transport position
configuration of the MEWP prescribed by the *responsible entity* (3.43) in which the MEWP is to be transported

Note 1 to entry: The transport position, *access position* (3.1), *lowered travel position* (3.21) and *stowed position* (3.51) can be identical.

3.53
travelling
movement of the *chassis* (3.5) except when the MEWP is being transported

Note 1 to entry: See Figure 1.

3.54
type test
test on a representative model of a new design, or a model incorporating significant changes to an existing design, carried out by or on behalf of the *responsible entity* (3.43) or their authorized representative

3.55
wireless control
means by which an operator's commands are transmitted without any physical connection for at least part of the distance between a control console and the MEWP system

3.56
wire rope drive system
system that comprises one or more wire ropes running on rope drums and on or over rope pulleys, as well as any associated rope drums, rope pulleys and compensating pulleys

3.57
working envelope
space in which the *work platform* (3.58) is designed to work within the specified loads and forces, under normal operation conditions

Note 1 to entry: A MEWP can have more than one working envelope.

3.58
work platform
component of the MEWP intended for carrying a person(s) along with their necessary tools and materials

EXAMPLE Cage, bucket, basket.

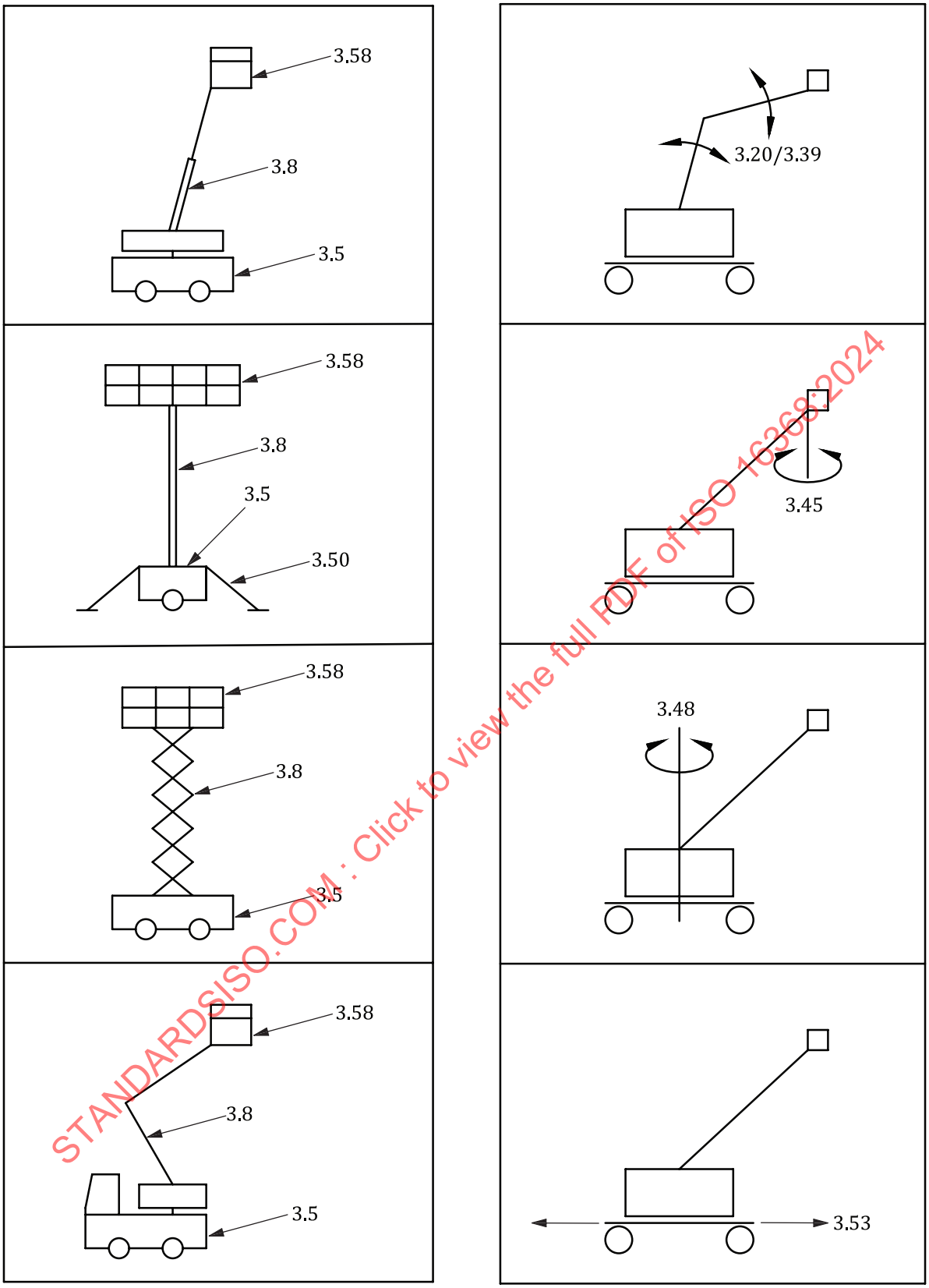


Figure 1 — Illustration of key terms

4 Safety requirements and/or protective/risk reduction measures

4.1 General

4.1.1 MEWPs shall comply with the safety requirements and/or protective/risk reduction measures of Clause 4.

4.1.2 In addition, the MEWP shall be designed in accordance with the principles of ISO 12100 for relevant but not significant hazards, which are not dealt with by this document.

4.1.3 Verification methods of safety requirements in Clause 4 can be found in Table 7. Where necessary, specific verification methods are provided for individual subclauses.

NOTE National or local requirements can be more stringent.

4.2 Stability and structural calculations

4.2.1 Calculations and rated load

4.2.1.1 The responsible entity shall perform:

a) stability calculations, to identify the various positions of the MEWP and combinations of loads and forces which together create conditions of minimum stability;

b) structural calculations, to evaluate the individual loads and forces in their positions, directions and combinations which produce the most unfavourable stresses in the components.

4.2.1.2 The rated load, equivalent to a mass, m, shall be determined from:

$$m = \left(n \times m_p\right) + m_e$$

where

m_p is 80 kg (mass of a person);

m_e is ≥ 40 kg, representing the mass of tools and materials;

n is the permitted number of persons on the work platform.

4.2.1.3 All MEWPs shall have at least one rated load ≥ 120 kg.

4.2.1.4 For group B MEWPs with multiple rated loads, it is permissible to have rated loads ≥ 80 kg and < 120 kg if fitted with both a load-sensing system and a moment-sensing system.

4.2.2 Loads and forces acting on MEWP structure

4.2.2.1 General

The following loads and forces shall be taken into account:

a) forces created by rated load and structural masses (4.2.2.2);

b) wind forces (4.2.2.3);

c) manual forces (4.2.2.4);

d) special loads and forces (see 4.2.2.5).

4.2.2.2 Forces created by rated load and structural masses

4.2.2.2.1 Gravitational and dynamic forces

4.2.2.2.1.1 Gravitational forces created by the rated load and structural masses shall be taken to act vertically downwards at the component centres of mass. These forces shall be calculated by multiplying the component masses by 1,0 *g*.

NOTE The factor *g* represents the acceleration due to gravity (9,81 m/s^2).

4.2.2.2.1.2 Dynamic forces created by acceleration and deceleration of rated load and structural masses shall be represented by forces acting in the line of motion of the component centres of mass.

4.2.2.2.1.3 Dynamic forces created by extension or retraction of the extending structure shall be calculated by multiplying the structural masses by 0,1 *g*. Values lower than 0,1 *g* may be used, provided they have been verified by measurement of the effects of acceleration and deceleration.

4.2.2.2.1.4 Dynamic forces created by travelling movements of type 2 and type 3 MEWPs shall be calculated by multiplying the structural masses by *z* times *g*. Factor *z*·*g* represents the acceleration/deceleration of the MEWP due to travel and its angular acceleration/deceleration due to travel over ground obstacles such as that which occurs during the kerb test (see 5.1.4.2.2.2). Factor *z* shall be a minimum of 0,1 unless determined by calculation or testing (see Annex E for an example of the calculation of *z*).

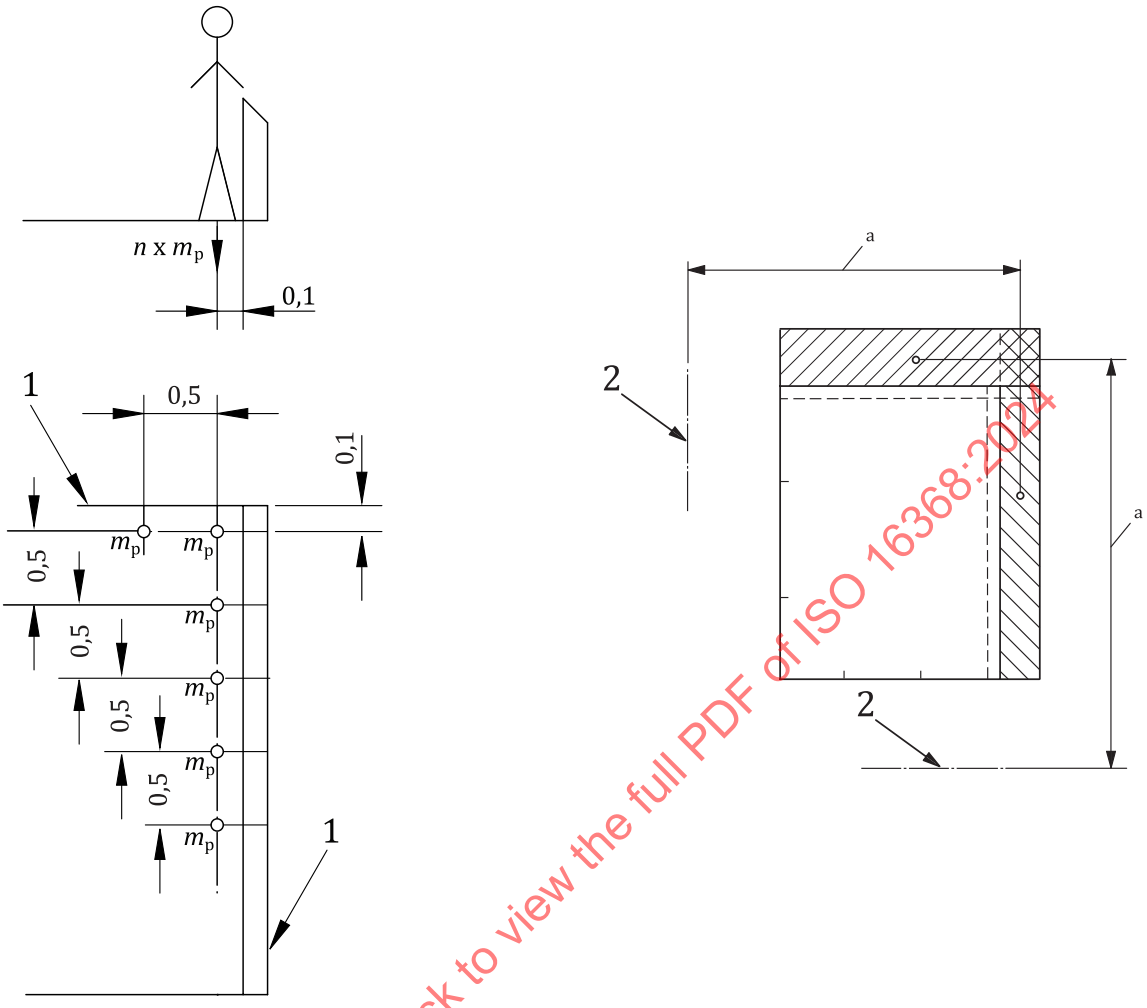
4.2.2.2.2 Load distribution on work platform

4.2.2.2.2.1 The mass of each person is assumed to act as a point load on the work platform and any platform extension at a horizontal distance of 0,1 m from the upper inside edge of the top rail. The distance between the point loads shall be 0,5 m [see Figure 2 a) as an example].

4.2.2.2.2.2 Tools and materials are assumed to act as an evenly distributed load on 25 % of the floor of the work platform. If the resulting pressure exceeds 3 kN/m^2, the value of 25 % may be increased to give a pressure of 3 kN/m^2 [see Figure 2 b) as an example].

4.2.2.2.2.3 All these loads are assumed to be located in the positions giving the worst-case results.

Dimensions in metres



a) Person **b) Tools and materials**

Key

1 edge of work platform

2 tipping line

[a] Max.

Figure 2 — Rated load

4.2.2.3 Wind forces

4.2.2.3.1 MEWPs designated for outdoor use

4.2.2.3.1.1 All MEWPs designated for outdoor use are regarded as being affected by wind at a pressure of 100 N/m^2, derived from a wind speed of 12,5 m/s (Beaufort scale 6, see Annex A).

4.2.2.3.1.2 It is permissible to use data from computational fluid dynamics (CFD) modelling or physical testing to meet this requirement. The CFD analysis shall include a summary of the boundary conditions applied. Physical testing shall include the modelling and dimensional similarity parameters used.

4.2.2.3.1.3 Wind forces are assumed to act horizontally at the centre of surface of the parts of the MEWP, persons and tools and materials on the work platform.

4.2.2.3.2 Shape factors applied to surfaces exposed to wind

4.2.2.3.2.1 The following shape factors are applicable to surfaces exposed to wind:

a) L-, U-, T-, I-sections: 1,6;

b) box sections: 1,4;

c) large flat areas: 1,2;

d) circular sections, according to size: (values in accordance with ISO 4302:2016, 5.4);

e) persons directly exposed: 1,0.

4.2.2.3.2.2 For additional shape factors and shielded structural areas, the requirements of ISO 4302 shall apply. For shielded persons, see 4.2.2.3.3.

4.2.2.3.3 Surface area of persons on a work platform exposed to wind

4.2.2.3.3.1 The full surface area of one person shall be 0,7 m^2 (0,4 m average width × 1,75 m height) with the centre of area 1,0 m above the work platform floor.

4.2.2.3.3.2 The exposed surface area of one person standing on a work platform behind an imperforate (not perforated) section of fencing 1,1 m high shall be 0,35 m^2, with the centre of area 1,45 m above the work platform floor.

4.2.2.3.3.3 The number of persons directly exposed to the wind shall be calculated as follows:

a) the length of the side of the work platform exposed to the wind, rounded to the nearest 0,5 m, divided by 0,5 m;

b) the number of persons allowed on the work platform, if less than the number calculated in a).

4.2.2.3.3.4 If the number of persons allowed on the work platform is greater than for a) above, a shape factor of 0,6 shall be applied to the extra number of persons.

4.2.2.3.4 Tools and materials on work platform exposed to wind

The wind force (W) on exposed tools and materials on the work platform shall be calculated as 0,03 g multiplied by their mass acting horizontally at a height of 0,5 m above the work platform floor:

$$W = 0{,}03\, g \times m_e$$

where m_e is the mass of tools and materials.

4.2.2.4 Manual forces

The minimum value for a manual force, F_m, shall be taken as 200 N for MEWPs designed to carry only one person, and 400 N for MEWPs designed to carry more than one person. Manual forces are to be applied at a height of 1,1 m above the work platform floor. Any greater force permitted shall be specified by the responsible entity.

4.2.2.5 Special loads and forces

If a MEWP is designed for use with special working methods or conditions, such as

a) objects carried on the outside of the work platform,

b) person(s) getting on or off the work platform at height,

c) wind forces on large objects carried on the work platform,

d) wind speeds greater than 12,5 m/s,

e) forces imposed by winches or other material handling devices,

f) a combination of forces,

the resulting loads and forces shall be taken into consideration as a modification to the rated load, structural load, wind load, and/or manual forces, as appropriate.

4.2.3 Stability calculations

4.2.3.1 Forces created by rated load and structural masses

4.2.3.1.1 Forces created by rated load and structural masses, causing overturning or stabilising moments, shall be multiplied by a factor of 1,0 *g*, and calculated as acting vertically downwards.

4.2.3.1.2 In the case of movement of the extending structure these forces shall be multiplied by a factor of 0,1 *g* and applied as additional forces acting in the direction of movement creating the greatest overturning moment. Manufacturers may use factors lower than 0,1 *g* provided they have been proved by measurement of the effects of acceleration and deceleration.

4.2.3.1.3 For the travelling movements of MEWP of type 2 and type 3 the factor of 0,1 *g* shall be replaced by a factor *z* representing the forces produced by acceleration and deceleration, or during the kerb and depression tests (see 5.1.4.2.2). This factor shall be determined by calculation or tests (see Annex E for a calculation example).

4.2.3.1.4 The maximum allowable chassis inclination shall be increased by 0,5° (as shown in Figure 3) to allow for inaccuracy in setting up the MEWP.

4.2.3.2 Wind forces

Wind forces shall be multiplied by a factor of 1,1 and taken to be acting horizontally.

4.2.3.3 Manual forces

Manual forces applied by persons on the work platform shall be multiplied by a factor of 1,1 and taken to be acting in the direction creating the greatest overturning moment (see Figure 3 for examples).

4.2.3.4 Special loads and forces

Special loads and forces, as determined by the responsible entity, shall be included in the calculation.

4.2.3.5 Calculation of overturning and stabilising moments

4.2.3.5.1 The MEWP shall be taken to be operating in the most adverse stability situation with respect to the combination of chassis inclination, structural configuration, position, structural motions and vehicle travel motion.

4.2.3.5.2 The maximum overturning and corresponding stabilising moments shall be calculated about the least favourable tipping lines. Tipping lines shall be determined in accordance with ISO 4305; however, for solid and foam-filled tyres, the tipping lines may be taken at a point on the tyre ground contact at a distance of 25 % from the outside edge of the ground contact width.

4.2.3.5.3 All forces shall be taken to act in their allowable direction that will produce the least stable outcome. Forces that can act simultaneously shall be considered in their least favourable combinations.

4.2.3.5.4 When the load has a stabilising effect, additional stability calculations shall be made assuming the least favourable load combination on the work platform.

NOTE For examples, see Table 1 and Figure 3.

4.2.3.5.5 In each case, the calculated stabilising moment shall be greater than the calculated overturning moment.

4.2.3.5.6 The calculation shall include the following factors:

a) tolerances in the manufacture of the components;

b) clearances that allow movement in the connections of the extending structure;

c) elastic deformations due to the effects of forces;

d) failure of any one tyre in the case of MEWPs supported by pneumatic tyres in the working position, unless the MEWP is equipped with stabilising devices that eliminate the dependence on tyres for stability or with a tyre pressure monitoring system (TPMS) that warns the operator before the tyre pressure has dropped below 75 % of the inflation pressure specified by the MEWP manufacturer;

e) performance characteristics (accuracy) of the load-sensing system, moment-sensing system, and position control, which can be affected by, for example,

   — peaks caused by short-term dynamic effects,

   — hysteresis,

   — chassis inclination of the MEWP,

   — ambient temperature,

   — different positions and distribution of load on the work platform (see 4.2.2.2.2),

   — accuracy of the system.

4.2.3.5.7 When using the criteria for enhanced stability in 4.4.1.5, the rated load shall be replaced by 150 % of the rated load.

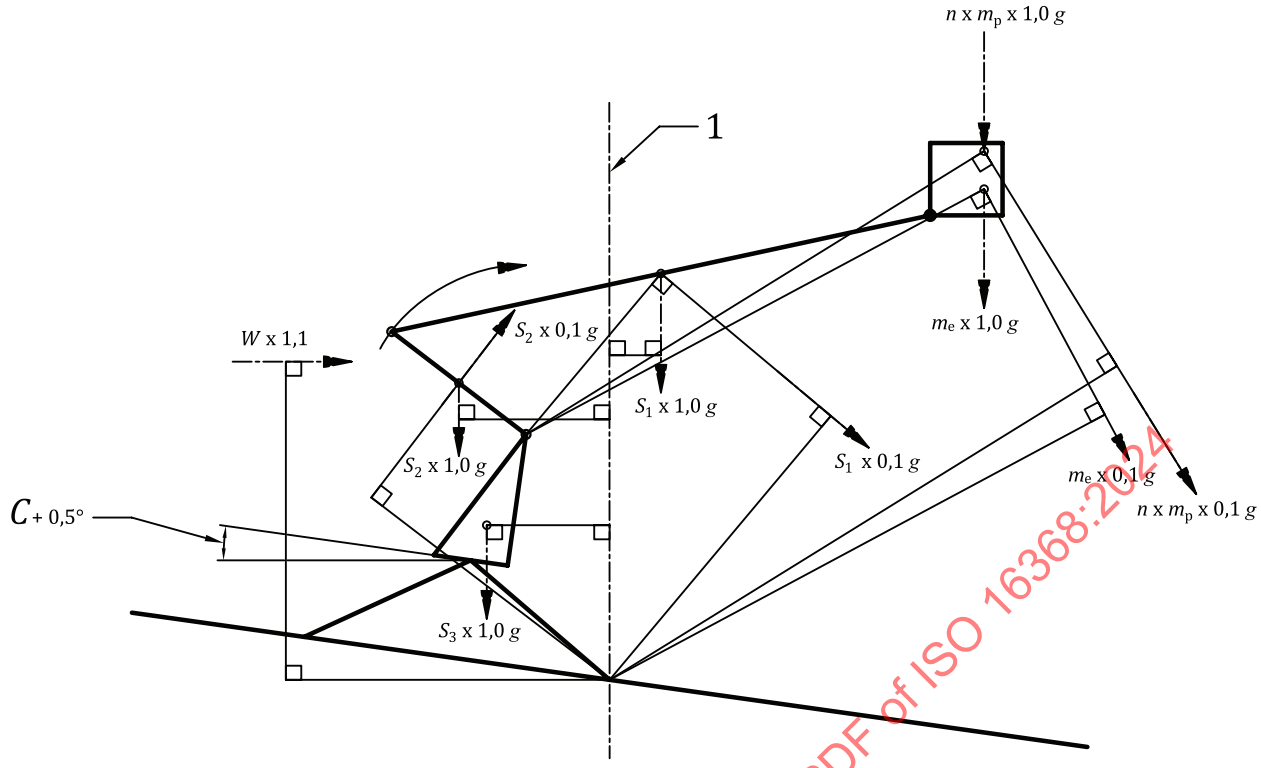
4.2.3.5.8 The determination of elastic deformations shall be obtained by experiment or by calculation.

Table 1 — Examples of load and force directions and combinations for stability calculations (see Figure 3)

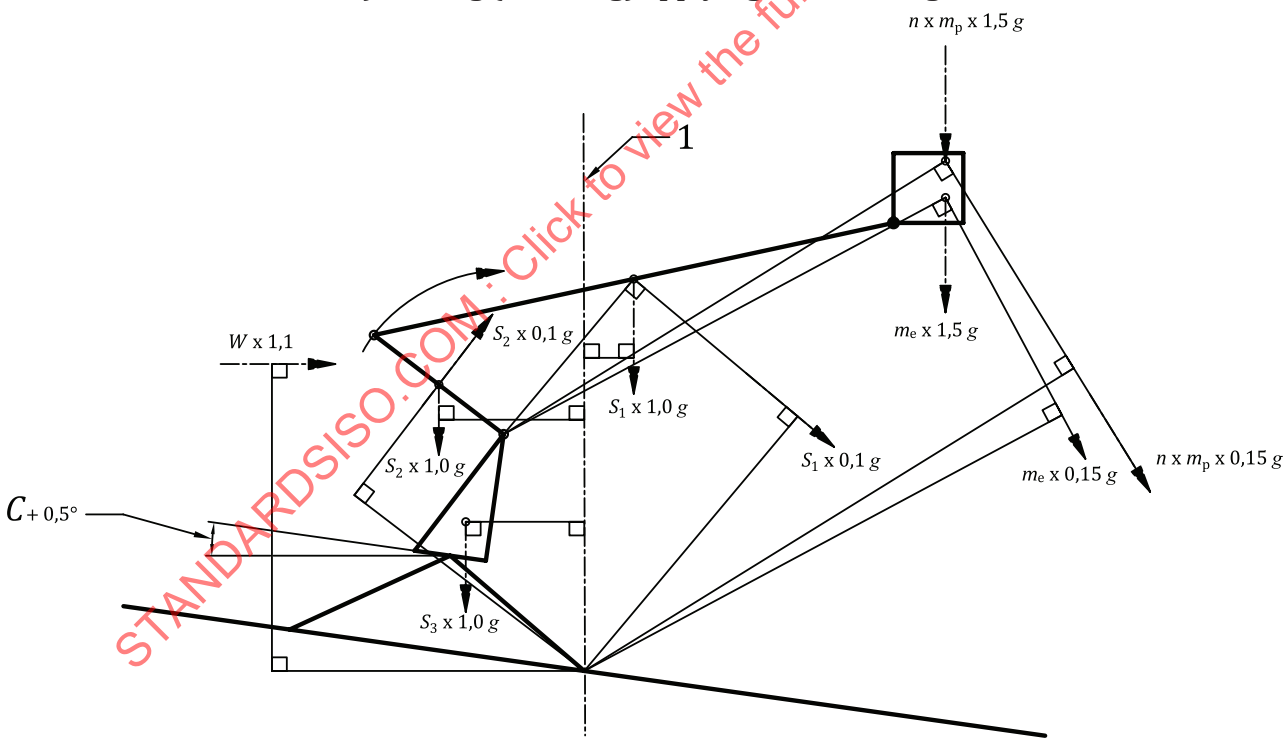
				80 kg up to rated load				Structural force S_n		Manual force F_m	Wind force W
Working configuration	**Figure example**	**Load-sensing**	**Enhanced stability criteria**	**x 1,0**	**x 1,5[a]**	**x 0,1[c]**	**x 0,15[b,d]**	**x 1,0**	**x 0,1[c]**	**x 1,1**	**x 1,1**
Raising (lowering)	3a	X	-	V	-	A	-	V	A	-	H
Raising (lowering)	3b	-	X	-	V	-	A	V	A	-	H
Traveling	3c	X	-	V	-	S	-	V	S	-	H
Traveling	3d	-	X	-	V	-	S	V	S	-	H
Traveling	3e	X	-	V	-	S	-	V	S	-	H
Traveling	3f	-	X	-	V	-	S	V	S	-	H
Forward stability, stationary on slope	3g	X	-	V	-	-	-	V	-	A	H
Forward stability, stationary on slope	3h	-	X	-	V	-	-	V	-	A	H
Backward stability, stationary on slope	3i	X	X	V	-	-	-	V	-	A	H
Limited reach, forward stability, stationary on a slope, raising (lowering)	3j	X	-	V	-	A	-	V	A	-	H
Limited reach, forward stability, stationary on a slope, raising (lowering)	3k	-	X	-	V	-	A	V	A	-	H
Stationary, on slope	3l	X	-	V	-	-	-	V	-	A	H
Stationary, on slope	3m	-	X	-	V	-	-	V	-	A	H
Stationary, on level ground	3n	X	X	V	V	-	-	V	-	A	H
Underbridge, stationary on slope	3o	X	-	V	-	-	-	V	-	A	H
Underbridge, stationary on slope	3p	-	X	-	V	-	-	V	-	A	H

V – vertical
H – horizontal
A – angular
S – at slope angle

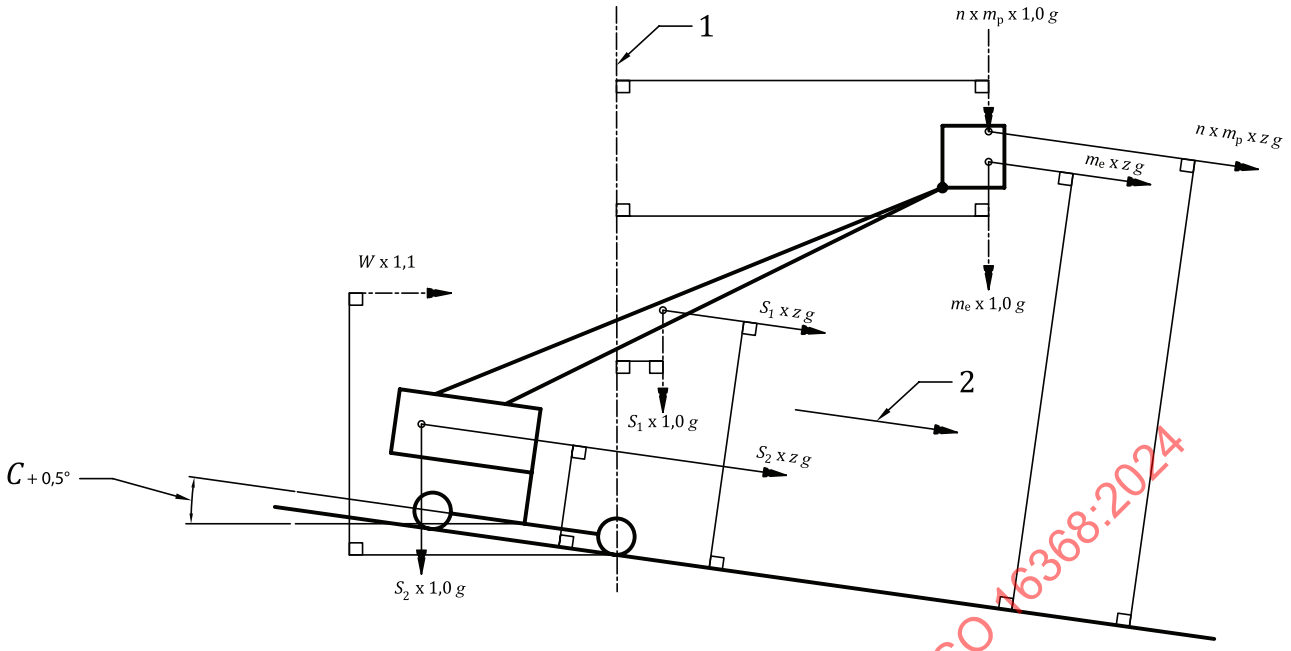
[a] 1,5 instead of 1,0 to be applied if enhanced stability criteria are applicable according to 4.4.1.5.
[b] 0,15 instead of 0,1 to be applied if enhanced stability criteria are applicable according to 4.4.1.5
[c] z (see 4.2.2.2.1.4) instead of 0,1 to be applied when traveling on slope [example in Figure 3 c), d), e) and f)].
[d] z (see 4.2.2.2.1.4) instead of 0,15 to be applied when traveling on slope [example in Figure 3 d) and f)].



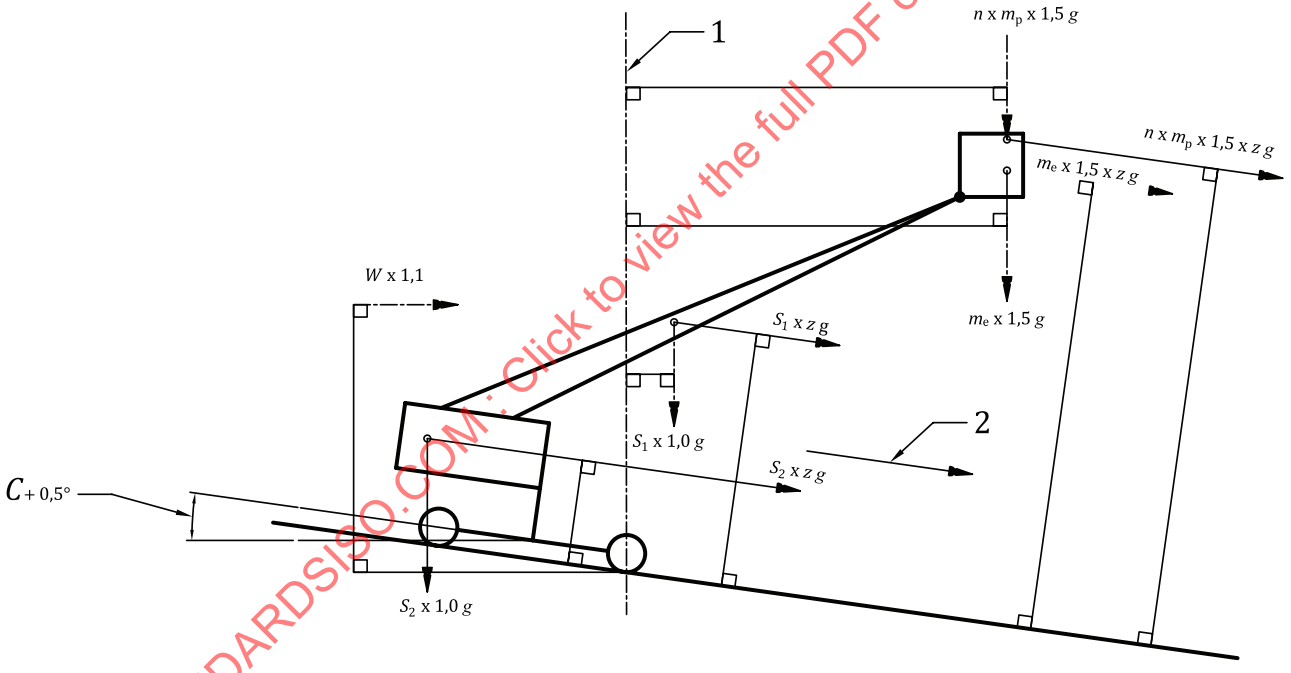
a) Raising (lowering) applying load-sensing



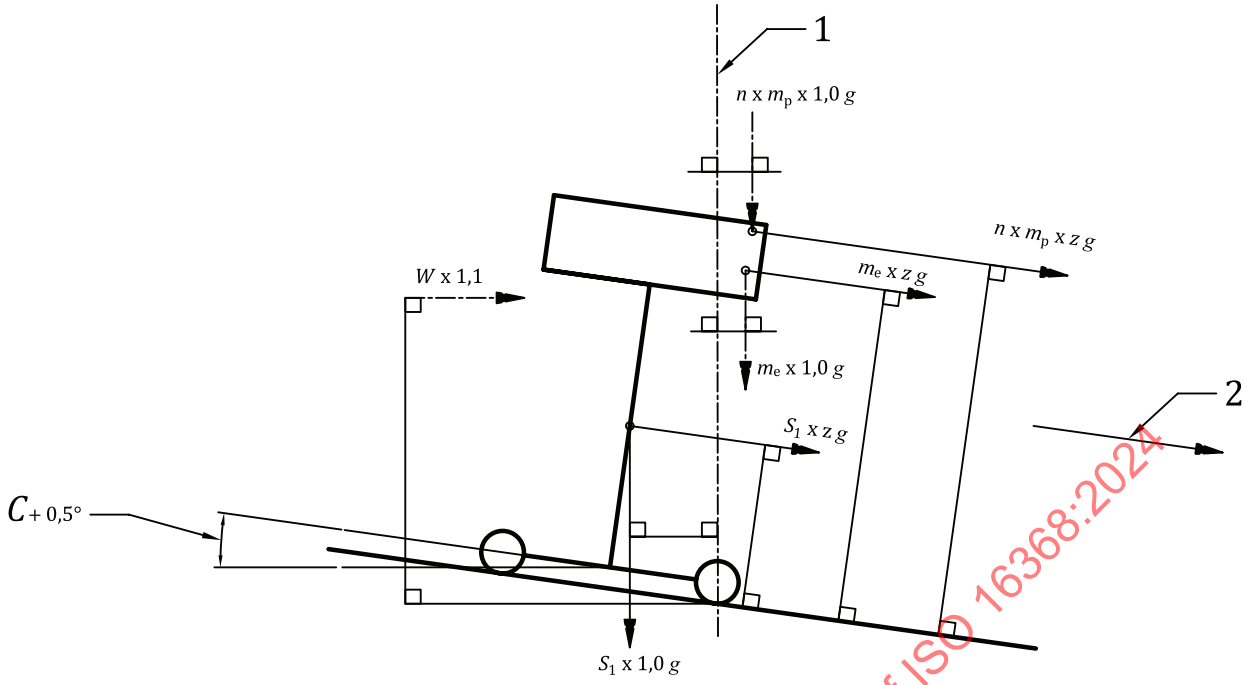
b) Raising (lowering) applying enhanced stability criteria



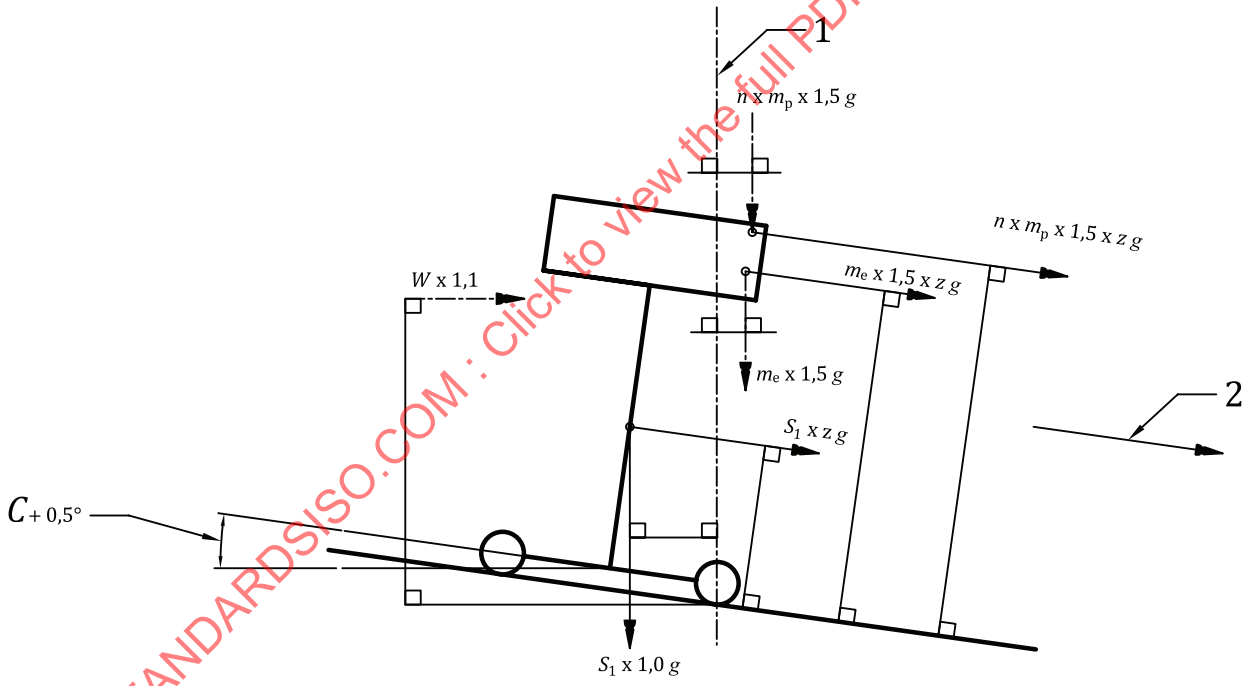
c) Traveling applying load-sensing



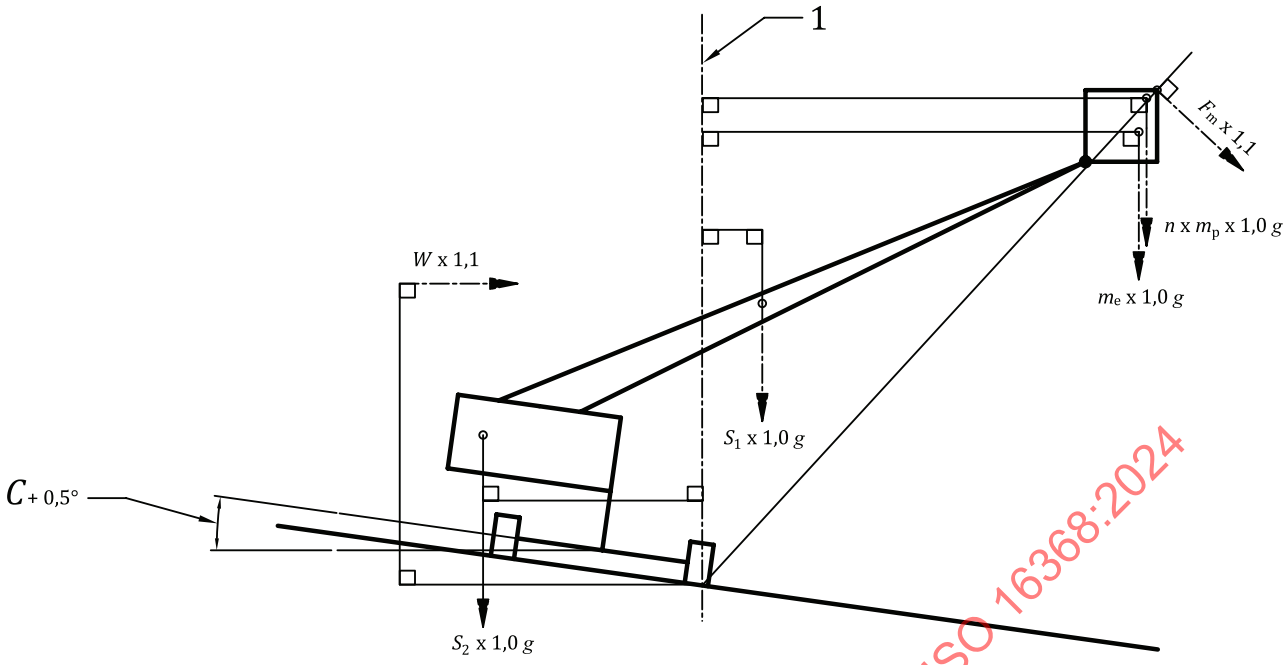
d) Traveling applying enhanced stability criteria



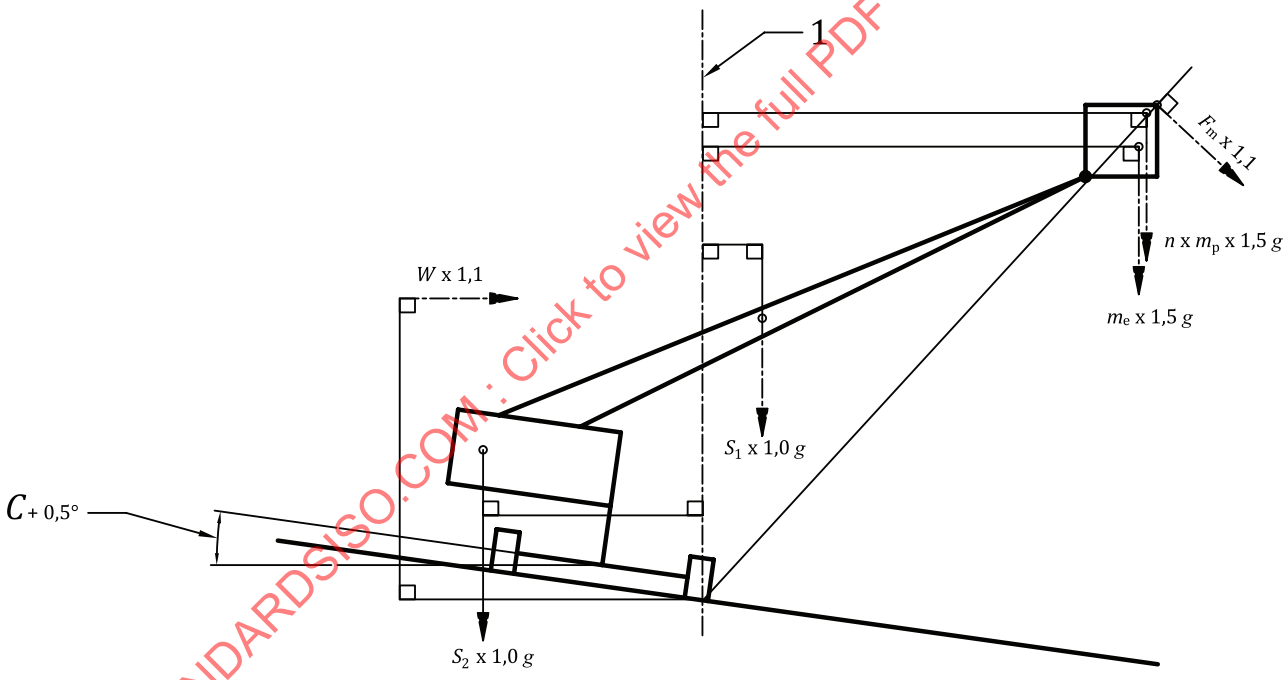
e) Traveling applying load-sensing



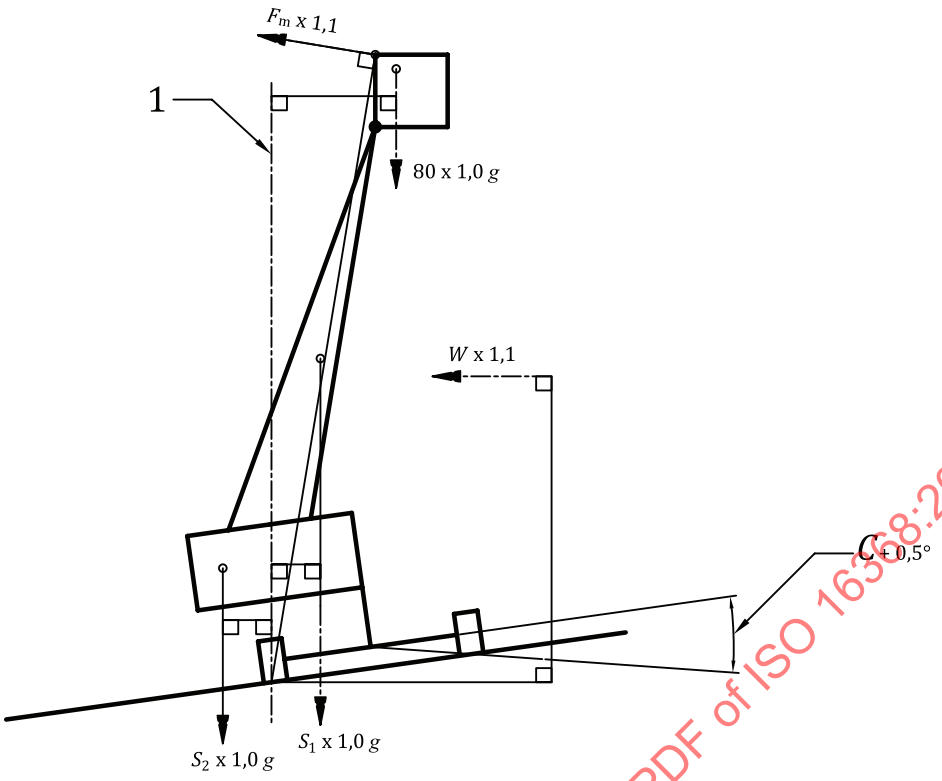
f) Traveling applying enhanced stability criteria



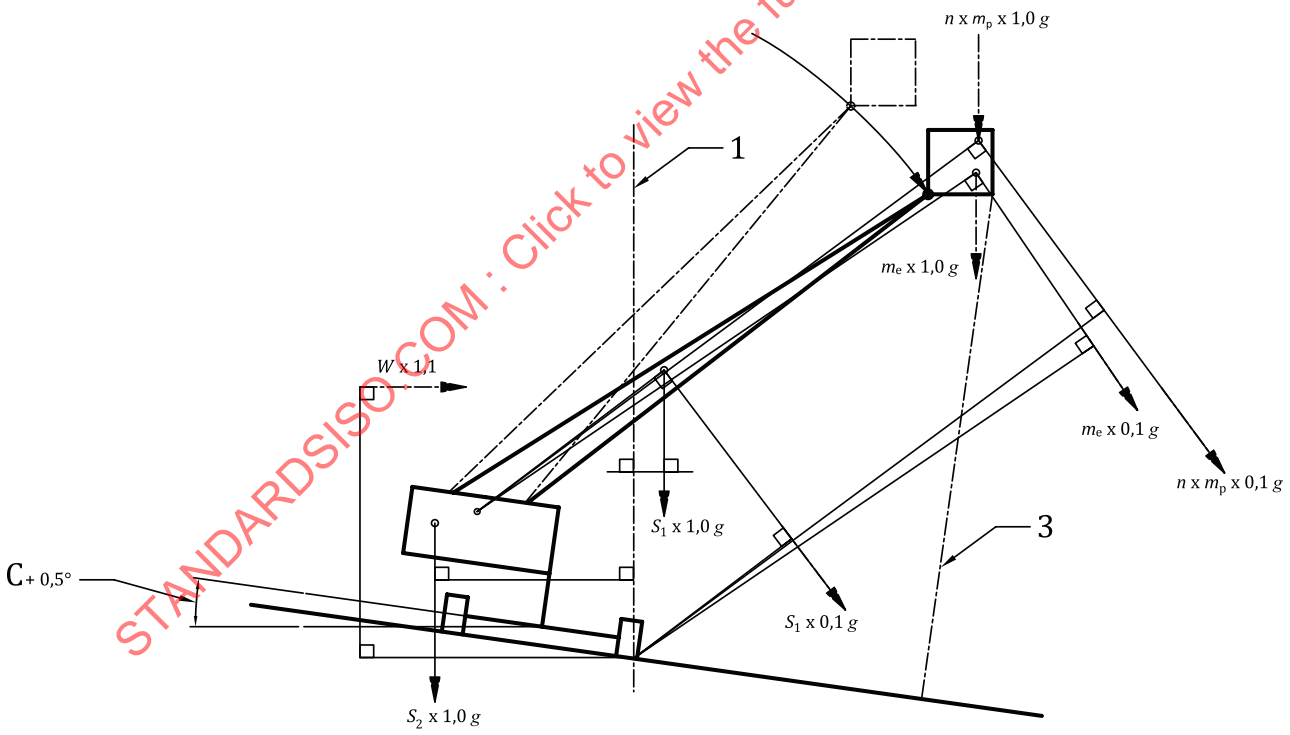
g) Forward stability, stationary on slope applying load-sensing



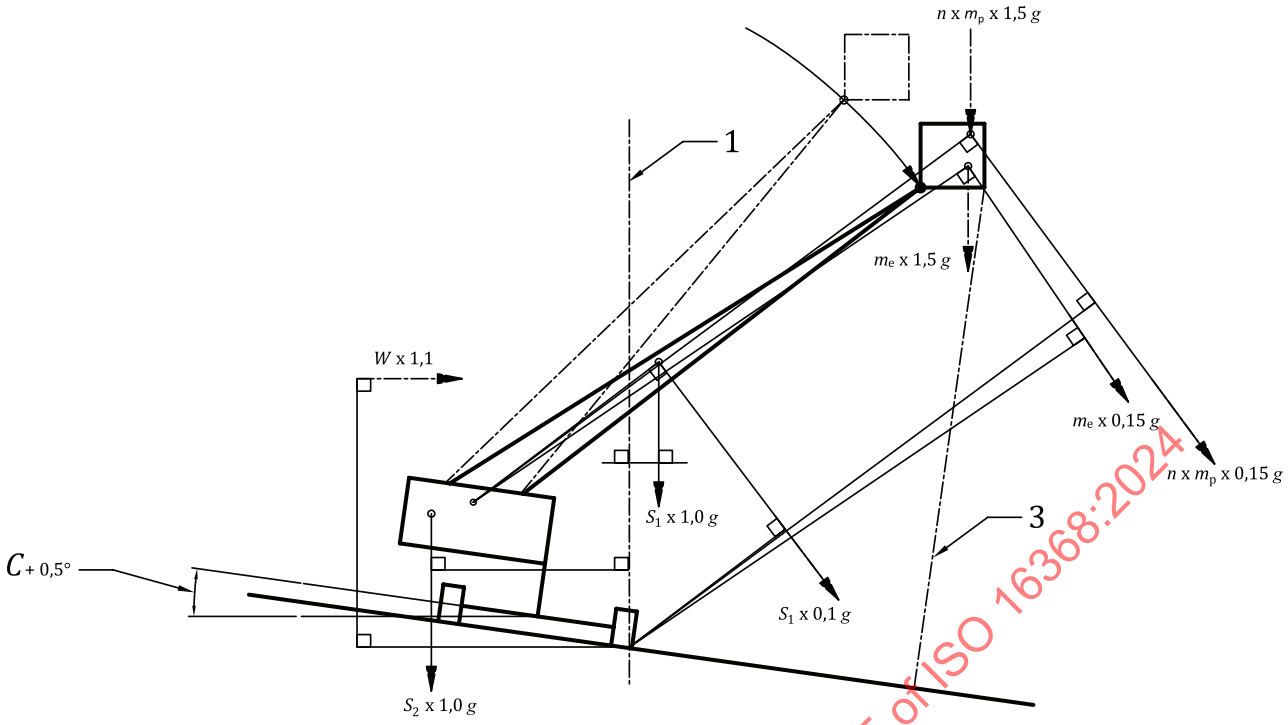
h) Forward stability, stationary on slope applying enhanced stability criteria



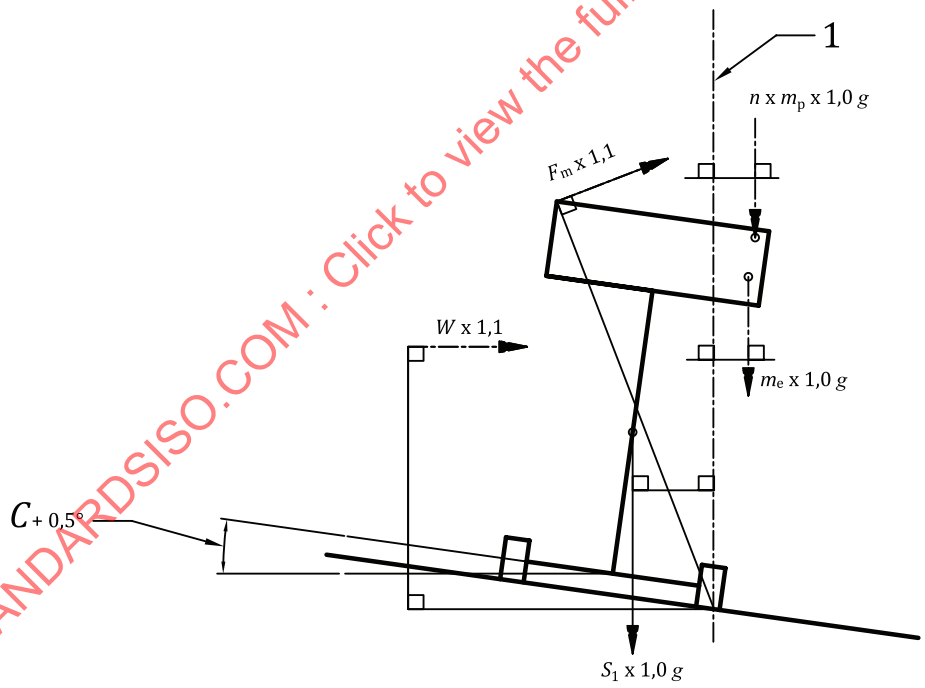
i) Backward stability, stationary on slope applying load-sensing and enhanced stability criteria



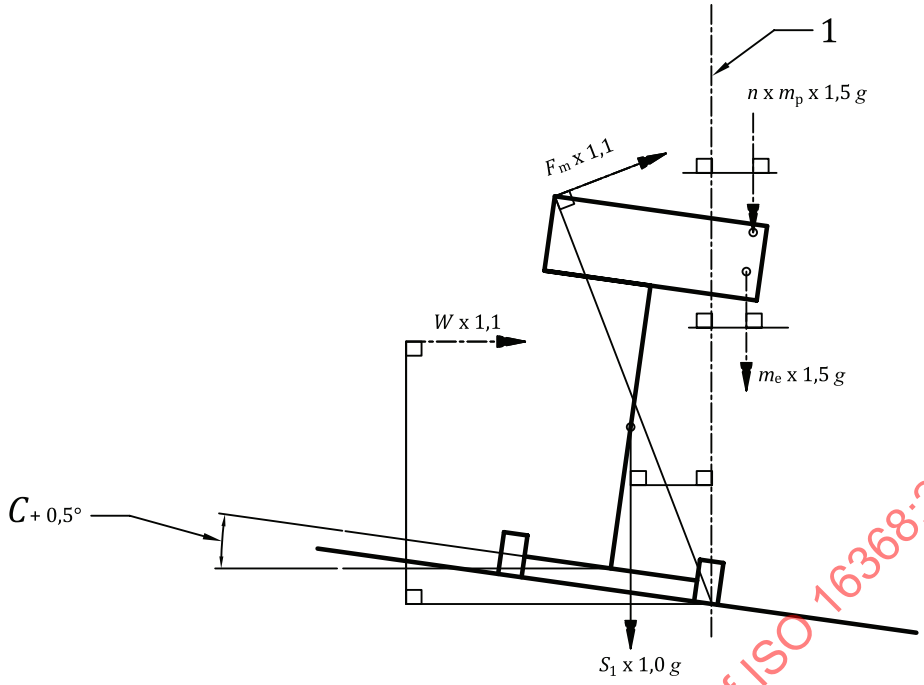
j) Limited reach, forward stability stationary on slope, raising (lowering) applying load-sensing



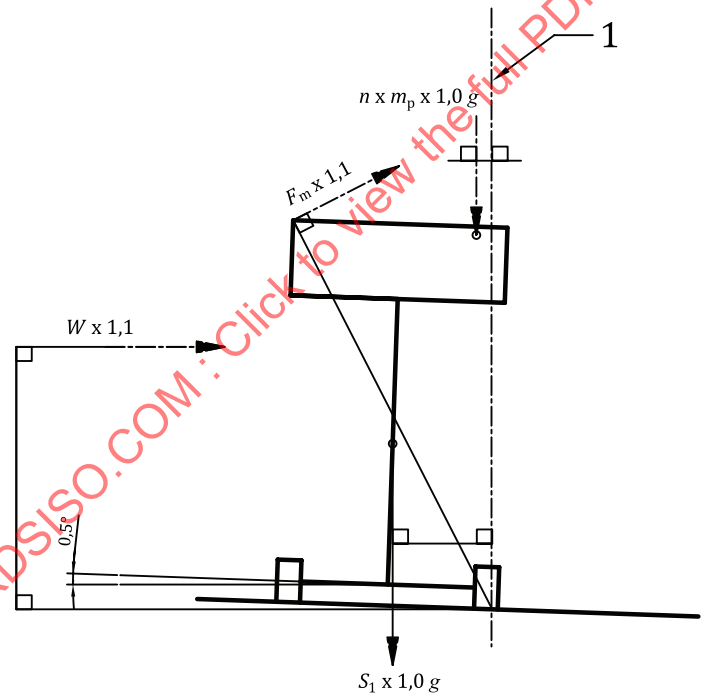
k) Limited reach, forward stability stationary on slope, raising (lowering) applying enhanced stability criteria



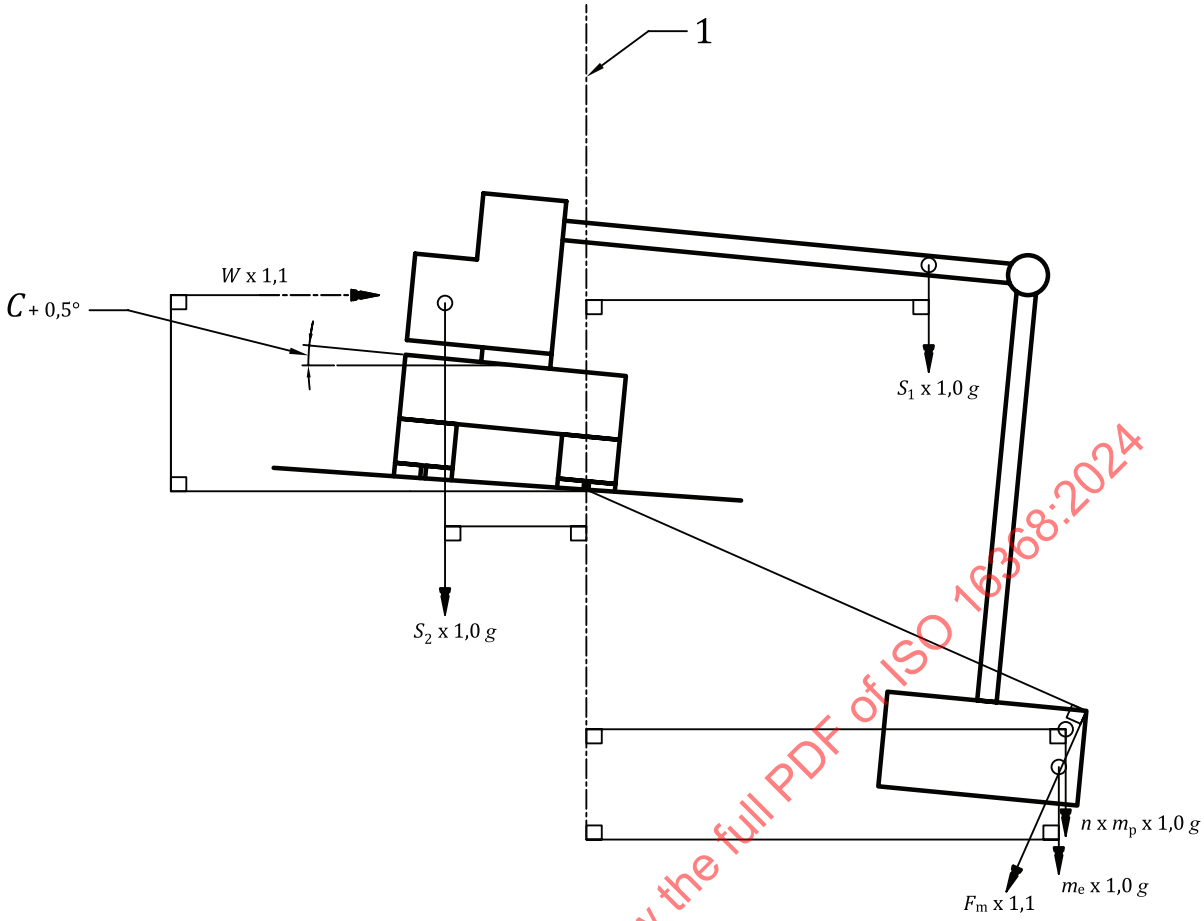
l) Stationary on slope, applying load-sensing



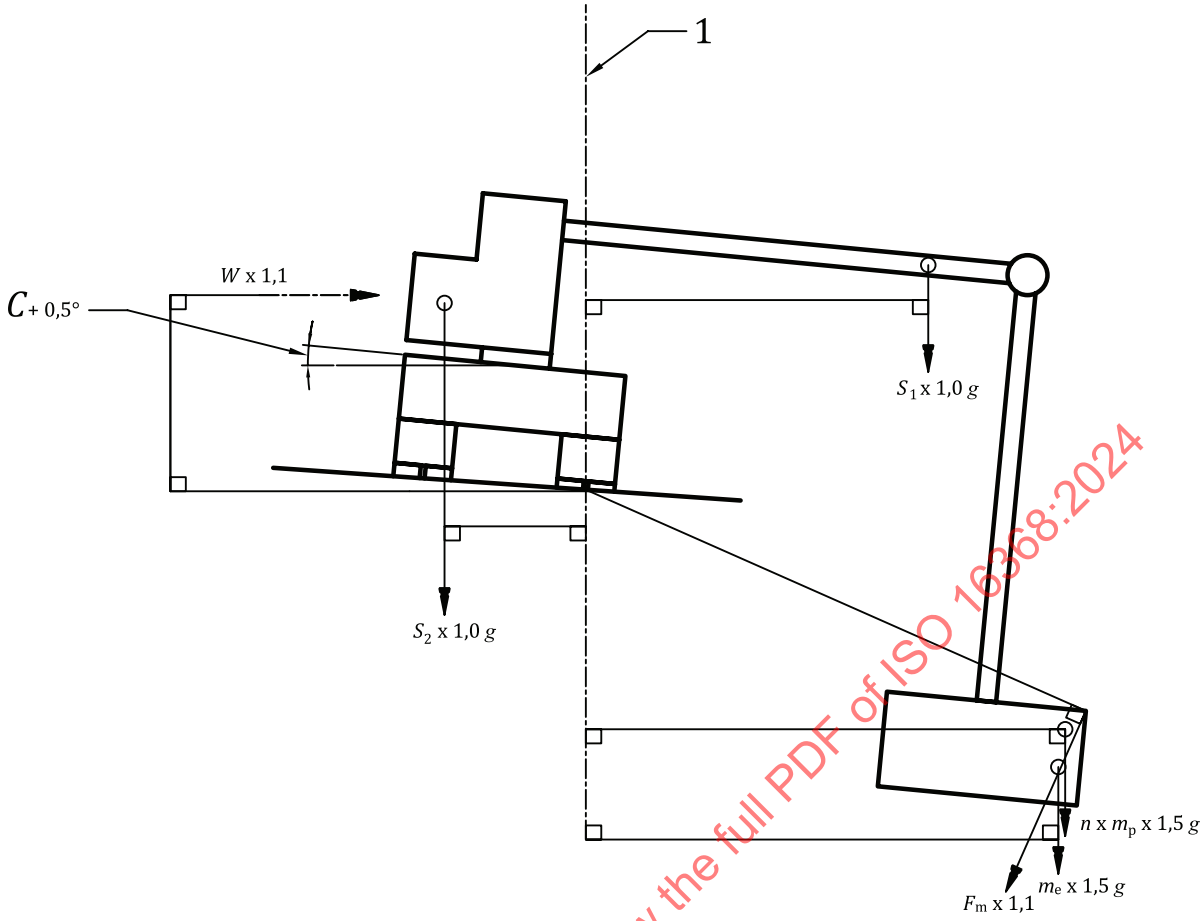
m) Stationary, on slope applying enhanced stability criteria



n) Stationary, on level ground applying load-sensing and enhanced stability criteria



o) Underbridge, stationary on slope applying load-sensing



p) Underbridge, stationary on slope applying enhanced stability criteria

Key

1 tipping line
2 direction of travel
3 limited reach
C maximum chassis inclination

Figure 3 — Example of load and force directions and combinations

4.2.4 Structural calculations

4.2.4.1 General

4.2.4.1.1 Structural calculations shall conform with the laws and principles of applied mechanics and strength of materials. If special formulas are used, the sources shall be given, or otherwise the formulas shall be developed from first principles, so that their validity can be checked.

4.2.4.1.2 Requirements given in 4.2.2, 4.2.3.1, 4.2.3.2, 4.2.3.3, 4.2.3.4 and 4.2.3.5.6 shall be considered for the determination of loads and forces to be used in the calculations.

4.2.4.1.3 Except where otherwise stated, the individual loads and forces shall be taken to act in the positions, directions and combinations that produce the least favourable conditions.

4.2.4.2 Analysis

4.2.4.2.1 General stress analysis

4.2.4.2.1.1 The general stress analysis shall be used to analyse failure by yielding, buckling, and fracturing. This analysis shall be made for all load-bearing components and joints.

4.2.4.2.1.2 The required information on stresses or safety factors shall be included in the analysis. Details of the main dimensions, cross-sections and materials for the individual components and joints shall be stated.

4.2.4.2.1.3 Finite element analysis (FEA) may be used to meet the requirements of 4.2.4.2. The FEA model shall be specified and include an explanation of the loading areas, load types, constraint areas and constraint types.

4.2.4.2.1.4 Stress analysis shall be performed by one of the stress analysis methods described in 4.2.4.2.2. When using criteria for the enhanced overload method in 4.4.1.6, the rated load shall be replaced by 150 % of the rated load.

4.2.4.2.2 Stress analysis methods

4.2.4.2.2.1 Permissible stress method

Stresses imposed by the load and force combinations defined in 4.2.4.1 shall not exceed 66,7 % of either the minimum yield strength or the buckling strength of the ductile materials. When using the criteria for enhanced overload methods in 4.4.1.6, stresses imposed by the load and force combinations defined in 4.2.4.1 shall not exceed 50 % of either the minimum yield strength or the column strength of the ductile materials. Structural elements made of non-ductile materials shall have a design stress of no more than 20 % of the minimum ultimate strength of the material.

4.2.4.2.2.2 Limit state method

Using the limited state method:

a) Loads can be considered to be either regular or occasional:

   — regular loads are either rated load or structural masses and occur frequently under normal operation;

   — occasional loads occur infrequently, are usually neglected in fatigue assessment and are either loads due to in-service wind or due to manual force.

b) These loads are combined into two load combinations:

   — load combination A is comprised of only regular loads;

   — load combination B is comprised of both regular and occasional loads.

c) The static strength of the structure shall be assessed for both load combination A and B. The loads and forces defined in 4.2 shall thereby be multiplied by the partial safety factors γ_p given in Table 2.

Table 2 — Partial safety factors

Clause	Loading	Partial safety factors γ_p	
		Load combination A	Load combination B
4.2.1.2	Rated load	1,34	1,22
4.2.2.2	Structural masses	1,22	1,16
4.2.2.3	Wind forces (loads)	-	1,22
4.2.2.4	Manual force	-	1,22

d) Forces due to structural masses that are acting favourably (for example, counterweights that reduce forces and stresses) in some load carrying parts, shall be assigned the value γ_p = 1 when calculating those load-carrying parts.

NOTE 1 Load combinations from ISO 8686-2 are not applicable within this document.

e) The strength of load bearing steel structures shall be calculated and proofed in accordance with ISO 20332. When ISO 20332 is not applicable, (for example, the fatigue strength of welded connections with plates thinner than 3 mm), the calculation and proof of the load bearing structures shall follow the principles of ISO 20332 and appropriate limits states shall be obtained from relevant sources.

f) Structural elements made of non-ductile materials not covered by ISO 20332 shall have a design stress of no more than 20 % of the minimum ultimate strength of the material. The partial load factors in Table 2 shall be taken as 1.

NOTE 2 DNVGL-C501 can be used for composite components.

g) Components that have been qualified by test or acceptable design criteria, or both, such as gears, gearboxes, bearings, and threaded fasteners, shall be considered as providing equivalent levels of safety. For these components, the original manufacturer's ratings shall not be exceeded.

h) Test criteria should be established by reference to relevant standards, design methods and application.

4.2.4.2.3 Elastic stability analysis

Elastic stability analysis shall be used to analyse and avoid failure by elastic instability (for example, buckling, crippling). This analysis shall be made for all load-bearing components subjected to compressive loads.

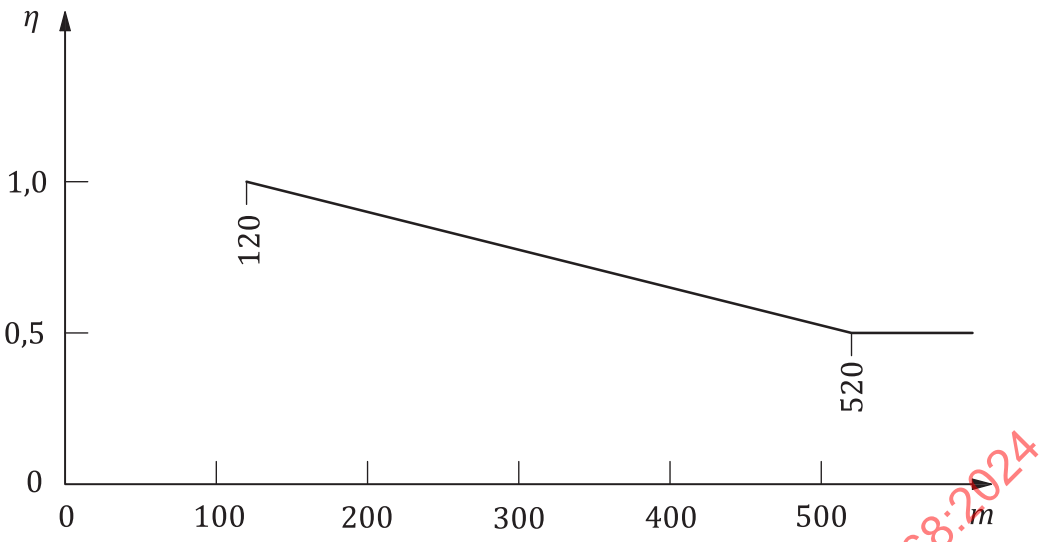
4.2.4.2.4 Fatigue stress analysis

4.2.4.2.4.1 Fatigue stress analysis shall be used to analyse and avoid failure by fatigue due to stress fluctuations during normal operation and transport. This analysis shall be made for all load-bearing components and joints critical to fatigue, taking into account the construction details, the degree of stress fluctuation and the number of stress cycles. The number of stress cycles may be a multiple of the number of load cycles. Other stress variations during use, caused by movements (for example, slewing, raising or travelling), can also contribute to the number of stress cycles. Usually, only regular loads need to be considered and the partial safety factors γ_p shall be set to 1. Loads due to misuse need not be considered.

4.2.4.2.4.2 As the number of stress fluctuations during transport cannot be calculated with any degree of accuracy, the stress in the transport position in components subject to vibration during transport shall be low enough to ensure virtually infinite fatigue life (see also 4.4.6 and 4.6.14).

4.2.4.2.4.3 When determining the load combinations, it is permissible for the rated load to be reduced by the load spectrum factor in accordance with Figure 4; wind loads need not be taken into account.

NOTE For the design of wire-rope drive systems, see Annex C and Annex D.



Key

m mass, kg

η load spectrum factor

Figure 4 — Load spectrum factor

4.2.4.2.5 Effects of stress concentration and ambient temperature

The analysis shall consider the effects of stress concentration and the effects of ambient temperature in the temperature range for which the MEWP has been designed.

4.3 Chassis and stabilising devices

4.3.1 Travel prevention

An automatic safety device in accordance with 4.11 shall be fitted to prevent the travel of pedestrian-controlled MEWPs and power-driven type 1 MEWPs when the work platform is out of the transport or stowed position.

4.3.2 Chassis inclination

4.3.2.1 Every MEWP shall have a device to indicate when the inclination of the chassis exceeds the limits permitted by the responsible entity when the MEWP is out of the lowered travel position. The device shall also prevent elevation beyond the lowered travel position when the chassis inclination is beyond that specified by the responsible entity for that configuration. This device shall be automatic, in accordance with 4.11 and shall be protected against damage and accidental change of its setting. Adjustment of the device shall require the use of tools.

4.3.2.2 For type 1 MEWPs, the device in 4.3.2.1 may be replaced by a spirit level. For those MEWPs with power-driven stabilising devices, the indication shall be clearly visible from each stabilising device control position.

4.3.2.3 For type 2 MEWPs, when travelling in the elevated travel position, an audible warning shall sound at each control position before reaching the maximum limits specified by the responsible entity.

4.3.2.4 For type 3 MEWPs, when travelling in the elevated travel position, upon reaching the limits specified by the responsible entity, the device shall prevent the MEWP from continuation of travel in the

selected direction and an audible warning shall sound. Travel may be resumed provided that stability is maintained or improved. For group A MEWPs, further elevation shall also be prevented.

4.3.3 Locking pins

Any locking pins shall be secured against unintentional disengagement and loss.

4.3.4 Control bars and tow bars

Control bars on pedestrian-controlled MEWPs and tow bars shall be securely fastened to the chassis.

4.3.5 Control bars and tow bars held in vertical position

4.3.5.1 If control bars and tow bars, when not in use, are raised to the vertical position, an automatic device (for example, hook) shall be provided to hold the bars in this position.

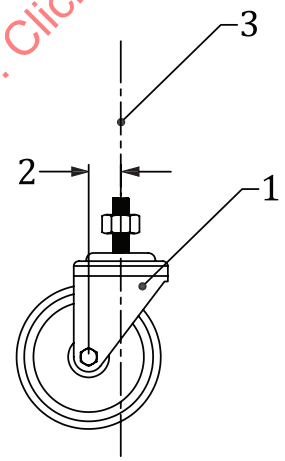
4.3.5.2 For multi-axle chassis, the minimum clearance between the fully lowered control bar or tow bar and the ground shall be 120 mm.

4.3.6 Stabilising device ground contact points

4.3.6.1 The stabilising device ground contact points shall be constructed to accommodate ground unevenness of at least 10°. Stabilising devices equipped with rollers are exempt from the 10° ground unevenness requirement.

4.3.6.2 Castor wheels with an offset, as defined in ISO 22877, are not permitted to be used unless rotation about the vertical axis is automatically prevented when the work platform is raised out of the lowered travel position (see Figure 5).

4.3.6.3 The requirements of 4.3.6.2 do not apply to self-propelled MEWPs.



Key

1 castor wheel
2 offset
3 vertical axis

Figure 5 — Castor wheel with offset

4.3.7 Permitted work platform positions

4.3.7.1 MEWPs shall be fitted with a safety device in accordance with 4.11 that prevents the work platform operating outside permitted positions unless the stabilising devices are set in accordance with the operating instructions.

4.3.7.2 MEWPs constructed for operation without stabilising devices for a limited range of operation shall be equipped with safety devices in accordance with 4.11 that prevent operation outside that limited range without stabilising devices.

4.3.8 Totally manually operated MEWPs

4.3.8.1 The requirements of 4.3.7 are not applicable to MEWPs that are totally manually operated and have a work platform floor height less than or equal to 5 m above ground level (see 6.4.15).

4.3.8.2 These MEWPs are also exempt from all safety requirements that cannot be met without a power supply.

4.3.9 Prevention of powered stabilising devices movement

MEWPs with powered stabilising devices shall be fitted with a safety device in accordance with 4.11 to prevent movement of the stabilising devices, unless the extending structure and the work platform are in the stowed or transport position or within the limited range specified in 4.3.7. When the extending structure and the work platform are inside the limited range, the operation of the stabilising devices shall not create an unstable situation.

4.3.10 Manually operated stabilising devices

Manually operated stabilising devices shall be designed to prevent unintentional movement.

4.3.11 Movement of stabilising devices

4.3.11.1 The movements of stabilising devices shall be limited by mechanical stops. Hydraulic cylinders fulfil this requirement if designed for that purpose.

4.3.11.2 For MEWPs with permanently attached stabilising devices that increase their width or length when deployed, a mechanical means shall be provided to prevent uncontrolled movements of stabilising devices from the transport position. Each stabilising device shall be locked in the transport position by two separate locking devices for each stabilizer, at least one of which operates automatically (for example, a gravity locking pin plus a detent). Powered stabilising devices meeting the requirements of 4.3.9 and 4.10 are regarded as meeting this requirement.

4.3.12 Vehicle-mounted MEWP transport position indicators

Vehicle-mounted MEWPs shall be equipped with one or more indicators visible from the travelling controls to indicate if all parts of the stabilising devices, the extending structure, the access ladders and the work platform of the MEWP are in the transport positions.

4.3.13 Visual contact at control positions

4.3.13.1 Any control position shall provide the operator with visual contact with the resulting movements.

4.3.13.2 The operator positions for powered stabilising devices that deploy beyond the width or length of the chassis shall allow a clear view of the movement of each stabilising device until it reaches the supporting surface.

4.3.13.3 Travel controls fixed to the chassis and operated from ground level shall be positioned so as to cause the operator to stand at least 1 m from the vertical tangent of the wheels or crawlers.

4.3.14 Levelling stabilising devices

4.3.14.1 For MEWPs which are constructed for operation with levelling stabilising devices, the stabilising devices shall be capable of levelling the chassis or the extending structure to within the maximum allowable chassis inclination when operating on the maximum slope permitted by the manufacturer.

4.3.14.2 MEWPs equipped with tilting chassis and/or extending structure in which stability of the machine when operating is dependent on control or locking of the tilting shall satisfy the following requirements:

a) On type 1 MEWPs in which stability is dependent on control or locking of the tilting mechanism(s), a safety device in accordance with 4.11 shall prevent deployment of the extending structure until tilting of the chassis and/or superstructure is positively controlled or locked.

b) On type 2 and type 3 MEWPs in which stability is dependent on control or locking of the tilting mechanism(s), it shall be shown by demonstration that the inclinations of the chassis and/or the superstructure remain within the limits specified by the manufacturer when the inclination of the chassis is at the maximum value permitted by the manufacturer. Safety devices which control or lock the tilting shall be in accordance with 4.11.

4.3.14.3 Hydraulic cylinders, if used as positional control or locking devices, shall comply with 4.10.

4.3.15 Oscillating axle lock or control systems

4.3.15.1 MEWPs equipped with one or more oscillating axles, in which stability of the machine when operating is dependent on systems which control or lock the oscillating axle(s), shall satisfy the following requirements:

a) On type 1 MEWPs, a safety device in accordance with 4.11 shall prevent deployment of the extending structure until oscillation of the axle(s) is locked or controlled.

b) On type 2 and type 3 MEWPs that have a means of locking or control of the oscillating axle(s), safety devices in accordance with 4.11 shall be incorporated.

4.3.15.2 Safety devices which control or lock the oscillation shall be in accordance with 4.11.

4.3.15.3 Hydraulic cylinders, if used for position control or locking devices, shall comply with 4.10.

4.3.15.4 Systems comprised solely of mechanical devices to control oscillating axles do not require any specific safety devices.

4.3.16 Maximum travel speeds in elevated travel position

4.3.16.1 Travel speeds for type 2 and type 3 MEWPs in the elevated travel position shall not exceed the following values:

a) 1,5 m/s for vehicle-mounted MEWPs when using the travelling controls;

b) 3,0 m/s for rail-mounted MEWPs;

c) 0,7 m/s for all other self-propelled type 2 and type 3 MEWPs.

4.3.16.2 Any travel speed restriction for self-propelled type 2 and type 3 MEWPs, when the work platform is out of the lowered travel position, shall be automatic and in accordance with 4.11.

4.3.17 Maximum travel speed of pedestrian-controlled MEWPs

The maximum travel speed of a pedestrian-controlled MEWP with its work platform in the transport or stowed position shall not exceed 1,4 m/s.

4.3.18 Self-propelled MEWP brakes

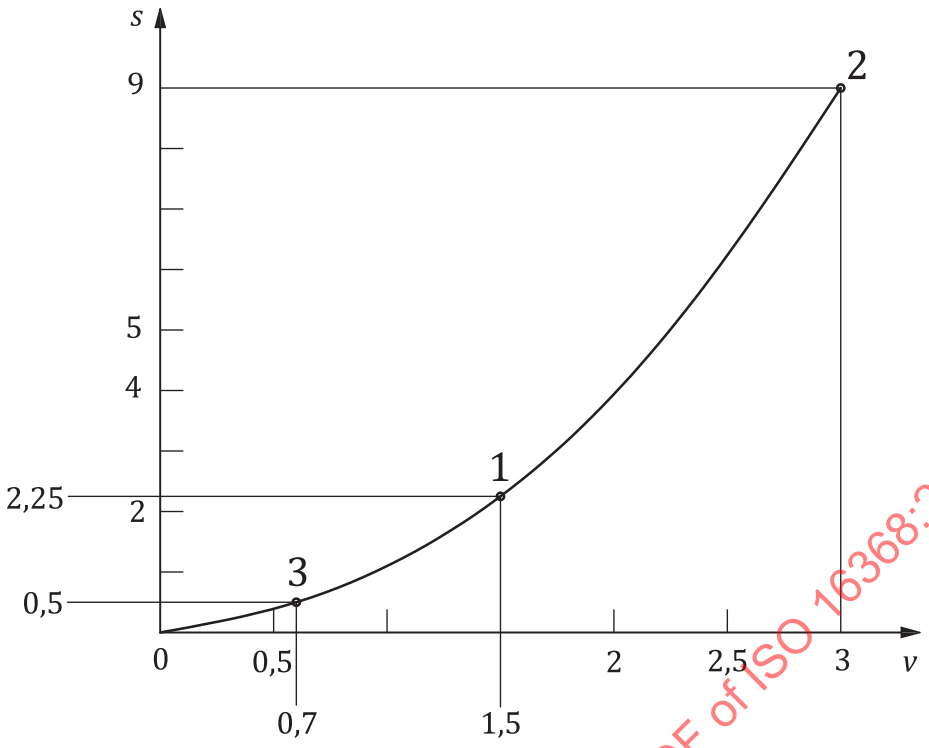
4.3.18.1 Self-propelled MEWPs shall be equipped with brakes on at least two wheels on the same axis that engage automatically when power to the brakes is removed or fails. Such brakes shall not rely on hydraulic or pneumatic pressure or electrical power to remain engaged.

4.3.18.2 When in an elevated travel position, the brakes shall be able to stop the MEWP in accordance with 4.3.19 and maintain the stopped position.

4.3.18.3 When in the lowered travel position, the brakes shall hold the unit on any slope it is capable of climbing, subject to adequate traction on the braking wheels. The MEWP shall be able to stop from maximum rated speeds when descending any slope that the unit is capable of climbing, provided the slope provides adequate traction on the braking wheels.

4.3.19 Stopping distances

MEWPs travelling in the elevated travel position and at the maximum speeds on the maximum chassis inclination allowed by the responsible entity shall be capable of being stopped within the distances stated in Figure 6. This requirement shall be satisfied for all permissible combinations of travel speed and rated chassis inclination.



Key

v speed, m/s
s stopping distance, m
1 for vehicle-mounted MEWPs
2 for rail-mounted MEWPs
3 for all other MEWPs

Figure 6 — Maximum stopping distance for type 2 and type 3 MEWPs

4.3.20 Unauthorized use

MEWPs shall be equipped with a device to prevent unauthorized use when the MEWP is unattended.

4.3.21 Thermal hazards

Persons at control positions or standing adjacent to the MEWP at ground level shall not be exposed to thermal hazards resulting from hot surfaces.

4.3.22 Engine exhaust

The exhaust from internal combustion engines shall be directed away from control positions.

4.3.23 Filling points for fluids

The filling points of gas and fluid reservoirs (other than for fire-resistant fluids) shall be positioned in order to avoid any fire from spillage onto hot parts (for example, engine exhaust).

4.3.24 Batteries and battery containers

4.3.24.1 All MEWP batteries and battery containers shall be constrained to prevent displacement which can result in a hazard. A means shall be provided that, in the event of overturning, the battery will be

constrained so as to avoid the risk of injury to the operator by the battery being displaced or release of electrolyte.

4.3.24.2 Suitable ventilation holes shall be provided in the battery container, compartment or cover so that dangerous accumulations of gases do not occur.

4.3.24.3 Batteries shall be accessible for inspection, service, or replacement.

4.3.25 Derailment and run-away prevention of rail-mounted MEWPs

4.3.25.1 General

4.3.25.1.1 The following requirements relate to the prevention of derailment of rail-mounted MEWPs during running and when moving along the track in working configuration.

4.3.25.1.2 When moving along the track in running and working configurations, rail-mounted MEWPs shall have all rail wheels loaded sufficiently to avoid derailment.

4.3.25.1.3 Rail-mounted MEWPs shall be provided with devices that act on the rails to prevent derailment and devices to remove obstacles on the rails, which might cause derailment (for example, track clearers).

4.3.25.2 Proof against derailment

4.3.25.2.1 MEWPs with structures that are movable and influence the potential to derail shall have proof against derailment.

4.3.25.2.2 For MEWPs with only one suspension in stationary or running modes, proof against derailment in the foreseen working conditions is deemed to have been shown if, simultaneously,

a) the suspension is not blocked out or, for MEWPs with three-point suspension, at least one of the three support points can turn freely and absorb the twist, or the MEWP (including the wheel sets) is flexible enough to absorb the track twist,

b) there is no rigid connection between several connected MEWP parts that would obstruct the turning freedom or the free movement in vertical and crosswise direction within the freedom of movement necessary for the threshold parameters between the parts.

4.3.25.2.3 For MEWPs having different axle or suspension configurations in stationary and running modes, proof against derailment is deemed to be shown by stationary tests, taking into account the work configurations according to 4.3.25.3. Neither when stationary nor when moving along the track shall it be possible to change from one configuration to the other if this would cause the load moment to reach or exceed 90 % of the rated load for the new configuration.

4.3.25.2.4 If one of these conditions is not observed, proof against derailment shall be achieved by stationary tests according to 4.3.25.3.

4.3.25.3 Load cases for prevention of derailment during moving

4.3.25.3.1 Wheel unloading shall be proven by stationary tests for rail-mounted MEWPs that could have their centre of gravity displaced when moving along the track. Using all possible unfavourable positions of the MEWP and load, and the worst combination of track cant, gradient and twist, no rail wheel shall leave the rail when 1,5 times the maximum load is applied.

4.3.25.3.2 In addition, at the most unfavourable track condition with a maximum load, no wheel shall unload by more than 60 % of its normal weight.

4.3.25.4 Limiting use of MEWPs due to derailment requirements

If the prevention of derailment is not ensured for all working configurations, the scope of the MEWP shall be limited, and this shall be indicated in the technical documentation and the operation and maintenance manual and shall be displayed on the MEWP.

4.3.25.5 Prevention of run-away — Placement and removal from rails

4.3.25.5.1 The documented procedure used to describe the placing of the vehicle on, or removal from the track, shall be assessed to ensure that there is no inadvertent movement of the vehicle at any time during the procedure. This requires that the MEWP have at least one braked axle (with the brakes applied), sufficient to hold the vehicle on the most adverse gradient on which it can be placed (in contact with either the rail or ground).

4.3.25.5.2 Where an emergency stop button is fitted, it shall apply the brakes by stopping rotation of the braked axle(s). The button's operation shall be tested to ensure that the brakes are applied in all possible vehicle configurations, including during both on- and off-tracking procedures.

4.3.26 Vehicle-mounted MEWP chassis selection

For vehicle-mounted MEWPs, the chassis shall be selected to meet the MEWP specifications. Installation criteria shall meet the chassis specifications and the specifications for mounted sub-assemblies.

4.4 Extending structure

4.4.1 Methods to avoid overturning and exceeding permissible stresses

4.4.1.1 General

In addition to the provisions of 4.2.3.5, MEWPs shall be provided with the systems or the enhanced methods to reduce the risk of overturning and the risk of exceeding permissible stresses by one of the equivalent solutions indicated in Table 3.

NOTE Load or moment controls are not able to protect against an overload that grossly exceeds the rated load.

Table 3 — Control devices

Group	Load-sensing system and position control (4.4.1.2 and 4.4.1.3)	Load-sensing and moment-sensing systems (4.4.1.2 and 4.4.1.4)	Moment-sensing systems and enhanced overload criteria (4.4.1.4 and 4.4.1.6)	Position control with enhanced stability and overload criteria (4.4.1.3, 4.4.1.5 and 4.4.1.6)
A	X	—	—	X
B	X	X	X	X

4.4.1.2 Load-sensing system

4.4.1.2.1 The load-sensing system shall operate as follows:

a) It shall trigger after the rated load is reached and before 120 % of the rated load is exceeded.

b) While the load-sensing system is triggered, it shall give a visual warning and an audible signal in accordance with IEC 61310-1 at each control position.

c) If the load-sensing system was triggered during movement of the work platform, the possibility of movement shall remain.

d) If the load-sensing system is triggered while the work platform is stationary, it shall prevent all movement of the work platform. Movement shall only restart if the overload is removed. For group A MEWPs, lowering movement is permitted.

4.4.1.2.2 For type 1, group A MEWPs, it is permitted for the load-control device to be effective only when raising the extending structure from the lowest position. In this case, for the overload test specified in 5.1.4.3.1, the test load shall be 150 % of the rated load.

4.4.1.2.3 For group A MEWPs, the load-sensing device need not be activated until the work platform is elevated more than 1 m or 10 % of lift height, whichever is the greater, above the lowest position. If an overload condition is sensed at or above this height, further elevation shall be prevented.

4.4.1.2.4 The load-sensing system shall be in accordance with 4.11.

4.4.1.3 Position control

4.4.1.3.1 General

Permissible positions of the MEWP's extending structure shall be limited automatically by mechanical limiting devices (see 4.4.1.3.2), non-mechanical limiting devices (see 4.4.1.3.3) or electrical safety devices (see 4.11) to prevent overturning of the MEWP or exceeding the permissible stresses in the structure of the MEWP.

4.4.1.3.2 Mechanical limiting devices

Where permissible positions are limited by mechanical limiting stops, they shall meet the requirements of 4.2.4.2. Hydraulic cylinders fulfil this requirement if designed for that purpose.

4.4.1.3.3 Non-mechanical limiting devices

Where non-mechanical limiting devices are used, permissible positions of the MEWP extending structure shall be limited by a device that measures positions of the extending structure and is operated through the control systems to limit movements to the working envelope. These devices shall be backed up by a safety device in accordance with 4.11.

4.4.1.4 Moment-sensing system

The moment-sensing system shall operate as follows:

a) When the portion of the permissible overturning moment (see 4.2.3.5) due to rated load and structural masses is reached, there shall be a visual and audible warning given and further movements shall be prevented, except those which reduce the overturning moment.

b) The control system for the moment-sensing system shall comply with the requirements of 4.11.

4.4.1.5 Criteria for enhanced stability for limited work-platform dimensions

MEWPs for one or two persons may be excluded from the requirements for load-sensing and moment-sensing systems if they meet the following criteria for enhanced stability.

a) The work platform at any horizontal section, including any extension, and excluding steps located outboard of the work platform shall have

— for one person, a platform floor area not greater than 0,6 m^2, with no side greater than 0,85 m,

— for two persons, a platform floor area not greater than 1,0 m^2, with no side greater than 1,4 m.

b) For the static test specified in 5.1.4.2.1, the test loads shall be calculated using 150 % of the rated load as identified in 4.2.1. The other load and force combinations specified in 4.2.2 shall remain applicable.

4.4.1.6 Criteria for enhanced overload for limited work platform dimensions

MEWPs for one or two persons may be excluded from the requirements for load-sensing systems if they meet the following criteria for enhanced overload.

a) The work platform at each horizontal section, excluding steps that might be present on the outside surfaces of the work platform shall have

   — for one person, a sectional platform floor area not greater than 0,6 m^2, with no side greater than 0,85 m;

   — for two persons, a sectional platform floor area not greater than 1,0 m^2, with no side greater than 1,4 m.

b) For the overload test specified in 5.1.4.3.1, the test load shall be 150 % of the rated load.

4.4.1.7 Variable working envelope with more than one rated load

4.4.1.7.1 MEWPs with more than one rated load and more than one working envelope shall have an indicator of the selected combination visible at the work platform.

NOTE The indicator can be a physical change to the configuration of the platform that affects its rated load.

4.4.1.7.2 The MEWP shall be fitted with load-sensing and moment-sensing systems or a load-sensing system and position control.

4.4.1.7.3 MEWPs with enhanced stability for two persons shall require activation of a load-sensing system when extended working envelope(s) are selected. The selection shall be possible only if the work platform is within the working envelope for the new selected rated load.

4.4.1.8 Variable working envelope with one rated load

For MEWPs with one rated load and a variable working envelope (for example, those with variable positions of stabilising devices), selection by manual means is acceptable. In such cases, the selection shall only be possible with the extending structure in the access position.

4.4.1.9 Variable range of operation

MEWPs constructed for a variable range of operation depending on the chassis inclination shall be equipped with safety devices in accordance with 4.11 that prevent operation outside that range.

4.4.2 Sequencing of extending structure

When the extending structure requires extension or retraction in a specific sequence, this sequence shall be automatic during normal operation.

4.4.3 Trapping and shearing

4.4.3.1 Trapping and shearing points between moving parts which are within reach of persons (see ISO 13857) on the work platform or standing adjacent to the MEWP at ground level shall primarily be avoided by providing safe clearances or guarding in accordance with ISO 13854.

4.4.3.2 For group A MEWPs, while the platform is being lowered utilizing the upper controls, a warning device shall be activated at ground level. This requirement does not apply to totally manually operated MEWPs.

4.4.4 Supporting extending structure for routine maintenance

When the work platform of a MEWP is required to be raised for routine servicing purposes, a means shall be provided to enable the extending structure to be held in the required position. This means shall be capable of supporting the unloaded work platform and of being operated from a safe position; it shall not cause

damage to any part of the MEWP (see 6.4.15). It shall also be capable of supporting the work platform even when a failure occurs on the raising/lowering system.

4.4.5 Speeds of extending structure

4.4.5.1 It shall not be possible to exceed the following speeds except where noted in 4.4.5.2:

a) 0,4 m/s for raising and lowering of the work platform;

b) 0,4 m/s for telescoping of the boom;

c) 0,7 m/s for slewing or rotation (horizontal speed at the outer edge of the work platform, measured at maximum range).

4.4.5.2 For MEWPs that have a work platforms guardrail system that is retractable, when retracted, the speed of the extending structure shall not exceed the following speeds;

a) 0,3 m/s for telescoping of the boom;

b) 0,5 m/s for slewing or rotation (horizontal speed at the outer edge of the work platform, measured at maximum range).

4.4.6 Support in transport position

The extending structure shall be supported in the transport position so as to limit vibrations during transport (see 4.2.4.2.4.2).

4.5 Extending structure drive systems

4.5.1 General

4.5.1.1 Unintended motion

Drive systems shall be designed and constructed to prevent any unintended motion of the extending structure.

4.5.1.2 Protection of extending structure from power sources

4.5.1.2.1 If the power source is capable of producing greater power than is required by the extending structure, the work platform drive system, or both, protection shall be provided to the extending structure, the work platform drive system, or both, to prevent damage.

4.5.1.2.2 The use of friction couplings does not fulfil this requirement.

4.5.1.3 Failure of transmission chain or belt

4.5.1.3.1 Transmission chains or belts shall only be used in drive systems if inadvertent movements of the work platform are automatically prevented in the event of failure of a chain or belt.

4.5.1.3.2 Flat belts shall not be used.

4.5.1.4 Kick-back of handles

Manual drive systems shall be designed and constructed to prevent kick-back of handles.

4.5.1.5 Powered and manual drive systems for the same function

If both powered and manual drive systems are provided for the same function and if there is a risk of injury from engaging both systems at the same time, simultaneous use of both systems shall be prevented.

4.5.1.6 Braking system for all drives

4.5.1.6.1 A braking system shall be provided on all drives. For raising movements, this system shall be an automatic lock or self-sustaining device. The braking system shall be automatically applied when the drive is no longer energized.

4.5.1.6.2 The braking system shall ensure that the work platform, loaded with 1,25 times the rated load for power-operated MEWPs or with 1,5 times the rated load for manually powered MEWPs, and 1,5 times the rated load for MEWPs that employ enhanced overload criteria, can be stopped and held at any position in all configurations of operation. The braking system shall be protected against inadvertent release.

4.5.2 Wire-rope drive systems

4.5.2.1 Wire-rope drive system safety

4.5.2.1.1 General

4.5.2.1.1.1 Wire rope, drum and pulley diameters shall be calculated in accordance with Annex C, assuming that all the load is taken on one wire rope system. Traction drive systems shall not be used.

4.5.2.1.1.2 Wire-rope drive systems shall have a device or system which, in the event of a wire-rope drive system failure, limits the vertical movement of the fully loaded work platform to 0,2 m. This requirement shall be met by either a mechanical safety device (see 4.5.2.1.2) or an additional wire-rope drive system (see 4.5.2.1.3).

4.5.2.1.2 Mechanical safety device

Mechanical safety devices shall be in accordance with 4.11 and shall operate by engaging with the extending structure. This safety device shall gradually bring the work platform plus the rated load to a stop and hold it in the event of the wire-rope drive system failure. The average deceleration shall not exceed 1,0 *g*. Any spring operating this device shall be a guided compression spring with secured ends or shall have a wire diameter of more than half the pitch in the operating condition, to limit the shortening of the spring should it fail.

4.5.2.1.3 Additional wire-rope drive system

4.5.2.1.3.1 The additional wire-rope drive system shall be designed either:

a) according to the first wire-rope system, with a device giving approximately equal tension in both systems; or

b) according to the first wire-rope system, with a device to ensure that the additional system takes less than half of the load in the operating condition, but is able to take the full load if the first system fails; or

c) according to a), but with larger drum and pulley diameters to increase the fatigue life of the additional wire-rope system to at least twice the calculated lifetime of the first system.

4.5.2.1.3.2 Failure of the first system shall be self-revealing.

4.5.2.2 Load-carrying wire ropes

4.5.2.2.1 Load-carrying wire ropes shall be made from galvanized steel wires or equivalent and shall have the following characteristics:

a) minimum diameter: 8 mm;

b) minimum number of wires: 114;

c) tensile grade of wires: minimum 1 570 N/mm^2, maximum 2 160 N/mm^2;

d) fatigue life suitable for the application (see Annex C);

e) corrosion resistance equivalent to galvanized steel;

f) required ratio of pulley diameter to wire diameter (see Annex C).

4.5.2.2.2 The responsible entity shall have on record a certificate giving the minimum design breaking load of the wire rope.

4.5.2.2.3 Wire ropes used directly for lifting or supporting the work platform shall not include any splicing, except at their ends.

4.5.2.2.4 Wire rope with other characteristics may be used if they provide equivalent safety.

4.5.2.3 System of multiple wire ropes

If more than one wire rope is attached at a single point, a device shall be provided for approximately equalizing the tension of the wire ropes.

4.5.2.4 Re-tensioning wire ropes

It shall be possible to re-tension wire ropes.

4.5.2.5 Terminations of wire ropes

4.5.2.5.1 For the terminations of wire ropes, only the following shall be used:

— splices;

— aluminium pressed ferrules;

— non-ageing steel pressed ferrules;

— wedge-socket anchorages.

4.5.2.5.2 The junction between a wire rope and its termination shall be able to resist at least 80 % of the minimum breaking load of the wire rope.

4.5.2.5.3 U-bolt grips shall not be used as wire rope terminations for load-carrying wire ropes.

4.5.2.6 Visual examination of wire rope terminations

4.5.2.6.1 Visual examination of wire rope terminations shall be possible, preferably without the removal of the wire ropes or major disassembly of the structural components of the MEWP.

4.5.2.6.2 If it is not feasible to use inspection openings, the MEWP responsible entity shall provide detailed instructions for examination.

4.5.2.7 Safety device for MEWP work platforms raised and lowered by wire ropes

MEWPs with work platforms raised and lowered by means of wire ropes shall be equipped with a safety device in accordance with 4.11 that interrupts movements that cause slack rope conditions. Movements in the opposite direction shall be possible. This device is unnecessary if no slack rope condition can develop.

4.5.2.8 Rope drum grooves and prevention of rope leaving the ends of the drum

Rope drums shall be grooved, and a means shall be provided to prevent the wire rope from leaving the ends of the drum, for example, flanges extending to a height of at least twice the wire rope diameter above the highest layer.

4.5.2.9 Layers of rope

Only one layer of wire rope shall be wound on the drum unless a level-wind spooling system is used.

4.5.2.10 Turns of rope

At least two turns of wire rope shall remain on the drum when the extending structure, the work platform, or both, is in its most extreme position.

4.5.2.11 Fastening rope to drum

Each wire rope shall be properly fastened to the drum. The fastening shall be able to take 80 % of the minimum breaking load of the wire rope.

4.5.2.12 Unintentional displacement of rope

A means shall be provided to prevent unintentional displacement of wire ropes from sheaves, even under slack rope conditions.

4.5.2.13 Drum and sheave grooves

The dimensions of the drum and sheave grooves shall be in accordance with the wire-rope manufacturer's recommendations.

4.5.3 Chain drive systems

4.5.3.1 General

4.5.3.1.1 Round-link chains shall not be used. Leaf chains may be used.

4.5.3.1.2 The responsible entity shall have on record a certificate, giving the minimum design breaking load of the chain.

4.5.3.2 Limit of vertical movement in case of failure

4.5.3.2.1 General

Chain drive systems shall have a device or system that, in the event of a chain drive system failure, limits the vertical movement of the fully loaded work platform to 0,2 m. This requirement shall be met by either of the drive systems specified in 4.5.3.2.2 and 4.5.3.2.3.

4.5.3.2.2 Single-chain drive systems

A single-chain drive system shall have a working coefficient of at least 5, plus a mechanical safety device in accordance with 4.11 that operates by engaging with the extending structure. This safety device shall gradually bring the work platform plus the rated load to a stop and hold it in the event of a drive system failure. The average deceleration shall not exceed 1,0 *g*. Any spring operating this device shall be a guided compression spring with secured ends or shall have a wire diameter of more than half the pitch in the operating condition, to limit the shortening of the spring, should it fail.

4.5.3.2.3 Two-chain drive systems

Two-chain drive systems shall meet the requirements of either 4.5.3.2.3.1 or 4.5.3.2.3.2.

4.5.3.2.3.1 Equal tension

Each chain of a two-chain drive system shall have a working coefficient of at least 4 (a total minimum coefficient of 8) and shall be provided with a device giving approximately equal tension in the two-chain system, or else shall comply with 4.5.3.2.3.2. Failure in the first chain shall be self-revealing.

4.5.3.2.3.2 Unequal tension

The first component of a two-chain drive system shall have a working coefficient of at least 5 when carrying the full load, and the second component shall have a working coefficient of at least 4 (a total minimum coefficient of 9 when carrying the full load) and be provided with a device to ensure that the second component takes less than half the load in the operating condition but is able to take the full load if the first component fails. Failure in the first component shall be self-revealing.

4.5.3.3 Multiple chains attached to a point

If more than one chain is attached at one point, a device shall be provided to approximately equalize the tension in the chains.

4.5.3.4 Tensioning chains

It shall be possible to re-tension chains.

4.5.3.5 Strength of junction between chain and termination

The junction between the chain and the chain termination shall be able to withstand at least 100 % of the minimum breaking load of the chain.

4.5.3.6 Visual examination of chains and terminations

4.5.3.6.1 Visual examination of chains and chain terminations shall be possible, preferably without the removal of the chains or major disassembly of structural components of the MEWP.

4.5.3.6.2 If it is not possible to provide inspection openings, the responsible entity shall provide detailed instructions for examination.

4.5.3.7 Safety device for MEWP work platforms raised and lowered by chains

MEWPs with work platforms raised and lowered by means of chains shall be equipped with a safety device in accordance with 4.11 that interrupts movements causing slack chain conditions. Movements in the opposite direction shall be possible. This device is unnecessary if no slack chain condition can develop.

4.5.3.8 Unintentional displacement of chain

A means shall be provided to prevent unintentional displacement of the chain from the sprockets or sheaves, even under slack conditions.

4.5.4 Lead screw drive systems

4.5.4.1 Lead screw and nut design stress and material

The design stress of lead screws and nuts shall not be more than 1/6 of the ultimate tensile stress of the material used. The lead screw material shall have a higher abrasion resistance than the load-bearing nut.

4.5.4.2 Separation of lead screw from work platform

The lead screw mechanism shall be designed to prevent separation of the work platform from the mechanism during normal use.

4.5.4.3 Load-bearing nut and safety nut

Each lead screw shall have a load-bearing nut and an unloaded safety nut. The safety nut shall only be loaded if the load-bearing nut fails. It shall not be possible to raise the work platform when the safety nut is under load.

4.5.4.4 Detection of wear on nuts

It shall be possible to detect the wear of the load-bearing nuts without disassembly.

4.5.5 Rack and pinion drive systems

4.5.5.1 Design stress of racks and pinions

The design stress of racks and pinions shall not be more than 1/6 of the ultimate tensile stress of the material used.

4.5.5.2 Safety device and over-speed governor

Rack and pinion drives shall have a safety device meeting the requirements of 4.11 actuated by an over-speed governor. This safety device shall gradually bring the work platform plus the rated load to a stop and hold it in the event of the lifting mechanism failing. The average deceleration shall not exceed 1,0 *g*. Actuation of the safety device shall automatically interrupt the power supply.

4.5.5.3 Device to prevent pinion disengagement

In addition to the normal work platform guide rollers, positive and effective devices shall be provided to prevent any driving or safety-device pinion from becoming disengaged from the rack. These devices shall ensure that axial movement of the pinion is limited so that a minimum of 2/3 of the tooth width is always in engagement with the rack. They shall also restrain radial movement of the pinion from its normal meshing position to no more than 1/3 of the tooth depth.

4.5.5.4 Visual examination of pinions

Visual examination of the pinions shall be possible without the removal of the pinions or major disassembly of structural components of the MEWP.

4.6 Work platform

4.6.1 Level of work platform

4.6.1.1 The level of the work platform shall not vary by more than 5° from the initial setting while the extending structure is being raised or lowered.

4.6.1.2 Manual adjustment of platform levels exceeding 5° shall only be possible when the extending structure is stationary. Alternatively, on MEWPs with full-flow control valves with control handles connected mechanically to the control valve spools, an additional feature that guards against inadvertent activation shall be provided.

4.6.1.3 The rate of change of platform angle during manual adjustment shall not exceed the maximum that occurs during lowering or raising in normal operation.

4.6.1.4 The levelling system, excepting hydraulic drive/driven levelling systems, shall incorporate a safety device complying with 4.11 that, in the case of a failure within the system, will maintain the work platform level within a further 5°. Mechanical levelling systems fulfil this requirement if designed to take at least twice the load imposed on them. If a single wire rope or chain is used, it shall be designed with a safety factor of five against breaking when subjected to twice the imposed loads.

4.6.1.5 Hydraulic cylinders in hydraulic levelling systems shall comply with 4.10.2.

4.6.2 Work platform materials

The work platform shall be made of at least non-flammable material(s), in other words, materials that will not sustain a flame after the ignition source has been removed.

4.6.3 Guardrail (protection) systems

4.6.3.1 Protection shall be provided on all sides of each work platform to prevent the fall of persons and materials. The protection shall be securely fastened to the work platform and shall, as a minimum, consist of guardrails at least 1,1 m high, toeguards at least 0,1 m high and intermediate guardrails not further than 0,55 m from either the guardrails or the toeguards.

4.6.3.2 Vertical posts may be used instead of an intermediate guardrail if the clear horizontal distance between those posts is no more than 180 mm. Clear space between guardrail segments shall not exceed 120 mm.

4.6.3.3 Clear horizontal space between toeguard segments shall not exceed 15 mm.

4.6.3.4 The guardrails shall be constructed to withstand concentrated loads of 500 N per person, applied at the least favourable positions and in the least favourable direction at 0,5 m intervals, without causing permanent deformation of the guardrails.

4.6.3.5 Each top rail, midrail or equivalent vertical barrier shall withstand a concentrated test load of 1 340 N applied at the least favourable positions and in the least favourable direction without reaching ultimate strength.

4.6.3.6 For MEWPs operated in countries where national or other MEWP regulations allow, a minimum of 0,9 m may be applied instead of 1,1 m for the guardrail height (this recognizes national variations in physical stature of persons).

4.6.3.7 Folding guardrails satisfy this requirement provided that they remain securely fastened to the work platform and are equipped with locking pins secured against unintentional disengagement and loss, or an equally effective means of locking.

4.6.3.8 Retractable guardrail system(s) on MEWPs shall:

a) be designed to meet the dimensional and strength requirements of 4.6.3.1 through 4.6.3.6 in all locked positions;

b) guard against falls through the use of a fall restraint system;

c) lock into a normal position that fully encloses the periphery of the work platform;

d) open and lock into one or more retracted positions with the locking means being readily accessible for inspection.

4.6.4 Anchorage(s)

4.6.4.1 General

4.6.4.1.1 All MEWPs shall be provided with anchorage(s). All anchorages on group B MEWPs shall be rated for fall arrest. Group A MEWPs may be equipped with either fall restraint or fall arrest anchorages.

4.6.4.1.2 The number of anchorages shall be equal to or exceed the allowable number of persons. More than one occupant may attach to a single anchorage if the anchorage is rated for more than one person.

4.6.4.1.3 Anchorages shall be designed so as to accept personal fall protection equipment. Exposed edges or corners shall be relieved either with a radius of at least 0,5 mm or a 45° chamfer.

4.6.4.1.4 Anchorages located within the platform shall be positioned not more than 750 mm above the floor of the work platform.

4.6.4.1.5 On all MEWPs with retractable guardrail system(s), a fall restraint anchorage(s) shall be provided for use when the guardrail system is retracted.

4.6.4.2 Fall restraint

Each fall restraint anchorage shall be capable of withstanding a static force of 3 kN for each person allowed by the manufacturer on the anchorage without reaching ultimate strength. This strength requirement shall only apply to the anchorage and its attachment to the MEWP in all possible load directions.

4.6.4.3 Fall arrest

4.6.4.3.1 Each fall arrest anchorage shall be capable of withstanding a static force of 16 kN for each person allowed by the manufacturer on the anchorage without reaching ultimate strength. For anchorages rated for more than one person, the strength requirement shall be increased by 20 % for each additional person. This strength requirement shall only apply to the anchorage and its attachment to the MEWP in all possible load directions.

4.6.4.3.2 The manufacturer shall test any anchors designated as fall arrest anchorages according to the requirements of 5.1.4.1.

4.6.5 Openings in guardrails for entrance and exit

4.6.5.1 General

4.6.5.1.1 Any part of the protection movable for the purpose of access to the work platform shall not fold or open outwards except as specified in 4.6.5.2. The gate shall either return automatically to the closed position or have an interlocking device that meets the requirements of 4.11 to prevent operation of the MEWP until it is closed. Inadvertent opening shall be prevented. Sliding or vertically hinged intermediate guardrails that return automatically to their protective position do not need fastening and interlocking. Consideration should be given to ease of entry and exit. The access system shall permit and, by proper placement of components, promote achievement of three-point support while ascending or descending the access system.

4.6.5.1.2 On work platforms without fixed top guardrails, the opening shall not be less than 420 mm.

4.6.5.1.3 On work platforms with fixed top guardrails, the opening shall not be less than 800 mm high and 645 mm wide.

4.6.5.2 Special-purpose work platforms

Work platforms of 0,5 m^2 floor area or less, designed for single occupant use, may be equipped with an outward-opening door, provided they have a self-closing top guardrail in accordance with 4.6.3.

4.6.6 Floor of work platform

4.6.6.1 The floor of the work platform, including any trapdoor, shall be slip-resistant and self-draining. Any opening in the floor or between the floor and toeguards or access gates shall be dimensioned so as to prevent the passage of a sphere of 15 mm diameter.

4.6.6.2 Platform floor width and length shall be at least 460 mm each.

4.6.6.3 The floor of the work platform and any trapdoor shall be able to take the rated load distributed according to 4.2.2.2.2.

4.6.6.4 On MEWPs with retractable guardrail system(s), the floor of the work platform shall contain a strip at the periphery where the guardrail is removable to define the boundary of the platform. This strip shall be contoured and shall not exceed 1 cm in height and 3 cm in width.

4.6.7 Chains or ropes

Chains or ropes or other flexible elements shall not be used as guardrails or access gates.

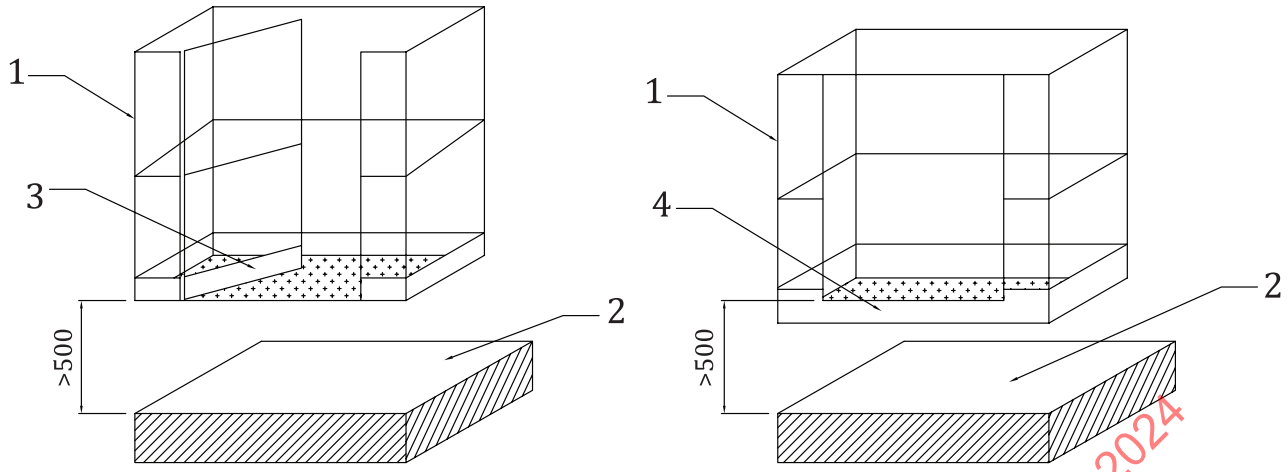
4.6.8 Accessing the work platform

4.6.8.1 Work platform access from the access level

4.6.8.1.1 When the distance between the access level (for example, standing surface, ground) and the floor of the work platform (or top of the toeguard if the toeguard is fixed) in the access position is > 500 mm as shown in Figure 7, the MEWP shall be equipped with an access system in accordance with 4.6.8.2.

4.6.8.1.2 MEWPs with fully enclosed non-conductive work platforms are not required to meet the requirements of 4.6.8.1.1. If equipped with an access system, the requirements of 4.6.8.2 apply and the distance from the top step to the upper edge of the platform shall meet the requirements of Table 4, *H*.

Dimensions in mm



Key

1 work platform
2 access level (standing surface or ground)
3 gate with toeguard
4 fixed toeguard

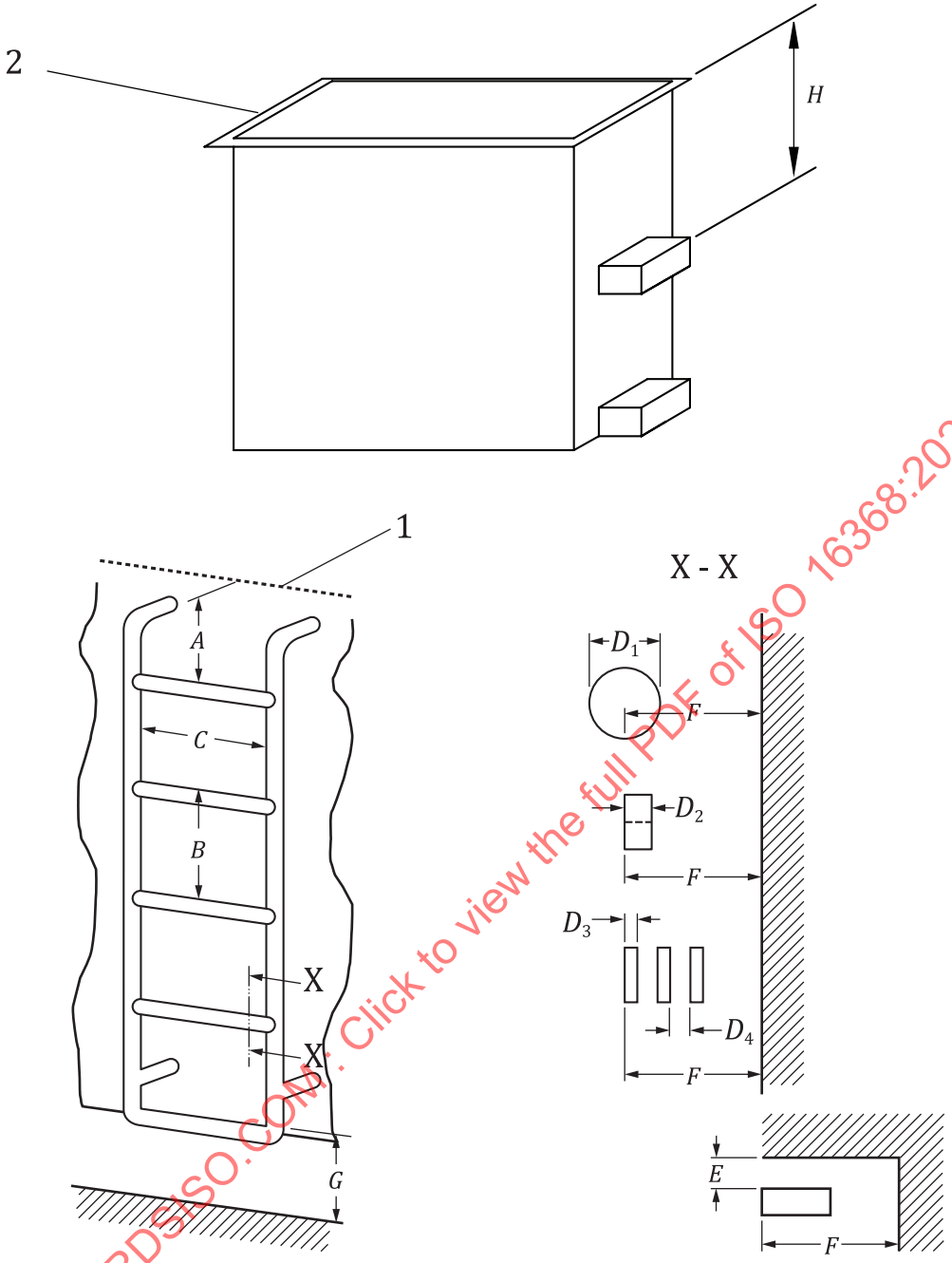
Figure 7 — Work platform access from the access level

4.6.8.1.3 If handrails and handholds are required for accessing the work platform to provide intuitive and continuous support to a person moving along the access system while maintaining three-points of contact, the handrails and handholds shall meet the requirements of 4.6.8.2.2.

4.6.8.2 Access system

4.6.8.2.1 Steps and ladders

Dimensions of steps and ladders shall meet the requirements as shown in Figure 8 with dimensions given in Table 4.



Key

1 work platform floor (w/gate) or top of toeguard if the toeguard is fixed

2 fully enclosed non-conductive work platform

A to *H* See Table 4.

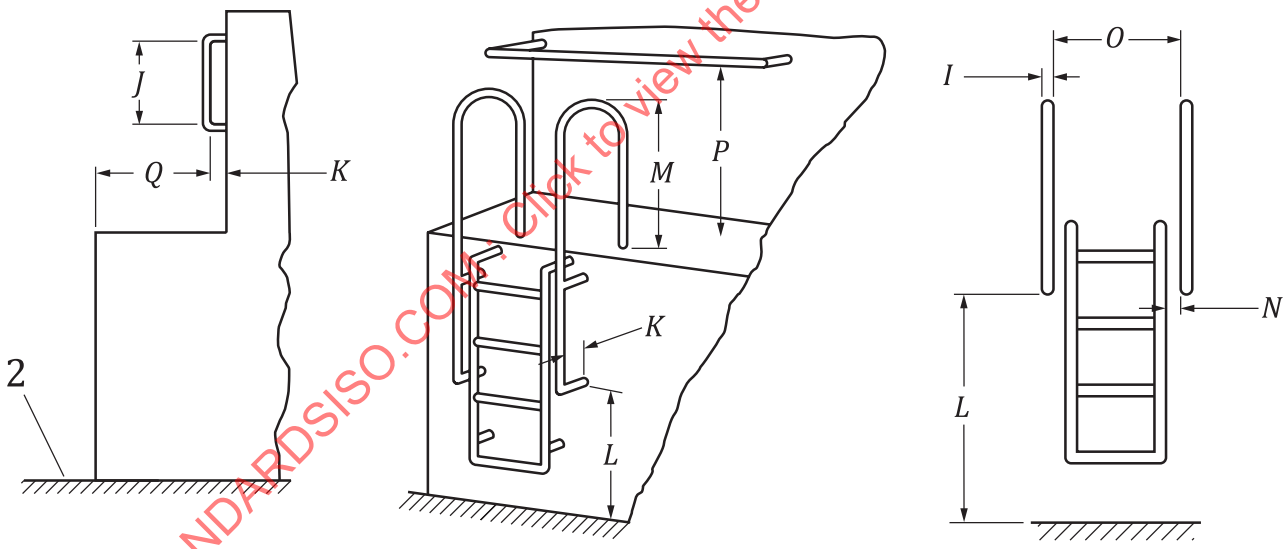
Figure 8 — Dimensions of access system steps and ladders

Table 4 — Dimensions of access system steps and ladders

Symbol	Description	Dimension (mm)	
		Min.	Max.
A	Height from top step of ladder to work platform floor (w/gate) or top of toeguard if the toeguard is fixed	230	400
B	Tread spacing (riser height)	—	300
C	Step width — for one foot	160	—
	Step width — for two feet	320	—
D_1	Tread depth — Circular	19	—
D_2	Tread depth — Square or rectangular	12	—
D_3	Tread element depth — Multiple element step	3	—
D_4	Tread element spacing — Multiple element step	—	50
E	Vertical instep clearance	150	—
F	Toe clearance (free space behind outer edge of step or centreline of circular step)	150	—
G	Height of first step of ladder from access level (standing surface or ground)	—	500
H	Distance from top step to upper edge of work platform on fully enclosed non-conductive work platform	400	500

4.6.8.2.2 Handrails and handholds

4.6.8.2.2.1 Handrails and handholds shall be appropriately placed within the access system as shown in Figure 9 with dimensions given in Table 5.



Key

2 access level (standing surface or ground)

I to *Q* See Table 5.

Figure 9 — Dimensions of handrails and handholds

Table 5 — Dimensions of handrails and handholds

Symbol	Description	Dimension (mm)	
		Min.	Max.
I	Ladder or step — Handrail diameter (or width across flats)	15[a]	38
J	Length between bend radii for support legs of handholds	150	—
K	Hand clearance to mounting surface	50	—
L	Distance above access level (standing surface or ground)	—	1 700
M	Vertical distance of handrail or handhold from edge of ladder/steps (if ladder/ steps and handrail are separate parts)	850	1 100[c]
N	Offset distance of handrail continuation above step or platform	50	200
O	Ladder — Width between parallel handrails	300[d]	950[b]
	Stairway and ramp — Width between parallel handrails	460	—
P	Distance above walkway, passageway, step or stairway step	850	1 400[c]
Q	Forward reach to handhold from the ground, step, platform	—	765

[a] 10 mm if orientation is vertical and the standing position for the handrail or handhold is greater than 3 m above the ground.

[b] Up to 1 100 mm maximum when the handrails/handholds are an integral part of a door opening.

[c] May be increased to 1 700 mm for handrails and handholds located above the work platform floor.

[d] 300 mm up to a maximum height of 450 mm (see M): over 450 mm height, a width of 460 mm is required.

4.6.8.2.2.2 The recommended cross-section of a handrail and handhold is circular. A square or rectangular cross-section with rounded corners according to ISO 12508 is permissible.

4.6.8.2.2.3 Any handrail or handhold on which the hand grasp surface extends beyond the support shall have a change of shape at the end of the hand grasp surface to provide some protection from the hand slipping off the end.

4.6.8.2.2.4 Handrails are recommended on each side of a ladder system instead of handholds. Handrails or handholds may be integral part of, or separate from, the ladder.

4.6.8.2.2.5 Handrails and handhold surfaces shall be free of roughness, sharp corners or protrusions that could cause injury to the hand.

4.6.8.2.2.6 Each handrail and handhold shall be capable of withstanding a concentrated test load of 1 340 N applied at any point from any direction without causing visible permanent deformation.

4.6.8.2.2.7 Handrails and handholds can be installed on a movable part (for example, door, cover, folding guardrail), only if the movable part can be locked in position when the force is applied to the handrails and handholds or the force is applied in a direction that does not lead to unexpected movement of the movable part.

4.6.9 Trapdoors

Trapdoors in work platforms shall be securely fastened to the work platform and designed to prevent inadvertent opening. It shall not be possible for trapdoors to open downward or to slide sideward.

4.6.10 Protecting controls and hands

Means shall be provided to reduce the risk of trapping or crushing injury to the hands of persons operating the controls or holding handrails.

4.6.11 Audible warning device

Type 3 MEWPs shall be equipped with an audible warning device (for example, a horn) operated from the work platform.

4.6.12 Means of communication

Type 2 MEWPs shall be equipped with a means of exclusive and direct communication between the persons on the work platform and the operator of the chassis.

4.6.13 Mechanical stops

The movements of work platform(s) relative to the extending structure shall be limited by mechanical stops. Hydraulic cylinders fulfil this requirement if designed for that purpose.

4.6.14 Support in transport position

The work platform shall be supported in the transport position in such a way as to avoid harmful vibrations during transport (see 4.2.4.2.4.2).

4.7 Controls

4.7.1 General

4.7.1.1 Controls on MEWPs shall meet the requirements of ISO 21455.

4.7.1.2 Controls shall be positioned to avoid danger to the operator from the moving parts of the MEWP.

4.7.1.3 If wireless control systems are used, they shall comply with Annex B. Operation of extending structure and elevated drive functions shall only be possible when the wireless controls are located in the work platform in a position specifically designed by the manufacturer.

4.7.1.4 On MEWPs with retractable guardrail system(s), operator controls shall be located in an area where the guardrails cannot be retracted.

4.7.2 Sustained involuntary operation protection

Hand-operated controls in the platform shall be protected against sustained involuntary operation. This protection should either prevent further movement of the machine in the direction of trapping or allow the operator to reverse or stop the trapping movement.

4.7.3 Location, accessibility, protection, and selection among duplicate controls

4.7.3.1 Duplicate controls for all powered functions of the extending structure shall be provided at the base or ground level, except for drive or steering, and shall override controls situated on the work platform. Controls shall be readily accessible to the operator. Control boxes not permanently attached shall have their normal location and orientation clearly marked.

4.7.3.2 If movement can be controlled from additional control stations, a locking mechanism shall be provided such that movement is possible from only one pre-selected control station. The base or ground-level controls shall override all additional controls, including platform emergency stop control. The locking mechanism shall be a safety device that complies with 4.11.

4.7.3.3 Where the mechanism incorporates a key, the key shall only be able to be removed when the mechanism is in the neutral or off position.

4.7.3.4 On MEWPs designed to work near live electrical conductors, the lower controls shall be located such that an operator is not placed in the electrical path between the aerial device and the ground surface.

4.7.4 Emergency stops

MEWPs shall be provided with emergency stop controls meeting the requirements of ISO 13850 at each control position. These controls shall meet the requirements of 4.11.

4.7.5 Pilot and solenoid valves

Pilot and solenoid-operated control valves shall be so designed and installed that they stop the corresponding movement in the event of power failure.

4.7.6 Restoration of power after failure

On starting or on restoration of power after failure of the power supply, no movement shall occur without a deliberate action on the part of the operator.

4.7.7 Auxiliary lowering system

4.7.7.1 MEWPs shall be fitted with an auxiliary system to provide a backup in the event of failure of the primary power (for example, out of fuel, battery out of charge). This system shall be capable of returning the work platform from anywhere in the working envelope to an access position.

4.7.7.2 The auxiliary system controls shall be located in a position easily accessible from the ground; they may be duplicated on the work platform.

4.7.7.3 The above requirements need not apply if leaving or reaching any position of the work platform is possible in another way (for example, by means of fixed ladders).

4.7.8 Overriding of functions

4.7.8.1 Overriding of safety functions

4.7.8.1.1 Where overriding of safety functions is permitted as described in this document, it shall be done by the use of a control that:

a) is located at the base or ground level;

b) complies with 4.11;

c) is of hold-to-run type;

d) allows one motion at a time.

NOTE Overriding of functions can be performed using either the primary power unit or the auxiliary system.

4.7.8.1.2 Controls for overriding safety functions shall be marked in accordance with 6.4.5.

4.7.8.1.3 An additional control to override a safety functions can be located at the platform controls.

4.7.8.2 Overriding of emergency stop function

4.7.8.2.1 When the emergency stop function has been initiated by the engagement of the emergency stop device located on the work platform, overriding the emergency stop function from the ground level shall be possible to rescue a stranded and/or incapacitated operator on the work platform.

4.7.8.2.2 During the overriding of the emergency stop function:

— duplicate controls located at the base or ground level (see 4.7.3) shall be active;

— work platform controls shall remain deactivated;

— all the other safety functions shall remain active.

NOTE It is possible that load-sensing system override (4.7.8.1 applies) and emergency stop function override occur at the same time.

4.7.8.2.3 During the rescue manoeuvre, it is permissible to use either the main power supply or the auxiliary system.

4.7.9 Automatic or programmed operation

Automatic or programmed operation performed with the joystick, lever or switch released is permissible if appropriate safety measures are employed, such as a warning device alerting the operator that the machine is “under operation”, and provided a separate control is activated and release interrupts the movement.

4.7.10 Winch control on vehicle-mounted MEWPs

4.7.10.1 If the MEWP is equipped with a material-handling winch, it shall have both upper controls and the lower controls. The lower controls shall be located in close proximity to the lower control station.

4.7.10.2 On MEWPs designed to work near live electrical conductors, the lower control shall be located such that an operator of the lower winch control is not placed in the electrical path between the aerial device and the ground surface.

4.7.11 MEWPS with retractable guardrails

The drive function shall be disabled when the guardrails are retracted from the normal position.

4.8 Electrical equipment

4.8.1 Relevant norms and standards

The electrical equipment of MEWPs shall comply with the relevant standards, in particular with IEC 60204-1. If, owing to special conditions, MEWPs are used outside the ranges covered by IEC 60204-1 for direct current supplies, ambient air temperature, altitude, or connection to moving elements of the machine, then deviations will be necessary, and the responsible entity shall take the necessary safety measures and/or state any operating limitations in the operator's manual (see 6.2).

4.8.2 Main switch

A main switch shall be fitted in an easily accessible position. It shall be possible to secure it in a disconnected or "off" position by means of a locking device or equivalent, to prevent operation or unauthorized use of the MEWP.

4.8.3 Cables

Cables shall be multi-stranded when flexibility is necessary and, if necessary, shall be oil resistant.

4.8.4 Battery protection

Batteries shall be protected against damage due to short circuits and against mechanical damage. If batteries are the primary power source, the disconnection (isolation) of the battery, (in other words, breaking of one pole of the electrical supply), shall be easily possible without the use of tools.

4.8.5 Ingress of water

When necessary to prevent ingress of water, the minimum degree of protection provided by enclosures shall be IP 54 in accordance with IEC 60529. The responsible entity shall take into account any foreseeable conditions of use (for example, fluids other than water necessitating higher degrees of protection).

4.8.6 Electromagnetic compatibility (EMC)

The MEWPs shall have sufficient immunity to electromagnetic disturbances to enable them to operate safely as intended and not fail to danger when exposed to the levels and types of disturbances anticipated by the responsible entity. The design, installation and wiring of the equipment and sub-assemblies shall take into account the recommendations of the suppliers of these sub-assemblies.

4.8.7 Hourmeter

4.8.7.1 An hourmeter shall be provided on the MEWP to record accumulated time of operation while the power system is energized or activated.

4.8.7.2 For totally manually-operated MEWPs, the requirements of 4.8.7.1 do not apply.

4.9 Hydraulic systems

4.9.1 Pressure-limiting device

4.9.1.1 The hydraulic system shall include the pressure-limiting device such as a pressure-relief valve before the first control valve. If different maximum pressures are used in the hydraulic system, more than one pressure-limiting device shall be provided.

4.9.1.2 The adjustment of pressure-limiting devices shall require the use of tools and shall be capable of being sealed.

4.9.2 Strength of pipes and connections

Pipes and those of their connections which can be subjected to the maximum pressure permitted by any pressure-limiting device shall be designed to withstand at least twice that pressure without permanent deformation (yield stress $R_{p0,2}$). If, under normal operation, components can be subjected to higher pressures than those permitted by the pressure-limiting device, they shall be designed to withstand at least twice the higher pressure without permanent deformation ($R_{p0,2}$); see 4.10.1.3 for failure conditions.

4.9.3 Bursting strength of hoses and fittings

The bursting pressure of all fittings and hoses, which may be subjected to the maximum pressure permitted by any pressure limiting device, shall be not less than three times that pressure.

4.9.4 Pressure rating of other components

All components of the hydraulic system, other than those specified in 4.9.2, 4.9.3 and 4.10, shall be rated for at least the maximum pressure to which they will be subjected, including any temporary increase in pressure setting necessary for carrying out the overload test (see 5.1.4.3).

4.9.5 Gauge connections

Each hydraulic circuit shall be provided with sufficient connections for pressure gauges to allow checking for correct operation.

4.9.6 Venting of air

The design of the hydraulic system shall enable entrapped air to be vented.

4.9.7 Inlet filter

Any fluid reservoir open to the atmosphere shall be equipped with an air-inlet filter.

4.9.8 Fluid level indicators

Each fluid reservoir tank shall be equipped with easily accessible devices indicating both the permissible maximum fluid level and the necessary minimum level when the extending structure is fully lowered and retracted, and the stabilising devices fully retracted.

4.9.9 Fluid cleanliness

Each hydraulic system shall have means to ensure the fluid cleanliness level necessary for safe operation of the system and its components.

4.9.10 Gas-loaded accumulators

4.9.10.1 In hydraulic systems incorporating gas-loaded accumulators, a means shall be provided to vent the liquid pressure automatically or to positively isolate the accumulator when the system is in the unpressurized state.

4.9.10.2 If the gas-loaded accumulator pressure is required by design to be retained when the system is shut off, complete information for safe servicing shall be visually displayed on or near the accumulator in a visible location. Duplicate information shall be provided in the service manual on the circuit diagram.

4.10 Hydraulic cylinders

4.10.1 Structural design

4.10.1.1 General

The design of load supporting cylinders shall be based on an analysis of the pressures, imposed loads, and forces during normal operation and failure conditions (see 4.10.1.3). Cylinders acting as mechanical stops at full retraction or extension shall be designed to withstand twice the imposed load when in this position and shall include the additive effects of both external and internal forces such as those resulting from hydraulic pressure. All critical components shall have a minimum bursting strength of 3 times the operating pressure for which the system is designed.

4.10.1.2 Normal operating conditions

4.10.1.2.1 Buckling

The responsible entity shall identify the operating conditions which produce the combinations of extended length, pressure, deflections and externally applied loads and forces creating the maximum buckling conditions.

4.10.1.2.2 Constructional details

The design of welded joints shall conform to 4.2.4.2. Load-carrying threaded joints shall comply with relevant standards, and stress calculations shall take into account the reduced shear areas due to manufacturing tolerances and the elastic deformation caused by hydraulic pressures. The design of threaded joints subjected to varying tensile loads shall take into account the effects of fatigue and prevent inadvertent separation (unscrewing).

4.10.1.2.3 Conditions causing pressure above pressure-limiting device pressures (see Figures 10 to 14)

4.10.1.2.3.1 The following conditions cause pressures above those of the pressure-limiting devices:

a) the effect of devices that reduce the speed of the cylinders below the speed that could result from the full fluid supply to the cylinders, thereby causing an internal pressure loading additional to the normal pressure due to externally applied loads, with this additional pressure expressed by the ratio:

$$\frac{D^2}{D^2 - d^2}$$

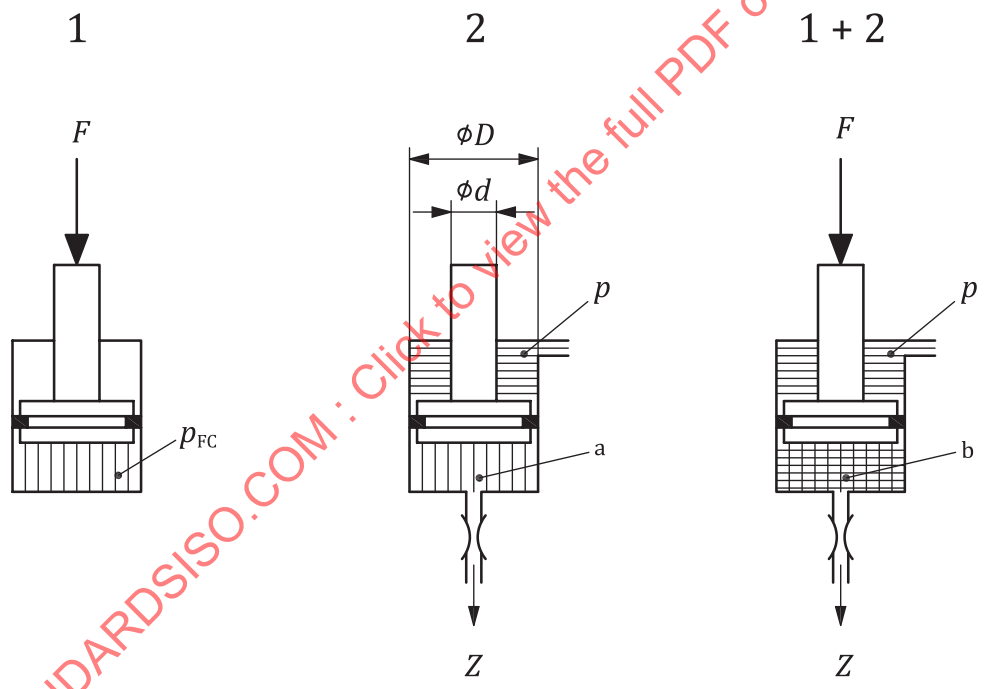
where

D is the diameter of the piston;

d is the diameter of the piston rod when a cylinder is in tension and the speed control device acts on the annulus;

b) the effect of thermal expansion of fluid confined in the cylinder when at rest.

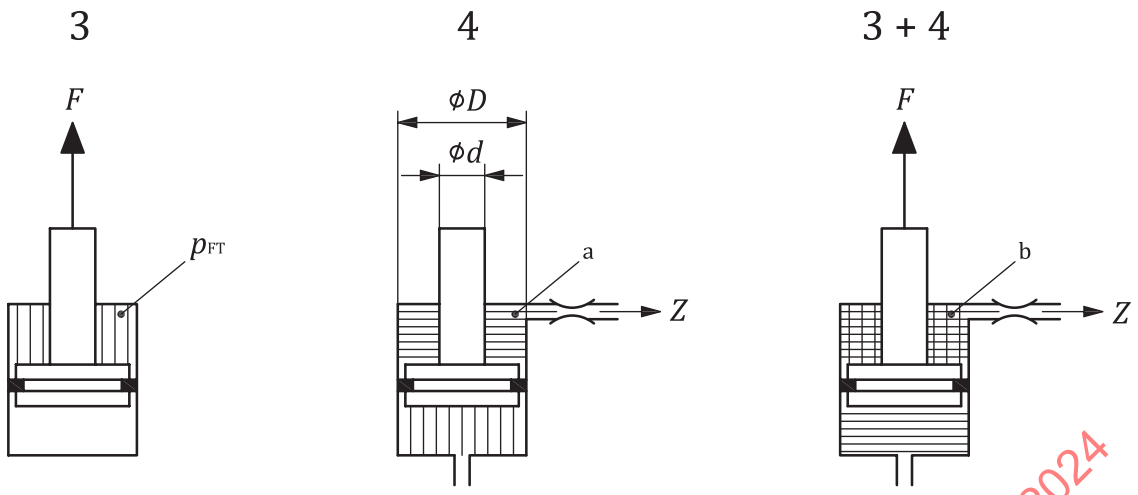
NOTE The speed control devices described in a) above can take the form of the control valve being partially open or closed.



Key

D	diameter of piston	a	$p \cdot \left(\frac{D^2 - d^2}{D^2} \right)$
d	diameter of piston rod with cylinder in tension and speed control device acting on annulus	b	$p_{FC} + p \cdot \left(\frac{D^2 - d^2}{D^2} \right)$
F	load		
p	system pressure		
p_{FC}	normal pressure		
Z	restricted flow		

Figure 10 — Cylinder pressures under normal operation — Cylinder in compression



Key

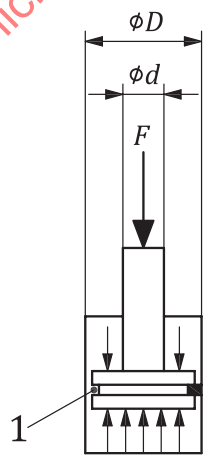
D	diameter of piston
d	diameter of piston rod with cylinder in tension and speed control device acting on annulus
F	load
p	system pressure
p_{FT}	normal pressure
Z	restricted flow

a $p \cdot \left(\frac{D^2}{D^2 - d^2} \right)$

b $p_{FT} + p \cdot \left(\frac{D^2}{D^2 - d^2} \right)$

Figure 11 — Cylinder pressures under normal operation — Cylinder in tension

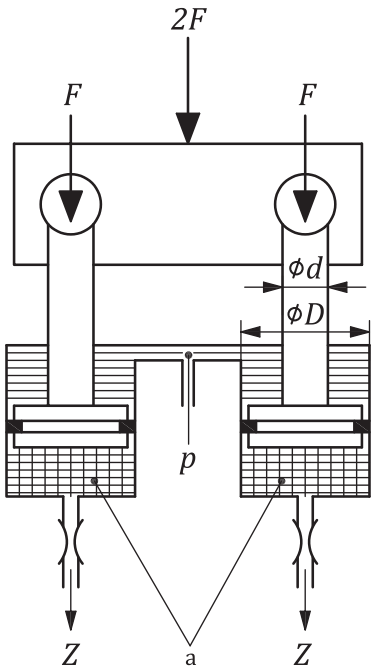
4.10.1.2.3.2 The pressure at the top of the piston is equal to the pressure at the bottom. The load is supported by the area of the rod, $\pi d^2/4$, instead of the area of the piston, $\pi D^2/4$. The normal pressure, p_{FC}, increases by the ratio D^2/d^2.



Key

D	diameter of piston
d	diameter of piston rod with cylinder in tension and speed control device acting on annulus
F	load
1	failed seal

Figure 12 — Cylinder pressures at seal failure

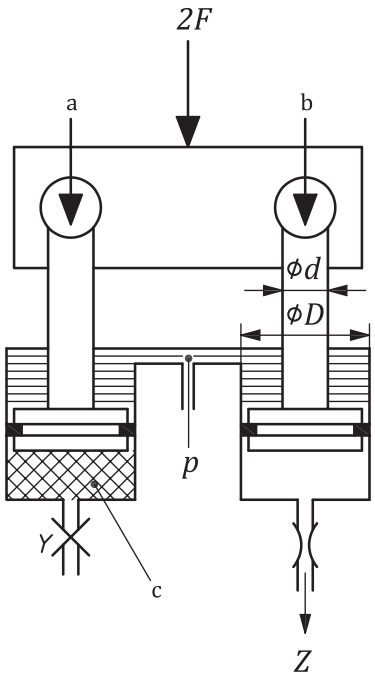


Key

D	diameter of piston
d	diameter of piston rod with cylinder in tension and speed control device acting on annulus
F	load
p	system pressure
p_{FC}	normal pressure
Z	restricted flow

a $p_{FC} + p \cdot \left(\frac{D^2 - d^2}{D^2} \right)$

Figure 13 — Twin cylinders under compression in normal operation



Key

D	diameter of piston	a	$F_B = 2F + p \cdot \left(\frac{\pi D^2 - \pi d^2}{4} \right)$
d	diameter of piston rod with cylinder in tension and speed control device acting on annulus	b	$p \cdot \frac{\left(\pi D^2 - \pi d^2 \right)}{4}$
F	load	c	$2\left[p_{FC} + p \cdot \left(\frac{D^2 - d^2}{D^2} \right) \right]$
F_B	buckling load		
p	system pressure		
p_{FC}	normal pressure due to load		
Z	restricted flow		

Figure 14 — Twin cylinders under compression, one line blocked

4.10.1.3 Failure conditions

4.10.1.3.1 Oil leaking past piston seals

The pressure normally generated can increase by the ratio D^2/d^2 where oil leaks past piston seals in double-acting cylinders under compressive loads. This particularly affects the stresses in the cylinder tube and the head, and these shall not exceed the yield stress ($R_{p0,2}$). This ratio is the minimum safety factor for valves, hoses and pipes which are at the same pressure as the cylinder, unless the pressure increase is limited by other hydraulic components.

4.10.1.3.2 Several cylinders operating the same mechanism

4.10.1.3.2.1 When more than one cylinder operates the same mechanism, illustrated in Figures 13 and 14, consideration shall be given to the effect of one cylinder being blocked and taking or causing greater loads. In the case of double-acting cylinders, this includes the force(s) generated by the other cylinder(s) or the force required to move the other cylinder.

4.10.1.3.2.2 Under failure conditions, the calculated maximum stress shall not exceed the yield stress of the material ($R_{p0,2}$).

4.10.2 Prevention of unintended movement of load-holding cylinders

4.10.2.1 Load-holding cylinders shall be fitted with a device to prevent unintended movement caused by failure of an external pipe [excluding those indicated in 4.10.2.3 c)] until it is released by an external force.

4.10.2.2 The effects of thermal expansion in load-holding cylinders shall be accounted for.

4.10.2.3 Such devices shall be either:

a) integral with the cylinder,

b) directly and rigidly flange-mounted to the cylinder,

c) placed close to the cylinder and connected to it by means of rigid pipes (as short as possible), having welded or flanged connections and whose characteristics are calculated in the same way as the cylinder.

4.10.2.4 Other types of fittings, such as compression fittings or flared pipe fittings, are not permitted between the cylinder and the lock valve.

NOTE These requirements, when met, also meet those of 4.5.1.6.

4.11 Safety devices and safety functions

4.11.1 General

4.11.1.1 Wherever reference is made to this clause, safety-related parts of control systems (SRP/CS) that perform the relevant safety function shall achieve the performance level in accordance with ISO 13849-1 specified in Table 6.

4.11.1.2 The validation of the safety functions and performance levels in 4.11.1 is given in ISO 13849-2.

4.11.1.3 It shall only be possible to override a safety device or safety function listed in Table 6 in a safe manner by using a separate device of the same performance level or better.

4.11.1.4 Audible warnings and visual signals shall meet the requirements of IEC 61310-1.

4.11.2 Safety functions of mechanical devices

For safety functions of mechanical devices, no specific performance level is required.

Table 6 — Performance levels for safety devices and safety functions

Subclause in this document	Required performance level (PLx) according to ISO 13849-1		Description of safety function
	group A, group B MEWPs		
	type 1	type 2, type 3	
4.3.1	c	N/A	Prevent travel of pedestrian-controlled MEWPs
4.3.2.1	c	d	Prevent elevation beyond the lowered travel position
4.3.2.4	N/A	c	Prevent travel above inclination limit
4.3.7.1	c		Monitoring of stabilising devices
4.3.7.2	d		Prevent operation outside limited range without stabilising devices
4.3.9	d		Safety device for powered stabilising devices
4.3.14.2 a)	c	N/A	Lock of tilting mechanism for levelling stabilising devices for type 1 MEWPs
4.3.14.2 b)	N/A	d	Lock of tilting mechanism for levelling stabilising devices for type 2 and type 3 MEWPs
4.3.15.1 a)	c	N/A	Control of oscillating axle lock
4.3.15.1 b)	N/A	d	Control of and safety device for oscillating axle lock
4.3.16.2	N/A	c	Limitation of travelling speed
4.4.1.2	d		Load-sensing system
4.4.1.3	d		Position control
4.4.1.4	d		Moment sensing system
4.4.1.9	d		Variable range of operation
4.5.1.3.1	c		Monitoring of chain/belt
4.5.2.7	c		Stop movement of slack rope conditions
4.5.3.7	c		Stop movement of slack chain conditions
4.5.5.2	c		Overspeed governor of rack and pinion drives
4.6.1.4	d		Levelling systems
4.6.5.1.1	c		Interlocking of guardrails
4.7.3.2	c		Interlocking of control position
4.7.4	c		Emergency stop
4.7.11	c		Retractable guardrail drive disable
4.10.2	c		Load holding cylinders

N/A – Not applicable

NOTE Control systems are defined in such a way that they end at the output of the power control elements. By this definition, for example, loading valves are considered to belong to the operating part of the system and not the safety related part of a control system.

4.12 Noise reduction

Noise reduction shall be an integral part of the design process for MEWPs, specifically taking into account technical progress and measures at source using ISO/TR 11688-1 for guidance.

NOTE ISO/TR 11688-2 gives further information on noise generation mechanisms in machinery. Some major sound sources of MEWPs are power generation and transmission equipment such as combustion engines, the cooling system, electric drive systems and hydraulic systems. Measures for noise reduction include enclosed power generation, transmission and hydraulic equipment, capsulated cooling system and exhaust silencers.

5 Verification of the safety requirements and/or protective/risk reductions measures

5.1 Examinations and tests

5.1.1 General

5.1.1.1 The MEWP shall comply with the safety requirements and/or protective/risk reduction measures of this document. These requirements and measures shall be verified according to Table 7. Where an "X" is indicated in Table 7, the corresponding verification method(s) shall be applied.

5.1.1.2 Examinations and tests to ensure that the MEWP complies with this document (see 5.2 and 5.3) shall consist of

a) design checks (see 5.1.2),

b) manufacturing checks (see 5.1.3), and

c) tests (see 5.1.4).

5.1.1.3 The results of examinations and tests shall be recorded.

Table 7 — Methods for the verification of safety requirements and/or protective/risk reduction measures

Clause	Title/description	Verification method			
		Design check	Test[a]	Visual examination	Additional or other method
4.2	Stability and structural calculations	X	X		A
4.3.1	Travel prevention	X	X		
4.3.2	Chassis inclination	X	X		
4.3.3	Locking pins			X	
4.3.4	Control bars and tow bars		X	X	
4.3.5	Control bars and tow bars held in vertical position		X	X	B
4.3.6.1	Stabilising device ground contact points (other than castor wheels)			X	B
4.3.7	Permitted work platform positions	X	X		
4.3.8	Totally manually operated MEWPs	X			
4.3.9	Prevention of powered stabilising devices movement	X	X		
4.3.10	Manually operated stabilising devices	X	X		
4.3.11	Movement of stabilising devices	X			
4.3.12	Vehicle-mounted MEWP transport position indicators		X		
4.3.13	Visual contact at control positions			X	
4.3.14.1	Levelling stabilising devices		X		B

a Functional test unless otherwise noted.

Key

A static tests and overload tests.

B verification by measurement

C see 5.1.2

D in accordance with 5.1.4

Table 7 *(continued)*

Clause	Title/description	Verification method			
		Design check	Test[a]	Visual examination	Additional or other method
4.3.14.3	Levelling stabilising devices – Hydraulic cylinders for positional control or locking devices		X		
4.3.15	Oscillating axle lock or control system	X	X		
4.3.16	Maximum travel speeds in elevated position	X	X		
4.3.17	Maximum travel speed of pedestrian-controlled MEWPs				B
4.3.18	Self-propelled MEWP brakes	X	X		
4.3.19	Stopping distances		X		
4.3.20	Unauthorized use		X		
4.3.21	Thermal hazards			X	
4.3.22	Engine exhaust			X	
4.3.23	Filling points for fluids			X	
4.3.24	Batteries and battery containers			X	
4.3.25	Derailment and run-away prevention of rail-mounted MEWPs		X		
4.3.26	Vehicle-mounted MEWP chassis selection	X			
4.4.1	Methods to avoid overturning and exceeding permissible stresses	C	D		
4.4.2	Sequencing of extending structure	X	X		
4.4.3	Trapping and shearing			X	B
4.4.4	Supporting extending structure for routine maintenance		X	X	
4.4.5	Speeds of extending structure		X		
4.4.6	Support in transport position	X		X	
4.5.1.1	Unintended motion	X	X		
4.5.1.2	Protection of extending structure from power sources	X			
4.5.1.3	Failure of transmission chain or belt	X	X		
4.5.1.4	Kick-back of handles	X		X	
4.5.1.5	Powered and manual drive systems for the same function	X	X		
4.5.1.6	Braking system for all drives	X	X		
4.5.2.1	Wire rope drive system safety	X		X	
4.5.2.2	Load-carrying wire ropes	X		X	
4.5.2.3	System of multiple wire ropes	X		X	
4.5.2.4	Re-tensioning of wire ropes	X		X	
4.5.2.5	Terminations of wire ropes	X		X	
4.5.2.6	Visual examination of wire rope terminations	X		X	

a Functional test unless otherwise noted.

Key

A static tests and overload tests.

B verification by measurement

C see 5.1.2

D in accordance with 5.1.4

Table 7 *(continued)*

Clause	Title/description	Verification method			
		Design check	Test[a]	Visual examination	Additional or other method
4.5.2.7	Safety device for MEWP work platforms raised and lowered by wire ropes	X	X		
4.5.2.8	Rope drum grooves and prevention of rope leaving the ends of the drum			X	
4.5.2.9	Layers of rope		X	X	
4.5.2.10	Turns of rope		X	X	
4.5.2.11	Fastening rope to drum	X		X	
4.5.2.12	Unintentional displacement of rope	X		X	
4.5.2.13	Drum and sheave grooves	X		X	
4.5.3.2.3	Two-chain drive systems	X		X	
4.5.3.3	Multiple chains attached to a point	X		X	
4.5.3.4	Tensioning chains	X		X	
4.5.3.5	Strength of junction between chain and termination	X			
4.5.3.6	Visual examination of chains and terminations	X		X	
4.5.3.7	Safety device for MEWP work platforms raised and lowered by chains	X	X		
4.5.3.8	Unintentional displacement of chain	X		X	
4.5.4.1	Lead screw and nut design stress and material	X			
4.5.4.2	Separation of lead screw from work platform			X	
4.5.4.3	Load-bearing nut and safety nut	X		X	
4.5.5.1	Design stress of racks and pinions	X			
4.5.5.2	Safety device and over-speed governor	X	X		
4.5.5.3	Device to prevent pinion displacement			X	
4.5.5.4	Visual examination of pinions			X	
4.6.1	Work platform – Level of work platform	X	X		
4.6.1.5	Work platform - Level control (hydraulic cylinders)		X		
4.6.4	Anchorages	X		X	
4.6.5	Openings in the guardrails for entrance and exit			X	
4.6.5.2	Special-purpose work platforms			X	
4.6.6	Floor of work platform	X		X	
4.6.7	Chains or ropes			X	
4.6.8.2	Access system	X		X	
4.6.8.2.2	Handrails and handholds	X		X	
4.6.9	Trapdoors			X	
4.6.11	Audible warning device		X		
4.6.12	Means of communication		X	X	

a Functional test unless otherwise noted.

Key

A static tests and overload tests.

B verification by measurement

C see 5.1.2

D in accordance with 5.1.4

Table 7 *(continued)*

Clause	Title/description	Verification method			
		Design check	Test[a]	Visual examination	Addi-tional or other method
4.6.13	Mechanical stops	X	X		
4.6.14	Support in transport position	X		X	
4.7.1	Controls - General		X	X	
4.7.3	Location, accessibility, protection, and selection among duplicate controls		X	X	
4.7.4	Emergency stops	X	X		
4.7.5	Pilot and solenoid valves	X	X		
4.7.6	Restoration of power after failure		X		
4.7.7	Auxiliary lowering system	X	X		
4.8.1	Electrical equipment - Relevant norms and standards	X		X	
4.8.2	Main switch	X		X	
4.8.3	Cables	X		X	
4.8.4	Battery protection			X	
4.8.5	Ingress of water	X		X	
4.8.7	Hourmeter	X			
4.9.1	Hydraulic system - Pressure-limiting device	X		X	
4.9.2	Strength of pipes and connections	X			
4.9.3	Bursting strength of hoses and fittings	X			
4.9.4	Pressure rating of other components	X			
4.9.6	Venting of air	X			
4.9.7	Inlet filter			X	
4.9.8	Fluid level indicators		X	X	
4.9.9	Fluid cleanliness	X			
4.9.10	Gas-loaded accumulators	X		X	
4.10	Hydraulic cylinders	X	X	X	

a Functional test unless otherwise noted.

Key

A static tests and overload tests.

B verification by measurement

C see 5.1.2

D in accordance with 5.1.4

5.1.2 Design check

The design check shall verify that the MEWP is designed in accordance with this document. It shall include verification of the following:

a) drawings containing the main dimensions of the MEWP;

b) description of the MEWP, with necessary information about its capabilities;

c) information about the materials used;

d) diagrams of the electrical, hydraulic and pneumatic circuits;

e) the operator's manual;

f) calculations.

5.1.3 Manufacturing checks

The manufacturing check shall verify that:

a) the MEWP is manufactured in accordance with the design check documents;

b) the components are in accordance with the drawings;

c) test certificates are available for each type of rope, chain and hydraulic or pneumatic hose, and that these certificates indicate the minimum breaking force or bursting pressure, as appropriate;

d) the quality of welds is ensured by use of the appropriate standard(s);

e) the construction and installation of parts, components and systems are in accordance with this document.

5.1.4 Tests

5.1.4.1 Fall arrest overturning test

5.1.4.1.1 MEWPs designed for use with a fall arrest system (see 4.6.4.3) shall successfully complete the following test. See Figure 15.

a) The MEWP shall, while positioned on a level surface, withstand the force of a free-falling 136 kg test mass or the rated platform load whichever is less

   — the origin of which has been placed so that its centre of gravity is 0,46 m outside of the top rail of the work platform in a direction that creates the most adverse stability condition,

   — which is attached by a non-shock-absorbing lanyard to a lanyard anchorage point nearest the test mass origin, the lanyard having been passed over the top rail of the work platform such that the overturning force is applied to the rail,

   — falling a minimum vertical distance of 1,2 m, without interference or obstruction and without hitting the floor/ground during the test.

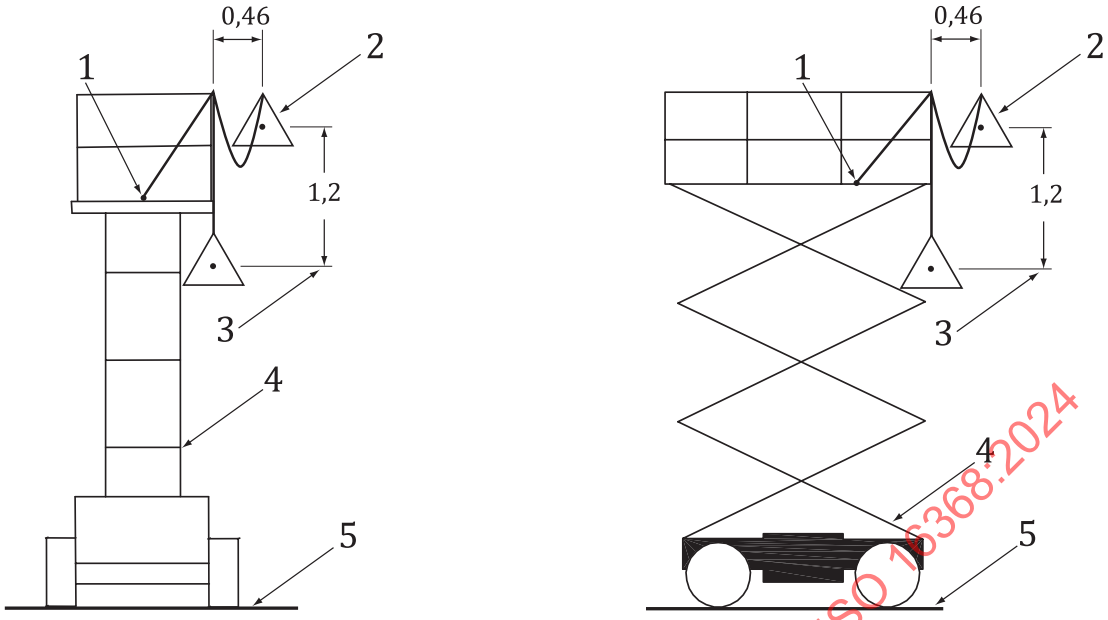
b) The MEWP shall be loaded to the most adverse stability condition during the test. The test mass plus the platform load shall equal the maximum platform rating. The test shall be conducted with no platform load if this is the condition of least stability. Any platform load shall be evenly distributed on the platform.

c) During the test, it is not necessary to include chassis inclination, permissible wind, and manual forces.

d) The MEWP shall not overturn as a result of this test. Permanent deformation of any part is acceptable, provided that the test mass is not released during the test.

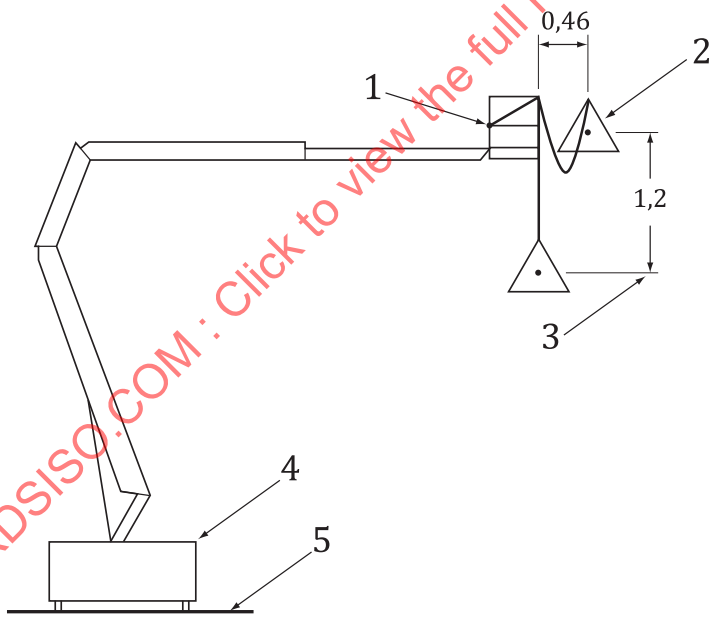
5.1.4.1.2 The configuration of the MEWP shall be in the most adverse configuration.

Dimensions in metres



Front view **Side view**

a) Group A MEWP front view and side view shown



b) Group B MEWP shown

Key

1 anchorage (see 4.6.4)
2 136 kg test mass
3 free-fall distance
4 MEWP
5 level surface

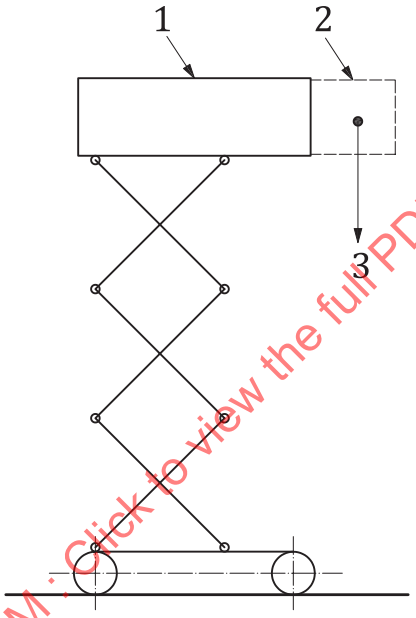
Figure 15 — Fall arrest overturning test

5.1.4.2 Stability tests

5.1.4.2.1 Static tests

5.1.4.2.1.1 The MEWP shall be set up on the maximum allowable chassis inclination defined by the responsible entity plus 0,5°. Stabilising devices, if provided, shall be used as specified by the responsible entity. If the MEWP is supported in the working position by pneumatic tyres and is not protected by a low-tyre-pressure operator warning system, the MEWP shall be set up with the inclination taking into account a deflated tyre. If the system incorporates a tyre pressure monitoring system (TPMS), the MEWP shall be set up at the tire inflation pressure when the TPMS activates. Test loads shall be applied to represent all the least favourable load and force combinations specified in 4.2.3.

5.1.4.2.1.2 For group A MEWPs that have platform extension(s) with rated load(s) different from the main work platform rated load, and which do not have specific load control of the extension(s), the rated load (see 4.2.1.1) shall be in accordance with Figure 16.



Key

1 main work platform
2 extension platform (fully extended)
3 rated load, *m*

Figure 16 — Static test

5.1.4.2.1.3 Rated load is expressed as (see also 4.2.1):

$$m = m_{\mathrm{p,work}} + m_{\mathrm{e,ext}}$$

where

$$m_{\mathrm{p,work}} = n_{\mathrm{p,work}} \times m_p$$

$n_{\mathrm{p,work}}$ is the permitted number of persons on the main work platform;

m_{p} is 80 kg (mass of a person);

$m_{\mathrm{e,ext}}$ is the mass of tools and materials permitted on the extension platform.

5.1.4.2.1.4 Persons and tools/material loads shall be distributed on the extension platform and, if necessary, on the main platform as specified in 4.2.2.2.2.

5.1.4.2.1.5 The test load(s) may be applied at any suitable strong point, if necessary, to avoid overstressing any part of the MEWP, provided the application point(s) chosen for the test load(s) induce deflection into the MEWP structure which represents conditions for which the MEWP is designed to be operated.

5.1.4.2.1.6 The test shall be repeated in all the least favourable extended and/or retracted positions. Examples are noted in Table 1 and shown in Figure 3.

NOTE The MEWP is considered to be stable if it can attain a stationary condition without overturning while supporting the test load(s). During the stability test, the lifting of tyres or outriggers alone does not indicate a condition of instability.

5.1.4.2.1.7 Additionally, it shall be demonstrated that following application of the manual forces in accordance with 4.2.2.4 in any position of the work platform, there is no permanent deformation of the work platform.

5.1.4.2.1.8 After removing the test load(s), the MEWP shall show no permanent deformation.

5.1.4.2.2 Dynamic tests on types 2 and 3 MEWPs

5.1.4.2.2.1 General

a) Types 2 and 3 MEWPs shall be subjected to kerb tests and braking tests with the rated load distributed evenly over the half of the work platform that will create the greatest overturning moment in the specific test case.

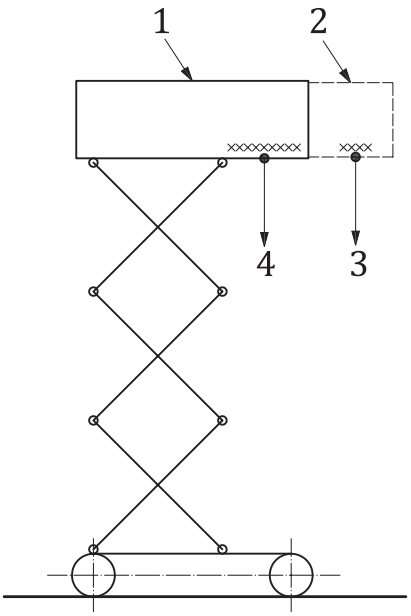
b) For types 2 and 3 MEWPs in group A that have platform extension(s) with rated loads different from the main work platform rated load and that do not have specific load control of the extension platform(s), the tests shall be carried out with the loads distributed in the same way and at the same time on both the main work platform and the extension platform. See Figure 17.

   1) Rated load m_{ext} is defined by (see also 4.2.1):

$$m_{\text{ext}} = \left(m_{\text{p,ext}} + m_{\text{e,ext}}\right) + m_p$$

   2) Rated load m_{work} is defined by (see also 4.2.1):

$$m_{\text{work}} = \left(m_{\text{p,work}} - m_{\text{p,ext}} - m_p\right) + \left(m_{e,\text{work}} - m_{\text{e,ext}}\right)$$



Key

1 main work platform
2 extension platform (fully extended)
3 rated load (extension platform), m_{ext}
4 rated load (main platform), m_{work}

Figure 17 — Dynamic tests on types 2 and 3 MEWPs

where

$m_{p,work}$ = $n_{p,work} \times m_p$

$m_{p,ext}$ = $n_{p,ext} \times m_p$

$n_{p,work}$ is the permitted number of persons on the main work platform;

$n_{p,ext}$ is the permitted number of persons or rated number of occupants on the extension platform;

$m_{e,work}$ is the mass of tools and materials permitted on the main work platform;

$m_{e,ext}$ is the mass of tools and materials permitted on the extension platform;

m_p is 80 kg (mass of a person).

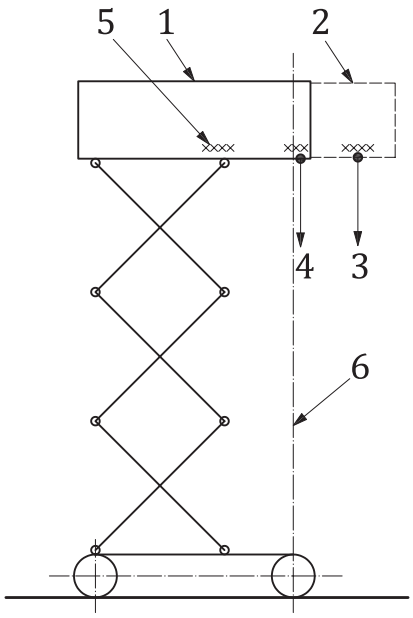
c) Tests shall also be carried out with only the extension load, distributed in the same way on the extension platform. In addition, the main work platform loads that increase the overturning moments shall be taken into account in accordance with 4.2.2.2.2. Any load on the main work platform that increases the stabilizing moment shall be removed. An example of where these loads would need to be taken into account is given in Figure 18.

1) Rated load m_{ext} is defined by (see also 4.2.1):

$$m_{ext} = \left(m_{p,ext} + m_{e,ext}\right) + m_p$$

2) Rated load m_{work} is defined by (see also 4.2.1):

$$m_{work} = \left[\left(m_{p,work} - m_{p,ext} - m_p\right) + \left(m_{e,work} - m_{e,ext}\right)\right] f$$



Key

1 main work platform
2 extension platform (fully extended)
3 rated load (extension platform), m_{ext}
4 rated load (main platform), m_{work}
5 removal of the stabilising proportion of the main work platform load
6 tipping line

Figure 18 — Dynamic test on types 2 and 3 MEWPs with load locations

where

$m_{p,work}$ = $n_{p,work} \times m_p$

$m_{p,ext}$ = $n_{p,ext} \times m_p$

$n_{p,work}$ is the permitted number of persons on the main work platform;

$n_{p,ext}$ is the permitted number of persons or rated number of occupants on the extension platform;

$m_{e,work}$ is the mass of tools and materials permitted on the main work platform;

$m_{e,ext}$ is the mass of tools and materials permitted on the extension platform;

m_p is 80 kg (mass of a person);

f is the proportion of the main work platform load outside the tipping line.

5.1.4.2.2.2 Kerb and depression tests

a) The tests shall be repeated, driving in both the forward and reverse directions, in each extended position of the MEWP and, if different travel speeds are allowed for different heights, at each of those heights, at the maximum permitted speed for each height. In all cases, the steering wheels shall be parallel to the length of the machine. If the MEWP is equipped with an oscillating axle(s) that are locked when in the test configuration, the axle(s) shall be blocked at the limit of axle articulation which allows travel with the platform elevated.

b) During the tests, it is not necessary to simulate the effect of the permissible wind speed.

c) The MEWP shall not overturn during the tests.

d) For kerb tests performed on types 2 and 3 MEWPs, excluding rail-mounted MEWPs, the drive control shall be maintained at maximum until the MEWP comes to a stop or both leading wheels/tracks climb the kerb. The MEWP shall be driven on level ground so that:

   1) each leading wheel/track in turn is driven into contact with a kerb of height 0,1 m perpendicular to the kerb

   2) both leading wheels/tracks simultaneously are brought into contact with the same kerb.

e) For depression tests performed on types 2 and 3 MEWPs intended for off-slab use, excluding rail-mounted MEWPs, the drive control shall be maintained at maximum until both leading wheels or tracks are driven into or over the depression. The MEWP shall be driven on level ground so that:

   1) each leading wheel/track in turn is driven off the edge of a depression of 0,1 m, with the test machine approaching the depression perpendicular to the depression and being driven until the leading wheel is in the depression,

   2) both leading wheels/tracks are driven simultaneously into the same depression.

f) For depression tests performed on types 2 and 3 MEWPs intended for paved/slab use only, excluding rail-mounted MEWPs, the MEWP shall be driven on level ground so that each leading wheel/track in turn is driven off the edge of a depression 0,6 m square with a vertical drop of 0,1 m, and with one front wheel/track aligned across (perpendicular to) the edge of the depression. The leading wheel/track shall enter at all points along the depression's edge, with only one leading wheel/track driven into the depression for each approach. Maximum speed shall be maintained until both leading wheels/tracks enter into, or are driven over, the depression.

5.1.4.2.2.3 Braking tests

a) Types 2 and 3 MEWPs shall be tested by being stopped as rapidly as their controls allow. This shall be done in both the forward and reverse directions, in each MEWP position, in each combination of chassis inclination, subject to adequate traction, loads and forces that will together create conditions of minimum stability, and where different travel speeds are allowed for different heights, at each of those heights, at the maximum permitted speed for each height.

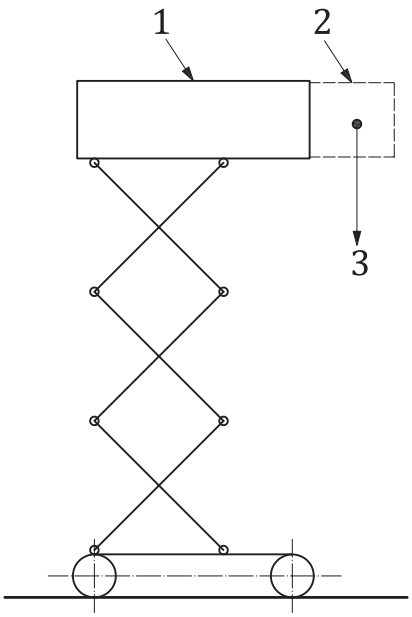
b) During the tests, it is not necessary to simulate the effect of the permissible wind speed.

c) The MEWP shall not overturn during the tests and the stopping distance shall comply with 4.3.19.

5.1.4.3 Overload test

5.1.4.3.1 The test load shall be 125 % of the rated load for power-operated MEWPs, and 150 % of the rated load for manually operated MEWPs and MEWPs which employ enhanced overload criteria.

5.1.4.3.2 In addition to the requirements of 5.1.4.3.1 for group A MEWPs that have platform extension(s) with rated loads different from the main work platform rated load, and that do not have specific load control of the extension(s), the test load shall be as shown in Figure 19.



Key

1 main work platform

2 extension platform (fully extended)

3 test load, m_{test}

Figure 19 — Position of test load for platforms with platform extension(s) at overload test

5.1.4.3.3 The test load described in 5.1.4.3.2, m_{test}, is defined by:

$$m_{test} = \left(m_{p,ext} + m_{e,ext}\right) \times 1,25 + \left(m_{p,work} - m_{p,ext}\right)$$

where

$$m_{p,work} = n_{p,work} \times m_p$$

$$m_{p,ext} = n_{p,ext} \times m_p$$

$n_{p,work}$ is the permitted number of persons on the main work platform;

$n_{p,ext}$ is the permitted number of persons or rated number of occupants on the extension platform;

$m_{e,ext}$ is the mass of tools and materials permitted on the extension platform;

m_p is 80 kg (mass of a person).

5.1.4.3.4 The person and tools/material loads shall be distributed on the extension and, if necessary, on the main work platform, as specified in 4.2.2.2.2.

5.1.4.3.5 Travelling and all movements of the extending structure with the test loads shall be carried out at accelerations and decelerations appropriate to safe control of the load. If several movements with the test load need to be carried out, the intended movements shall be carried out separately, when vibrations

associated with preceding movements have subsided, and with care, taking into due account the least favourable positions.

5.1.4.3.6 If, due to the various combinations of loads or outreaches of a MEWP, tests with different test loads are necessary, all movements shall be carried out with all test loads, except where the least-favourable conditions can be sufficiently simulated by one performance test.

5.1.4.3.7 During the overload test, the MEWP shall be on level ground and the extending structure put into each position which creates maximum stress in any load-bearing part of the MEWP.

5.1.4.3.8 During this test, it is not necessary to simulate the effect of the permissible wind speed.

5.1.4.3.9 The braking systems shall be capable of stopping and sustaining the test load(s).

5.1.4.3.10 After removing the test load(s), the MEWP shall show no permanent deformation.

5.1.4.4 Functional tests

Functional tests shall demonstrate that:

a) the MEWP can operate smoothly for all motions while carrying 110 % of the rated load at the rated speeds,

NOTE The load-sensing or moment-sensing systems can be temporarily disabled to perform this test.

b) all safety devices work correctly,

c) maximum permitted speeds are not exceeded.

5.2 Type tests

The first MEWP made to a new design or incorporating significant changes to an existing design shall be subjected to the following:

a) a design check (see 5.1.2);

b) a manufacturing check (see 5.1.3);

c) the appropriate testing (see 5.1.4).

5.3 Production tests

5.3.1 MEWPs not vehicle-mounted

Each production MEWP built in accordance with a type-tested model shall be subjected to the following tests before being placed on the market:

a) brake testing, where applicable (see 5.1.4.2.2.3);

b) overload testing (see 5.1.4.3);

c) functional testing (see 5.1.4.4).

5.3.2 Vehicle-mounted MEWPs

MEWPs built in accordance with a type-tested model shall be subjected to the following tests before being placed on the market:

a) a design check (see 5.1.2);

b) a manufacturing check (see 5.1.3)

c) brake testing, where applicable (see 5.1.4.2.2.3);

d) overload testing (see 5.1.4.3)

e) static stability testing (see 5.1.4.2.1)

f) functional testing (see 5.1.4.4).

6 Information for use

6.1 General

6.1.1 The responsible entity shall provide an operator's manual in at least one of the languages of each country in which the MEWP is intended for market, sale or lease by the responsible entity.

6.1.2 Weather-resistant storage for the operator's manual shall be provided on the MEWP and shall be located such that it is accessible from the work platform. This accessibility requirement does not apply to insulated MEWPs.

6.2 Operator's manual

6.2.1 Content

6.2.1.1 The operator's manual shall include, but not be limited to, the following information:

a) operating instructions which give details for safe use;

b) transport handling and storage information;

c) any special provisions for securing parts of the MEWP for transport between places of use;

d) lift points, mass, centre of gravity for lifting purposes and points to use for securing on transport vehicle;

e) precautions to be taken before periods of storage indoors or outdoors;

f) checks to be made on power supply, hydraulic oils, lubricants, etc. on first use, after long periods of storage or changes in environmental conditions (for example, heat, cold, moisture, dust);

g) information regarding placing the MEWP into service;

h) tests before placing the MEWP into service;

i) the responsible entity's recommended periodic examinations or tests;

j) maintenance information for use by trained personnel — instructions for maintenance operations to be carried out only by specialist maintenance personnel shall be separate from the other instructions;

k) parts that are detachable for functional reasons (see 6.4.9);

l) allowable ambient temperature range;

m) a listing of MEWP functions, features, operating characteristics, limitations and devices to be included in familiarisation;

n) information about setting up the MEWP, (for example, maximum permitted slope(s) for operation and travelling) and the applied forces created by the stabilising devices/wheels;

o) location, purpose and use of all normal controls, emergency lower and emergency stop equipment;

p) prohibition of overloading the work platform;

q) prohibition of use as a crane;

r) national traffic regulations (where applicable);

s) keeping clear of live electrical conductors;

t) avoidance of contact with fixed objects (for example, buildings) or moving objects (for example, other vehicles, cranes);

u) prohibition of any increase in reach or working height of the MEWP by use of additional equipment, (for example, ladders);

v) prohibition of any addition that would increase the wind loading on the MEWP;

w) maximum allowable wind speed, in metres per second, or where the MEWP is designed for use in non-wind conditions, a warning to that effect;

x) important daily checks on the safe condition of the MEWP;

y) installation of removable guardrails (where applicable);

z) for MEWPs with retractable guardrail system(s),

   1) operating instructions pertaining to the proper installation or retraction or removal, and installation of the retractable guardrail system(s);

   2) operating instructions that are unique to the conditions of use of a MEWP for which the guardrail system(s) are permitted to be retracted;

   3) manufacturer's fall restraint system equipment requirements (for example, maximum lanyard length);

aa) precautions on getting on and off the work platform when elevated;

bb) precautions for travelling with elevated work platform;

cc) precautions for travelling with crawler machines;

dd) precautions for when inspection or filling access points cannot be reached from the ground;

ee) guidance on personal fall protection systems;

ff) auxiliary lowering instructions;

gg) instructions on how to use the overriding emergency system;

hh) descriptions, specifications and ratings of the MEWP;

ii) tyre specifications.

6.2.2 Modification or repair

The operator's manual shall state that modifications or additions to a MEWP shall be made in accordance with the relevant requirements of ISO 18893.

6.3 Parts and service manuals

The responsible entity shall make available parts and service manuals.

NOTE ISO 18893 and ISO 18878 can be used for guidance.

6.4 Marking

6.4.1 Responsible entity's plate

6.4.1.1 Symbols used for marking shall comply with ISO 7000.

6.4.1.2 One or more durable responsible entity's plates giving the following information indelibly shall be permanently attached to the MEWP in an easily visible place:

a) responsible entity's or supplier's name;

b) country of manufacture/remanufacture;

c) model designation;

d) serial or fabrication number;

e) year of manufacture;

f) year of remanufacture (if applicable);

g) unloaded mass, in kilograms;

h) rated load, in kilograms;

i) the allowable number of persons;

j) for work platforms that have different specified rated loads, each rated load shall be given as the allowable number of persons and rated load, in kilograms;

k) maximum allowable manual force, in newtons;

l) maximum allowable wind speed, in metres per second;

m) maximum allowable chassis inclination, in degrees;

n) hydraulic supply information, if an external hydraulic power supply is used;

o) pneumatic supply information, if an external pneumatic power supply is used;

p) electrical supply information, if an external electric power supply is used;

q) name of the installer of the vehicle-mounted MEWP (if applicable);

r) the rated load capacity, including platform capacity and lifting attachment capacity (if applicable);

s) maximum work platform height, in metres.

6.4.1.3 The capacity rating shall be designated with extending structure and load-carrying attachments extended to the position of maximum overturning moment attainable throughout full rotation. Capacities of the MEWP in other positions shall be specified separately. The responsible entity shall state all applicable ratings in the manual and on placards affixed to the MEWP. If these capacity ratings are based on some fixed conditions of the load-carrying attachments, this shall be stated.

6.4.1.4 Portions of this information may be repeated at other appropriate places on the MEWP.

6.4.2 Work platform

6.4.2.1 Symbols used for marking shall comply with ISO 7000.

6.4.2.2 The following information shall be clearly marked in a durable manner at or on each work platform in an easily visible place:

a) the rated load, in kilograms;

b) the allowable number of persons;

c) the maximum allowable manual force, in newtons;

d) maximum allowable wind speed, in metres per second;

e) allowable special loads and forces, if applicable (see 4.2.3.3);

f) information indicating "non-insulated"; except if equipped with a work platform designed for work near live electrical conductors (see ISO 16653-2);

g) information related to the use and load rating of the equipment for material handling;

h) information related to the use and load rating of the MEWP for multiple configurations;

i) anchorage markings for fall restraint only;

j) anchorage markings for fall arrest only;

k) anchorage marking for fall restraint and fall arrest;

l) anchorage marking for the maximum number of persons allowed to attach to the anchorage;

m) on MEWPs with retractable guardrail system(s), information regarding the requirement to utilize the fall restraint system when the guardrail system(s) is retracted;

n) clearance requirements for energized electrical lines or apparatus, in accordance with ISO 18893 or by a governing authority if more stringent.

6.4.3 Multiple rated loads

If more than one rated load is designated, the loads shall be tabulated in relation to the configuration of the MEWP. MEWPs with a work platform which can be extended, enlarged or moved relative to the extending structure shall be marked with the rated load that can be carried in all positions and configurations of the work platform.

6.4.4 Auxiliary systems

6.4.4.1 The location and instructions for operating the auxiliary system(s) at the base of the MEWP shall be marked on the MEWP near the relevant controls.

6.4.4.2 The location for the auxiliary system(s) at the platform (if equipped) shall be marked near the relevant platform controls.

6.4.5 Overriding of functions

The location and instructions for operating the controls required to override functions (see 4.7.8) shall be marked on the MEWP near the relevant controls.

6.4.6 Work platform rated loads

MEWPs with main and secondary work platforms shall be marked with the total rated load as well as the rated loads of each work platform.

6.4.7 MEWPs designated for indoor use

MEWPs designed for indoor use where wind loads have not been taken into consideration during the design shall be clearly marked in a durable manner to that effect, including zero allowable wind speed in an easily visible place.

6.4.8 External power supply connections

Points for connection of external power supplies shall be clearly marked in a durable manner with the essential power supply information (see 6.4.1).

6.4.9 Detachable parts

Parts which can be detached for functional reasons (e.g. work platforms, stabilising devices) shall be clearly marked in a durable manner in an easily visible place with

a) the responsible entity's or supplier's name,

b) the model designation of the MEWP,

c) the part number.

6.4.10 Instructions

A durable label referring the operator to the manuals shall be clearly affixed in a durable manner and in a suitable location.

6.4.11 Projecting extremities

All projecting, movable extremities of MEWPs shall be marked with hazard colours in accordance with ISO 3864.

6.4.12 Wheel/stabilising device load

Each stabilising device/wheel shall be marked in a durable manner in an easily visible place with the maximum exerted load.

6.4.13 Tyre pressure

The pressure for pneumatic tyres shall be indicated on the MEWP.

6.4.14 Clearances

Where safe clearances or adequate guarding are not possible, warning notices shall be fitted (see 4.4.3).

6.4.15 Maintenance

MEWPs shall be clearly marked, in a durable manner, warning persons not to enter the space beneath a raised work platform and an extending structure during maintenance unless a means of structure support is in place.

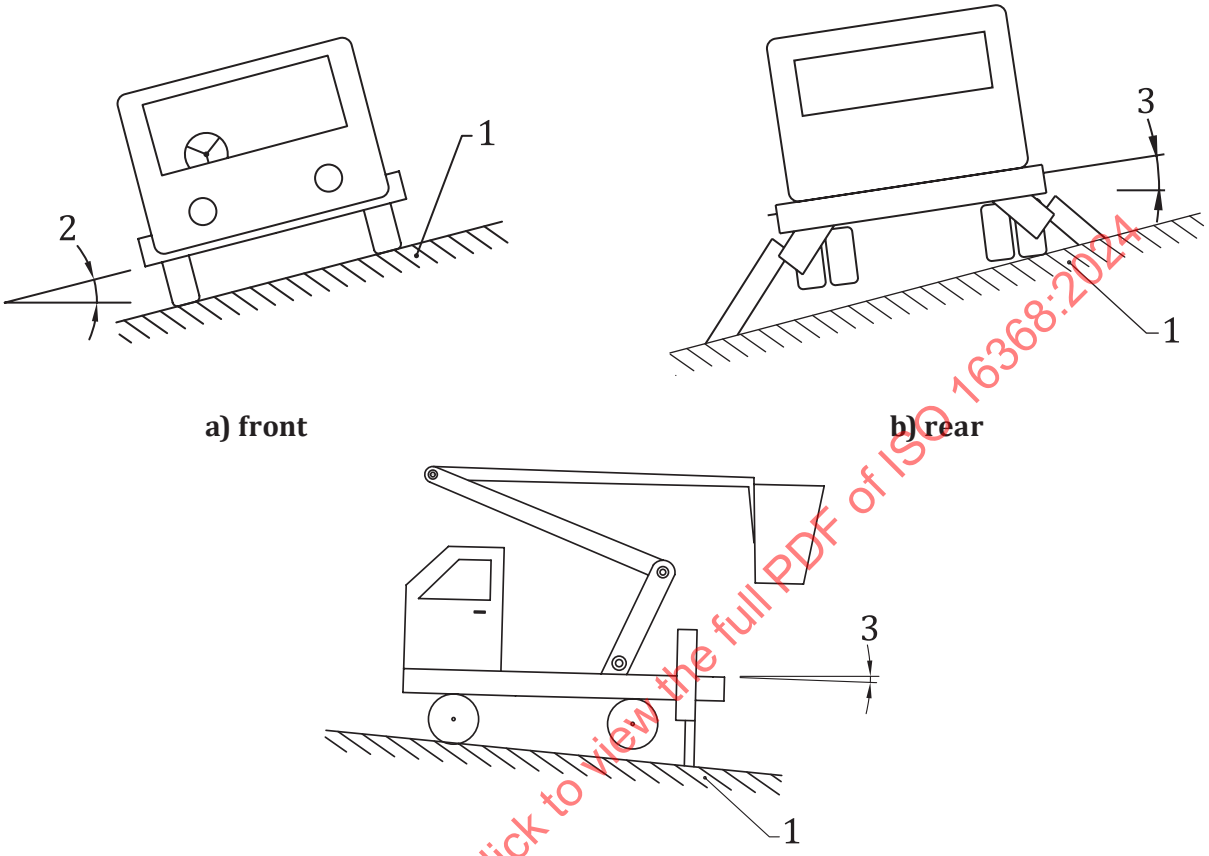
6.4.16 Stabilising device use

MEWPs requiring the use of stabilising devices shall be clearly marked in a durable manner with a warning at the operator's position to alert the operator of the need to position the stabilising devices.

6.4.17 Levelling instructions

For MEWPs with flexible chassis or suspension acting as part of the stabilizing medium, instructions detailing the necessary criteria (for example, chassis inclinations) to achieve stability shall be provided.

NOTE For examples, see Figure 20.



a) front **b) rear**

c) side

Key

1 support surface
2 maximum inclination on tyres, in degrees
3 maximum inclination on stabilising devices, in degrees

Figure 20 — Examples of levelling criteria

6.4.18 Pressurized vessel

Hydraulic systems with a gas-loaded accumulator shall have an appropriate warning label on the gas-loaded accumulator. Duplicate information shall be provided on the circuit diagram in the service manual.

6.4.19 Annual Inspection

A means shall be provided on the MEWP to mark the date on which each annual inspection was performed and the interval at which inspections are required.

Annex A
(informative)

Use of MEWPs in wind speeds greater than 12,5 m/s — Beaufort scale 6

A.1 Beaufort scale 6 was adopted for this document after examination of a number of previously existing standards and the experience of users of MEWPs. A significant reaction from users was that Beaufort Scale 6 represented a natural limit at which operators became aware of the effects of wind speed and were reluctant to use the machines.

A.2 The occasional, or locally regular, occurrence of higher wind speeds was recognized, but it was considered unreasonable to expect all MEWPs to be designed for exceptional circumstances which were readily recognizable by operators. This took into account the fact that wind forces increase by the square of the wind speed.

A.3 It was agreed that higher wind speeds are in the category of special loads and forces (see 4.2.3.4) and could be dealt with

a) by the responsible entity's specification that higher wind speeds are acceptable [see 6.4.1.2 l)],

b) by measures such as a reduction in the number of persons allowed on the work platform under such conditions.

A.4 Most responsible entities use procedure b), giving appropriate details in their operating instruction manuals.

Annex B
(normative)

Additional requirements for wireless controls and control systems

B.1 General

B.1.1 Wireless controls shall be designed according to IEC 60204-32:2023, 9.2.7, with the additions given in this annex.

B.1.2 The transmitter shall not transmit while the means to prevent unauthorized use is activated.

B.2 Control limitation

B.2.1 Activation of the transmitter shall be indicated on the transmitter and shall not initiate any movement of a MEWP.

B.2.2 The receiver shall provide output operating commands to the control system only when it is receiving frames containing the right address and correct command.

B.2.3 The MEWP contactor shall only be energized (in other words, controlled to the "on" state) by at least one correctly received frame without any operating commands but containing a start command.

B.2.4 To avoid inadvertent movements after any situation having caused the MEWP to stop (for example, power supply fault, battery replacement or lost signal condition), the system shall only output operating commands resulting in any MEWP movement after the MEWP driver has returned the controls to the "off" position for a suitable period of time, (in other words, it has received at least one frame without any operating commands).

B.2.5 Whenever the MEWP switch is de-energized, all operating command outputs for MEWP movements from the receiver shall cease.

B.3 Stop

B.3.1 The part of the wireless control system to perform the stop function is a safety-related part of the MEWP's control system.

B.3.2 The control system shall initiate a stop of all MEWP movements when no valid frame has been correctly received within 0,5 s.

B.3.3 Unless the receiver monitors that the state of the control system corresponds with the state of the receiver outputs, the stop specified in B.3.2 shall also de-energize the MEWP switch. If the receiver monitors that the state of the control system corresponds with the state of the receiver outputs, the de-energizing of the MEWP switch may be delayed by up to a maximum of 5 min.

B.3.4 If emergency stop functions of category 0, as required by IEC 60204-32:2023, 9.2.5.4.2, create any additional risk, the stop function can be of category 1.

B.4 Serial data communication

B.4.1 The frame shall be sent repeatedly during operation.

B.4.2 The system shall provide a transmission reliability to a hamming distance of the total number of bits in a frame divided by 20 and at least 4, or other means which ensure an equal level of reliability such that the probability of an erroneous frame getting through is less than 10−8.

B.5 Use of more than one operator control station

B.5.1 Transferral of control from one transmitter to another shall not be possible until the first transmitter has been de-activated by a deliberate action, specifically designed for this purpose.

B.5.2 A means shall be provided to enable several transmitter/receiver pairs to operate in the transmission range without unwanted interference with each other.

B.5.3 The means provided in B.5.2 shall be protected from accidental or unintentional change.

B.6 Battery-powered operator control stations

After the warning and the period required in IEC 60204-32:2023, 9.2.7.6 (when the transmitter battery voltage becomes so low that a reliable transmission cannot be guaranteed) the transmitter shall go automatically to the locked-off condition (in other words, the receiver stops all MEWP motions and de-energizes the MEWP switch).

B.7 Receiver

The receiver shall withstand the vibration, random wide band test, Test Fh, in accordance with IEC 60068-2-64.

B.8 Warnings

B.8.1 Where persons can be expected to be in the vicinity of the MEWP or a part of the MEWP (for example, in the case of a travelling MEWP or slewing MEWP) and the risk exists (for example, persons being trapped, run over), then warnings in addition to those specified in 6.4 shall be provided.

B.8.2 The MEWP shall be provided with a marking at the access onto the MEWP stating that the MEWP is provided with a cableless control system, and either a continuous visual warning while a wireless control system is engaged or an automatic acoustic and/or visual warning prior to movements of the MEWP.

B.9 Information for use

B.9.1 The manufacturer's instructions shall include installation information to ensure that when a wireless control system is in use, it shall not interfere with, or be interfered by, other systems in use at that location.

B.9.2 The manufacturer shall state the actual delay for the stop function specified in B.3.2.

Annex C
(normative)

Calculation of wire-rope drive systems

C.1 General

C.1.1 A wire-rope drive system comprises the wire ropes running on rope drums and on or over rope pulleys as well as any associated rope drums, rope pulleys and compensating pulleys.

C.1.2 Compensating pulleys are rope pulleys over which the wire rope normally runs during operation over a segment not exceeding three times the diameter of the wire rope.

C.1.3 The categories of running time are given in Table C.1.

C.1.4 This annex does not address wire ropes which do not run on rope drums and/or over rope pulleys (carrying ropes and tensioning ropes) or sling ropes.

C.2 Calculation of wire-rope drive systems

C.2.1 When calculating the wire-rope drive systems, the following factors which influence the service life of a wire rope shall be taken into consideration:

a) mode of operation (drive group);

b) wire-rope diameter (coefficient c);

c) diameters of rope drums, rope pulleys and compensating pulleys [coefficient $(h_1 \cdot h_2)$];

d) rope grooves.

C.2.2 The mechanical components shall be graded according to their mode of operation into a "drive group" in accordance with Table C.1, in order to achieve an adequately long service life. The grading is made according to running-time categories, which take the average running time of the wire-rope drive system