INTERNATIONAL STANDARD

ISO 16369

Second edition
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Elevating work platforms — Mast-climbing work platforms

Plates-formes élévatrices de personnel — Plate-formes se déplaçant le long de mât(s)

Reference number
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Foreword

ISO (the International Organization for Standardization) is a worldwide federation of national standards bodies (ISO member bodies). The work of preparing International Standards is normally carried out through ISO technical committees. Each member body interested in a subject for which a technical committee has been established has the right to be represented on that committee. International organizations, governmental and non-governmental, in liaison with ISO, also take part in the work. ISO collaborates closely with the International Electrotechnical Commission (IEC) on all matters of electrotechnical standardization.

International Standards are drafted in accordance with the rules given in the ISO/IEC Directives, Part 2.

The main task of technical committees is to prepare International Standards. Draft International Standards adopted by the technical committees are circulated to the member bodies for voting. Publication as an International Standard requires approval by at least 75 % of the member bodies casting a vote.

Attention is drawn to the possibility that some of the elements of this document may be the subject of patent rights. ISO shall not be held responsible for identifying any or all such patent rights.

ISO 16369 was prepared by Technical Committee ISO/TC 214, *Elevating work platforms*.

This second edition cancels and replaces the first edition (ISO 16369:2000), which has been technically revised.

Introduction

This International Standard is one of a series of standards produced by ISO/TC 214 as part of its programme of work regarding standardization of terminology, ratings, general principles (technical performance requirements and risk assessment), safety requirements, test methods, maintenance and operation for elevating work platforms used to raise (elevate) and position personnel (and related work tools and materials) to a work position where a task is to be performed.

The extent to which hazards are covered is indicated in the scope of this International Standard. In addition, ISO 12100-1 and ISO 12100-2 address lifting equipment hazards which are not covered by this International Standard.

Elevating work platforms — Mast-climbing work platforms

1 Scope

This International Standard specifies particular safety requirements for mast-climbing work platforms (MCWP) which are temporarily installed and are manually or power-operated, and which are designed to be used by one or more persons from which to carry out work.

NOTE The vertical-moving components (work platforms) are also used to move those same persons and their equipment and materials to and from a single boarding point. These restrictions differentiate MCWP from builder's hoists.

This International Standard is also applicable to permanently installed MCWP.

This International Standard is applicable to work platforms which are elevated by a drive system and guided by and moved along their supporting masts, where the masts may or may not require lateral restraint from separate supporting structures.

This International Standard is applicable to any combination of the following alternatives:

- one or more masts;
- mast tied or untied;
- mast of fixed or variable length;
- masts vertical or inclined between 0° and 30° to the vertical;
- masts which are standing or hanging;
- movable or static base (chassis or base frame);
- manual or power-operated elevation;
- towed or self-powered ground travel on site, excluding road traffic regulation requirements;
- driven using electric, pneumatic, hydraulic motors or internal combustion engines.

This International Standard identifies the hazards arising during the various phases in the life of such equipment and describes methods for the elimination or reduction of these hazards and for the use of safe working practices.

This International Standard does not specify the requirements for dealing with the hazards involved in the manoeuvring, erection or dismantling, fixing or removing of any materials or equipment which are not part of the MCWP, nor does it deal with the handling of specific hazardous materials.

This International Standard does not specify the requirements for delivering persons and materials to fixed landing levels. Such equipment is referred to as lifts or hoists and is dealt with by other International Standards.

This International Standard does not apply to mobile elevating work platforms (MEWPs) in accordance with ISO 16368, suspended access equipment in accordance with EN 1808 or lifting tables in accordance with EN 1570.

2 Normative references

The following referenced documents are indispensable for the application of this document. For dated references, only the edition cited applies. For undated references, the latest edition of the referenced document (including any amendments) applies.

ISO 4301-1, *Cranes and lifting appliances — Classification — Part 1: General*

ISO 4302, *Cranes — Wind load assessment*

ISO 6336-1, *Calculation of load capacity of spur and helical gears — Part 1: Basic principles, introduction and general influence factors*

ISO 6336-2, *Calculation of load capacity of spur and helical gears — Part 2: Calculation of surface durability (pitting)*

ISO 6336-3, *Calculation of load capacity of spur and helical gears — Part 3: Calculation of tooth bending strength*

ISO 6336-5, *Calculation of load capacity of spur and helical gears — Part 5: Strength and quality of materials*

ISO 8686-1, *Cranes — Design principles for loads and load combinations — Part 1: General*

ISO 12100-2:2003, *Safety of machinery — Basic concepts, general principles for design — Part 2: Technical principles*

ISO 13849-1:2006, *Safety of machinery — Safety-related parts of control systems — Part 1: General principles for design*

ISO 13852, *Safety of machinery — Safety distances to prevent danger zones being reached by the upper limbs*

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

IEC 60065, *Audio, video and similar electronic apparatus — Safety requirements*

IEC 60204-1:2005, *Safety of machinery — Electrical equipment of machines — Part 1: General requirements*

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

IEC 60947-5-1:2003, *Low-voltage switchgear and controlgear — Part 5-1: Control circuit devices and switching elements — Electromechanical control circuit devices*

EN 614-1, *Safety of machinery — Ergonomic design principles — Part 1: Terminology and general principles*

EN 953, *Safety of machinery — Guards — General requirements for the design and construction of fixed and movable guards*

EN 982, *Safety of machinery — Safety requirements for fluid power systems and their components — Hydraulics*

3 Terms and definitions

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

NOTE Elements of MCWP defined below are illustrated in Figures 1 and 2.

3.1
rated load
load for which the MCWP has been designed for normal operation, as stated in the load diagram

3.2
load diagram
notice displayed on the work platform showing the permitted number of persons and the mass and distribution of materials for the particular configuration

3.3
rated speed
vertical or horizontal speed for which the MCWP has been designed

3.4
transfer
any horizontal movement of the MCWP from one position to another on the same working site

3.5
transfer condition
configuration of the MCWP in which it is moved from one position to another on the same working site, including any limitation on the weather and the load or persons on the MCWP

3.6
transport
any movement of the MCWP outside the boundaries of the working site

3.7
transport condition
configuration of the MCWP in which it is moved outside the boundaries of the working site

EXAMPLE Road transport.

3.8
transfer [transport] interlocks
any design features on the MCWP which prevent unsafe transfer [transport]

3.9
base frame
part of the MCWP which provides support for the mast and elevating assembly

3.10
chassis
part of the MCWP which provides mobility and support for the mast and elevating assembly

3.11
rail-mounted chassis
chassis designed to transmit horizontal as well as vertical force to the ground via rails

3.12
outrigger
support at the base-frame level used to maintain or increase the stability of the MCWP within specified conditions

NOTE Outriggers can also be used for levelling.

3.13
outrigger beam
part of an outrigger assembly which moves in an essentially horizontal plane and may be powered or operated manually

3.14
mast
structure that supports and guides the platform

3.15
fixed-length mast
mast whose length cannot be varied, even by the attachment of further mast sections

3.16
variable-length mast
mast whose length can be varied by the attachment of successive lengths of prepared sections

3.17
guide
part of the mast which provides guiding for the work platform

3.18
mast tie
anchorage system used to provide lateral restraint to the mast from a building or other structure

3.19
work platform
vertical travelling part of the installation upon which the persons, equipment and materials are carried and from which work is carried out

NOTE The work platform includes the main platform and any platform extension, in contrast to the MCWP, which refers to the whole of the installation, including work platform, mast, mast ties, base and chassis.

3.20
available platform area
area of the work platform, measured at the work platform floor level

3.21
main platform
part of the work platform built up using primary structural elements

3.22
platform extension
additional part of the work platform, built up using secondary structural elements, whose support and location is dependent upon the main platform

NOTE Platform extensions are used to extend the main work platform, usually along its longitudinal working edge. They can form irregular shapes which conform with the work site. They can also extend at a level just above or below the main platform level.

3.23
multilevel work platform
two or more work platforms travelling on the same mast or an additional working level attached to and totally supported by a work platform

NOTE For illustration, see Annex B.

3.24
counter-roller
roller used to counteract the gear-meshing separation forces between a rack and pinion

3.25
automatic brake
device to decelerate and stop moving parts in case of interruption of the power supply

3.26
buffer
stop at the end of travel, comprising a resilient means of arrest using fluids, springs or similar means

3.27
overspeed
any speed above rated speed

3.28
overspeed detector
device which, when the work platform attains a predetermined speed above rated speed, causes the overspeed safety device to be applied

3.29
overspeed safety device
mechanical device for stopping and maintaining the work platform stationary on the mast in the event of overspeed

3.30
competent person
person having the practical and theoretical knowledge and the experience of a particular MCWP needed to carry out a function satisfactorily

3.31
user
user organization
person or organization having direct control over use of the MCWP

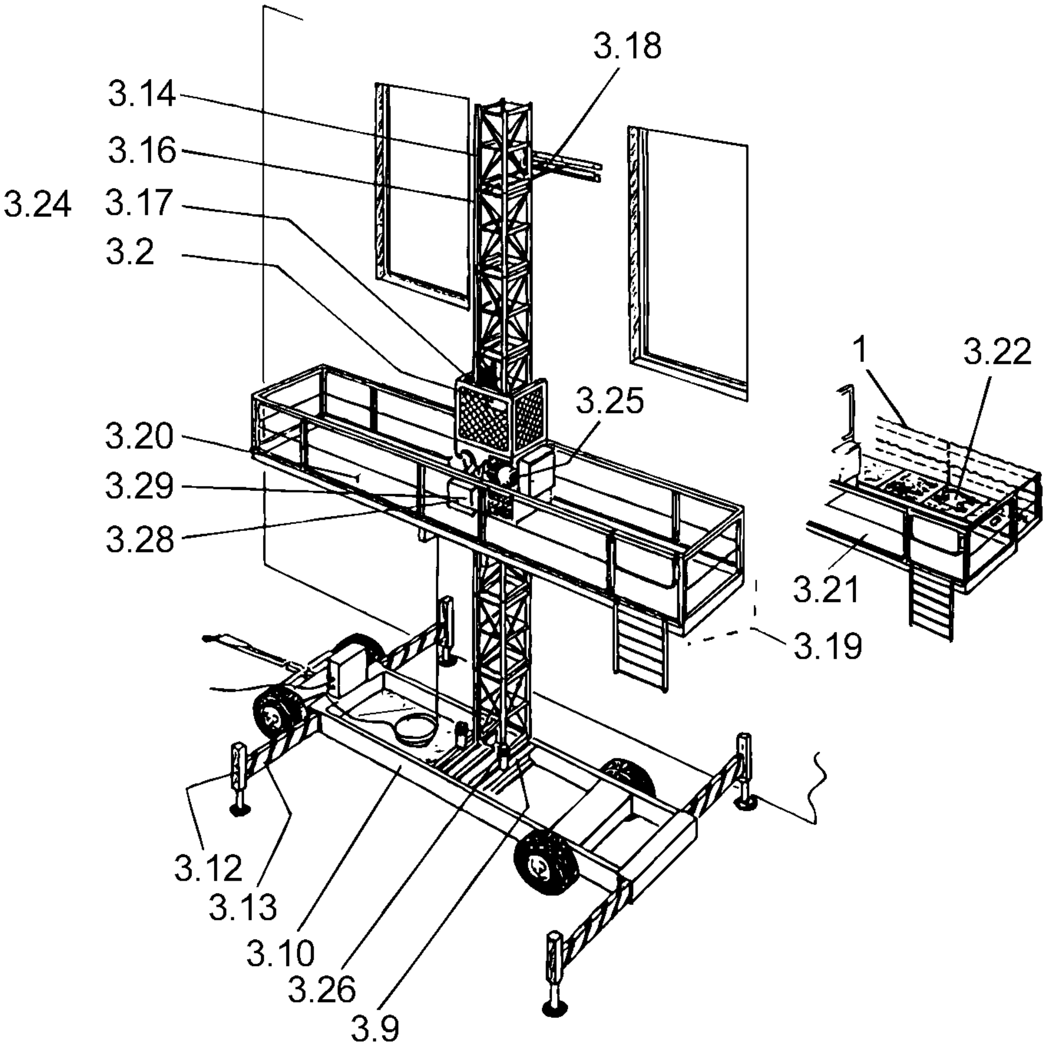
3.32
rack and pinion drive system
drive system using a gearing arrangement consisting of a cylindrical gear (pinion) which engages a linear gear (rack) attached to the mast

3.33
ratchet drive system
drive system that operates by attaching a ratcheting device to the rungs or other element of the mast in an alternating manner and elevates or lowers the platform a predefined distance

NOTE The platform can be supported by a pawl or similar device when the drive mechanism is not engaged.

3.34
screw drive system
drive system consisting of a mast-mounted rack which meshes with a powered drive screw attached to the platform

NOTE Rotation of the powered drive screw elevates or lowers the platform.

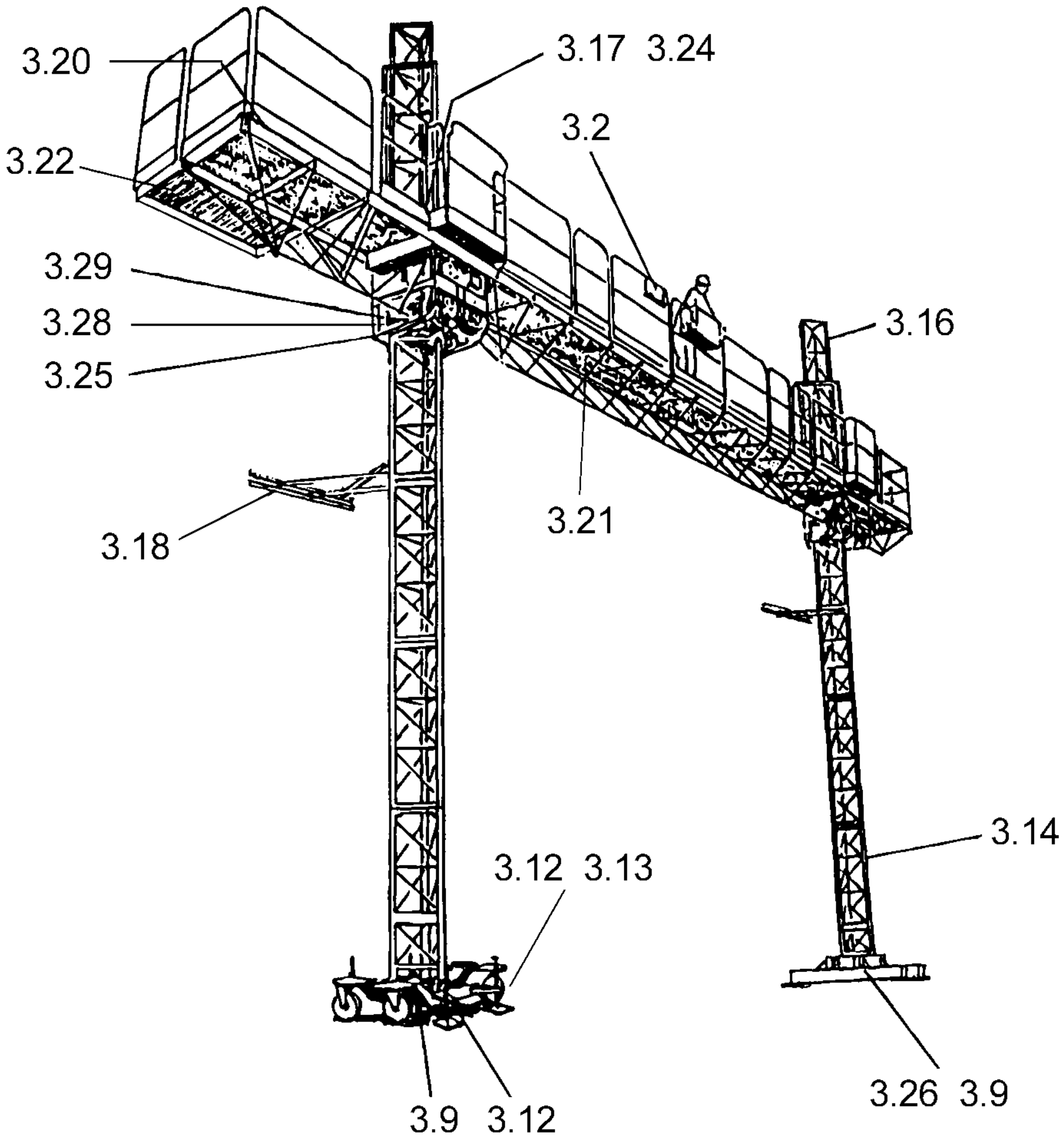


Key

1 removable handrails

NOTE Numbers correspond to terms and definitions given in Clause 3.

Figure 1 — Typical single-mast MCWP



NOTE Numbers correspond to terms and definitions given in Clause 3.

Figure 2 — Typical twin-mast MCWP

4 List of hazards

The list of hazards according to Table 1 is based on ISO 12100-1 and ISO 12100-2.

Table 1 lists the hazards which have been identified and where corresponding requirements have been formulated in this International Standard in order to limit the risk or reduce these hazards in each situation.

A hazard which is not applicable or is not significant and for which, therefore, no requirements are formulated in this International Standard, is shown in the relevant clauses column as NA (not applicable).

Table 1 — List of hazards

Hazard	Relevant clauses in this International Standard
1 Mechanical hazards	
1.1 Crushing	5.2.1.3; 5.3.2; 5.4.1
1.2 Shearing	5.2.1.3; 5.3.2; 5.4.1
1.3 Cutting or severing	5.3.2; 5.4.1
1.4 Entanglement	5.4.1
1.5 Drawing-in or trapping	5.2.1.3; 5.3.2; 5.4.1
1.6 Impact	5.4.6
1.7 Stabbing or puncture	NA
1.8 Friction or abrasion	NA
1.9 High-pressure fluid ejection	5.10.1.7; 5.10.1.8; 5.10.1.9; 5.10.1.10
1.10 Ejection of parts	5.2.1.4; 5.2.1.5
1.11 Loss of stability	5.1.5; 5.2.2.4; 5.2.2.5; 5.2.5
1.12 Slip, trip and fall	5.2.2.1; 5.3.1
2 Electrical hazards	
2.1 Electrical contact	5.8
2.2 Electrostatic phenomena	NA
2.3 Thermal radiation	NA
2.4 External influences	5.7.15, Annex B
3 Thermal hazards	
3.1 Burns and scalds from possible exposure of persons to flames or explosions and also to radiation from heat sources	5.9.1; 5.9.2; 5.9.3
3.2 Health-damaging effects of hot or cold work environment	5.9.2
4 Hazards generated by noise	Relevant but not dealt with
5 Hazards generated by vibration	5.1.2.3.2
6 Hazards generated by radiation	NA
7 Hazards generated by materials and substances processed, used or emitted by machinery	
7.1 Contact with or inhalation of harmful fluids, gases, mists, fumes and dusts	5.9.2; 5.10
7.2 Fire or explosion	5.9.3; 5.9.4
7.3 Biological and microbiological hazards	NA
8 Hazards generated by neglecting ergonomic principles in machine design	
8.1 Unhealthy postures or excessive effort	5.2.1.6; 5.2.5.2; 5.6.2; 5.13; 5.13.8
8.2 Inadequate consideration of human hand/arm or foot/leg anatomy	NA
8.3 Neglected use of personal protection equipment	5.13.8
8.4 Inadequate area lighting	7.1.2 f)
8.5 Mental overload or underload, stress	NA
8.6 Human error	5.2.2.1; 5.13

Table 1 (*continued*)

Hazard	Relevant clauses in this International Standard
9 Hazard combinations	5.1.1.1; 5.1.1.2; 5.1.3
10 Hazards caused by failure of energy supply, breakdown of machinery parts and other functional disorders	5.1
10.1 Failure of energy supply	5.2.2.1; 5.6; 5.8.1.2; 5.12.7
10.2 Unexpected ejection of machine parts or fluids	5.10.1.7; 5.10.1.8; 5.10.1.9; 5.10.1.10
10.3 Failure or malfunction of control system	5.2.1.5
10.4 Errors of fitting	5.1.5.1.5
10.5 Overturn, unexpected loss of machine stability	5.1.1.2; 5.1.5; 5.7
11 Hazards caused by missing and/or incorrectly positioned safety-related measures/means	
11.1 Guards	5.2.1.3; 5.3.2; 5.4.1; 5.9.1; 7.1.2 f); 7.1.2 i); 7.1.2 l); 7.2.2;
11.2 Safety-related (protection) devices	5.7
11.3 Starting and stopping devices	5.1.1; 5.12
11.4 Safety signs and signals	5.2.2.7; 7.2
11.5 Information or warning devices	7.2
11.6 Energy-supply disconnecting devices	5.2.1.2; 5.8.2.1
11.7 Emergency devices	5.5; 5.6
11.8 Means of feeding/removal of work pieces	NA
11.9 Essential equipment and accessories for safe adjustment and/or maintenance	5.2.3.1; 5.4.2.9; 5.4.3.1.2; 5.4.4.3.5
11.10 Equipment for evacuating gases	5.9.1; 5.9.2; 5.9.3
HAZARDS INVOLVING THE MOBILITY AND LOAD-LIFTING ABILITY OF MCWP	
12 Inadequate lighting of moving/working area	7.1.2 f)
13 Hazards due to sudden movement, instability, etc. during handling	5.1.5; 5.2.2.1; 5.2.2.3; 5.2.2.4; 5.4.5
14 Inadequate/non-ergonomic design of operating position	
14.1 Hazards due to dangerous environments (contact with moving parts, exhaust gases, etc.)	5.2.2; 5.9.1; 5.9.2
14.2 Inadequate visibility from operator's position	5.13.2; 5.13.5
14.3 Inadequate seat/seating	NA
14.4 Inadequate/non-ergonomic design/positioning of controls	5.13
14.5 Starting/moving of self-propelled machinery	5.13
14.6 Road traffic of self-propelled machinery	7.1.2 f)
14.7 Movement of pedestrian-controlled machinery	7.1.2 f)
15 Mechanical hazards	5.1.1.1
15.1 Hazards to persons exposed to uncontrolled movement	5.2.2.1; 5.2.4; 5.3.1.5; 5.4.1; 7.1.2 f)
15.2 Hazards due to break-up and/or ejection of parts	5.2.1.4; 5.2.1.5; 5.2.2.3
15.3 Hazards due to rolling over (ROPS)	5.1.5
15.4 Hazards due to falling objects (FOPS)	7.1.2 f)

Table 1 (*continued*)

Hazard	Relevant clauses in this International Standard
15.5 Inadequate means of access	5.3.3; 5.3.4
15.6 Hazards due to towing, coupling, connecting, transmission, etc.	5.2.2.6
15.7 Hazards due to batteries, fire, emissions, etc.	5.9.2; 5.9.3; 5.9.5
16 Hazards due to lifting operations	
16.1 Lack of stability	5.1.5; 5.1.1.2; 5.2.2.4; 5.2.2.5; 5.2.5.1
16.2 Derailment of machinery	5.2.2.4; 5.4.1.5; 5.4.2; 5.4.3; 5.4.4
16.3 Loss of mechanical strength of machinery and lifting accessories	5.1; 5.2.1.7; 5.2.1.8; 5.2.2.2; 5.2.2.3; 5.2.3.2; 5.2.3.3; 5.2.5.2; 5.2.5.3; 5.3.1.4; 5.4.2; 5.4.3; 5.4.4; 5.4.5; 5.4.6
16.4 Hazards caused by uncontrolled movement	5.2.2.5; 5.2.4; 5.4.1; 5.4.3.4; 5.4.3.5; 5.4.4; 5.12
17 Inadequate view of trajectories of the moving parts	5.13
18 Hazards caused by lightning	7.1.2
19 Hazards due to loading/overloading	5.7
HAZARDS INVOLVING THE LIFTING OF PERSONS BY MCWP	
20 Overloading or overcrowding of the carrier	5.1.2, 5.7, 5.11, see Annex C
21 Unexpected movement of the carrier in response to external controls or other movements of the machine	5.13.7
22 Excess speed	5.4.1; 5.5; 5.6.3
23 Persons falling from the carrier	5.3
24 Falling or overturning of the carrier	5.2.2.3; 5.4.1; 5.5; 5.11; 5.12
25 Excess acceleration or braking of the carrier	5.2.2.4; 5.4.5.1.2; 5.4.6
26 Hazards due to imprecise markings	5.2.2.7; 7.2

5 Safety requirements and/or measures

5.1 Structural and stability calculations

5.1.1 General

5.1.1.1 All loads and forces which can occur in any allowed configuration during erection, operation, out-of-service, dismantling and transfer shall be considered. This shall also include inclined or hanging masts.

5.1.1.2 The manufacturer shall be responsible for

— stability calculations, in order to identify the various configurations of the MCWP and the combinations of loads and deflections which together create conditions of instability;

— structural calculations, to evaluate the individual forces and to make allowance for deflections. All combinations of forces shall be considered, including those which produce the most unfavourable stresses in the components.

5.1.2 Loads and forces

The following loads and forces shall be taken into account.

5.1.2.1 Structural loads

The masses of the components of the MCWP when they are not moving are considered to be static structural loads.

The masses of the components of the MCWP when they are moving are considered to be dynamic structural loads.

5.1.2.2 Rated load

5.1.2.2.1 The rated load, m, expressed in kilograms, for design purposes is as given in Equation (1):

$$m = (n \cdot m_p) + m_{e+m} + (2m_e) \tag{1}$$

where

m_p = 80 kg; mass of each person;

m_e = 40 kg; mass of personal equipment (for the first two persons only);

m_{e+m} is the mass, in kilograms, of material and equipment on the work platform (excluding personal equipment);

n is the number of persons on the work platform.

The mass of persons and the mass of equipment and material shall act simultaneously.

The minimum number of persons shall be two (2) for single-mast platforms and four (4) for multiple-mast platforms.

The mass of the personal equipment, m_e, shall be assumed to act on the point coincident with each of the two persons who give the highest stresses.

5.1.2.2.2 The mass of each person is assumed to act as a point load on the MCWP at a horizontal distance 0,1 m from the upper inside edge of the top guardrail. The distance between the point loads shall be 0,5 m (see the example in Figure 3).

5.1.2.2.3 The mass T shall be evenly distributed over the entire area of the main platform, giving a specific load per length t.

The centre of gravity of the mass T shall be assumed to act on a point 0,15 B (where B is the width of the main platform) away from the longitudinal centreline of the main platform, on the side giving the highest stresses. See Figure 4.

Calculations shall allow for the possibility that a reduced load giving an unbalanced load case may result in higher stresses in some parts of the MCWP than a balanced rated load case would give.

For single-mast machines, the bending moment, M, on masts and platforms shall be calculated according to the equation in Figure 5, where L_{max} is the greater of the distances L_1 and L_2 in Figure 5.

For multiple-mast machines, the bending moment, M, on masts and platforms shall be calculated according to the equations in Figure 6. The factors 1,15 and 1,2 are used in the equations in Figures 5 and 6 in order to cover the situations in use where, instead of a uniformly distributed load, a concentration of the same load is placed elsewhere within that individual length.

Dimensions in metres

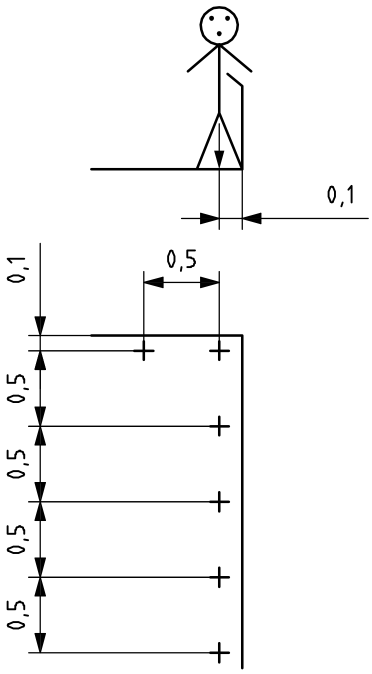
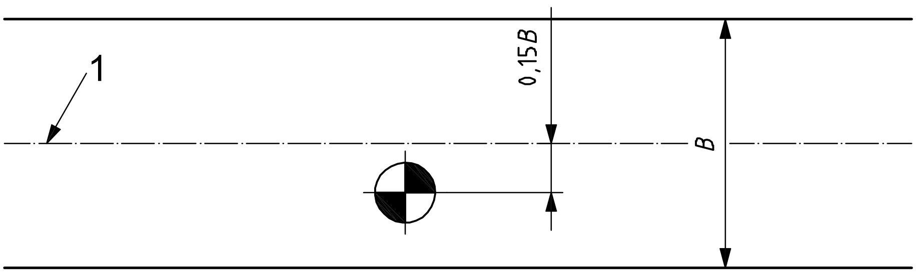


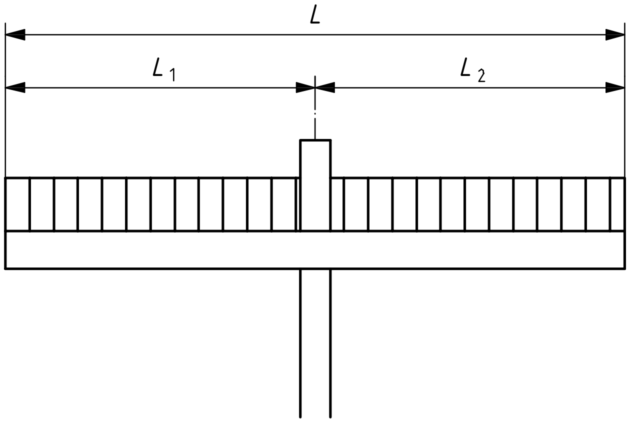
Figure 3 — Example of the distribution of persons on the main platform or platform extensions



Key

1 centreline of main platform excluding any extension

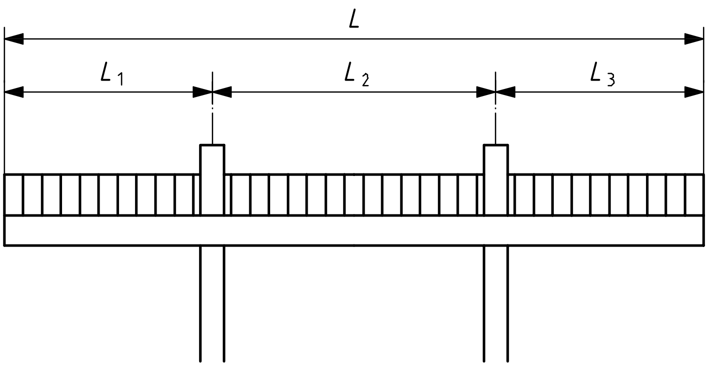
Figure 4 — Eccentric loading normal to the centreline



$$M_{max} = \frac{t \times L_{max}^2 \times 1,15}{2}$$

Specific load $t = \frac{T}{L}$

Figure 5 — Loading in the longitudinal direction for single-mast machines



Equations:

$$M_1 = \frac{t \times L_1^2 \times 1,15}{2}$$

$$M_3 = \frac{t \times L_3^2 \times 1,15}{2}$$

$$M_2 = \frac{t \times L_2^2 \times 1,2}{8}$$

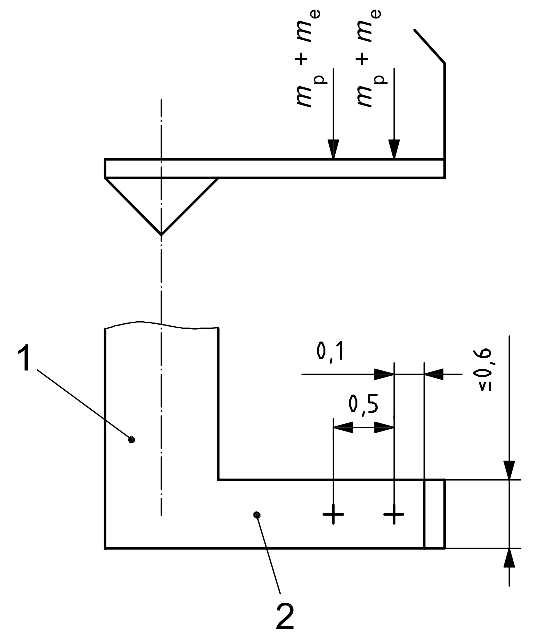
Specific load $t = \frac{T}{L}$

Figure 6 — Loading in the longitudinal direction for multiple-mast machines

5.1.2.2.4 If the area of the main platform, or part of it, is increased by means of extensions, usually to the longitudinal edge of the platform, the mass of the number of persons allowed on the platform, according to 5.1.2.2.1, shall be assumed to act on these longitudinal edges according to 5.1.2.2 2.

5.1.2.2.5 In order to provide long cantilever extensions of restricted width to reach more distant work points, an exception to 5.1.2.2.4 may be made, but shall be clearly explained on a sign easily visible on that particular extension to the main platform. In no such case shall the load on the extension be calculated for less than two persons, m_p, carrying their personal equipment, m_e. In order to restrict the available platform extension area, such extensions shall not be more than 0,6 m wide. See Figure 7.

Dimensions in metres



Key

1 main platform

2 platform extension

Figure 7 — Long cantilever extensions

5.1.2.2.6 Where the manufacturer includes in his design provision for the use of a handling crane, then the mass of the crane and the crane's rated load shall together be treated as part of the rated load of the MCWP. The location of the force resulting from the use of the crane shall be dictated by the manufacturer's chosen mounting positions for the crane supports.

5.1.2.3 Horizontal forces

5.1.2.3.1 Manual forces

The minimum value for the manual force is assumed to be 200 N for each of the first two persons on the platform and 100 N for each additional person permitted on the work platform.

It is assumed that the force is applied at a height of 1,1 m above the floor of the work platform and acts in a horizontal direction.

5.1.2.3.2 Forces from the use of power tools

Where the manufacturer of the MCWP permits the use of power tools which impose horizontal reaction forces on the work platform which are in excess of those given in 5.1.2.3.1, then the manufacturer shall specify the maximum force permitted. Application of the force shall be assumed at a minimum height of 1,1 m above the floor of the work platform.

Such forces may be caused by the use of, for example:

— water-jetting equipment;

— sand- or grit-blasting equipment;

— mechanically assisted drilling machine;

— hammer-assisted drill;

— electrically driven hammer/breaker.

5.1.2.3.3 Forces from the use of weather-protection screens on the work platform

If the work platform is designed to permit the use of weather protection in the form of a roof over part of, or the whole of, the platform, then the resulting wind forces shall be considered to act on walls which reach the full height, from the work platform floor to the top of the roof. Wind forces shall be calculated according to 5.1.2.5 and 5.1.2.8. For platform regions protected by such weather screens, the wind forces on persons, equipment and material coming under the protection of these weather screens may be neglected.

The mass of the weather-protection screens shall be treated as part of the rated load.

5.1.2.4 Dynamic forces

Dynamic forces shall be taken into account by multiplying all moving masses by a dynamic factor of 1,15.

The term "moving" includes raising and lowering of the work platform and also transfer of the MCWP in its transfer condition.

5.1.2.5 In-service wind loads

5.1.2.5.1 All MCWP used out-of-doors or otherwise exposed to wind whilst in service shall be regarded as being affected by a minimum wind pressure in accordance with Table 2.

Table 2 — Minimum design in-service wind data

Installation	Wind velocity m/s	Wind pressure N/m^2
Free-standing or MCWP during erection and dismantling	12,7	100
Tied MCWP	15,5	150

5.1.2.5.2 Wind forces are assumed to act horizontally at the centre of the windward area of the exposed structural parts of the MCWP.

5.1.2.5.3 The wind force coefficients applied to areas exposed to the wind shall be in accordance with ISO 4302. The wind force coefficient for persons exposed to the wind is 1,0.

5.1.2.5.4 The full area of one person is 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.

5.1.2.5.5 The exposed area of one person standing on a work platform behind an imperforate section of fencing 1,1 m high is 0,35 m^2, with the centre of area 1,45 m above the work platform floor.

5.1.2.5.6 The number of persons directly exposed to the wind is calculated as

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

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

5.1.2.5.7 If the number of persons permitted on the work platform is greater than calculated in 5.1.2.5.6 a), a reducing coefficient of 0,6 may be applied to the extra number of persons.

5.1.2.5.8 The wind force on exposed equipment and material on the work platform is calculated as 3 % of the mass, T, acting horizontally at a height of 1,0 m above the work platform floor.

5.1.2.6 Loads and forces occurring during transfer conditions

Inertia forces plus any load permitted by the manufacturer on the work platform shall be taken into account when the MCWP is subject to transfer conditions.

5.1.2.7 Erection and dismantling loads

The load for which the MCWP has been designed during erection and dismantling shall be recorded. Erection load may be higher than rated load.

If a handling crane, as described in 5.1.2.2.6, is used during erection and dismantling of the MCWP, then the crane's mass and the rated load shall together be treated as part of the erection load.

5.1.2.8 Out-of-service wind loads

The wind pressure used for the calculations for out-of-service condition, with the work platform in a safe position, shall be in accordance with Table 3.

The limiting wind pressure shall be considered in the most unfavourable direction.

Table 3 — Design out-of-service wind pressures

Height of member above ground level m	Wind velocity m/s	Wind pressure N/m^2
0 to 20	35,8	800
over 20 to 100	42	1 100
over 100	45,9	1 300
The values given for wind velocity and wind pressure are minimum values. Information set out in specific national standards shall be used, particularly in special locations.		

5.1.2.9 Buffer forces

Buffer forces shall be calculated taking into account the characteristics of the buffer according to 5.4.6. Where buffers are not used, deceleration or impact forces shall be taken into account.

5.1.2.10 Action of the safety means according to 5.5

To determine the forces produced by an operation of these means, the sum total of all travelling masses shall be multiplied by a factor of 2. A lower factor, but not less than 1,2, may be used if it can be verified by test under all conditions of loading up to 1,5 times the rated load.

5.1.2.11 Inaccuracies in setting-up

For the purposes of calculation, an allowance of an additional 0,5° shall be made to allow for user inaccuracy when erecting the mast.

5.1.3 Load combinations and safety factors

The load combinations to be taken into consideration shall be as follows:

- load combination A1: MCWP in service without wind, static;
- load combination A2: MCWP in service without wind, dynamic;
- load combination B1: MCWP in service with wind, static;
- load combination B2: MCWP in service with wind, dynamic;
- load combination B3: MCWP during erection or dismantling;
- load combination B4: MCWP during transfer condition;
- load combination C1: MCWP striking the buffer whilst in service;
- load combination C2: MCWP during action of the safety means whilst in service;
- load combination C3: MCWP out of service.

The above load-combination references (A1, A2, B1, B2, etc.) are used in Annex A as load case A, load case B and load case C as appropriate.

In each load combination, the loads and forces acting on the MCWP shall be in accordance with Table 4. Safety factors for structural steels and aluminium alloys are given in Table 5 and Table 6 respectively.

Table 4 — Load combinations that shall be taken into consideration

Loads	Ref. subclause	Load combination								
		A1	A2	B1	B2	B3	B4	C1	C2	C3
Structural loads	5.1.2.1	X	X	X	X	X	X	X	X	X
Rated load	5.1.2.2	X	X	X	X			X	X	
Horizontal forces	5.1.2.3	X		X						
Dynamic forces	5.1.2.4		X		X	X	X			
In-service wind loads	5.1.2.5			X	X	X	X			
Loads and forces during transfer	5.1.2.6					X	X			
Erection and dismantling loads	5.1.2.7					X				
Out-of-service wind loads	5.1.2.8									X
Buffer forces	5.1.2.9							X		
Action of safety means	5.1.2.10								X	
Inaccuracies in set-up	5.1.2.11	X	X	X	X	X	X			

Table 5 — Safety factors for structural steels

Load case	Safety factor
A1, A2	1,5
B1, B2, B3, B4	1,33
C1, C2, C3	1,25

Table 6 — Safety factors for structural aluminium alloys

Load case	Safety factor
A1, A2	1,7
B1, B2, B3, B4	1,55
C1, C2, C3	1,4

5.1.4 Structural calculations

See Annex A.

5.1.5 Stability calculations

5.1.5.1 Calculation of forces

5.1.5.1.1 Forces causing overturning moments shall, when created by structural masses, be multiplied by a factor of 1,1 and when created by rated loads be multiplied by a factor of 1,2. It shall be remembered here that an inclination of the mast from the vertical will result in an increasing overturning moment as the work platform travels upwards.

All forces causing stabilizing moments shall be multiplied by a factor of 1,0.

5.1.5.1.2 Wind forces shall be multiplied by a factor of 1,2 and assumed to be acting horizontally.

5.1.5.1.3 Horizontal forces as detailed in 5.1.2.3 shall be multiplied by a factor of 1,2 and assumed to be acting in the direction creating the greatest overturning moment.

5.1.5.1.4 Forces in accordance with 5.1.2.6 shall be treated in the same way as specified in 5.1.5.1.1, 5.1.5.1.2 and 5.1.5.1.3 as appropriate.

5.1.5.1.5 Inaccuracies in setting-up in accordance with 5.1.2.11 shall be taken into account in the stability calculation.

5.1.5.2 Calculation of overturning and stabilizing moments

The maximum overturning and corresponding stabilizing moments shall be calculated about the most unfavourable tipping lines.

The calculations shall be made with the MCWP in the most unfavourable configurations, with the maximum allowable inclination of the chassis defined by the manufacturer. Every load and force combination, including inaccuracy in setting-up, shall be taken into account in their most unfavourable combinations.

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

5.2 General requirements for machine, base frame, chassis and mast

5.2.1 General machine requirements

5.2.1.1 The MCWP and all parts belonging to it shall be calculated in accordance with 5.1.

5.2.1.2 MCWP shall be equipped with a permanently installed device on the work platform to switch off the work platform and secure it against unauthorized use whilst out of service.

Similar devices shall be permanently installed at the chassis of self-propelled MCWP which isolates all movements of the MCWP.

Such devices shall be secured by a padlock or similar device.

5.2.1.3 Trapping and shearing points between the chassis and work platform shall be avoided by providing safe clearances or adequate guarding in accordance with ISO 13854 and EN 953.

If safe clearance or adequate guarding is not possible, then an acoustic warning device, which at least gives a continuous warning when the work platform is moving within 2,5 m of the chassis, shall be fitted to the work platform.

Trapping, crushing and shearing points need only be considered at those areas within reach of persons on the work platform or standing adjacent to the MCWP at ground level, or at other points of access.

5.2.1.4 Locking pins shall be designed to be mechanically secured against unintentional disengagement and loss, e.g. by means of a split-pin locking nut, whilst in position. In addition, they shall be provided with means to secure against unintentional loss when out of use, e.g. by means of a captive chain.

5.2.1.5 Where compression springs are used for a safety function, they shall be guided with secured ends. Their design shall be such that if they break then the parts cannot coil into each other.

5.2.1.6 The design of all components that have to be handled during erection, e.g. mast sections, platform components, erection cranes, shall have their masses assessed against manual handling. Where the permissible mass for normal handling is exceeded, the manufacturer shall give recommendations in the instruction handbook concerning suitable lifting equipment.

5.2.1.7 Where components are erected by means of lifting equipment, provision shall be made for adequate attachment of the lifting equipment. This shall ensure that the component is securely attached and lifted in the correct attitude for assembly.

5.2.1.8 Any dedicated lifting equipment shall be designed in accordance with ISO 8686-1 and ISO 4301-1 and shall not impose loads on the MCWP structure for which the MCWP was not designed.

5.2.2 Base frame and chassis

5.2.2.1 General

If chains or belts are used in drive systems, inadvertent movements of the chassis shall be automatically prevented if failure of a chain or belt occurs.

If powered and manual drive systems are provided for the same movement, interlocks shall prevent both systems from being engaged at the same time.

After failure of the power supply, no inadvertent movement shall occur.

Walkways on the base frame or chassis shall be equipped with a slip-resistant surface.

5.2.2.2 Base frame

The base frame shall be equipped with fixings for safe and secure attachment of other parts of the construction, such as mast and outriggers.

5.2.2.3 Chassis

The chassis shall be equipped with fixings for safe and secure attachment of other parts of the construction, such as mast and outriggers.

Means shall be provided to ensure, or at least to give proper warning, that the MCWP is in the proper transfer (or transport) condition.

If the platform must be locked at a position on the chassis during transport, then transport interlocks shall be provided.

Means shall be provided to prevent instability of the MCWP due to failure of any tyre of the chassis, for example by the provision of foam-filled tyres or by giving instructions in the user manual regarding use of outriggers.

5.2.2.4 Drive to wheels (excluding road transport)

The chassis shall be capable of being stopped and held stationary with a braking device under all ground conditions and also the worst combination of horizontal speed and maximum gradient specified by the manufacturer. The brakes shall only be released and kept released by an intended action. Under all other conditions, the brake shall apply automatically. After being applied, the means of braking shall not depend on an exhaustible energy source.

Acceleration and retardation shall be within the manufacturer's stability criteria. It shall be possible to disengage the drive to the wheels before towing the MCWP.

For rail-mounted chassis, means shall be provided to stop the machine safely at the limits of travel.

If axles are detachable, the chassis shall be equipped with fixings for safe and secure attachment of the axles when they are in use.

5.2.2.5 Outriggers

Outriggers shall be capable of carrying all loads permitted by the manufacturer. Maximum allowable inclination and operation on the maximum gradient permitted by the manufacturer shall also be considered.

The feet of the outriggers shall be designed to swivel in all directions by an amount equal to the maximum gradient specified by the manufacturer plus at least 10°.

A notice on the outriggers shall refer the user to the instruction handbook for information on the applied ground pressure resulting from the outrigger feet.

Movement of the outrigger beams shall be limited by mechanical stops. It shall also be possible to lock them, at least in their extreme positions.

The outriggers shall be designed and manufactured so that unintentional movement is prevented.

Any hydraulic outrigger shall be equipped with a load-holding valve, mounted directly to the cylinder. This valve, e.g. a pilot-operated check valve or brake valve, shall prevent unintended flow of oil to or from the cylinder, even in case of pipe or hose rupture. The closing of this valve shall not cause a dangerous situation.

Power-operated outriggers shall be fitted with a device to prevent power-operated movement of the outriggers unless the work platform is in its intended position.

Outriggers relying on a permanent pneumatic pressure to provide support during use of the platform shall not be used.

Where central supports are provided directly beneath the masts, these shall also comply with the relevant requirements of this clause.

5.2.2.6 Towbar

If towbars, when not in use, are left in a raised position, an automatic device shall be provided to hold the towbar in this position. Unintentional release shall not be possible.

Towbar and steering mechanisms shall be designed to prevent handling hazards to the user.

5.2.2.7 Warning marks

Outriggers, outrigger beams and other parts of the base frame or chassis protruding from the main outline of the platform shall be marked with warning colours.

5.2.3 Mast structure

5.2.3.1 General

Structural components of the mast required for the drive system for elevation (e.g. rack, drive tracks, rungs) shall be visible for detailed examination without dismantling.

5.2.3.2 Racks and similar devices

The racks and similar devices shall be securely attached to the mast. Joints between adjacent sections of the rack shall be accurately aligned to avoid faulty meshing or damage to teeth or similar components.

5.2.3.3 Tie attachment points

If the MCWP is to be tied into a separate supporting structure, the mast sections shall be designed to accommodate the attachment of ties at appropriate intervals. Attachment points shall be designed in accordance with 5.1.

5.2.3.4 Marking

All mast sections shall be marked with an individual identification or serial number, enabling the date of manufacture to be determined.

5.2.4 Mast design with regard to erection

Effective means shall be provided to ensure, so far as practicable, that only correctly interchangeable mast sections can be connected together.

The design of the mast shall ensure effective load transfer between adjacent mast sections, and that alignment is maintained.

Where the vertical members of the mast sections are used as guides for drive frame guide rollers, the joints of adjacent sections shall provide a continuous path.

MCWP with masts which are tilted to the working position for use shall be equipped with a device to ensure that the mast is mechanically locked in the working position automatically. It shall not be possible to raise the work platform unless this lock is engaged.

5.2.5 Mast ties

5.2.5.1 General

The mast requires lateral restraint from an adjoining separate supporting structure when erected above the manufacturer's specified maximum free-standing height. This restraint will normally be in the form of mast ties attached at intervals between the mast and the supporting structure.

5.2.5.2 Design

Mast ties shall be designed for manual handling and ease of assembly using hand tools, and shall provide a degree of adjustment to accommodate tolerances between the mast and the supporting structure. They shall provide sufficient torsional rigidity to the mast.

5.2.5.3 Attachment to the supporting structure

The attachment of the mast ties to the supporting structure shall be designed to resist all forces generated, both in and out of service.

Sufficient information shall be provided in the instruction handbook to enable the forces applied to the supporting structure to be calculated.

5.3 Work platform

5.3.1 General

5.3.1.1 The work platform shall remain horizontal, ± 2°, during normal movements of the platform and under the application of the rated load and other forces exerted during normal operation. During operation of the means described in 5.5 and the emergency lowering/raising device in 5.6, the maximum permitted variation from horizontal shall be ± 5°.

5.3.1.2 Trapdoors in the work platform shall be securely fastened and shall not open downwards.

5.3.1.3 The floor material shall be slip-resistant. The floor shall be easy to clean and shall be 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. The floor material shall be securely fixed to the work platform. Any extensions shall be prepared for fixing of the floor material.

5.3.1.4 The work platform floor shall be designed to withstand without permanent deformation a static load of at least 200 kg exerted on the least favourable area of 0,1 m × 0,1 m.

5.3.1.5 Any extensions of the main platform shall be able to be secured to prevent their inadvertent movement.

There shall be a clear indication of the maximum permitted extended position. The platform extension shall be designed to prevent extension beyond this maximum permitted position.

5.3.1.6 Platform extensions shall not be more than 0,5 m above or below the level of the main platform.

5.3.2 Guarding

5.3.2.1 All sides of the main platform and any platform extension shall be designed to be equipped with a guardrail which can be securely fastened in position.

5.3.2.2 Except for the cases given in 5.3.2.4, the guardrails shall be at least 1,1 m high and the toeboards 0,15 m high, with intermediate guardrails not further than 0,5 m from the top guardrail or from the toeboards.

5.3.2.3 The guardrails shall be constructed to withstand concentrated forces of 300 N for each person permitted on the platform, applied in the outwards horizontal direction at 0,5 m intervals.

The top of each guardrail shall also be constructed to withstand a single vertical load of 100 kg applied in the least favourable position but not simultaneously with the horizontal load.

5.3.2.4 If the platform is erected towards a wall and the distance is more than 0,3 m but not more than 0,5 m, a guardrail of minimum 0,7 m height (without intermediate rail but with toeboard) shall be provided to prevent persons from falling between the wall and the platform. If the distance is more than 0,5 m, a normal guardrail of 1,1 m height in accordance with 5.3.2.2 shall be provided.

When it is possible to have a horizontal distance between the wall and platform of not more than 0,3 m, then a guardrail is not necessary. See 7.1.2 l).

5.3.2.5 Chains or ropes shall not be used as guardrails.

5.3.2.6 If the movement or speed of the main platform and any extensions exceed 0,06 m/s, or the clearance between the platform and the mast is less than 150 mm, guarding shall be installed to a height of at least 2,0 m to prevent access to the mast.

A toeboard 150 mm in height shall be provided at the edge of the platform at the mast.

Apertures shall comply with ISO 13852.

5.3.2.7 If extensions of the work platform are positioned between the mast and the building, then means shall be provided to prevent travel of the work platform with the extension in place.

5.3.2.8 Where the platform extension is not flush with the main platform, the unprotected opening between the two levels shall be guarded at least with a toeboard of 0,15 m height located on the lower level.

5.3.3 Access

5.3.3.1 At least one access gate shall be provided and it shall not open outwards. All access gates shall be constructed so as to either close automatically or be electrically interlocked, in order to prevent operation of the work platform unless they are closed. Inadvertent opening of the access gate shall not be possible. Chains or ropes shall not be used as access gates.

5.3.3.2 When the distance between the access level and the floor of the work platform in the access position exceeds 0,5 m, the MCWP shall be equipped with an access ladder or stairs symmetrical with the access gate. The steps or rungs shall be divided equally over the distance between the access level and the floor of the work platform, and in no case shall the step rise be more than 0,3 m.

The front of the steps or rungs shall be located to give at least 0,15 m toe clearance.

5.3.3.3 Handholds, handrails or similar adequate devices shall be provided to facilitate climbing the access ladder to the work platform.

5.3.4 Multilevel work platforms

For multilevel work platforms, the special requirements given in Annex B for options A and B shall be taken into account. In addition the following shall apply.

a) All additional components that are used with multilevel MCWP shall be calculated in accordance with 5.1.

b) All additional forces imposed upon the main platform and the mast structure shall be calculated according to 5.1.

c) Guarding shall be in accordance with 5.3.2.

d) Roof protection shall be arranged for the lowest platform in option B to protect persons from falling objects. The roof construction for the lowest platform shall

   — be designed to withstand a load of 100 kg distributed on any area 0,1 m × 0,1 m, and

   — be designed so as to prevent the passage of a sphere of 15 mm diameter.

e) In option A the two work platforms shall not be separated by more than 3 m between platform floor levels. If the area under the upper platform is a working area, the clearance between the platforms shall be at least 1,5 m.

   The separation distance between work platforms in option B shall be controlled by safety contact switches. This distance shall not be less than 2,5 m in normal operation taking into account levelling inaccuracies.

f) Ladders for option A shall comply with 5.3.3. Fixed access between the two work platforms shall be provided within the platform guarded area. Trapdoors shall comply with 5.3.1.2.

   For option B, direct access between work platforms shall not be provided.

g) For option A, with multiple mast applications, platform levelling shall be in accordance with 5.3.1.1. The design shall ensure that clearance remains between the subsidiary work platform and the mast over the full levelling range.

h) Controls shall be in accordance with 5.13.

i) Buffers shall be in accordance with 5.4.6. For option A where the subsidiary work platform is located below the primary work platform, the height of the buffer shall be increased in order to act on the primary work platform.

j) For option A, travel limit switches shall be in accordance with 5.12, taking into account the position of the subsidiary work platform.

   For option B, separate travel limit switches shall be provided for each work platform, all in accordance with 5.12, making allowance for the separation distance required in 5.3.4 e).

5.4 Drive systems for elevation

5.4.1 General

5.4.1.1 The maximum rated speed when raising and lowering the platform shall be no more than 0,2 m/s.

5.4.1.2 Fixed guarding shall be provided to prevent the entry of any material that might cause damage to any part of the drive system and to protect persons from injury.

5.4.1.3 Chains or belts shall only be used in drive mechanisms in conjunction with an electrical safety device which stops the work platform and keeps it stopped as soon as failure of a chain or belt occurs.

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

5.4.1.5 Measures shall be taken to prevent the uppermost guide rollers or shoes running off the top of the guides during normal operation. Further measures shall be taken to ensure that under no circumstances, including erection and dismantling, can any safety device pinion come out of mesh with the rack or any mechanical safety device designed to prevent uncontrolled descent become inoperative.

5.4.1.6 Measures shall be taken to ensure the continued stability of the work platform in the case of failure of any guide roller or shoe.

5.4.1.7 Any hydraulic drive shall conform to EN 982 and to the applicable requirements in 5.10.

5.4.1.8 When more than one drive unit is used on the same mast, it shall be permissible to share the design loads between the drive units only if a self-adjusting measure is provided to ensure load-sharing under all normal running conditions.

5.4.2 Rack and pinion drive system

This subclause applies to a MCWP elevated by a power-operated rack and pinion drive system.

5.4.2.1 Means shall be provided to maintain the rack and the driving or any safety gear pinion constantly in mesh under all conditions of load. Such means shall not rely upon the platform guide rollers. The devices used shall restrict movement of the pinion on its axis such that at least two-thirds of the tooth is always in engagement with the rack.

5.4.2.2 In addition it shall not be possible for the pinion to move out of its correct engagement with the rack by more than one-third of the tooth height, even in the event of failure of a counter-roller or other mesh-control feature or local bending or deflection of the mast.

5.4.2.3 The rack-and-pinion tooth module shall not be less than

— four (4) for drive systems in which the counter-roller or other mesh-control feature reacts directly on the rack without the interposition of any other mast profiles, and

— six (6) for drive systems in which the reaction of the counter-roller or other mesh-control feature is by means of another element of the mast, which is then in immediate contact with the rack.

5.4.2.4 Any safety gear pinion shall be situated lower than the drive pinions.

5.4.2.5 The drive pinion shall be designed in accordance with ISO 6336-1, ISO 6336-2, ISO 6336-3 and ISO 6336-5 regarding tooth strength, for a minimum of 10^8 load cycles. The pinion shall be so dimensioned that, based on ISO 6336-5, there shall exist a minimum safety factor of 1,5 for tooth strength taking into account the actual stress induced in the teeth under the total suspended static load per pinion.

5.4.2.6 The rack shall be made from material having properties matching those of the pinion in terms of wear and shall be designed according to ISO 6336-1, ISO 6336-2, ISO 6336-3 and ISO 6336-5 regarding tooth strength, for a minimum of 10^4 load cycles representing static strength.

The rack shall be so dimensioned that, based on ISO 6336-5, there shall exist a minimum safety factor of 1,5 for tooth-strength for the actual stress induced in the teeth.

5.4.2.7 When more than one drive pinion is meshing with the rack, it shall be permissible to share the design loads between the pinions only if a self-adjusting measure is provided to guarantee load-sharing under all normal running conditions.

5.4.2.8 A pinion shall never be used as a guide roller.

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

5.4.3 Ratchet drive systems

This subclause applies to a MCWP elevated by a power-operated ratchet drive system.

5.4.3.1 General requirements

5.4.3.1.1 The maximum rated speed when raising and lowering the platform shall be no more than 0,06 m/s.

5.4.3.1.2 Means shall be provided to ensure the proper engagement of the drive system or any safety device on the rungs or other elements of the mast. Such means shall not rely on the platform guide rollers.

5.4.3.1.3 Visual examination of the drive mechanism shall be possible without major disassembly.

5.4.3.1.4 A drive mechanism shall never be used as a guide roller.

5.4.3.2 Design requirements

5.4.3.2.1 The drive system shall always have at least one contact point fully engaged with the mast.

5.4.3.2.2 The drive system shall be designed in accordance with 5.1.

5.4.3.2.3 The ratchet drive mechanism shall be designed in accordance with generally accepted engineering principles using a minimum fatigue safety factor of 1,5, taking to account the actual stress induced under the total suspended static load. The fatigue load cycles shall be 10^6 for the dynamic component of the drive mechanism.

5.4.3.2.4 When more than one drive unit is used on the same mast, it shall be permissible to share the design loads between the drive units only if a self-adjusting measure is provided to ensure load-sharing under all normal running conditions.

5.4.3.3 Safety devices for ratchet drive systems

5.4.3.3.1 The MCWP shall be provided with a safety device that meets the applicable requirements of 5.5, and that will prevent the platform from free falling in the event of a failure of the drive system.

5.4.3.3.2 The safety device shall be situated lower than the drive system.

5.4.3.3.3 The components of the mast supporting the safety device shall have a safety factor of 2,5 based on the ultimate strength of the material and the highest force that can occur at the rated load and maximum possible speed.

5.4.3.4 Lower travel limit switches

Ratchet drive systems need not be provided with lower travel limit switches if the drive unit cannot induce uplift forces into the mast or base. The base may act as the buffer if the requirements of 5.4.6.2 are met.

5.4.3.5 Upper travel limit switches

Upper travel limit switches are not required where the ratchet drive system cannot disengage the guide rollers with the mast, and the upper guide roller of the platform cannot disengage the guide rollers with the mast.

5.4.4 Screw drive systems

This subclause applies to an MCWP elevated by a power-operated screw drive system.

5.4.4.1 General

The screw drive components shall be designed using a fatigue safety factor of 1,5, taking into account the actual stress induced under the total suspended static load. The fatigue load cycles shall be 10^4 for the rack component and 10^8 for the dynamic components of the drive mechanism.

5.4.4.2 Rack

The rack or similar support device shall be securely attached to the mast.

Adjacent sections of the racks on the adjacent mast sections shall be accurately aligned, to avoid faulty meshing or damage to the drive system.

5.4.4.3 Screw drive unit

5.4.4.3.1 Means shall be provided to maintain the rack and any screw drive unit constantly in mesh under all conditions of load. The guide rollers used shall restrict movement of the screw system on its axis, such that there is adequate engagement with the rack and screw drive unit to ensure its safe operation.

5.4.4.3.2 It shall not be possible for the screw drive to move out of its correct engagement with the rack by more than one-third of the contact surface, even in the event of failure of a counter-roller or local bending or deflection of the mast.

5.4.4.3.3 When more than one drive screw is meshing with the rack, it shall be permissible to share the design loads between the drive screws only if a self-adjusting measure is provided to guarantee load-sharing under all normal running conditions.

5.4.4.3.4 The safety device shall be situated lower than the drive system.

5.4.4.3.5 Visual examination of the drive screw shall be possible without removal of the drive screw or major disassembly of structural components of the MCWP.

5.4.4.4 Lower travel limit switches

Lower terminal stopping and lower final limit switches need not be provided if all of the following conditions are met:

a) the maximum speed of descent does not exceed 0,2 m/s under all circumstances, including operation of the safety system (5.5.1.1);

b) buffers are provided which have no moving parts and are designed for repeated use without wear;

c) the buffer is designed according to 5.4.6, taking into account the possibility that the platform may be driven into the buffer;

d) the drive system is designed with a load-limiting device that limits the strain on the drive in the event the platform can be driven into the buffer, and the drive system is designed taking into consideration the resulting forces.

5.4.4.5 Upper travel limit switches

Screw drive systems are not required to be provided with upper terminal stopping or upper final limit switches all of the following conditions are met:

a) the MCWP is designed so that the uppermost guide rollers or shoes cannot run off the top of the guides during normal operation;

b) the work platform cannot be driven off the top of the mast under any circumstances;

c) the platform remains stable in the horizontal position according to 5.3.1.1 under all conditions, including erection and maximum unbalanced platform loading.

5.4.5 Braking system

5.4.5.1 General requirements

5.4.5.1.1 Every work platform shall be provided with a brake system which operates automatically

a) in the event of loss of the main power supply, or

b) in the event of loss of the supply to control circuits.

If two or more masts are used, there shall be a braking ability for each mast.

Belts or chains for coupling a drive pinion to the component on which the brake operates are not permitted.

5.4.5.1.2 The braking system on its own shall be capable of stopping the platform travelling at rated speed and with 1,25 times the rated load with a retardation between 0,2 g and 1,0 g. In addition, the braking system on its own shall be capable of stopping the machine when travelling at the triggering speed of the overspeed detector with the rated load.

5.4.5.1.3 In the case of only one brake, all the mechanical components of the brake which take part in the application of the braking action on the drum or disc or the drive pinion shall be constructed and installed in such a way that if a failure in one of them occurs, sufficient braking shall remain to bring the work platform with rated load to a stop.

5.4.5.1.4 The components on which the brake operates shall be positively coupled to a sprocket, drive pinion or similar device.

5.4.5.1.5 Any machine fitted with an emergency lowering or raising device according to 5.6 shall be capable of having the brake released manually and shall require a constant effort to keep the brake open.

5.4.5.1.6 The action of the brake shall be exerted by compression springs. The springs shall be adequately supported and shall not be stressed in excess of 80 % of the torsional elastic limit of the material.

5.4.5.1.7 Brake blocks and linings shall be of incombustible material (the use of asbestos is forbidden) and shall be so secured that normal wear does not weaken their fixings.

Brakes shall be provided with means of adjustment.

The braking system shall be protected against ingress of lubricants, water, dust or other contaminants to at least IP 23 in accordance with IEC 60529.

5.4.5.1.8 Band brakes shall not be used.

5.4.5.2 Special requirements for electromechanical brakes

5.4.5.2.1 In normal operation, a continuous flow of current shall be required to hold off the brake.

The interruption of this current shall be effected by at least two independent electrical devices, whether or not integral with those which cause interruption of the power supply of the drive motor.

If, when the work platform is stationary, one of the contactors has not opened the main contacts, further movement shall be prevented at the latest at the next change in direction of motion.

5.4.5.2.2 When the motor of the work platform is likely to function as a generator, it shall not be possible for the electric device operating the brake to be fed by the driving motor.

Braking shall become effective without delay after opening of the brake-release circuit (the use of a diode or capacitor connected directly to the terminals of the brake coils shall not be considered as a means of delay).

5.4.5.3 Special requirements for hydromechanical brakes

5.4.5.3.1 In normal operation, a continuous oil pressure shall be required to hold off the brake.

5.4.5.3.2 When the motion of the platform is initiated, the braking system shall not reach the hold-off position before the normal operating torque for the drive is attained.

5.4.6 Buffers

5.4.6.1 If the deceleration of the work platform at the bottom limit of travel of the work platform could exceed 1,0 g, buffers shall be provided.

5.4.6.2 The total possible stroke of the buffer(s) shall be at least equal to the stopping distance corresponding to the work platform with rated load being arrested by the buffers from its maximum possible speed at a deceleration of 1,0 g. The maximum possible speed to be considered shall be that which can occur in service, or the tripping speed of the overspeed safety device or speed-limiting system, whichever is greater.

5.4.6.3 If the buffers travel with the work platform, they shall strike against a clearly recognizable pedestal.

5.5 Means to prevent the work platform from falling with overspeed

5.5.1 General

5.5.1.1 All MCWP shall be equipped with a device or means which prevents the work platform from falling in the event of any failure (other than a structural failure of the mast/work platform) and which operates before a speed of 0,5 m/s is exceeded. This device, or means, shall automatically arrest and sustain the work platform with 1,1 × the rated load.

These devices or means shall, when tripped, cause a deceleration not less than 0,05 g and not more than 1,0 g.

This shall be achieved by one of the following systems:

a) an overspeed safety device as specified in 5.5.2, or

b) multiple drive units as specified in 5.5.3.

5.5.1.2 Adjustable components which have a safety-related function shall either require tools for their adjustment or be capable of being sealed against unauthorized adjustment.

5.5.1.3 These devices or means shall be designed to ensure that environmental conditions cannot affect their safe operation.

5.5.2 Overspeed safety devices

An overspeed safety device shall consist of an overspeed detector and a mechanical device for stopping and maintaining the work platform in a stationary position on the mast.

5.5.2.1 Design requirements

The overspeed safety device specified in 5.5.1.1 a) shall

a) be independent of the drive machinery, other than the rack or rungs,

b) be always fully operational in normal use, erecting, maintenance and dismantling,

c) not be dependent on energizing or maintaining an electrical or other auxiliary circuit,

d) be accessible for inspection, maintenance and testing without major dismantling,

e) be designed using a safety factor of 2,5 based on the ultimate strength of the material and the highest force which can occur in the device with rated load and maximum possible speed (see 5.5.1.1),

f) be able to be tested by a competent person remote from the work platform so that persons are not exposed to danger,

g) not be used for guidance of the work platform,

h) positively actuate on the masts or racks and be tripped by an overspeed detector (see 5.5.2.2),

i) be designed so that all control circuits for normal operation are automatically interrupted by a safety switch before or at the time the overspeed safety device is applied,

j) be designed so that the method of release of the safety device requires the intervention of a competent person in order to return the MCWP to normal operation,

k) be designed such that the braking effect of the overspeed safety device increases progressively from the point of tripping of the overspeed detector to the point of bringing the platform to rest.

5.5.2.2 Overspeed detector

5.5.2.2.1 The overspeed detector shall trip at a speed defined by the manufacturer, but in no case shall the work platform exceed the speed stated in 5.5.1.1.

5.5.2.2.2 Overspeed detectors shall operate mechanically and shall be driven either by the overspeed safety device or by wire rope.

5.5.2.2.3 If wire ropes and pulleys are used for overspeed detectors, then

— the wire rope diameter shall not be less than 6 mm,

— the ratio between the diameters of the ropes and the rope pulleys shall not be less than 20,

— the ratio between the highest pull force which could occur in the rope and the minimum breaking force of the rope shall not be less than 8, and

— the minimum generated force shall not be less than 300 N and not less than twice the force necessary to engage the overspeed safety device.

5.5.3 Multiple drive units

If multiple drive units are used to meet the requirements of 5.5.1.1 b), the following shall apply.

a) The MCWP shall have at least two independent direct-drive units of identical capacity fitted to each mast. Each drive unit shall have its own brake, and each brake unit shall be completely independent and be positively but separately connected to the mast.

b) In the event of the failure of a drive unit or its braking system, the remaining braking system shall be capable of stopping and sustaining the work platform when carrying 1,1 × the rated load, from the maximum possible speed even under emergency lowering conditions (see 5.6).

   In addition, each brake shall have a minimum capacity of twice the design load of each drive unit.

c) Each drive unit shall always be fully operational in normal use, erection, maintenance and dismantling.

d) The brake mechanism shall be able to be tested to verify the requirements of 5.3.3 b).

e) The brake system shall be accessible for inspection, maintenance and functional testing of the system without major dismantling.

f) Each drive unit, including the rack where applicable, shall be designed using a safety factor of 2,5 based on the ultimate strength of the material and the highest force that can occur in the drive at the rated load and maximum possible speed.

   The load on each drive unit shall be determined considering the failure of at least one drive unit.

g) The drive system shall detect any malfunction in a drive unit that impedes its proper function, and when such malfunction is detected, the brakes shall be automatically applied and normal operation of the drive system prevented.

   Electrically powered drive systems shall at least indicate loss of mechanical integrity which results in a differential in the current demand between each drive unit exceeding 25 % of the full-load current.

   Hydraulically powered drive systems shall at least indicate a loss of mechanical integrity which results in a differential in the torque demand between each drive unit exceeding 25 % of the full-load torque.

h) The drive system shall have a speed-limiting system that automatically prevents the work platform from exceeding a descent speed of 0,4 m/s.

   The speed limiting system shall be capable of carrying the work platform and its rated load in the most disadvantageous configuration, and shall have a safety factor of at least 2,5 based on the ultimate strength of the material and the highest force which can occur in the event of the failure of a brake or mechanical failure occurring in a drive unit.

5.6 Means for emergency lowering and raising the work platform

5.6.1 The MCWP shall be fitted with means which permit the manually controlled emergency lowering of the work platform under certain circumstances. Such circumstances shall include power system failures but may exclude those mechanical failures which would prevent the safe movement of the work platform.

It is intended that such means shall offer the possibility of the emergency lowering of the work platform, such that persons can leave it, dependent upon suitable site conditions being available.

5.6.2 The means shall:

a) be operated from a safe but easily accessible location on the work platform, which also permits the best possible view of the travel area;

b) have controls which are adequately shrouded or otherwise arranged to prevent, as far as possible, accidental operation from any cause;

c) only be operable by a hold-to-run control which permits lowering of the work platform only as long as the control is manually held in a set position by a manual force of no more than 400 N;

d) require the temporary release of the braking system (see 5.4.5);

e) permit the immediate automatic re-application of the braking system upon release of the emergency lowering controls;

f) permit lowering whilst the work platform is carrying 1,1 × the rated load;

g) allow that no part of the work platform shall exceed ± 5° from the horizontal, in accordance with 5.3.1.1, during emergency lowering.

5.6.3 The emergency lowering means shall not prevent the operation of the devices in accordance with 5.5.1.1 a) and b).

5.6.4 Means for emergency raising of the work platform may be fitted, in addition to the means for emergency lowering. When fitted, the emergency raising means shall comply with 5.6.1 and 5.6.2, as well as 5.6.3, with the word “raising” substituted for “lowering” in all cases.

5.7 Overload/moment device

5.7.1 The MCWP shall be provided with an overload- and moment-detecting and -indicating device. For exceptions, see 5.7.16.

5.7.2 This device shall detect the total load due to persons, equipment and materials on the work platform. It shall also detect those moments, due to these loads, that are likely to lead to overturning or failure of the MCWP. This device shall at least detect:

— bending and torque moments on cantilevered main platforms;

— bending and torque moments on the central part of simply supported main platforms;

— bending moment on the mast.

5.7.3 Overload/moment detection shall be capable of being carried out at least whilst the work platform is stationary.

5.7.4 The overload/moment detector shall be consistent with the rated loads and their locations shown or described on the rated load chart(s) for the MCWP.

5.7.5 The overload and moment detection and indication shall function

a) automatically for the different possible platform configurations, or

b) if automatic detection and indication are not possible for different configurations, then a work platform configuration selector shall be provided which allows a clear classification of the chosen setting in comparison with actual work platform configuration, by either:

   1) a clear sign of the respective platform configuration, or

   2) a code at each setting; in this case, clear reference shall be given to the explanation of the code on a separate code or configuration sign.

5.7.6 The number of possible selections permitting use of the work platform shall not exceed the number of configurations for the work platform.

5.7.7 The selector shall be so situated or protected so as to be inaccessible to unauthorized persons.

5.7.8 The overload/moment detector shall be triggered before reaching a load/moment of 1,1 × rated load/moment, and once triggered shall continuously isolate the controls concerned until the overload/moment has been removed.

5.7.9 The design and installation of overload/moment detectors and indicators shall take into account the need to test the MCWP with overloads without dismantling and without affecting the performance of the detector or indicator.

5.7.10 The overload/moment indicator shall continuously, visually and audibly warn the operator and other persons in the vicinity of the work platform when the overload/moment detector is activated.

5.7.11 No provision shall be made for the user to cancel the warning.

5.7.12 Visual warnings shall be positioned in full view of persons on the work platform.

5.7.13 The overload/moment detector and indicator shall be arranged so that their operation (but not necessarily their accuracy) can be checked without applying loads to the work platform.

5.7.14 The overload/moment detector and indicator shall comply with 5.11.

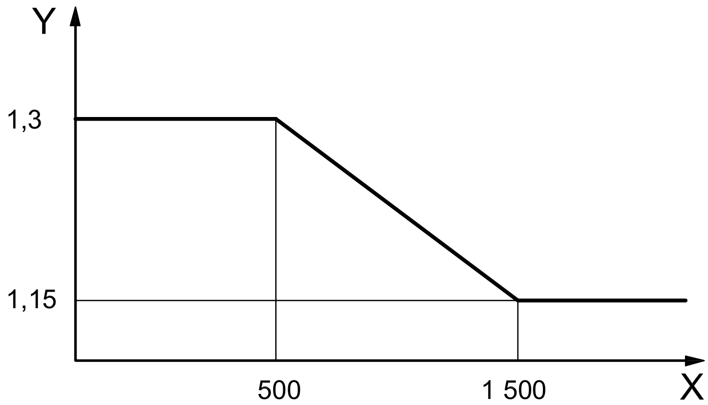
5.7.15 The electrical and electronic requirements for overload-detection devices are given in Annex C.

5.7.16 Devices in accordance with 5.7.1 to 5.7.15 are not required if the following requirements are met.

— All design calculations are based on the loads m_p, m_e and T that are related to the rated load, m, defined in 5.1.2.2.1 increased by a further factor f as a function of, m, in accordance with Figure 8.

— Brakes and safety devices/means are calculated with the same loads as mentioned above.

— For stability calculations, the increased loads shall be considered in case they result in overturning moments.



Key

X rated load, m, in kilograms

Y factor f

Figure 8 — Factor f as a function of rated load

5.8 Electrical systems

5.8.1 General

5.8.1.1 Electrical and electronic installations and their appliances shall be in accordance with IEC 60204-1, which applies in full.

5.8.1.2 Safety and control circuits shall be in accordance with IEC 60204-1. The safety and control circuits shall be electrically separated from all other circuits.

5.8.1.3 Transformers shall be used for supplying control circuits. Such transformer shall have separate winding, and one side of the control circuit shall be connected to the protective bonding circuit (PE) (see IEC 60204-1).

5.8.1.4 All safety contacts shall be of the positive-opening operation type complying with the requirements of IEC 60947-5-1.

5.8.2 Electrically powered drive systems

5.8.2.1 At the chassis or base, a main switch shall be mounted in accordance with IEC 60204-1 at an easily accessible position.

5.8.2.2 Any drive system shall have, within a distance of not more than 2 m from the drive, a supply-disconnecting device able to separate the energy supply from the drive in all poles of phase.

5.8.2.3 In the event of failure of one phase of the supply to the directional control device, the machine shall stop.

5.8.2.4 Precautions shall be taken to ensure the free and safe movement of any trailing cable throughout the full range of travel of the work platform. If the mast is inclined or multilevel work platforms to option B (Annex B) are used, additional precautions are necessary, for example by making the cable follow the incline of the mast by the use of guides or the use of automatic cable-reeling drums.

5.8.3 Safety switches

The operation of a safety switch shall be by positive separation of the contacts, even if the contacts have welded together. Safety switches shall comply with 5.8.1.4 and the conditions set out in Table 7.

Table 7 — Conditions for use of electric switches

Subclause	Devices checked	Switch[a]	Category of control system according to ISO 13849-1
5.3.4 e)	Separation distance switch	sc	1
5.5.2.1 i)	Operation of overspeed safety devices	sc	1
5.12.1	Terminal stopping switch	ssr	B
5.12.2	Final limit switch	sc	1

[a] sc = safety switch in a safety circuit; ssr = safety switch, self-resetting.

5.8.4 Control system

The control system shall comply with category 1 of ISO 13849-1:2006 unless otherwise stated in Table 7. This includes any control system using electrical or hydraulic power.

In redundancy-type circuits and diversity-type circuits, measures shall be taken to limit as far as possible the risk of defects occurring simultaneously in more than one circuit arising from a single cause.

5.9 Drive systems powered by internal combustion engine

5.9.1 Guards shall be provided to protect persons at control positions, or standing adjacent to the MCWP at ground level, or at other points of access, against thermal or mechanical hazards.

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

5.9.3 The filling points of gas and fluid reservoirs (other than for fire-resistant fluids) shall be positioned to avoid any fire from spillage onto very hot parts (e.g. engine exhaust).

5.9.4 A fire extinguisher shall be provided with the MCWP in a suitable location where flammable fuels are used.

5.9.5 Batteries and containers shall be constrained to prevent displacement which could create a hazard.

5.9.6 Suitable ventilation holes shall be provided in the battery container, compartment or cover to prevent the accumulation of gases.

5.10 Hydraulic system

5.10.1 General

5.10.1.1 The hydraulic system shall be designed so that the safety requirements for fluid power systems and components in EN 982 are met.

5.10.1.2 It shall be the responsibility of the manufacturer to determine, by calculations and test, the working pressures which can occur in any part of the circuit.

5.10.1.3 Each hydraulic circuit shall be provided with a sufficient connection for a pressure gauge.

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

5.10.1.5 Any hydraulic tank open to atmosphere shall be equipped with an air-breathing filter.

5.10.1.6 Each hydraulic tank shall be equipped with a device indicating the fluid level and marked with the maximum and minimum levels.

5.10.1.7 The hydraulic system shall be fitted with a pressure-relief valve in order to provide protection against excess pressure. It shall be adjustable, sealed and designed so that the setting shall only be possible with the aid of special tools. The valve shall be adjusted for a pressure which is no more than 20 % above the pressure in operation with the rated load. If different maximum pressures are used in the hydraulic system, then a corresponding number of pressure-relief valves shall be provided.

5.10.1.8 Pressurized parts of the hydraulic system which may be subjected to the maximum pressures permitted by the pressure-relief valve shall be designed to withstand at least twice that pressure without permanent deformation.

5.10.1.9 The bursting pressure of hoses, including fittings, which may be subjected to the maximum pressure permitted by the pressure-relief valve shall be not less than four times that pressure.

5.10.1.10 All other parts of the hydraulic system shall be designed to withstand at least the maximum pressure to which they will be subjected.

5.10.1.11 Pilot-operated control valves shall be so designed and installed that they fail to safety in the event of power failure.

5.10.2 Hydraulic cylinders

5.10.2.1 Hydraulic cylinders shall be designed and installed in accordance with the applicable standard for fluid power systems and components (EN 982 or equivalent).

5.10.2.2 The design of threaded joints subjected to varying tensile loads shall take into account the effects of fatigue and prevent inadvertent separation (unscrewing). The visible threaded joints shall be marked with a line of paint for easy checking of unscrewing.

5.10.2.3 Load-holding cylinders shall be fitted with a device to prevent unintended movement caused by failure of an external pipe until they are opened by an external force.

The device shall be either

a) integral with the cylinder, or

b) directly and rigidly flange-mounted, or

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 being calculated in the same way as the cylinder.

5.11 Special requirements for safety devices depending on auxiliary circuits, and for overload/moment detection devices

5.11.1 The device shall be compatible with the designed use of the MCWP.

5.11.2 Devices shall be in accordance with IEC 60204-1. Systems shall enable periodic functional checks to be carried out to verify that all functions are operating correctly.

5.11.3 If interruption of the power occurs, all data and calibration of the indicators shall be retained.

5.11.4 Limiting- and indicating-device systems shall fail to a “safe” condition, in which any fault results in a shutdown of the control circuits for normal operation.

5.12 Travel limit switches

5.12.1 Terminal stopping switches with contacts in accordance with chapter 3 of IEC 60947-5-1:2003 shall be provided and positioned so that they automatically stop the work platform from rated speed at the highest and lowest levels. At the lowest level, initiation of stopping shall occur before contact with the buffer and before contact with the final-limit switch. At the highest level, initiation of stopping shall occur before contact with the final-limit switch.

5.12.2 An upper final-limit switch shall be provided. It shall be positioned such that the work platform will come to a complete stop before reaching the top of the mast. After triggering the upper final-limit switch, downward movement of the work platform may be permitted but no further upward movement shall be possible until corrective action has been taken by a competent person.

A lower final-limit switch shall be provided. It shall interrupt the electric supply such that the work platform is not powered into the buffers. After triggering the lower final-limit switch, all movements of the work platform shall be prevented until corrective action has been taken by a competent person.

5.12.3 Separately mounted actuating and control devices shall be used for the terminal stopping (travel limit) switches and the final-limit switches.

It is permitted to have one final-limit switch to serve both the upper- and lower-limit switch functions.

5.13 Controls

5.13.1 On self-propelled MCWP it shall not be possible to operate horizontal and vertical movements simultaneously for the transfer controls.

5.13.2 The control device for normal vertical movement shall be situated on the work platform only. The control device for horizontal movement of the MCWP chassis shall not be situated on the platform.

5.13.3 If movement can be controlled from different control positions, the controls shall be interlocked in such a way that control is only possible from one pre-selected control position.

5.13.4 Platforms shall be provided with hand-operated controls such that all movement of the platforms can only take place whilst the control is being actuated. When released, the controls shall automatically return to the neutral position. All controls shall be arranged to prevent inadvertent operation.

5.13.5 Whilst moving the platform vertically, the control station shall be positioned to provide the operator with the best possible view of the travel area and to ensure safe movement of the platform. A warning sign shall be mounted on any movable station stating that vertical operation of the work platform from places other than the work platform itself is forbidden.

5.13.6 Emergency-stop controls shall be arranged on the platform in accordance with IEC 60204-1.

5.13.7 On starting or restoration of power after failure of the power supply, no further movement shall occur without the intervention of the operator.

5.13.8 Controls shall conform to EN 614-1, taking into account the possibility of the operator wearing gloves.

6 Verification of safety requirements and/or measures for each new model of MCWP

6.1 Design check

The design check shall verify that the MCWP is designed in accordance with this International Standard. It will include *inter alia* verification of the following documents:

a) drawings containing the main dimensions of the MCWP;

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

c) information about the materials used;

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

e) operating instructions.

The above documents shall give all necessary information to enable

— the stability calculations to be checked (see 5.1.5), and

— the structural calculations to be checked (see 5.1.4).

6.2 Practical tests

6.2.1 General

Practical tests shall be made to verify that

— the MCWP is stable,

— the MCWP is structurally sound, and

— all functions work correctly and safely.

These tests shall be made:

a) in the case of a free-standing MCWP, with the mast erected to its maximum free-standing height;

b) in the case of a tied-in MCWP, with at least two ties in position at their maximum permitted spacings with maximum permitted top overhang.

MCWP which are capable of operating in both free-standing and tied-in conditions shall be tested in both configurations.

6.2.2 Stability tests

6.2.2.1 General

The MCWP shall be set up on the maximum allowable inclination of the chassis defined by the manufacturer plus 0,5°, with outriggers (if fitted) used as specified by the manufacturer. Test loads shall be applied to represent all the most unfavourable load and force combinations specified in 5.1.5.

The test may be carried out on level ground if the test loads are recalculated to include the effects of the maximum allowable inclination of the chassis defined by the manufacturer plus 0,5°.

The test loads may be applied at any suitable strong point, if necessary, to avoid overstressing any part of the MCWP.

The test shall be repeated in all the most unfavourable extended and/or retracted positions.

The untied MCWP is stable if it can come to a stationary condition without overturning while supporting the test load and force combination(s).

6.2.2.2 Braking test of the chassis

All MCWP fitted with wheeled chassis shall be subjected to a brake test with the unloaded platform in the worst transfer condition. The brake shall be able to stop and hold the MCWP in the worst transfer condition. Application of the brake shall not induce instability.

6.2.2.3 Overload test

The test load shall be 125 % of the rated load. All movements of the MCWP with the test loads shall be carried out at accelerations and decelerations appropriate to safe control of the load.

When, due to the various combinations of load or outreach of a MCWP, tests with different test loads are necessary, all movements shall be carried out with all test loads except where the most unfavourable conditions can be sufficiently simulated by one performance test.

During the overload test, the test load shall be put into each position which creates maximum stress in any load-carrying part of the MCWP.

During the overload test, the brakes shall be capable of stopping and sustaining the test load(s). After removing the test load(s), the MCWP shall show no permanent deformation.

The overload/moment device, if provided, shall be checked for compliance with 5.7.3 to 5.7.14.

6.2.2.4 Functional tests

6.2.2.4.1 General

Functional tests shall demonstrate that

- the MCWP can operate smoothly for all motions whilst carrying the rated load at the rated speeds,
- all safety devices work correctly, and
- maximum permitted speeds are not substantially exceeded.

6.2.2.4.2 Test of the systems to prevent the work platform from falling with overspeed according to 5.5.1.1 a)

Functional tests of the safety gear shall be carried out with the platform carrying 1,1 × the rated load. The work platform shall be allowed to overspeed to the governor-tripping speed in order to determine that

a) the overspeed device operates as specified by the designer, and

b) the safety gear is capable of arresting the motion of the work platform, without the assistance of motor brakes, within the designer's quoted stopping distance.

6.2.2.4.3 Test of the systems to prevent the work platform from falling with overspeed according to 5.5.1.1 b)

Functional tests of the independent drive units shall be carried out with the platform carrying 1,1 × rated load. It shall be determined that

a) the work platform can be stopped and sustained from rated speed by each of the drive units in turn by intentional release of the motor brake of each one of the drive units in turn during the test,

b) the platform can be stopped and sustained from rated speed by intentional activation of the safety system in accordance with 5.5.3, and

c) in each case, the stopping distance is within the quoted design specification.

6.2.2.4.4 Test of the means for emergency lowering (and raising) of the work platform

a) For work platforms equipped with an overspeed safety device in accordance with 5.5.1.1 a), check that the controls comply with 5.6.1 and 5.6.2, and that the work platform speed with 1,1 × rated load can be controlled according to the user instructions. Whilst lowering, permit the speed to increase further to the point where the overspeed safety device operates, in accordance with 5.6.3.

b) For work platforms equipped with means in accordance with 5.5.1.1 b), check that the controls comply with 5.6.1 and 5.6.2, and that the lowering (and raising, if applicable) speed does not exceed 0,3 m/s with 1,1 × rated load on the work platform.

7 Information to be provided

7.1 Instruction handbook

7.1.1 Comprehensive information

Manufacturers or suppliers of MCWP shall supply, in one of the official languages of the country where the MCWP is to be used, sufficient comprehensive information for the safe use of the MCWP. Presentation of this information shall comply with Clause 6 of ISO 12100-2:2003.

7.1.2 Content of the instruction handbook

The manufacturer and/or importer/supplier shall make available to the user an instruction handbook containing the following information, as a minimum:

a) General information

— Manufacturer's or supplier's name and address,

— country of manufacture,

- model designation,
- serial or fabrication number,
- year of manufacture,
- vertical travel speed, in metres per second,
- horizontal transfer speed, in metres per second,
- outdoor/indoor installation,
- maximum allowable free-standing height, in and out of service, in metres,
- maximum allowable wind speed during erection and dismantling, in metres per second,
- maximum allowable wind speed, in and out of service, in metres per second,
- hydraulic supply information if an external hydraulic power supply is used,
- pneumatic supply information if an external pneumatic power supply is used,
- electrical supply information if an external electric power supply is used,
- warning sign required regarding movable control stations.

b) Capacity information

The following information shall be made available, both for MCWP with non-varying work platform configurations and for MCWP with varying work platform configurations. In the case of variable configuration designs, the rated loads for particular main platform and platform extension configurations, and any limitation as to load distribution shall be displayed each time the MCWP is installed (see 7.2.3):

- maximum platform dimensions (length × width, including platform extensions, in metres);
- rated load, in kilograms;
- maximum lifting height, untied mast, in metres;
- maximum lifting height, tied mast, in metres;
- tie distance, in metres;
- top overhang in operation, in metres;
- maximum permitted force, in newtons, applied to tools (manually or mechanically assisted) that is to be resisted by the work platform;
- maximum rated load on platform extensions, in kilograms;
- any load, including persons, permitted on the work platform during transfer condition.

Sufficient information shall be given in the instruction handbook provided by the manufacturer to permit the owner can derive the particular details for each configuration. These particular details shall then be augmented by the name of the erection site and a reference to the relevant chapter in the instruction handbook, such that the user can display this load diagram on the MCWP.

c) **Dimensions and masses**

- Height from the ground to the work platform in its lowest position for access, in metres,
- platform section: length × width × height, in metres,
- platform section: mass, in kilograms,
- mast section: length × width × height, in metres,
- mast section: mass, in kilograms,
- drive unit: length × width × height, in metres,
- drive unit: mass, in kilograms,
- chassis: length × width × height, in metres,
- chassis: mass, in kilograms,
- outrigger spread and configuration: length × width, in metres,
- base unit (specified transport configuration): mass, in kilograms, and dimensions of length × width × height, in metres,
- MCWP installed by crane: mass, in kilograms,
- MCWP installed by crane: max. height of mast, in metres,
- minimum area required for installation: length × width, in metres.

d) **Electrical data**

- Power for lifting machinery, in kilowatts,
- power for transfer machinery, in kilowatts,
- supply voltage/frequency, in volts per hertz,
- control voltage/frequency, in volts per hertz,
- maximum starting current, in amperes,
- maximum power consumption, in kilovolt amperes,
- minimum power supply, in kilovolt amperes,
- main power supply fuses and type, in amperes,
- outlets for portable tools: voltage and current, in volts and amperes respectively.

e) **Safety equipment**

- Type of safety equipment (e.g. safety gear, terminal stopping switches and final-limit switches),
- additional safety equipment for erection and dismantling,
- emergency lowering equipment.

f) Additional technical information

This shall include the following:

— outrigger arrangements;

— ground-bearing pressure and hazards associated with changing ground conditions;

— tie arrangement and forces imposed on the supporting structure, for given wind zones;

— free-standing arrangements for given wind speeds;

— need for protection regarding hazardous areas around the MCWP;

— provision of adequate lighting for safe operation;

— precautions about platform extension between the building and the mast;

— information regarding any lifting points;

— consideration of the possible requirements for lightning protection;

— consideration of the effects of any item which significantly increase the wind area (see 5.1.2.3.3);

— consideration of any effects which significantly increase the wind speed, e.g. adjacent tall buildings, etc.;

— where any non-standard configurations are required, these shall be agreed between manufacturer, owner and user, and this information shall be added as an addendum to the instruction handbook;

— transport procedure to and from site, including the need for meeting traffic regulations;

— transfer of the MCWP around the site, including maximum gradient;

— instructions with regard to the use of slightly raised outriggers during transfer conditions in order to avoid instability from, for instance, failure of one tyre.

g) Operating instructions

These shall include the following information:

— operating procedures, including information on safe distances, such as the clearance to power cables and other overhead structures and between the platform and the building;

— emergency procedures, including the operation of safety devices, resetting by a competent person and action to be taken in case of power loss, including safe use of the means for emergency lowering; this shall include clear instructions regarding safe lowering-distance increments and any rest periods needed in order to avoid overheating of brake linings;

— that travelling controls cannot be operated with any other movement unless the MCWP is in transfer condition;

— use of relevant personal protective equipment, such as hard-hats, protective shoes and eye protection.

h) Requirements for operating personnel

The instruction handbook shall state to the user the minimum qualifications of operating personnel.

i) Operating procedure requirements

These shall include the following points:

— each day before the MCWP is put into use, check the operating devices, brakes and emergency stops. Also check the condition of all trailing cables, travel limit switches, guardrails, structural connecting mast ties, cables and information plates;

— keep the work platform free from waste, building materials and debris, snow, etc.;

— before any work is begun, visually check the outriggers and any timber or other packing on the ground to ensure that it is in good order;

— ensure that tools and other objects do not project outside the perimeter of the MCWP;

— during the work, carefully follow the operating instructions;

— at the end of the work period, bring the platform into the “out-of-service” position and isolate it to prevent unauthorized operation;

— in the event of a fault with the MCWP which can jeopardise safety, immediately immobilise the MCWP and notify a responsible person;

— in case of emergency, follow the relevant instruction in the user's manual.

j) Maintenance instructions

These shall include the following points:

— schedule of regular maintenance and the intervals required, together with requirements for adjustments and tolerances, and for personnel skills;

— information and precautions to be taken regarding hazards during maintenance;

— regular replacement of specific parts, including discard criteria;

— information on the replacement of safety-critical parts by identical components;

— information on how to seal adjustable components which have safety-related functions;

— trouble-shooting information;

— electrical/hydraulic/pneumatic schematic diagrams;

— parts lists/diagrams;

— list of maintenance work to be carried out only by specially trained persons, together with a definition of that training.

The manufacturer shall stress that regular maintenance shall include visual inspection and necessary functional test and maintenance measures. Special attention shall be given to the inspection of load-bearing parts with attachments, driving and stopping devices, operating and safety devices, racks and pinions, etc.

k) Periodic examinations and test on MCWP

The instruction handbook shall state that the frequency and extent of periodic examinations and tests depend on national regulations, manufacturers' requirements, operating conditions and frequency of use. It is normally not necessary to dismantle parts at periodic examinations, unless there are any doubts in relation to reliability and safety. The removal of covers, the exposure of observation apertures, and bringing the MCWP to the transport position are not considered to be dismantling.

The instruction handbook shall state the maximum interval between periodic examinations and tests. Such examinations and tests shall at least consist of the following:

— visual examination of the structure, with special attention to corrosion and other damage of load-bearing parts and welds; and

— examination of the mechanical, hydraulic, pneumatic and electrical systems, with special attention to safety devices.

l) Instructions for erection and dismantling

These shall include the following information:

— detailed explanation of erection and dismantling procedure, with special attention to mast assembly, mast tie system, platform and extension assembly;

— mention of special hazards which can arise during erection and dismantling, with a description of any additional safety equipment and how this can be used to reduce these hazards; the use of personal protective equipment shall be mentioned in this connection;

— preparation of the site with special regard to the load-bearing capacity of the foundation, gantry, asphalt, etc.;

— preparation of the site so that under no circumstances can instability occur during transfer of the equipment when using movable chassis;

— if platform travel must be limited due to obstructions in the travel path and the platform therefore does not reach the normal limit switches, additional travel-limiting devices shall be installed to protect persons and material on the platform or the platform itself from hazardous situations;

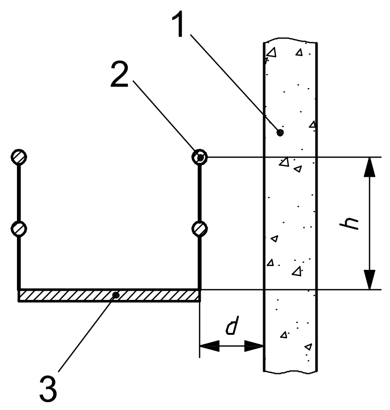
— specific procedures to be observed when preparing the MCWP for transport;

— suitable loading procedures, if the MCWP can be loaded onto a vehicle for transport or transfer;

— that the clear gap between the ends of adjacent MCWP shall be not less than 0,5 m;

— precautions to be taken to ensure the free and safe movement of any trailing cable throughout the full range of travel of the work platform. If the mast is inclined or if multilevel work platforms to option B (see Annex B) are used, additional precautions are necessary, for example by making the cable follow the incline of the mast by the use of guides or the use of automatic cable-reeling drums.

Where the platform is erected towards a wall, the instructions shall furthermore contain information regarding the required height, h, of guardrails on the work platform depending on the distance, d, between the platform and the wall in accordance with Figure 9 and Table 8.



Key

1 wall

2 guardrail

3 work platform

Figure 9 — Distance between platform and wall

Table 8 — Height of guardrails

Dimensions in metres

d	⩽ 0,3	0,3 ⩽ d ⩽ 0,5	> 0,5
h	0	⩾ 0,7 [a]	⩾ 1,1 [b]

[a] Without intermediate rail but with toeboard.

[b] With intermediate rail and toeboard according to 5.3.2.2.

m) Examination and test after major alterations or major repairs to MCWP already in use

These shall consist of the following:

— design check (see 6.1);

— practical tests (see 6.2),

to an extent corresponding to the type of alteration or repair.

For the purposes of this International Standard, “major alterations” are modifications of the whole or part of a MCWP which affect stability, strength or performance.

n) Check list

A list shall be provided in the instruction handbook which contains all safety-relevant parts of the MCWP to be checked after each erection. The result of the checks after each erection, and the name and address of person(s) making the checks, shall be recorded in a signed report.

7.2 Marking

7.2.1 General

The manufacturer shall provide the following information on one or more durable signs or plates mounted in a prominent place on the MCWP, in the official language of the country in which the MCWP is to be used.

7.2.2 Information, permanent

- Manufacturer's or supplier's name and address,
- country of manufacture,
- model designation,
- serial or fabrication number,
- year of manufacture,
- vertical travel speed, in metres per second,
- transfer travel speed, in metres per second,
- outdoor/indoor installation,
- maximum allowable free-standing height, in metres, in- and out-of-service,
- limiting wind speed during erection/dismantling,
- maximum allowable wind speed in-service/out-of-service, in metres per second,
- hydraulic supply information, if an external hydraulic power supply is used,
- pneumatic supply information, if an external pneumatic power supply is used,
- electrical supply information, if an external electric power supply is used,
- notice that all guardrails are to be in place at all times, except for loading and unloading at the access level.

7.2.3 Information, variable

7.2.3.1 Capacity

A load diagram showing the rated loads for particular main platform and platform extension configurations and any limitation as to load distribution. This shall be derived from information presented by the manufacturer in accordance with 7.1.2.

The load diagram shall take the form of a durable sign or plate and its preparation shall be the responsibility of the user.

The manufacturer shall provide a means of mounting the load diagram.

7.2.3.2 Additional technical information

Outrigger arrangements and required ground-bearing pressure shall be provided.

Annex A
(informative)

Structural calculations

A.1 General

Structural calculations for MCWP should conform with the rules and principles of applied mechanics and strength of materials. If special formulae are used, the sources should be given, if they are generally available. Otherwise the formulae should be developed from first principles, so that their validity can be checked.

A.2 Steel structures

A.2.1 General

In the absence of an international standard for design calculations, the general permissible stresses and calculations given in A.2.2 to A.2.5 may be applied for the design of steel structures.

A.2.2 Permissible stresses

A.2.2.1 Symbols

f_y	yield strength, in newtons per square millimetre;
f_u	ultimate strength, in newtons per square millimetre;
$E = 210\ 000$	modulus of elasticity, in newtons per square millimetre;
$G = E/[2 \times (1 + v)]$	shear modulus, in newtons per square millimetre;
$v = 0{,}3$	Poisson's ratio;
δ_5	elongation at failure on gauge length of 5 times the diameter of the original cross-section, expressed as a percentage;
S	safety factor on yield strength.

A.2.2.2 Non-alloy structural steels in accordance with EN 10025-2

See Tables A.1 and A.2.

Table A.1 — Nominal values of material properties

Type	Yield strength [a] f_y N/mm^2	Ultimate strength [b] f_u N/mm^2
S235 (Fe360)	235	360
S275 (Fe430)	275	430
S355 (Fe510)	355	510

[a] Standard value for smaller thickness.

[b] Minimum.

Permissible stresses for non-alloy structural steels are calculated using the following formula:

$$\sigma_o = f_y / S$$

Table A.2 — Permissible stresses for non-alloy structural steels

Forces in newtons per square millimetre

	Load case								
	A			**B**			**C**		
S	1,5			1,33			1,25		
Steel grade	235	275	355	235	275	355	235	275	355
Basic material and butt weld									
$\sigma_a = \sigma_o$	157	183	237	176	206	266	188	220	284
$\tau_a = \sigma_o/\sqrt{3}$	90	106	137	102	119	154	109	127	164
Fillet weld									
$\sigma_a = \sigma_o$	157	183	237	176	206	266	188	220	284
$\tau_a = \sigma_o/\sqrt{2}$	111	130	167	125	146	188	133	156	201
The indicated permissible stresses are valid up to a thickness of 40 mm. In the case of larger thicknesses, the corresponding value of f_y should be taken into consideration.									

When selecting the materials, any special requirements should be taken into account, e.g.:

— weldability;

— use of the appliance in extreme climatic zones.

A.2.2.3 Other steel grades

Depending on the minimum strength, f_u, and the elongation at failure δ_5, the following condition exists:

$510 < f_u \leqslant 590 \qquad \delta_5 \cdot f_u \geqslant 10\,800$

$590 < f_u \qquad \delta_5 \cdot f_u \geqslant 9\,800$

It these conditions are fulfilled, the following applies: $f'_y = 0{,}8 \times f_u$

If the conditions are not fulfilled, a reduced yield strength, f'_y, should be defined with the factor r, which is applied to the ultimate strength f_u:

$$r = \frac{26\,000 - f_u\left(6 + \delta_5\right)}{9\,600}$$

$$1{,}28 \leqslant r \leqslant 1{,}44$$

$$f'_y = \frac{f_u}{r}$$

Values of r to be used should be not less than 1,28 and not more than 1,44.

Based on the lower value of the yield strength f_y or f'_y, the permissible stresses should be calculated with the safety factors given for non-alloy structural steels.

A.2.2.4 Bolts

A.2.2.4.1 Black and fitted bolts

The permissible stresses in Table A.3 are derived from X, which is the lower value of f_y and $0{,}7 \times f_u$.

$\sigma_a = X/S$ $\tau_a = \sigma_a/\sqrt{2}$

Table A.3 — Permissible stresses in bolts

Forces in newtons per square millimetre

			Grade					
			4.6	**5.6**	**6.6**	**6.8**	**8.8**	**10.9**
Load case	S	f_y	240	300	360	480	640	900
		X	240	300	360	420	560	700
A	1,5	σ_a	160	200	240	280	373	467
		τ_a	113	141	180	198	264	330
B	1,33	σ_a	180	225	270	315	420	525
		τ_a	127	159	191	223	297	371
C	1,25	σ_a	192	240	288	336	448	560
		τ_a	136	170	204	238	317	396

A.2.2.4.2 Preloaded bolts

Grades 8.8 and 10.9 only. Grade 12.9 may be used, however, if the conditions stated below are fulfilled. (See Eurocode 3 – EN 1993-1-1.)

Symbols:

A_s tensile-stress area of bolt, in square millimetres;

F_v preload, in newtons;

d nominal bolt diameter, in millimetres;

M_t tightening torque, in kilonewtons per metre.

Bolts used once $F_v = 0{,}8\ (f_y \cdot A_s)$

Bolts used several times $F_v = 0{,}7 \times 0{,}8\ (f_y \cdot A_s)$

Tightening torque $$M_t = \frac{0{,}18\left(d \cdot F_v\right)}{1\,000}$$

The applied load, F, in relation to the preload, F_v, should be:

$F/F_v \leqslant 0{,}67$ for load case A

$F/F_v \leqslant 0{,}75$ for load case B

$F/F_v \leqslant 0{,}8$ for load case C

A.2.2.4.3 Bearing pressure

The permissible bearing pressure, σ_L, (see Table A.4) depends on the basic material and is valid for bolted connections and also for pins.

Loose connection $\sigma_L = 1{,}3 \times \sigma_o$

Low accuracy, fixed connection $\sigma_L = 1{,}5 \times \sigma_o$

High accuracy, fixed connection $\sigma_L = 2{,}0 \times \sigma_o$

Table A.4 — Permissible bearing pressure

Forces in newtons per square millimetre

	Load case								
	A			B			C		
	Steel grade			Steel grade			Steel grade		
	235	275	355	235	275	355	235	275	355
Loose connection	204	238	308	229	268	346	244	286	369
Low accuracy, fixed connection	235	275	335	264	309	399	282	330	426
High accuracy, fixed connection	313	367	473	352	412	532	376	440	568

A.2.2.5 Combined stresses

Load-carrying parts and butt welds:

$$\sigma = \sqrt{\sigma_x{}^2 + \sigma_y{}^2 - \sigma_x \cdot \sigma_y + 3\tau^2}$$

Bolts, pin and fillet welds:

$$\sigma = \sqrt{\sigma_x{}^2 + \sigma_y{}^2 - \sigma_x \cdot \sigma_y + 2\tau^2}$$

A.2.2.6 Elastic stability

A.2.2.6.1 Crippling

Symbols:

λ slenderness;

λ' specific slenderness;

ω crippling factor;

F compressive force, in newtons;

A area, in square centimetres;

M bending moment, in newton centimetres;

W_c section modulus; compressive edge, in cubic centimetres;

W_t section modulus; tensile edge, in cubic centimetres;

σ_a permissible stress, in newtons per square centimetre.

The crippling factor is defined in the following way:

$$\lambda' = \frac{\lambda}{\pi} \cdot \sqrt{f_y / E}$$

For $0 < \lambda' \leqslant 1{,}195$, $\omega = \dfrac{1}{1 - 0{,}195\lambda' - 0{,}185\lambda'^{\,2{,}5}}$

For $\lambda' > 1{,}195$, $\omega = 1{,}465\ \lambda'^{\,2}$

The ω-factor is already calculated for non-alloy structural steels (see Tables A.5 to A.7).

The highest permitted slenderness is $\lambda = 250$.

The following conditions should be fulfilled:

$$\omega \cdot \frac{F}{A} + 0{,}9 \cdot \frac{M}{W_c} \leq \sigma_a$$

$$\omega \cdot \frac{F}{A} + \frac{300 + 2\lambda}{1\,000} \cdot \frac{M}{W_t} \leq \sigma_a$$

A.2.2.6.2 Buckling

Symbols:

t thickness of plate, in centimetres;

b width of plate, in centimetres;

k factor depending on the stress conditions;

σ_e Euler's buckling stress, in newtons per square millimetre;

σ_{ki} ideal buckling stress, in newtons per square millimetre;

σ_{vki} ideal combined buckling stress, in newtons per square millimetre;

σ_{vk} reduced combined buckling stress, in newtons per square millimetre;

σ_1 higher stress, in newtons per square millimetre;

σ_2 lower stress, in newtons per square millimetre.

$$\sigma_{ki} = k_\sigma \times \sigma_e$$

$$\tau_{ki} = k_\tau \times \sigma_e$$

$$\psi = \sigma_1 / \sigma_2$$

The reduced buckling stress, σ_{vk}, is defined in the following way:

if $\sigma_{vki} < 0,7 f_y$ then $\sigma_{vk} = \sigma_{vki}$

if $\sigma_{vki} \geqslant 0,7 f_y$ then $\sigma_{vk} = f_y \sqrt[4]{1 - 0,461/\left(\sigma_{vki} / f_y\right)^{1,4}}$

The required minimum safety factor, ν, depends on the load combination:

— Load case A $\nu \geqslant 1,71 + 0,180\ (\psi - 1,0)$

— Load case B $\nu \geqslant 1,50 + 0,125\ (\psi - 1,0)$

— Load case C $\nu \geqslant 1,33 + 0,075\ (\psi - 1,0)$

For further information, refer to accepted buckling calculation methods.

A.2.3 Limit-state method

The deflection of a structure should be taken into consideration when calculating the stresses. This is very important when calculating a slender design or using materials with a low modulus of elasticity, and can be done by using the second-order theory. The safety factors, S, against f_y or f'_y should be at least the following:

— Load case A: $S \geqslant 1,50$

— Load case B: $S \geqslant 1,33$

— Load case C: $S \geqslant 1,25$

A.2.4 ω-values for non-alloy structural steels

See Tables A.5 to A.7.

Table A.5 — ω-values for S 235

S 235 — Yield strength $f_y = 235$ N/mm²										
λ	0	1	2	3	4	5	6	7	8	9
20	1,05	1,05	1,05	1,06	1,06	1,06	1,07	1,07	1,07	1,08
30	1,08	1,08	1,09	1,09	1,10	1,10	1,10	1,11	1,11	1,11
40	1,12	1,12	1,12	1,13	1,14	1,14	1,14	1,15	1,16	1,16
50	1,17	1,17	1,18	1,18	1,19	1,19	1,20	1,21	1,21	1,22
60	1,23	1,23	1,24	1,25	1,26	1,26	1,27	1,28	1,29	1,30
70	1,31	1,31	1,32	1,33	1,34	1,35	1,36	1,37	1,39	1,40
80	1,41	1,42	1,43	1,45	1,46	1,47	1,49	1,50	1,52	1,53
90	1,55	1,56	1,58	1,60	1,61	1,63	1,65	1,67	1,69	1,71
100	1,74	1,76	1,78	1,81	1,83	1,86	1,89	1,92	1,95	1,98
110	2,01	2,05	2,08	2,12	2,16	2,20	2,24	2,27	2,31	2,35
120	2,39	2,43	2,47	2,51	2,55	2,60	2,64	2,68	2,72	2,76
130	2,81	2,85	2,89	2,94	2,98	3,03	3,07	3,12	3,16	3,21
140	3,26	3,30	3,35	3,40	3,44	3,49	3,54	3,59	3,64	3,69
150	3,74	3,79	3,84	3,89	3,94	3,99	4,04	4,09	4,15	4,20
160	4,25	4,31	4,36	4,41	4,47	4,52	4,58	4,63	4,69	4,74
170	4,80	4,86	4,91	4,97	5,03	5,09	5,15	5,20	5,26	5,32
180	5,38	5,44	5,50	5,56	5,62	5,69	5,75	5,81	5,87	5,93
190	6,00	6,06	6,12	6,19	6,25	6,32	6,38	6,45	6,51	6,58
200	6,64	6,71	6,78	6,85	6,91	6,98	7,05	7,12	7,19	7,26
210	7,33	7,40	7,47	7,54	7,61	7,68	7,75	7,82	7,89	7,97
220	8,04	8,11	8,19	8,26	8,33	8,41	8,48	8,56	8,63	8,71
230	8,79	8,86	8,94	9,02	9,10	9,17	9,25	9,33	9,41	9,49
240	9,57	9,65	9,73	9,81	9,89	9,97	10,05	10,13	10,22	10,30

Table A.6 — ω-values for S 275

S 275 — Yield strength $f_y = 275$ N/mm²										
λ	0	1	2	3	4	5	6	7	8	9
20	1,05	1,06	1,06	1,06	1,07	1,07	1,07	1,08	1,08	1,08
30	1,09	1,09	1,10	1,10	1,10	1,11	1,11	1,12	1,12	1,13
40	1,13	1,14	1,14	1,15	1,16	1,16	1,16	1,17	1,18	1,18
50	1,19	1,20	1,20	1,21	1,22	1,22	1,23	1,24	1,25	1,25
60	1,26	1,27	1,28	1,29	1,30	1,31	1,32	1,33	1,34	1,35
70	1,36	1,37	1,38	1,40	1,41	1,42	1,44	1,45	1,46	1,48
80	1,49	1,51	1,53	1,54	1,56	1,58	1,60	1,62	1,64	1,66
90	1,68	1,70	1,73	1,75	1,78	1,80	1,83	1,86	1,89	1,92
100	1,95	1,99	2,02	2,06	2,10	2,14	2,18	2,23	2,27	2,31
110	2,35	2,39	2,44	2,48	2,53	2,57	2,62	2,66	2,71	2,75
120	2,80	2,85	2,89	2,94	2,99	3,04	3,09	3,14	3,18	3,23
130	3,29	3,34	3,39	3,44	3,49	3,54	3,60	3,65	3,70	3,76
140	3,81	3,86	3,92	3,97	4,03	4,09	4,14	4,20	4,26	4,32
150	4,37	4,43	4,49	4,55	4,61	4,67	4,73	4,79	4,85	4,91
160	4,98	5,04	5,10	5,16	5,23	5,29	5,36	5,42	5,49	5,55
170	5,62	5,68	5,75	5,82	5,89	5,95	6,02	6,09	6,16	6,23
180	6,30	6,37	6,44	6,51	6,58	6,65	6,72	6,80	6,87	6,94
190	7,02	7,09	7,17	7,24	7,32	7,39	7,47	7,55	7,62	7,70
200	7,78	7,85	7,93	8,01	8,09	8,17	8,25	8,33	8,41	8,49
210	8,57	8,65	8,74	8,82	8,90	8,99	9,07	9,15	9,24	9,32
220	9,41	9,49	9,58	9,67	9,75	9,84	9,93	10,02	10,10	10,19
230	10,28	10,37	10,46	10,55	10,64	10,73	10,83	10,92	11,01	11,10
240	11,20	11,29	11,38	11,48	11,57	11,67	11,76	11,86	11,96	12,05

Table A.7 — ω-values for S 355

S 355 — Yield strength f_y = 355 N/mm^2										
λ	0	1	2	3	4	5	6	7	8	9
20	1,06	1,06	1,07	1,07	1,08	1,08	1,09	1,09	1,09	1,10
30	1,10	1,11	1,11	1,12	1,13	1,13	1,14	1,14	1,15	1,15
40	1,16	1,17	1,17	1,19	1,19	1,20	1,20	1,21	1,22	1,23
50	1,24	1,25	1,26	1,26	1,27	1,28	1,30	1,31	1,32	1,33
60	1,34	1,35	1,37	1,38	1,39	1,39	1,41	1,42	1,44	1,47
70	1,49	1,50	1,52	1,54	1,56	1,58	1,60	1,63	1,65	1,67
80	1,70	1,73	1,75	1,78	1,81	1,85	1,88	1,92	1,95	1,99
90	2,03	2,08	2,12	2,17	2,22	2,26	2,31	2,36	2,41	2,46
100	2,51	2,56	2,61	2,66	2,71	2,77	2,82	2,87	2,93	2,98
110	3,04	3,09	3,15	3,20	3,26	3,32	3,38	3,43	3,49	3,55
120	3,61	3,67	3,73	3,80	3,86	3,92	3,98	4,05	4,11	4,18
130	4,24	4,31	4,37	4,44	4,51	4,57	4,64	4,71	4,78	4,85
140	4,92	4,99	5,06	5,13	5,20	5,28	5,35	5,42	5,50	5,57
150	5,65	5,72	5,80	5,87	5,95	6,03	6,11	6,19	6,26	6,34
160	6,42	6,50	6,59	6,67	6,75	6,83	6,91	7,00	7,08	7,17
170	7,25	7,34	7,42	7,51	7,60	7,68	7,77	7,86	7,95	8,04
180	8,13	8,22	8,31	8,40	8,50	8,59	8,68	8,77	8,87	8,96
190	9,06	9,15	9,25	9,35	9,44	9,54	9,64	9,74	9,84	9,94
200	10,05	10,14	10,24	10,34	10,44	10,55	10,65	10,75	10,86	10,96
210	11,07	11,17	11,28	11,38	11,49	11,60	11,71	11,82	11,93	12,03
220	12,14	12,26	12,37	12,48	12,59	12,70	12,82	12,93	13,04	13,16
230	13,27	13,39	13,51	13,62	13,74	13,86	13,98	14,09	14,21	14,33
240	14,45	14,57	14,70	14,82	14,94	15,06	15,19	15,31	15,43	15,56

A.2.5 Analysis

A.2.5.1 General stress analysis

The general stress analysis is the proof against failure by yield or fracture. The analysis should be made for all load-bearing components and joints.

A.2.5.2 Elastic stability analysis

The elastic stability analysis is the proof against failure by elastic instability (e.g. buckling, crippling). The analysis should be made for all load-bearing components subject to compressive loading.

A.2.5.3 Fatigue stress analysis

Only load case A has to be considered.

The fatigue stress analysis is the proof against failure by fatigue due to stress fluctuations. The analysis should be made for all load-bearing components and joints which are critical to fatigue, taking into account the constructional 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.

The number of load cycles for a MCWP is normally 2×10^4 for intermittent duty (e.g. 10 years, 40 weeks per year, 25 h per week, 2 cycles per hour).

It is permissible for the rated load to be multiplied by a load spectrum factor 0,5.

For further information, refer to accepted fatigue stress analysis methods.

A.3 Aluminium structures

A.3.1 General

In the absence of an International Standard for design calculations, the permissible stresses and calculations given in A.3.2 and A.3.3 may be applied for the design of aluminium structures.

A.3.2 Permissible stresses

A.3.2.1 Symbols

f_y yield strength, in newtons per square millimetre;

f_u ultimate strength, in newtons per square millimetre;

$E = 70\ 000$ modulus of elasticity, in newtons per square millimetre;

$G = 27\ 000$ shear modulus, in newtons per square millimetre;

δ_5 elongation at failure on gauge length of 5 times the diameter of the original cross-section, expressed as a percentage;

S safety factor on yield strength;

V safety factor on tensile strength.

A.3.2.2 Standardized structural aluminium alloys (see Tables A.8 to A.10)

Table A.8 — Standardized aluminium alloys

Alloy No.	Alloy	Condition
1	AlZn4,5Mg11	F35
2	AlMgSi1	F32
3	AlMgSi1	F28
4	AlMgSi0,5	F22
5	AlMg4,5Mn	G31
6	AlMg4,5Mn	W28
7	AlMg4,5Mn	F27
8	AlMg2Mn0,8	F20
9	AlMg2Mn0,8	F19
10	AlMg3	F18

Table A.9 — Nominal values of material properties of standardized aluminium alloys

Alloy No.	Nominal thickness t of the element $\leqslant$ 10 mm	
	f_y N/mm^2	f_u N/mm^2
1	275	350
2	255	315
3	200	275
4	160	215
5	205	310
6	125	275
7	125	275
8	100	200
9	80	180
10	80	180

Table A.10 — Permissible stresses for standardized aluminium alloys

Forces in newtons per square millimetre

Alloy No.	Load case											
	A				B				C			
	Basic material		Welds		Basic material		Welds		Basic material		Welds	
	σ_a	τ_a	σ_a	τ_a	σ_a	τ_a	σ_a	τ_a	σ_a	τ_a	σ_a	τ_a
1	160	95	75	60	180	110	85	70	200	120	90	80
2	145	90	55	40	165	100	60	45	180	110	65	50
3	115	70	55	40	130	80	60	45	110	90	65	40
4	95	55	35	25	105	60	40	30	115	65	45	30
5	120	70	55	45	135	80	65	40	150	90	70	55
6	70	45	55	45	80	50	65	50	90	55	70	55
7	70	45	55	45	80	50	65	50	90	55	70	55
8	55	35	35	30	65	40	40	35	70	45	45	40
9	45	30	35	30	50	35	40	35	55	40	45	40
10	45	30	35	30	50	35	40	35	55	40	45	40

$\sigma_o = f_y/S$ and f_u/V

$S_A \approx 1{,}7$; $V_A \approx 2{,}5$; $S_B \approx 1{,}55$; $V_B \approx 2{,}25$; $S_C \approx 1{,}4$; $V_C \approx 2{,}05$

When selecting the materials, any special requirements should be taken into account, for example:

- condition after heat treatment and ageing;
- weldability;
- use of the appliance in extreme climatic zones/conditions.

For other material characteristics, consult national standards.

A.3.2.3 Combined stresses

Load-bearing parts and butt welds:

$$\sigma = \sqrt{{\sigma_x}^2 + {\sigma_y}^2 - \sigma_x \cdot \sigma_y + 3\tau^2}$$

A.3.2.4 Elastic stability

A.3.2.4.1 General

Aluminium has a very low modulus of elasticity and a low shear modulus (approximately 1/3 of the values of steel). Therefore the problems with the elastic stability are much more obvious compared with steel structures. Crippling, buckling, torsion buckling, etc. should be checked. Very slender constructions should be checked according to the second-order theory.

A.3.2.4.2 Crippling — Omega method

Symbols:

λ slenderness;

ω crippling factor.

ω factors are already calculated for aluminium (see Tables A.11 to A.14).

A.3.2.4.3 Limit state method

The deflection of a construction should be taken into consideration when calculating the stresses. This is very important when calculating a slender design or using materials with a low modulus of elasticity, e.g. aluminium, and can be done by using the second-order theory. The safety factors against f_y or f'_y should be at least the following:

Load case A	$S \geqslant 1{,}7$
Load case B	$S \geqslant 1{,}55$
Load case C	$S \geqslant 1{,}4$

A.3.3 ω-values for aluminium alloys

The values in Tables A.11 to A.14 are valid for profiles, but may also be used for tubes.

Table A.11 — ω-values for aluminium alloys 1 and 2

	Alloy 1 Yield strength $f_y = 235$ N/mm^2					Alloy 2 Yield strength $f_y = 260$ N/mm^2				
λ	**0**	**2**	**4**	**6**	**8**	**0**	**2**	**4**	**6**	**8**
20	1,00	1,01	1,03	1,05	1,07	1,00	1,00	1,02	1,04	1,06
30	1,10	1,12	1,15	1,18	1,21	1,08	1,11	1,14	1,17	1,20
40	1,25	1,29	1,33	1,38	1,43	1,23	1,27	1,31	1,36	1,40
50	1,43	1,60	1,73	1,86	1,99	1,45	1,50	1,60	1,73	1,85
60	2,13	2,28	2,43	2,58	2,74	1,98	2,12	2,25	2,40	2,54
70	2,90	3,07	3,25	3,42	3,61	2,70	2,85	3,01	3,18	3,35
80	3,79	3,98	4,18	4,38	4,59	3,52	3,70	3,88	4,07	4,26
90	4,80	5,02	5,24	5,46	5,69	4,46	4,66	4,86	5,07	5,28
100	5,93	6,17	6,41	6,66	6,91	5,50	5,72	5,95	6,18	6,42
110	7,17	7,43	7,70	7,97	8,25	6,66	6,90	7,15	7,40	7,66
120	8,53	8,82	9,11	9,41	9,71	7,92	8,19	8,46	8,74	9,01
130	10,01	10,32	10,64	10,96	11,28	9,30	9,59	9,88	10,18	10,48
140	11,61	11,95	12,29	12,63	12,98	10,78	11,09	11,41	11,73	12,05
150	13,33	13,69	14,05	14,42	14,79	12,38	12,71	13,05	13,39	13,74
160	15,17	15,55	15,94	16,33	16,72	14,09	14,44	14,80	15,16	15,53
170	17,12	17,53	17,94	18,35	18,77	15,90	16,28	16,66	17,04	17,43
180	19,20	19,63	20,06	20,50	20,94	17,83	18,22	18,63	19,03	19,45
190	21,39	21,84	22,30	22,76	23,23	19,86	20,28	20,71	21,14	21,57
200	23,70	24,18	24,66	25,14	25,63	22,01	22,45	22,90	23,35	23,80

Table A.12 — ω-values for aluminium alloys 3, 4 and 5

	Alloys 3 and 5 Yield strength $f_y = 200$ N/mm^2					Alloy 4 Yield strength $f_y = 160$ N/mm^2				
λ	**0**	**2**	**4**	**6**	**8**	**0**	**2**	**4**	**6**	**8**
20	1,00	1,00	1,02	1,04	1,06	1,00	1,00	1,02	1,04	1,05
30	1,08	1,10	1,13	1,15	1,18	1,08	1,10	1,13	1,15	1,18
40	1,21	1,24	1,28	1,31	1,34	1,20	1,23	1,25	1,27	1,30
50	1,38	1,42	1,47	1,52	1,57	1,33	1,37	1,41	1,45	1,49
60	1,63	1,71	1,82	1,94	2,06	1,53	1,58	1,62	1,66	1,71
70	2,18	2,30	2,43	2,57	2,70	1,76	1,82	1,87	1,96	2,06
80	2,84	2,99	3,14	3,29	3,44	2,17	2,28	2,39	2,50	2,62
90	3,60	3,76	3,93	4,10	4,27	2,74	2,87	2,99	3,12	3,25
100	4,44	4,62	4,81	4,99	5,18	3,39	3,52	3,66	3,80	3,95
110	5,38	5,57	5,78	5,98	6,19	4,10	4,25	4,40	4,56	4,71
120	6,40	6,61	6,83	7,06	7,28	4,88	5,04	5,21	5,38	5,55
130	7,51	7,74	7,98	8,22	8,46	5,72	5,90	6,08	6,26	6,45
140	8,71	8,96	9,22	9,47	9,73	6,64	6,83	7,02	7,22	7,42
150	10,0	10,2	10,5	10,8	11,0	7,62	7,82	8,03	8,24	8,45
160	11,3	11,6	11,9	12,2	12,5	8,67	8,89	9,11	9,33	9,56
170	12,8	13,1	13,4	13,7	14,0	9,79	10,0	10,2	10,4	10,7
180	14,4	14,7	15,0	15,3	15,7	10,9	11,2	11,4	11,7	11,9
190	16,0	16,3	16,7	17,0	17,4	12,2	12,4	12,7	13,0	13,2
200	17,7	18,1	18,4	18,8	19,2	13,5	13,8	14,0	14,3	14,6

Table A.13 — ω-values for aluminium alloys 6 and 7

	Alloy 7 (profiles) Yield strength $f_y = 140$ N/mm²					Alloys 6 and 7 (profiles and box sections of sheet metal) Yield strength $f_y = 125$ N/mm²				
λ	**0**	**2**	**4**	**6**	**8**	**0**	**2**	**4**	**6**	**8**
20	1,00	1,00	1,01	1,03	1,05	1,00	1,00	1,01	1,03	1,05
30	1,07	1,09	1,11	1,14	1,16	1,07	1,09	1,11	1,14	1,16
40	1,19	1,21	1,24	1,27	1,30	1,19	1,21	1,24	1,26	1,29
50	1,33	1,35	1,38	1,42	1,45	1,32	1,35	1,38	1,41	1,44
60	1,49	1,53	1,57	1,61	1,65	1,47	1,51	1,55	1,58	1,62
70	1,70	1,75	1,80	1,85	1,90	1,66	1,70	1,75	1,79	1,84
80	1,96	2,01	2,09	2,19	2,29	1,88	1,93	1,98	2,03	2,08
90	2,40	2,51	2,62	2,73	2,85	2,14	2,24	2,34	2,44	2,55
100	2,96	3,08	3,20	3,33	3,46	2,65	2,75	2,87	2,98	3,09
110	3,59	3,72	3,85	3,99	4,13	3,21	3,32	3,44	3,57	3,69
120	4,27	4,41	4,56	4,70	4,85	3,82	3,94	4,07	4,21	4,34
130	5,01	5,18	5,32	5,48	5,64	4,48	4,62	4,76	4,90	5,05
140	5,81	5,97	6,14	6,32	6,49	5,19	5,34	5,50	5,65	5,82
150	6,67	6,85	7,03	7,21	7,40	5,96	6,12	6,28	6,45	6,62
160	7,58	7,78	7,97	8,16	8,36	6,78	6,95	7,13	7,30	7,48
170	8,56	8,77	8,97	9,18	9,39	7,66	7,84	8,02	8,21	8,40
180	9,60	9,81	10,0	10,2	10,4	8,59	8,78	8,97	9,17	9,37
190	10,7	10,9	11,1	11,3	11,6	9,57	9,77	9,97	10,1	10,3
200	11,8	12,0	12,3	12,5	12,8	10,6	10,8	11,0	12,2	11,4

Table A.14 — ω-values for aluminium alloys 8, 9 and 10

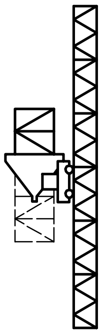
	Alloy 8 Yield strength $f_y = 100$ N/mm^2					Alloys 9 and 10 Yield strength $f_y = 80$ N/mm^2				
λ	**0**	**2**	**4**	**6**	**8**	**0**	**2**	**4**	**6**	**8**
20	1,00	1,00	1,01	1,03	1,05	1,00	1,00	1,00	1,02	1,04
30	1,07	1,09	1,11	1,14	1,16	1,06	1,09	1,11	1,14	1,16
40	1,19	1,21	1,24	1,26	1,29	1,18	1,21	1,23	1,26	1,28
50	1,31	1,34	1,37	1,40	1,43	1,31	1,34	1,37	1,40	1,43
60	1,46	1,50	1,53	1,57	1,60	1,46	1,49	1,52	1,56	1,59
70	1,63	1,67	1,71	1,75	1,79	1,62	1,66	1,69	1,73	1,77
80	1,83	1,87	1,91	1,95	2,00	1,80	1,84	1,87	1,91	1,95
90	2,05	2,10	2,15	2,20	2,25	1,99	2,03	2,08	2,12	2,17
100	2,31	2,37	2,42	2,48	2,54	2,21	2,26	2,30	2,35	2,40
110	2,60	2,67	2,75	2,85	2,95	2,45	2,50	2,56	2,61	2,66
120	3,05	3,15	3,25	3,36	3,47	2,72	2,78	2,83	2,89	2,95
130	3,58	3,69	3,80	3,91	4,03	3,01	3,08	3,15	3,21	3,28
140	4,15	4,27	4,39	4,51	4,64	3,35	3,42	3,51	3,61	3,71
150	4,76	4,89	5,02	5,15	5,28	3,81	3,91	4,02	4,12	4,23
160	5,42	5,55	5,69	5,83	5,97	4,33	4,44	4,55	4,67	4,78
170	6,12	6,26	6,44	6,56	6,74	4,93	5,01	5,13	5,24	5,36
180	6,86	7,01	7,16	7,32	7,48	5,49	5,61	5,73	5,86	5,98
190	7,64	7,80	7,96	8,13	8,30	6,11	6,24	6,37	6,50	6,64
200	8,47	8,64	8,81	8,98	9,16	6,77	6,91	7,05	7,18	7,32

Annex B
(normative)

Special requirements for multilevel work platforms

See Tables B.1 and B.2.

Table B.1 — Option A

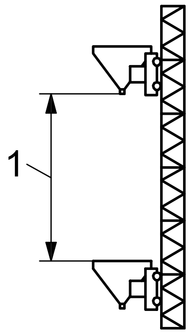


OPTION A
Mounted on and/or below the primary work platform

Requirements	Single mast	Multiple masts
Allow for the effect on calculations/rated load	Allow for mass of multilevel work platform	
Allow for additional forces on mast and mast ties	Yes	Yes
Allow for additional in- and out-of-service wind forces	Yes	Yes
Allow for the effect on stability	Yes	Yes
Guardrails and toeboards	Yes	Yes
Ladder	Yes	Yes
Trap door	Yes	Yes
Fixings and stability of subsidiary work platform in relation to the primary work platform	Yes, by adequate fixings to primary work platform	
Supported on primary work platform or on platform extensions or both	Yes, any combination	
Platform levelling	According to 5.3.1.1	According to 5.3.1.1 with assurance that clearance remains between subsidiary work platform and mast for full levelling range
Controls	Visibility shall remain at control point	
Protection from falling objects	NA	
Emergency lowering	Standard arrangements	
Buffers	According to 5.3.4 i) and Instruction handbook	
Upper travel limit switch	Standard arrangements	
Lower travel limit switch	Special adjustment when subsidiary work platform is below primary work platform	
Separation distance between work platforms	Fixed separation $\leqslant$ 3 m For minimum clearance see 5.3.4 e)	
Safety devices against falling (see 5.5)	Allow for any extra load	
Instruction handbook	Full information shall be given on how to erect and dismantle and on the use of the multilevel platform	

NA = Not applicable.

Table B.2 — Option B



OPTION B

Two or more work platforms

separately driven on common mast(s)

Key

1 separation distance

Requirements	Single mast	Multiple masts
Allow for the effect on calculations/rated load	Independent calculation of each work platform	
Allow for additional forces on mast and mast ties	Yes	Yes
Allow for additional in- and out-of-service wind forces	Yes	Yes
Allow for the effect on stability	Yes	Yes
Guardrails and toeboards	Yes	Yes
Ladder	No – See 5.3.4 f)	
Trap door	NA	NA
Fixings and stability of subsidiary work platform in relation to the primary work platform	NA	NA
Supported on primary work platform or on platform extensions	NA	NA
Platform levelling	Separate arrangements for each platform	
Controls	Separate controls for each platform	
Protection from falling objects	Lower work platform(s) shall be protected from upper work platform. See 5.3.4 d) and Instruction handbook	
Emergency lowering	Standard arrangements	
Buffers	Standard buffers according to 5.4.6	
Upper travel limit switch	Separate switches for each platform	
Lower travel limit switch	Separate switches for each platform	
Separation distance between work platforms	See 5.3.4 e)	
Safety devices against falling (see 5.5)	Separate arrangements each work platform	
Instruction handbook	Full information shall be given on how to create and dismantle and on the use of the multilevel platform	
NA = Not applicable.		

Annex C
(normative)

Requirements for electrical and electronic aspects for overload-detection devices

C.1 Reliability

C.1.1 Electronic components shall be selected on the basis of the most unfavourable load, temperature and tolerance parameters.

C.1.2 The power consumption of electronic components shall not exceed 66 % of the power stated by the manufacturer at an ambient temperature outside the housing of 60 °C.

C.1.3 Detection devices shall be such that their sound operation is not affected by ambient temperatures between – 20 °C and 60 °C outside the housings. Within the range of these temperatures, deviation from the set value shall not exceed ± 3 %.

The design should take into account that, under the circumstances described, a temperature higher than 60 °C can be reached inside the housing.

C.1.4 Electronic detection devices or their components shall be such that their operation is not affected by the following.

a) Voltage pulses superimposed on the mains voltage:

- amplitude: 1 000 V;
- pulse duration: 50 µs (measured at 50 % of the peak value of the voltage pulse);
- rise time: 0,2 µs to 0,5 µs.

b) Voltage pulses between mains and earth:

- amplitude: 500 V;
- pulse duration: 100 ns (measured at 50 % of the peak value of the voltage pulse);
- rise time: 10 ns;
- pulse repetition rate: 10 Hz.

c) Voltage pulses between inputs or outputs and earth (common mode):

- amplitude: 500 V;
- pulse duration: 100 ns (measured at 50 % of the peak value of the voltage pulse);
- pulse repetition rate: 10 Hz;
- rise time: 10 ns.

d) Alternating magnetic fields:

- magnetic field strength: 400 A/m;
- frequency: 50 Hz.

e) Electromagnetic fields:

— strength: 4 V/m;

— frequency: 100 kHz to 500 MHz.

C.2 Reporting defects

C.2.1 The occurrence in a detection device of the defects given below in C.2.3 shall not cause inability to switch off the MCWP if the limit value is exceeded.

C.2.2 The detection device shall be designed and connected to the electric installation of the MCWP in such a way that:

a) after the occurrence of one of the defects or actions given under C.2.3.1 a), the MCWP installation is automatically switched off and can no longer be started before the defect or interruption is eliminated, and

b) after occurrence of one of the defects given under C.2.3.1 b) and after the MCWP is switched off, the MCWP can no longer be started before the defect is eliminated. This requirement does not apply if continued safe operation of the MCWP is automatically ensured by the detecting device.

These provisions can be met by one of the following measures.

— Design the circuit of the detecting device in such a way that the prescribed continued switched-off condition of the MCWP is achieved when a defect has developed.

— Use a circuit to check the circuits in the detecting device for the presence of a defect; such a circuit shall be designed and connected in such a way that

  — the relevant test key shall be operated after each MCWP shut-down before the MCWP installation can be started, and

  — the MCWP installation cannot be started if there is a defect in the test circuit or in the detecting device.

— Design multiple circuits in the detecting device and incorporate them in a test circuit; the test circuit shall be designed and connected in such a way that the MCWP is switched off if there is a defect in the test circuit or one of the parallel circuits of the detecting device.

— Earth or connect to the frame of a circuit in which relays or solenoid switches are incorporated to ensure the MCWP is switched off if earth or frame leakage occurs.

C.2.3 Defects to be anticipated

C.2.3.1 The following defects can be anticipated, and subsequent actions shall be taken into account on the basis of C.2.1 and C.2.2.

a) A break, dislodging or detachment of a cable forming the connection between the individual units of the installation which are mounted in cabinets, as evidenced by the following:

  — interruption or drop in (one of) the supply voltage(s) at any moment;

  — earth or frame leakage or interruption in the circuit;

  — relay contact or contactor failing to open or close;

  — auxiliary switch (such as a limit switch, hand operated switch, etc.) failing to open or close;

- interruption or short-circuit in a signal transmitter (such as a potentiometer, strain-gauge bridge or transducer);
- interrupted connection of or short-circuit in a semiconductor component (such as a transistor, diode or optocoupler) or a capacitor;
- short-circuit or interruption in a resistor;
- a defect causing the output of an integrated circuit to give a positive or negative potential. If several similar circuits are mounted on a semiconductor printed circuit board, allowance shall be made for the same defect occurring simultaneously in all circuits.

NOTE Requirements for microprocessor applications are under consideration.

C.2.3.2 The provisions of C.2.3.1 do not apply to the following defects:

- short-circuit between the cores of a cable if the cable satisfies the requirements provided in the relevant national standard(s) and if the rated voltage of the auxiliary circuit does not exceed that of the cable;
- a contact not opening if the relay satisfies the requirements in IEC 60947-5-1 and proper protection against influences from the ambience is installed;
- a contactor contact not opening if the contact load does not exceed 25 % of its rated power and proper protection against influences from the ambience is installed;
- a control switch not opening which is forced open mechanically if the values specified by the manufacturer for electrical protection, rated power, method of installation, rate and angle of operation, etc. are take into account for installation of the contact; bridging of an auxiliary switch by (an) insulation defect(s) (but do apply if this results from earth leakage or moisture, against which a waterproof housing is often a reasonable solution);
- interruption of or short-circuit between tracks of printed circuits if the printed circuits satisfy the applicable requirements specified in IEC 60065;
- short-circuit in an optocoupler if the creepage paths and air gaps between the connecting wires may be regarded as adequate and a test voltage of 2,8 kV can be sustained between the input and output circuits;
- interruption or short-circuit in a resistor if the resistor has an insulating paint coating, a reduction of the rate power up to approximately 66 % has been applied, and short-circuit of the resistor is otherwise also prevented (by, for example, its arrangement).

C.2.3.3 If more defects can occur in the detecting device due to a defect in a component, the provisions of C.2.1 and C.2.2 are then also applicable.

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