BS EN 1777:2010

BSI Standards Publication

Hydraulic platforms (HPs) for fire fighting and rescue services — Safety requirements and testing

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National foreword

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The UK participation in its preparation was entrusted to Technical Committee FSH/17/9, Fire appliances and associated operational equipment.

A list of organizations represented on this committee can be obtained on request to its secretary.

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ISBN 978 0 580 59458 8

ICS 13.220.10

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This British Standard was published under the authority of the Standards Policy and Strategy Committee on 31 August 2010.

Amendments issued since publication

Date	Text affected

EUROPEAN STANDARD

NORME EUROPÉENNE

EUROPÄISCHE NORM

EN 1777

March 2010

ICS 13.220.10

Supersedes EN 1777:2004+A1:2009

English Version

Hydraulic platforms (HPs) for fire fighting and rescue services - Safety requirements and testing

Bras Élévateur Aérien (BEA) des services d'incendie et de secours - Prescriptions de sécurité et essais

Hubrettungsfahrzeuge für Feuerwehren und Rettungsdienste, Hubarbeitsbühnen (HABn) - Sicherheitstechnische Anforderungen und Prüfung

This European Standard was approved by CEN on 6 February 2010.

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Ref. No. EN 1777:2010: E

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Foreword

This document (EN 1777:2010) has been prepared by Technical Committee CEN/TC 192 “Fire service equipment”, the secretariat of which is held by BSI.

This European Standard shall be given the status of a national standard, either by publication of an identical text or by endorsement, at the latest by September 2010, and conflicting national standards shall be withdrawn at the latest by September 2010.

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

This document supersedes EN 1777:2004+A1:2009.

This document has been prepared under a mandate given to CEN by the European Commission and the European Free Trade Association, and supports essential requirements of EU Directive(s).

For relationship with EU Directive(s), see informative Annex ZA, which is an integral part of this document.

Significant changes

The significant changes with respect to the previous edition EN 1777:2004+A1:2009 are listed below:

a) Scope revised to state more precisely, limitation of scope to HP's with classification group B – type 1 according to EN 280:2001, 1.4 only and deletion of requirements and tests relating to all other groups and types not covered by the scope, flat belts for extending structure drive systems excluded from scope;

b) terms and definitions of "hydraulic platform (HP)" and "levelling" added;

c) some terms and definitions revised;

d) list of significant hazards editorially revised and hazards relating to self propelled HP's and Group A HP's (where the vertical projection of the centre of gravity of the load is always inside the tipping lines) deleted, which are outside the scope;

e) specific tests directly linked to the appropriate requirement;

f) requirements relating to temperature range, forces, calculation, fatigue stress analyses, chassis and stabilizers revised;

g) requirements and tests added relating to "Moment sensing system with increased safety requirements and enhanced overload criteria" as a new, fourth solution to reduce tilting hazards and hazards caused by exceeding of permissible loads;

h) requirements and tests added relating to a minimum residual load of 6 % of the vehicle's unladen mass (obtained on the not loaded side, in the most unfavourable position);

i) new subclause 5.13 "Safety devices" added analogous to EN 280/A1:2004;

j) requirement added that the extending structure shall be supported in the transport position in such a way as to avoid harmful vibrations during transport;

k) requirement added that failures in wire rope or chain drive systems for extending structure shall be self-revealing;

l) maximum tensile grade of the wires in wire rope drive systems for extending structure increased to 2 160 N/mm^2;

m) leadscrew and rack and pinion drive systems deleted;

n) warning signals shall consist of a continuous visual warning and an acoustic signal;

o) height difference after the static overload test is now depending from the rescue height (for HP's with a rescue height up to 30 m, the height difference shall be less than 100 mm following application of 150 % of the rated load 10 min after unloading, for HP's with a rescue height greater than 30 m the manufacturer shall state the maximum height difference);

p) emergency evacuation means for the platform added (rescue ladder fixed in parallel to the extending structure or alternatives after carrying out a risk assessment);

q) requirements on platform doors and guardrails/handrails revised;

r) anchoring points for the allowed number of persons in the cage for personal protective equipment against falling added;

s) device added to stop all aggravating movements on sustaining impact;

t) requirements and tests relating to operator seat, controls and electrical systems revised;

u) pneumatic and hydraulic control systems revised that besides the specific requirements the basic standards EN 983 and EN 982 applies;

v) requirements and tests revised relating to static tilt angle δ;

w) at acceptance tests and at periodical examinations and tests the static overload test has been added;

x) instruction handbook added with test report, where appropriate, detailing the static and dynamic tests;

y) operating instructions for emergency added;

z) marking revised;

aa) Annex A and Annex B revised according to the changes in EN 280;

bb) former Annex F (Calculation example — Dynamic factor, kerb test) deleted, because the kerb test relates to self propelled HP's, which are outside the scope;

cc) content of standard editorially revised.

According to the CEN/CENELEC Internal Regulations, the national standards organizations of the following countries are bound to implement this European Standard: Austria, Belgium, Bulgaria, Croatia, Cyprus, Czech Republic, Denmark, Estonia, Finland, France, Germany, Greece, Hungary, Iceland, Ireland, Italy, Latvia, Lithuania, Luxembourg, Malta, Netherlands, Norway, Poland, Portugal, Romania, Slovakia, Slovenia, Spain, Sweden, Switzerland and the United Kingdom.

Introduction

This document is a type C standard as stated in EN ISO 12100.

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

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

As no satisfactory explanation could be found for the dynamic factors used for stability calculations in EN 280 and previous national standards, the results of the tests carried out by CEN/TC 98 "Lifting platforms" to determine a suitable factor and stability calculation method for mobile elevating work platforms (MEWPs) have been adopted. The test method is described in Annex B as a guide for manufacturers wishing to use higher or lower operating speeds and to take advantage of developments in control systems.

Similarly, to avoid the unexplained inconsistencies in wire rope coefficients of utilization and drum and pulley diameters found in other standards for lifting devices, EN 280:2001, Annex C based on DIN 15020-1, together with EN 280:2001, Annex D, have been adopted.

1 Scope

This European Standard applies to vehicle mounted Hydraulic Platforms (HP's) as defined in 3.1, intended for use by fire and rescue services. HP's may participate in fire fighting, rescue or protection of persons, protection of the environment and in a variety of other technical operations.

This document identifies the significant hazards (see Clause 4) for all sizes of HP's used by fire and rescue services, on the basis that they are supplied in a complete form, tested and ready for use. It also gives methods for the elimination or reduction of these hazards. This document applies only to HP's classified in group B – type 1 according to EN 280:2001, 1.4.

NOTE 1 HPs of group B – type 1 are those where the vertical projection of the centre of gravity of the load may be outside the tipping lines and for which travelling is only allowed with the HP in its travel condition.

Consequently this document does not apply to HP's with the following classification according to EN 280:2001, 1.4:

— group A – type 1;

— group A – type 2;

— group A – type 3;

— group B – type 2;

— group B – type 3.

This document is intended to be used in conjunction with EN 1846-2 and EN 1846-3.

This document deals with the technical safety requirements to minimise the hazards listed in Clause 4 which can arise during the commissioning, the operational use, the routine checking and maintenance of hydraulic platforms when carried out in accordance with the specifications given by the manufacturer or his authorised representative.

This document deals with all significant hazards, hazardous situations and events relevant to HP's, when they are used as intended and under conditions of misuse which are reasonably foreseeable by the manufacturer and taking account of their whole lifecycle (see Clause 4).

NOTE 2 The lifecycle includes construction, transport, assembly and installation, commissioning, use (including setting, teaching/programming or process changeover), operation, cleaning, fault finding, maintenance, decommissioning, dismantling and, as far as safety is concerned, disposal.

This document does not deal with the additional hazards for:

— use in underground work (mines);

— use in potentially explosive atmospheres;

— flat belts for extending structure drive systems.

This document is not applicable to HP's which were manufactured before the date of publication of this document by CEN.

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.

EN 349, *Safety of machinery — Minimum gaps to avoid crushing of parts of the human body*

EN 842, *Safety of machinery — Visual danger signals — General requirements, design and testing*

EN 894-1, *Safety of machinery — Ergonomics requirements for the design of displays and control actuators — Part 1: General principles for human interactions with displays and control actuators*

EN 894-2, *Safety of machinery — Ergonomics requirements for the design of displays and control actuators — Part 2: Displays*

EN 894-3, *Safety of machinery — Ergonomics requirements for the design of displays and control actuators — Part 3: Control actuators*

prEN 894-4, *Safety of machinery — Ergonomics requirements for the design of displays and control actuators — Part 4: Location and arrangement of displays and control actuators*

EN 981, *Safety of machinery — System of auditory and visual danger and information signals*

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

EN 983, *Safety of machinery — Safety requirements for fluid power systems and their components — Pneumatics*

EN 1846-1:1998, *Firefighting and rescue service vehicles — Part 1: Nomenclature and designation*

EN 1846-2:2009, *Firefighting and rescue service vehicles — Part 2: Common requirements — Safety and performance*

EN 1846-3, *Firefighting and rescue service vehicles — Part 3: Permanently installed equipment — Safety and performance*

EN 60204-1:2006, *Safety of machinery — Electrical equipment of machines — Part 1: General requirements (IEC 60204-1:2005, modified)*

EN 60529, *Degrees of protection provided by enclosures (IP code) (IEC 60529:1989)*

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

CEN/TS 15989, *Firefighting vehicles and equipment — Symbols for operator controls and other displays*

EN ISO 12100-1:2003, *Safety of machinery — Basic concepts, general principles for design — Part 1: Basic terminology, methodology (ISO 12100-1:2003)*

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

EN ISO 13732-1, *Ergonomics of the thermal environment — Methods for the assessment of human responses to contact with surfaces — Part 1: Hot surfaces (ISO 13732-1:2006)*

EN ISO 13849-1:2008, *Safety of machinery — Safety-related parts of control systems — Part 1: General principles for design (ISO 13849-1:2006)*

EN ISO 13849-2, *Safety of machinery — Safety-related parts of control systems — Part 2: Validation (ISO 13849-2:2003)*

EN ISO 13850, *Safety of machinery — Emergency stop — Principles for design (ISO 13850:2006)*

EN ISO 14122-3, *Safety of machinery — Permanent means of access to machinery — Part 3: Stairs, stepladders and guard-rails (ISO 14122-3:2001)*

EN ISO 14122-4, *Safety of machinery — Permanent means of access to machinery — Part 4: Fixed ladders (ISO 14122-4:2004)*

ISO 2408:2004, *Steel wire ropes for general purposes — Minimum requirements*

ISO 3864-1, *Graphical symbols — Safety colours and safety signs — Part 1: Design principles for safety signs in workplaces and public areas*

ISO 3864-2:2004, *Graphical symbols — Safety colours and safety signs — Part 2: Design principles for product safety labels*

ISO 3864-3, *Graphical symbols — Safety colours and safety signs — Part 3: Design principles for graphical symbols for use in safety signs*

ISO 4305, *Mobile cranes — Determination of stability*

ISO 4309, *Cranes — Wire ropes — Care, maintenance, installation, examination and discard*

3 Terms and definitions

For the purposes of this document, the terms and definitions given in EN 1846-1:1998, EN 1846-2:2009, EN ISO 12100-1:2003 and the following apply.

NOTE The terms platform, extending structure, base, lowering/raising, slewing, rotating and travelling are illustrated in Figure 1 and Figure 2.

3.1
hydraulic platform
HP
<high rise aerial appliances for fire and rescue services> elevating platform consisting of a work platform and a hydraulic extending structure, mounted on a base that is a self propelled chassis and intended for moving persons and their equipment, and in some cases also fire fighting monitors, to working locations for interventions such as those related to fire fighting, rescue or protection of persons, protection of the environment and in a variety of other technical operations

3.2
platform
<high rise aerial appliances for fire and rescue services> fenced platform in which persons and equipment are carried and which can be moved under load to the required working position by the extending structure and/or by movement of the base

NOTE Secondary platforms may include for example extended floors outside guardrails for rescue purposes or landings for access to boom ladders.

3.3
extending structure
<high rise aerial appliances for fire and rescue services> one or more rigid or telescopic or articulating mechanisms, or any combination of them in the form of booms and/or ladders or scissor mechanism which may or may not slew on the base

3.4
stabilizer
<high rise aerial appliances for fire and rescue services> device or system used to maintain the stability of the HP

NOTE These include for example screw jacks, hydraulic jacks, outriggers, vehicle suspension locking devices, extending axles, systems for levelling the extending structure relative to the base, etc.

3.5
access position
<high rise aerial appliances for fire and rescue services> position of the HP to provide access to the platform

NOTE Access position and travel condition (see 3.6) may be identical.

3.6
travel condition
<high rise aerial appliances for fire and rescue services> condition of the HP prescribed by the manufacturer for travelling to and from the place of use

NOTE Access position (see 3.5) and travel condition may be identical.

3.7
lowering
operation to move the platform to a lower level

3.8
raising
operation to move the platform to a higher level

3.9
rotating
circular movement of the platform relative to the extending structure, around a vertical axis

3.10
slewing
circular movement of the extending structure around a vertical axis

3.11
travelling
<high rise aerial appliances for fire and rescue services> movement of the base

3.12
rated load
<high rise aerial appliances for fire and rescue services> maximum load at which a platform may be loaded vertically in the limits of the corresponding working envelope of the extending structure, composed of persons and loose equipment and except permanently fixed items which are not part of the rated load

NOTE There may be more than one combination of rated load and working envelope (see 3.13).

3.13
working envelope
<high rise aerial appliances for fire and rescue services> space, defined by the manufacturer, within which the platform, with rated load, can be operated

NOTE There may be more than one combination of rated load (see 3.12) and working envelope.

3.14
residual slope
<high rise aerial appliances for fire and rescue services> deviation from horizontal of the base or any slewing mechanism after deployment of the stabilizers

3.15
full flow hydraulic/pneumatic control
control where the control level or handle used by the operator is an integral part of, or is connected mechanically to, the valve which directs the full flow of the medium to the machine actuators (motors, cylinders, etc.) with no other intermediate control system (pilot hydraulic, master/slave, electrical, pneumatic, etc.)

NOTE There are hydraulic or pneumatic full flow controls.

3.16
operating time
<high rise aerial appliances for fire and rescue services> time required from the travel condition with the crew in the cab, to set any stabilizers to full width on a level supporting surface and, with one person on the platform, to reach the maximum rescue height, using the vehicle crew, and, if slewing exists, to reach the maximum rescue height at a position 90° to the longitudinal axis of the vehicle

NOTE See Figure 16.

3.17
rescue height
<high rise aerial appliances for fire and rescue services> vertical height from the horizontal ground surface to the bottom of the rescue cage without loading

NOTE The rescue height is expressed in metres (m).

3.18
rescue ladder rated load
<high rise aerial appliances for fire and rescue services> maximum number of persons each with a mass of 90 kg allowed on a ladder as specified by the manufacturer

3.19
access ladder
<high rise aerial appliances for fire and rescue services> ladder intended to access to the deck of the base and to the platform

3.20
rescue ladder
<high rise aerial appliances for fire and rescue services> ladder on or being part of the extending structure intended to be used for rescuing persons by carrying them down and for the crew by stepping down from the cage to the deck of the base

3.21
loose equipment
<high rise aerial appliances for fire and rescue services> item carried on the platform which is neither permanently secured nor part of the operator's basic minimum protective equipment

EXAMPLES Hoses, nozzles, rescue lines, resuscitators, etc.

3.22
manual force
<high rise aerial appliances for fire and rescue services> force exerted by operators on the platform on objects/structures which is outside of the platform when the platform is stationary

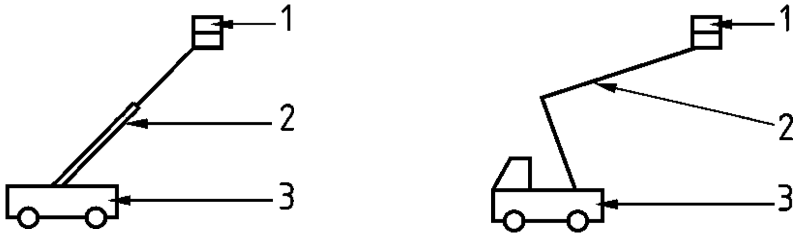
3.23
load sensing system
<high rise aerial appliances for fire and rescue services> system of monitoring the vertical load and vertical forces on the platform

NOTE The system includes the measuring device(s), the method of mounting the measuring device(s) and the signal processing system.

3.24
moment sensing system
<high rise aerial appliances for fire and rescue services> system of monitoring the overturning moment acting about the tipping line tending to overturn the hydraulic platform and system of monitoring exceeding permissible stresses

NOTE The system includes the measuring devices(s), the method of mounting the measuring devices(s) and the signal processing system.

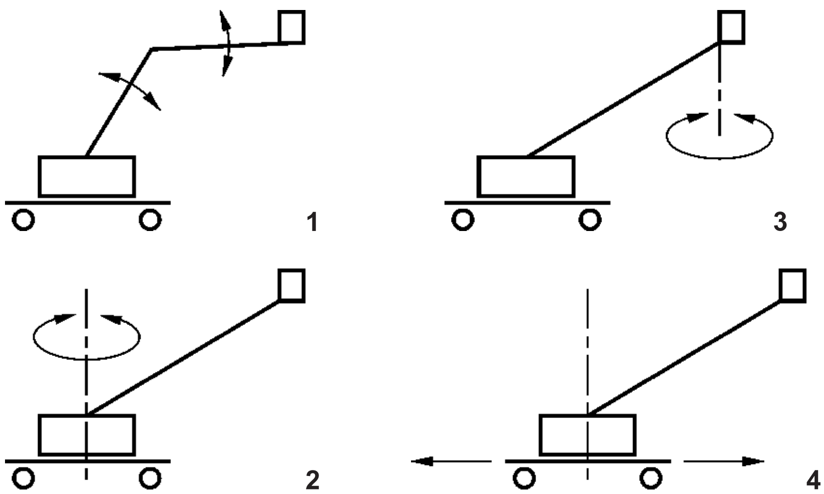
3.25
levelling
<high rise aerial appliances for fire and rescue services> device allowing the platform floor to be maintained at the horizontal position



Key

1 platform (3.2)
2 extending structure (3.3)
3 base

Figure 1 — Illustration of definitions in 3.2 and 3.3



Key

1	lowering/raising (3.7/3.8)	3	rotating (3.9)
2	slewing (3.10)	4	travelling (3.11)

Figure 2 — Illustration of definitions in 3.7 to 3.11

4 List of significant hazards

This clause contains in Table 1 all the significant hazards, hazardous situations and events, as far as they are dealt with in this document, identified by risk assessment as significant for this type of machinery and which require action to eliminate or reduce the risk.

The significant hazards are based on EN ISO 14121-1:2007, Annex A. Also shown are the subclause references to the safety requirements and/or protective measures in this document, if applicable.

Table 1 — List of significant hazards

No	Hazard	Corresponding clause/subclause in this document
4.1	**Mechanical hazards:**	
4.1.1	Crushing hazards	5.3.12, 5.4.4, 5.3.13, 5.6.7
4.1.2	Shearing hazards	5.3.12, 5.4.4
4.1.3	Cutting or Severing hazard	5.7.11
4.1.4	Entanglement hazard	5.3.14
4.1.5	Drawing-in or trapping hazard	5.3.14
4.1.6	Impact hazard	7.1.2, g) and 7.1.2, p)
4.1.7	Friction or abrasion hazard	7.1.7, e)
4.1.8	High pressure fluid injection hazard	5.7.15
4.1.9	Loss of stability (of machinery and machine parts)	5.2.4
4.1.10	Slip, trip and fall hazards	5.3.6, 5.3.18, 5.6.2, 5.6.3, 5.6.5, 5.6.6, 5.6.7
4.2	**Electrical hazards, caused for example by:**	
4.2.1	Electrical contact, direct or indirect	7.1.2, g)
4.2.2	Electrostatic phenomena	5.3.20
4.2.3	Thermal radiation	5.8
4.2.4	External influences on electrical equipment	5.8
4.3	**Thermal hazards, resulting for example in:**	
4.3.1	Burns and scalds by a possible contact of persons by flames or explosions and also by the radiation of heat sources	5.3.14
4.3.2	Health-damaging effects by hot or cold work environment	5.3.14
4.4	**Hazards generated by noise, resulting for example in:**	
4.4.1	Hearing losses (deafness) other physiological disorders e.g. loss of balance, loss of awareness, etc.)	5.3.10
4.4.2	Interference with speech communication, acoustic signals, etc	5.3.10
4.5	**Hazards generated by vibration (resulting in a variety of neurological and vascular disorders)**	7.1.2, k)
4.6	**Hazards generated by radiation, especially by:**	
4.6.1	Machine making use of high frequency electromagnetic fields	5.8
4.7	**Hazards generated by materials and substances processed, used or exhausted by machinery for example:**	
4.7.1	Hazards resulting from contact with or inhalation of harmful fluids, gases, mists, dusts and fumes	5.3.16
4.7.2	Fire or explosion hazard	5.3.18
4.8	**Hazards generated by neglecting ergonomic principles in machine design (mismatch of machinery with human characteristics and abilities) caused e.g. by:**	
4.8.1	Unhealthy postures or excessive efforts	5.6.7
4.8.2	Inadequacy with human hand-arm or foot-leg anatomy	5.7.4, 5.7.5
4.8.3	Neglected use of personal protection equipment	5.7.4, 5.7.5
4.8.4	Inadequate local lighting	5.7.1
4.8.5	Mental overload or under-load, stress, etc.	5.4.6, 5.7.1, 5.7.6
4.8.6	Human errors	5.9.8, 5.10.11

Table 1 *(continued)*

No	Hazard	Corresponding clause/subclause in this document
4.9	**Hazards caused by failure of energy supply, breaking down of machinery parts, and other functional disorders e.g.:**	
4.9.1	Failure of energy supply (of power and/or control circuits)	5.7.8, 5.7.11, 5.7.14
4.9.2	Unexpected ejection of machine parts or fluids	5.7.15
4.9.3	Failure/disorder of control system	5.7.1, 7.2.2
4.9.4	Errors of fitting	5.8, 5.9.8, 5.10.11
4.9.5	Overturn, unexpected loss of machine stability	5.2.4, 6.1.2, 6.1.6
4.10	**Hazards caused by (temporary) missing and/or incorrectly positioned safety-related measures/means, e.g.:**	
4.10.1	All kinds of guard	5.3.14
4.10.2	All kinds of safety related (protection) devices	5.3.12, 5.4.4
4.10.3	Starting and stopping devices	5.7.1, 5.7.7
4.10.4	Safety signs and tags	5.10.10, 7.2.2, 7.3
4.10.5	All kinds of information or warning devices	5.3.1, 5.3.9, 7.1.7, c), 7.2
4.10.6	Energy supply disconnecting devices	5.10.10
4.10.7	Emergency devices	5.7.7, 5.7.11
4.10.8	Essential equipment and accessories for safe adjusting and/or maintaining	7.1.7, d)
4.10.9	Equipment evacuating gases, etc.	5.3.16
4.11	**Inadequate lighting of moving/working area**	5.7.1
4.12	**Hazards due to sudden movement, instability, etc. during handling**	5.2, 5.2.3
4.13	**Inadequate/non ergonomic design of driving/operating position:**	
4.13.1	Hazards due to dangerous environments (contact with moving parts, exhaust gases, etc.)	5.3.14, 5.3.16
4.13.2	Inadequate visibility from driver's/operator's position	5.3.13, 5.7.6
4.13.3	Inadequate seat/seating (seat index point)	5.4.6
4.13.4	Inadequate/non ergonomic design/positioning of controls	5.7.1
4.13.5	Starting/moving of self-propelled machinery	5.7.2
4.14	**Mechanical hazards:**	
4.14.1	Hazards to exposed persons due to uncontrolled movement	5.7.1
4.14.2	Hazards due to break-up and/or ejection of parts	5.2
4.14.3	Inadequate means of access	5.3.18, 5.6.7
4.14.4	Hazards due to batteries, fire, emissions, etc.	5.3.17, 5.3.19
4.15	**Hazards due to lifting operation**	
4.15.1	Lack of stability	5.4.1, 6.1.2
4.15.2	Loss of mechanical strength of machinery and lifting accessories	5.2.5, 5.4.1
4.15.3	Hazards caused by uncontrolled movements	5.4.1, 5.5.1.1, 5.5.1.3
4.16	**Inadequate view of trajectories of the moving parts**	5.7.6
4.17	**Hazards caused by lightning**	5.3.20
4.18	**Hazards due to loading/overloading, etc.**	5.4.1

Table 1 *(continued)*

No	Hazard	Corresponding clause/subclause in this document
4.19	**General:**	
4.19.1	Mechanical strength	5.5.2.2, 5.5.3.2
4.19.2	Loading control	5.4.1
4.19.3	Vibration damages of extending structure during transport	5.4.7
4.20	**Controls:**	
4.20.1	Controls in carrier	5.7.6
4.20.2	Safe speed control	5.7.2
4.21	**Fall prevention:**	
4.21.1	Personal Protective Equipment in carrier	5.6.3
4.21.2	Trapdoors	5.6.8
4.21.3	Carrier tilt control	5.6.1, 5.6.2
4.22	**Carrier falling/overturning:**	
4.22.1	Falling/overturning	5.5.1.1, 5.6.1, 5.6.2
4.22.2	Acceleration/braking	5.7.2
4.22.3	Markings	7.2
4.23	**Insufficient means for evacuation/emergency exit**	5.4.5

5 Safety requirements and/or protective measures

5.1 General

Machinery shall comply with the safety requirements and/or protective measures of this clause. In addition, the machine shall be designed according to the principles of EN ISO 12100 (all parts) for relevant but not significant hazards, which are not dealt with by this document.

NOTE For hazards which are to be reduced by the application of a B-level standard such as EN ISO 13850, EN 982, EN 60204-1, the manufacturer should carry out a risk assessment to establish the requirements of the B-standard which are to be applied. This specific risk assessment should be part of the general risk assessment of the hydraulic platform.

Hydraulic platforms shall comply with the relevant clauses of EN 1846-2 and EN 1846-3.

Hydraulic platforms shall be designed and constructed taking account of the temperature range they are intended for.

5.2 Stability and structural calculations

5.2.1 General

Taking into account the relevant requirements of this document and the intended use of the machine, the manufacturer shall:

a) for stability calculations, identify the various positions of the HP and combinations of loads, forces and removable items creating together conditions of minimum stability; and

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

NOTE It is the user's responsibility to refer other uses to the manufacturer for approval (see 7.1.2, a) and 7.1.8).

5.2.2 Loads and forces

The following loads and forces shall be taken into account:

a) rated load;

b) structural loads;

c) wind loads;

d) manual forces;

e) additional loads and forces;

f) those resulting from operation on any residual slope;

g) those resulting from the use of the emergency stop in 5.7.7.

5.2.3 Determination of loads and forces

5.2.3.1 Rated load

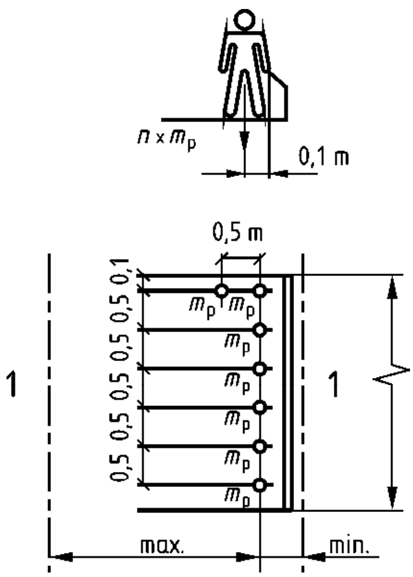
The rated load is made up of persons, each with a nominal mass of 90 kg, and any loose equipment on the platform, within the limits of the corresponding working envelope. The mass of each person shall be taken to act as a point load on the platform at a horizontal distance of 0,1 m from the inside edge of the top rail with a distance between the point loads of 0,5 m. The mass of loose equipment shall be taken to act as an evenly distributed load on 25 % of the floor of the platform. All these loads shall be calculated in the positions and combinations giving the most severe results (see Figure 3 and Figure 4 as examples.).

The rated load shall be taken to act:

a) statically when the platform is not moving;

b) dynamically when the platform is moving.

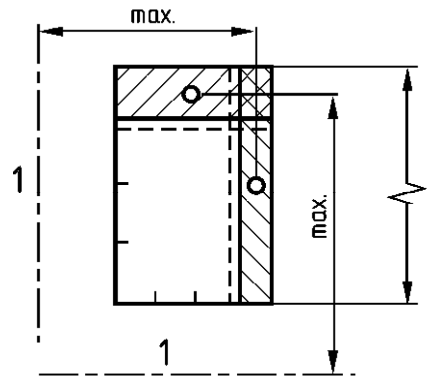
Dimensions in metres



Key

1 tipping line
n number of persons
m_p mass of each person

Figure 3 — Related load – persons



Key

1 tipping line

Figure 4 — Related load – equipment

5.2.3.2 Structural loads

The masses of the components of the HP and fixed items of equipment on the platform or the extending structure shall be taken to be static structural loads when they are not moving. These masses shall be taken to be dynamic structural loads when they are moving.

5.2.3.3 Rescue ladder rated load

The mass of each person on a ladder, on or forming part of the extending structure, shall be taken to act on one ladder rung. The maximum number of persons and their disposition on each ladder section shall be specified by the manufacturer.

5.2.3.4 Wind loads

5.2.3.4.1 HP's used out-of-doors shall be regarded as being affected by wind at a pressure of not less than 100 N/m^2, equivalent to a wind speed of 12,5 m/s (Beaufort Scale 6). See Annex A.

Wind forces are assumed to act horizontally at the centre of area of the parts of the HP and persons and equipment on the platform and/or ladders. They shall be taken to be dynamic forces.

If the HP is intended to be used at higher wind speed the corresponding higher forces shall be taken into account.

5.2.3.4.2 The following shape factors shall be applied to areas exposed to wind:

- L-, U-, T-, I-sections: 1,6
- Box sections: 1,4
- Large flat areas: 1,2
- Circular sections, according to size: 0,8/1,2
- Persons directly exposed: 1,0
- Shielded persons: see 5.2.3.4.3.4

NOTE If additional information is needed, especially concerning shielded structural areas, see ISO 4302.

5.2.3.4.3 Area of persons on a platform or ladder exposed to wind

5.2.3.4.3.1 The full area of one person shall be taken as 0,7 m^2 (0,4 m average width × 1,75 m height) with the centre of area 1,0 m above the platform floor or ladder rung.

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

5.2.3.4.3.3 The number of persons on a platform directly exposed to the wind shall be calculated as:

a) the length of the side of the 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 platform if less than the number calculated in a).

5.2.3.4.3.4 If the number of persons allowed on the platform is greater than in 5.2.3.4.3.3, a) a shape factor of 0,6 shall be applied to the extra number of persons.

5.2.3.4.4 The maximum number of persons allowed on the ladders or the platform and their disposition on the ladders shall be as specified by the manufacturer.

5.2.3.5 Manual force

Unless the intended use includes higher manual forces, the minimum value for the manual force to be taken into account shall be at least 200 N for HP's designed to carry only one person and 400 N for HP's designed to carry more than one person, applied at a height of 1,1 m above the platform floor.

5.2.3.6 Additional loads and forces

When applicable, the rated load specified in 5.2.3.1 shall be modified to take into account the effect of:

a) the mass of each person or equipment carried on secondary platforms taken to act as a point load at the centre of the floor area of the secondary platform;

b) the mass of external loads (attached to the outside of the platform or the extended platforms), e.g. generator and similar equipment, are taken to act as a single point load at the attachment point.

5.2.3.7 Monitor reaction force

The reaction force for straight jets of water from smooth nozzles shall be calculated as:

$$R = \frac{2pa}{10} \qquad (1)$$

where

R is the reaction force in newtons (N);

p is the pressure at the nozzle in bars;

a is the nozzle area in square millimetres (mm^2).

Figures for other types of nozzle (e.g. fog) or for fluid and semi-solid material (e.g. foam, dry powder) shall be taken from the manufacturer's specifications for the monitors or defined by testing.

5.2.4 Stability calculations

5.2.4.1 Calculation of forces and moments

5.2.4.1.1 Forces created by structural masses and rated loads

Forces acting vertically down that are created by structural masses and rated loads and which result in overturning or stabilizing moments shall be multiplied by a factor of 1,0 for the purpose of calculations. When these masses and loads are in motion they shall be multiplied by a factor of 0,1 to obtain the additional dynamic forces to be applied in the direction of movement creating the greatest overturning moment.

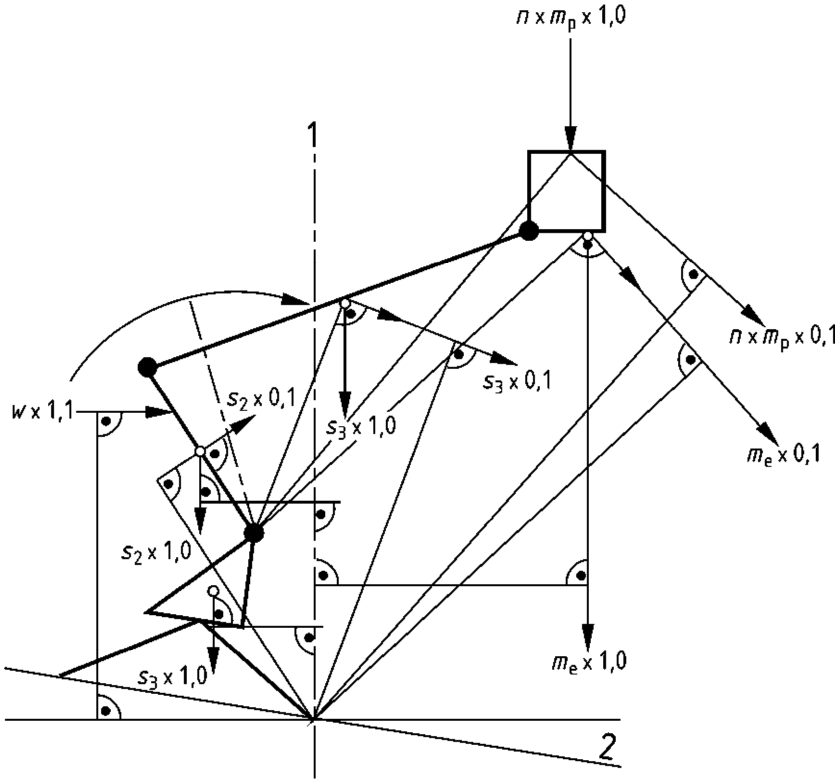
Manufacturers may use factors lower than 0,1 provided that their adequacy have been established by measurement of the effects of acceleration and deceleration in the most unfavourable situations.

5.2.4.1.2 Wind forces

Wind forces shall be multiplied by a factor of 1,1 and taken to be acting horizontally in the direction creating the greatest overturning moment.

5.2.4.1.3 Manual forces

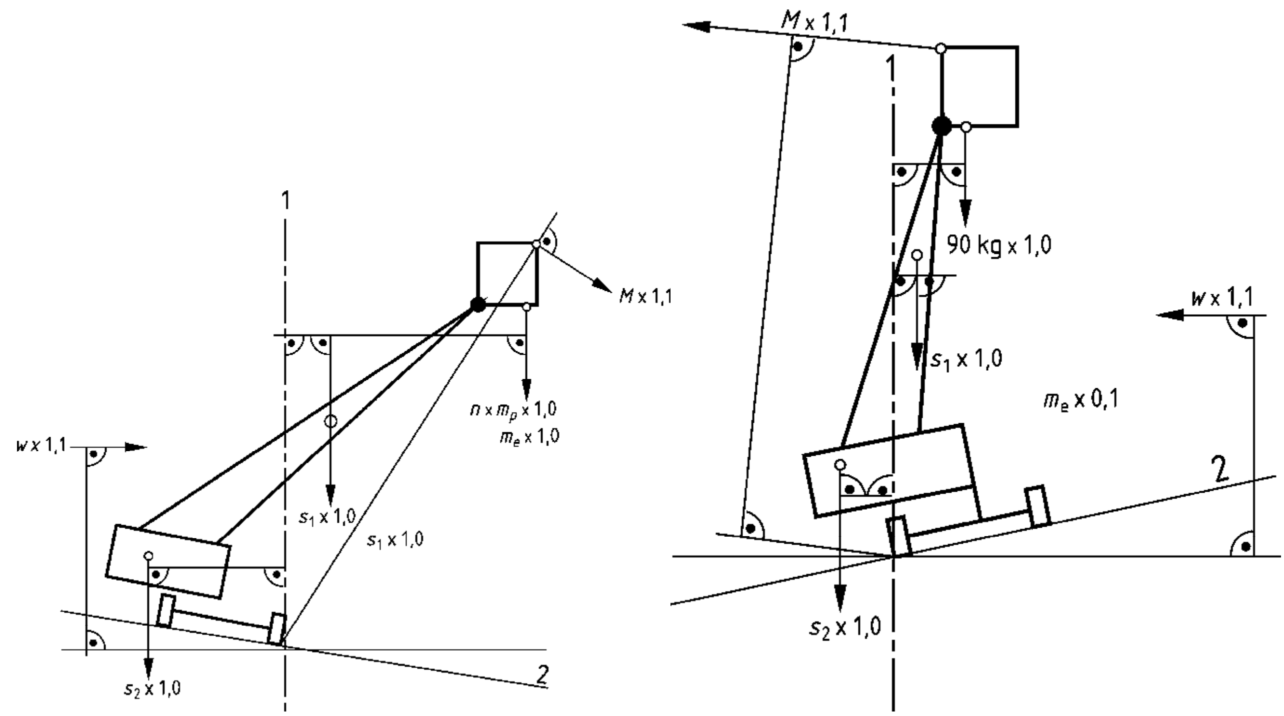
Manual forces applied by persons on the platform shall be multiplied by a factor of 1,1 and taken to be acting in the direction creating the greatest overturning moment (see Figure 5 to Figure 7 for examples).



Key

1	tipping line
2	max. slope + 0,5 °
n	number of persons
m_p	mass of each person
m_e	mass of loose equipment
s_1, s_2, s_3,	structural load
w	wind load

Figure 5 — Example 1 of maximum overturning load and force moment combinations (see Table 2)

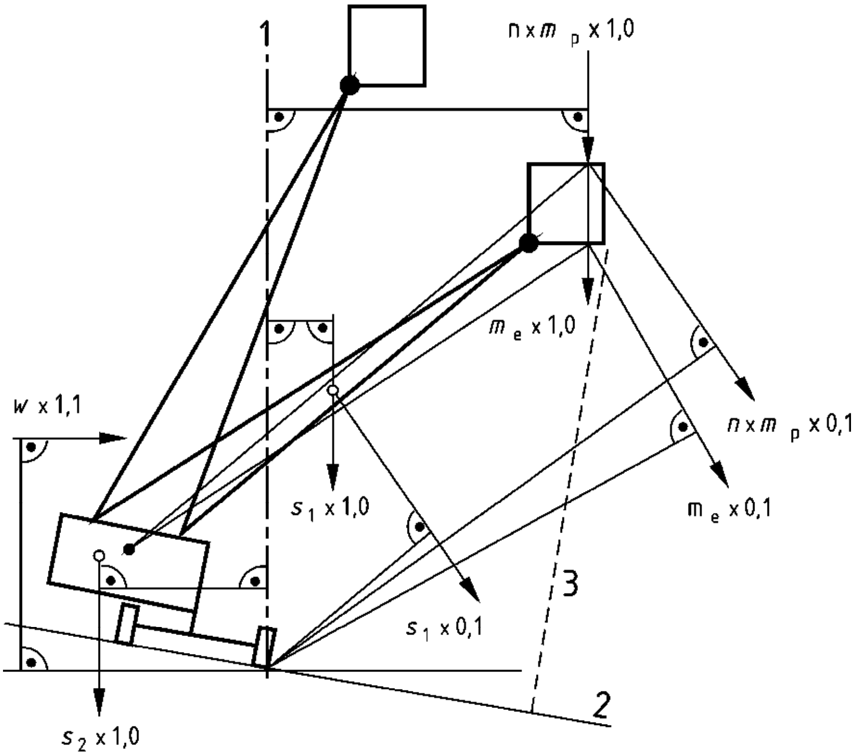


a) Example 2 **b) Example 3**

Key

1	tipping line
2	max slope + 0,5 °
n	number of persons
m_p	mass of each person
m_e	mass of loose equipment
s_1, s_2,	structural load
w	wind load
M	manuel force

Figure 6 — Examples 2 and 3 of maximum overturning load and force moment combinations (see Table 2)



Key

1	tipping line
2	max slope
3	limited reach
n	number of persons
m_p	mass of each person
m_e	mass of loose equipment
s_1, s_2,	structural load
w	wind load

Figure 7 — Example 4 of maximum overturning load and force moment combinations (see Table 2)

5.2.4.1.4 Additional loads and forces

Additional loads and forces according to 5.2.3.6 shall be treated in the same way as specified in 5.2.4.1.1, 5.2.4.1.2 and 5.2.4.1.3.

5.2.4.1.5 Calculation of overturning and stabilizing moments

The maximum overturning and corresponding stabilizing moments shall be calculated about the most unfavourable tipping lines, allowing for the failure of any one tyre in the case of HP's constructed for operation on pneumatic tyres.

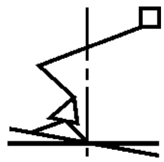
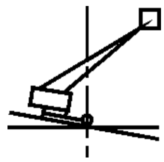
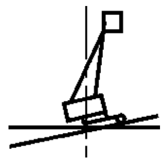
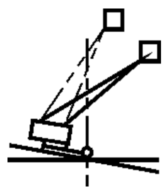
Tipping lines shall be determined as shown in ISO 4305 and Figure 5 to Figure 7 of this document.

For pneumatic tyres the tipping lines shall be taken at half the tyre width. For solid and foam filled tyres the tipping lines shall be taken at 1/4 of the tyre contact width from the outside of the contact width.

The calculations shall be made with the HP in the most unfavourable extended and/or retracted positions with the maximum allowable residual slope (see Figure 5 to Figure 7). An allowance of 0,5° inaccuracy in setting-up the HP shall be added to the maximum allowable residual slope defined by the manufacturer.

All loads and forces, which can act simultaneously shall be taken into account in their most unfavourable combinations. For example, when the load has a stabilizing effect an additional stability calculation shall be made assuming only one person (90 kg) is on the platform. Examples are shown in Table 2 and Figure 5 to Figure 7. Graphical methods may be used.

Table 2 — Example of load and force directions and combinations for stability calculations (see Figure 5 to Figure 7)

Example	Operating condition and movement	Rated load (R)		Structural loads (Sn)		Manual force (M)		Wind loads (W)		Additional forces		Diagram
		× 1,0	× 0,1	× 1,0	× 0,1	× 1,0	× 0,1	× 1,0	× 0,1	× 1,0	× 0,1	
1	Raising (lowering)	V	A	V	A	-	-	H	H	a	a	
2	Forward stability, stationary on slope	V	-	V	-	A	A	H	H	a	a	
3	Backward stability, stationary on slope	90 kg V	-	V	-	A	A	H	H	a	a	
4	With limited reach, forwards stability, stationary on slope lowering	V	A	V	A	-	-	H	H	a	a	

Key

V vertical
H horizontal
A angular
a to be specified by the manufacturer

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

Reference to Annex B will show that the safety margin is built into this method.

5.2.4.1.6 Influences on calculation

In the calculation the following influences shall be taken into account:

a) distortions due to inaccuracies in the manufacture of the components;

b) play in the connections of the extending structure;

c) elastic deflections due to the effects of forces;

d) performance of control devices (e.g. position/load/moment/movement controls);

e) failure of any one tyre in the case of HP's supported by pneumatic tyres in the working position.

The determination of the play and elastic deflections shall be obtained by experiment or by calculation.

5.2.4.2 Verification of calculation of forces and moments

Verification: by examination that the calculations are correct and by the stability type tests in 6.1.2.

5.2.5 Structural calculations

5.2.5.1 General

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

For all load bearing components and joints the required information on stresses or safety factors shall be included in the calculations in a clear and easily verifiable form. If necessary for checking the calculations, details of the main dimensions, cross-sections and materials for the individual components and joints shall be given.

5.2.5.2 Calculation methods

Where no relevant harmonised European Standards are available the calculation methods shall comply with generally accepted standard(s) for lifting appliances and mobile cranes, which include fatigue stress calculation methods

Requirements laid down in 5.2.2 and 5.2.3 shall be considered for the determination of loads and forces to be used in the calculations.

The analysis defined in 5.2.5.3 shall be made for the worst load combinations and shall include the effects of a static overload test with 1,25 × rated load or 1,5 × rated load (see 6.1.4) and a dynamic overload test with 1,1 × rated load (see 6.1.6.1.3).

The elastic deformations of slender components shall be taken into account.

The calculated stresses shall not exceed permissible values. The calculated safety factors shall not fall below the required values.

NOTE 1 Manufacturers are recommended, by strain-gauge tests or equivalent methods of analysis, to check peak stresses under the above dynamic test conditions (see also Annex B).

NOTE 2 The permissible values of stresses and the required values of safety factors depend on the material, the load combination and the calculation method.

For the design of hydraulic cylinders see 5.11.

5.2.5.3 Analysis

5.2.5.3.1 General stress analysis

The general stress analysis is the proof against failure by yielding or fracturing. The analysis shall be made for all load bearing components and joints.

5.2.5.3.2 Elastic stability analysis

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

5.2.5.3.3 Fatigue stress analysis

The fatigue stress analysis is the proof against failure due to stress fluctuations.

When determining the load combinations for fatigue stress analysis it is permissible for the rated load to be reduced by the load spectrum factor according to Figure 8, and wind loads and other intermittent loads need not be taken into account. The analysis shall 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 for components may be a multiple of the number of load cycles.

For the purpose of this document a load cycle starts when the platform is loaded in the access position and finishes when the platform is unloaded in the access position after being extended to a working position. Some of the load cycles shall include the fully extended working position.

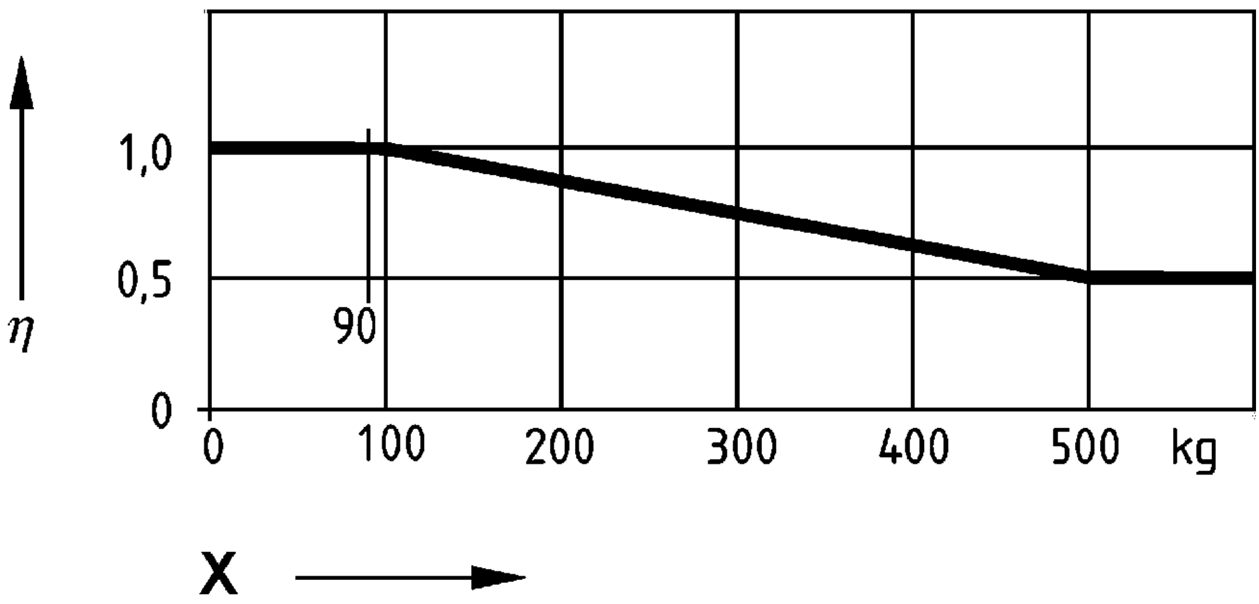
NOTE 1 A precise number of load cycles including full extension is still under consideration.

As the number of stress fluctuations during transport cannot be calculated with any degree of accuracy, the stress in the transport position in components subject to vibration during transport shall be low enough to ensure virtually infinite fatigue life (see also 5.4.7).

For calculation purposes the number of load cycles for HP's in fire service use shall be taken as:

— 58,000 - (15 years, 52 weeks per year, 15 h per week, five cycles per hour).

NOTE 2 For the design of wire rope drive systems see Annex D.



Key

X rated load

η load spectrum factor

Figure 8 — Load spectrum factor η

5.2.5.4 Ladders on or forming part of the extending structure

Each rung shall be designed to support a test load of 180 kg for access ladders, or 300 kg for rescue ladders, applied vertically downwards at any possible position of the ladder, on the central 100 mm width of the rung, without permanent distortion (yield strength Rp 0,2). The supports of any ladders attached to the extending structure shall be designed to support a 180 kg test weight for each of the maximum number of persons allowed on each ladder section and with the distribution specified by the manufacturer, without permanent distortion (yield strength Rp 0,2).

Side rails shall be designed to support a side force of 200 N for each person allowed on the ladder by the manufacturer at 2 m spacing along their length without permanent distortion (yield strength Rp 0,2).

5.2.5.5 Verification of structural calculations

Verification by examination of design calculations, the static overload type test in 6.1.4 and the ladder type tests in 6.1.5.

5.3 Chassis and stabilizers

5.3.1 HP's shall have a safety device (e.g. spirit level) to indicate whether the inclination of the chassis is within the limits permitted by the manufacturer. If relevant the parts of the control system related to this device shall be in accordance with 5.13. This device shall be protected against damage and accidental change of its setting.

For HP's with power driven stabilisers the indication shall be clearly visible from each control position of the stabilizers.

Verification: by visual examination and functional test.

5.3.2 HP's which are constructed for operation with stabilizers shall be equipped with devices in accordance with 5.13 which prevent operation of the extending structure, except as permitted by 5.3.3, unless all the stabilizers are correctly deployed.

Verification: by design check and functional test.

5.3.3 Movement of the extending structure before the stabilizers are correctly deployed shall only be possible provided it is not creating an unstable condition.

Verification: by functional test.

5.3.4 It shall only be possible to operate any stabilizers if the extending structure is in the travel condition.

Verification: by design check and functional test.

5.3.5 Means shall be provided to prevent uncontrolled movements of the stabilizers in the travel condition. This requirement is considered to be satisfied for powered stabilizers in accordance with 5.11. Other stabilizers shall be locked in the travel condition by two separate locking devices for each stabilizer, at least one of which operates automatically, e.g. a gravity locking pin plus a detent.

Verification: by design check and functional test.

5.3.6 HP's with stabilizers shall be capable of levelling the extending structure as follows:

a) rescue height ≤ 30 m: levelling for a residual slope of ≥ 7° in each direction, for special chassis (e.g. low level chassis with long cabin beyond the front axle) levelling for a residual slope of ≥ 5° in longitudinal front direction;

   NOTE For defining the limits of the intended use in relation with the maximum ground inclination see national constructional regulations.

b) rescue height greater than 30 m: levelling in each direction for maximum slope the HP is intended for by the manufacturer;

c) depressions up to 50 mm;

d) humps (kerbs) up to 150 mm.

Verification: by functional test.

5.3.7 The movements of stabilizers shall be limited by mechanical stops. These stops shall be of sufficient strength to absorb the maximum force exerted.

NOTE The ends of hydraulic cylinders, if properly constructed for the purpose, fulfil this requirement.

Verification: by design check.

5.3.8 Any stabilizer feet shall be constructed to accommodate ground unevenness of at least 15° in any direction.

Verification: by measurement.

5.3.9 HP's shall be equipped with an indicating device conforming to the design principles specified in relevant parts of EN 894 visible to the driver to indicate whether or not the HP is in travel condition.

Verification: by functional test.

5.3.10 HP's shall comply with all of the noise reduction requirements of EN 1846-2.

5.3.11 An automatic safety device shall be fitted to prevent travel when the platform is out of the travel condition, e.g. by interlocking the two drive controls.

Verification: by design check and functional test.

5.3.12 Crushing and shearing points between parts of the stabilizers and the base or ground shall be avoided by providing safe clearances in accordance with EN 349 or adequate guarding. For areas such as stabilizers retracting into the transport position where providing safe clearances in accordance with EN 349 or adequate guarding is not practicable, warning signs shall be fitted (see 7.2.13).

Crushing and shearing points need only be considered at those areas within reach of persons standing adjacent to the HP at ground level, at control positions or at other points of access.

Verification: by visual examination.

5.3.13 The position of controls for stabilizers with feet shall provide the operator with visual contact with the stabilizer(s) being operated until the first ground contact of the stabilizer feet.

Verification: by visual examination.

5.3.14 Guards shall be provided to prevent persons at control positions, standing adjacent to the HP at ground level or at other points of access, from reaching hot parts (in accordance with EN ISO 13732-1) or dangerous moving parts of drive systems. Opening or removal of these guards shall only be possible by the use of tools or keys provided with the HP.

Verification: by visual examination.

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

Verification: by visual examination.

5.3.16 Exhaust gases from internal combustion engines shall be led away so that persons are not impaired at control positions or at the site of operation.

Verification: by visual examination.

5.3.17 The filling points of fuel and hydraulic oil tanks shall be positioned to avoid any fire risk from spillage onto very hot parts, e.g. engine exhausts.

Verification: by visual examination.

5.3.18 When the distance between the ground and the floor of the main control stand exceeds 0,5 m, the HP shall be equipped with a means of access. The height of the bottom step or rung from the ground shall not exceed 0,5 m. The steps or rungs shall divide equally the distance between the bottom step or rung and the floor of the main control stand. Each step or rung shall be at least 0,25 m wide, at least 25 mm deep horizontally, and shall be slip-resistant. The front of the steps or rungs shall be at least 0,15 m horizontally away from the supporting structure or any other components of the HP.

Hand holds, handrails or similar adequate devices shall be provided to facilitate safe access. They shall be arranged to avoid the use of controls and piping for hand holds or foot-steps.

Verification: by visual examination and measurement in the normal operating position on a horizontal surface.

5.3.19 Batteries used to power the HP shall be located and installed so as to avoid as far as possible the chance of electrolyte being ejected onto the operator in the event of rollover and/or to avoid the accumulation of vapours in places occupied by operators. The HP shall be designed and constructed in such a way that batteries can be disconnected with the aid of an easily accessible device provided for that purpose.

Verification: by visual examination.

5.3.20 An electrically conducting connection between the HP and the bearing surface shall be ensured during operation. For HP's which are constructed for operation with stabilizers, the jacking devices shall provide an electrically conducting connection between the HP and the bearing surface. Blocks shall conform to these requirements.

Verification: by visual examination.

5.4 Extending structure

5.4.1 Methods to reduce the risk of overturning and exceeding permissible stresses

5.4.1.1 General

For HP's with more than one combination of rated load and working envelope, avoidance of overturning and overloading the structure during operation shall be controlled by automatic control of the variable working envelopes of the extending structure (position control) and/or load moment, with appropriate information/indicators for the operator on the permitted number of persons on the platform where this is variable.

One or more of the systems in Table 3 shall be provided.

Table 3 — Solutions for the reduction of risk of overturning and of exceeding permissible stresses

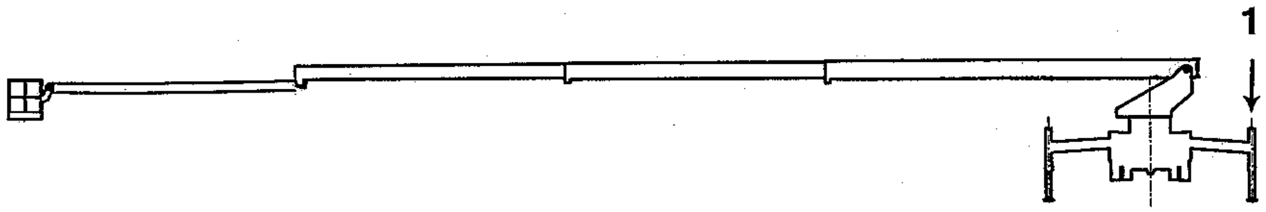
System 1	System 2	System 3	System 4
Load sensing system and position control (see 5.4.1.4 and 5.4.1.5)	Load and moment sensing system (see 5.4.1.4 and 5.4.1.6)	Moment sensing system with increased safety requirements and enhanced overload criteria (see 5.4.1.6, 5.4.1.8 and 5.4.1.9)	Position control with enhanced stability and overload criteria (see 5.4.1.5, 5.4.1.7 and 5.4.1.8)

System 4 in Table 3 shall only be applicable for HP's with one rated load.

Before using System 3 or System 4 in Table 3, the manufacturers risk analysis shall take into account that the structural calculation in 5.2.5.2 includes the 150 % rated load test (see 6.1.4) and that the stability calculations in 5.2.4 includes not only the effects of the mass of the extending structure etc. but also the dynamic factors.

5.4.1.2 Residual load

The residual load shall not be less than 6 % of the vehicle's unladen mass (minus the driver mass and the mass of the loose equipment, with fuel tank at the minimum level). The residual load is obtained on the unloaded side, in the most unfavourable position (i.e. the maximum value of the horizontal position of the extending structure with or without a load on the platform, see Figure 9).



Key

1 minimum residual load

Figure 9 — Residual load

5.4.1.3 Combinations of rated load

On HP's with separate combinations of rated load and working envelope, pre-selection of each combination by manual means giving automatic control of the working envelope is acceptable. The rated load for the selected combination shall be indicated at the extending structure control positions, but selection shall only be possible if the platform is in the working envelope for the new selected rated load.

5.4.1.4 Load sensing system

The load sensing system shall:

a) prevent all movements when the vertical load on the platform exceeds 120 % of the rated load;

b) provide a warning when the vertical load on the platform exceeds 100 % of the rated load. The warning shall consist of a visual warning and an acoustic signal in accordance with EN 842 and EN 981.

The load sensing system shall comply with the requirements of 5.13. An over-ride device shall be provided at each control position to permit further movement within the working envelope after the load sensing system has operated. An over-ride device shall require continuous positive action by the operator.

5.4.1.5 Position control

5.4.1.5.1 General

The working envelope of the extending structure shall be limited automatically to avoid overturning, or overloading the structure of the HP. This also applies where stabilisers have variable positions which affect the working envelope of the extending structure.

5.4.1.5.2 Mechanical limiting systems

Where permissible positions are limited by mechanical stops these shall be of sufficient strength to absorb the maximum force exerted.

NOTE The ends of hydraulic cylinders, if properly constructed for the purpose, fulfil this requirement.

Mechanical devices/systems shall be designed and installed to provide safety levels equivalent to those specified for electrical/electronic systems. This requirement is fulfilled if the components, e.g. rods, levers, wire ropes and chains, etc., are designed to take at least twice the load imposed on them.

5.4.1.5.3 Non-mechanical limiting systems

5.4.1.5.3.1 Where non-mechanical limiting devices/systems are used, permissible positions shall be limited by devices/systems which measure positions of the extending structure or which determine the overturning moment, and operate through the control systems to limit movements to the positions/overturning moments permitted by the manufacturer. This device/system shall be backed up by a safety device in accordance with 5.13.

5.4.1.5.3.2 Hydraulic/pneumatic parts of these devices/systems acting directly on full flow valves of hydraulic/pneumatic systems do not need to be duplicated if failure of one component does not cause a dangerous situation, but pilot operated control valves in these devices/systems shall be so designed and installed that they fail to safety, e.g. they stop any further movement, in the event of power failure.

5.4.1.5.3.3 Where these devices/systems operate through electric limit switches these shall have an operating life equivalent to at least twice the number of load cycles for which the HP is designed and shall be installed in protected places where they can be easily inspected. They shall be backed up by ultimate limit switches to EN 60947-5-1, i.e. with positive separation of their circuit breaking contacts. Operation of the ultimate limit switch shall stop all movements, thus indicating a failure of the limit switch.

Other types of switch, including proximity switches, shall only be used where the system safety integrity will be equivalent to that achieved by using limit switches and ultimate limit switches according to this clause.

5.4.1.5.3.4 In electronic limit measuring devices/systems, the following shall be taken into account:

Should a fault occur, the device or system shall fail to a safe condition, i.e. avoiding overturning, or overloading the structure of the HP.

All hardware devices, with the exception of audible and visual devices and displays and data input switches, the failure of which would cause the device/system to fail or malfunction in a manner that would not be immediately obvious to the operator, shall be automatically monitored.

The operation of transducers, associated conductors and connections shall be monitored for out-of-range conditions.

Sensors measuring the position of parts of the HP shall be duplicated, and monitored by the device/system. Unacceptable differences between the two sensors monitored by the device/system shall create a safe condition but operations for reducing the moment are still allowed. If sensing different parts of the HP the output signals shall be compared to provide equivalent safety.

If continuous monitoring is not possible the correct operation of the device/system shall be self-verifying at start-up.

5.4.1.6 Moment sensing system

The moment sensing system shall

a) warn the operator by an automatic warning device when the permissible moment is reached (see 5.2.4). The warning shall consist of a continuous visual and audible warning in accordance with EN 981;

b) prevent any movement which increases the overturning moment when the permissible moment is reached.

The control system for the moment sensing system shall comply with the requirements of 5.13.

5.4.1.7 Enhanced stability criteria

To meet the requirement of enhanced stability (see Table 3), the HP shall be designed according to the following criteria:

a) the outside dimensions of the platform in any horizontal section shall be at least 0,7 m and maximum surface area 0,6 m^2 per person forming part of the rated load;

b) for the static test described in 6.1.2, the test load shall be increased to 150 % of the rated load.

5.4.1.8 Enhanced overload criteria

To meet the requirement of enhanced overload (see Table 3), the HP shall be designed according to the following criteria:

a) the outside dimensions of the platform in any horizontal section shall be at least 0,7 m and maximum surface area 0,6 m^2 per person forming part of the rated load;

b) for the static overload test described in 6.1.4, the test load shall be 150 % of the rated load. For the height difference after the test the following requirements apply:

   1) for HP's with a rescue height up to 30 m, the height difference shall be less than 100 mm following application of 150 % of the rated load 10 min after unloading;

   2) for HP's with a rescue height greater than 30 m the manufacturer shall state the maximum height difference after 10 min following application of 150 % of the rated load.

5.4.1.9 Moment sensing system with enhanced safety requirements

The moment sensing system with enhanced safety requirements shall comply with the following requirements:

a) the moment sensing system shall be duplicated. The correct function of the sensing system shall be monitored by continuous plausibility checks during operation. Should a fault of the sensing system occur, operation for reducing the moment is still allowed. A corresponding warning (light or text message) shall inform the operator about the restriction;

b) when the allowed moment (see 5.2.4 and 6.1.7.3) is reached, the operator shall be warned by an automatic warning system. The warning shall consist of a continuous visual and audible warning in accordance with EN 981;

c) when the allowed moment is reached, any movement which increases the overturning moments shall be prevented by the system;

d) when the allowed moment is reached, a minimum residual load of 6 % according to 5.4.1.2 shall remain on the unloaded side of the HP.

The control system for the moment sensing system with enhanced safety requirements shall comply with the requirements of 5.13.

5.4.1.10 Verification of methods to reduce the risk of overturning and exceeding permissible stresses in 5.4.1.1 to 5.4.1.9

Verification of 5.4.1.1 to 5.4.1.9 by design check and functional test.

5.4.2 Operation of the extending structure in a specific sequence to avoid instability

When the extending structure needs to be extended or retracted in a specific sequence to avoid overloading and/or overturning, this sequence shall be automatic. The automatic sequence shall be part of the position control (see 5.4.1.5) or moment sensing system (see 5.4.1.6).

Verification: by design check and functional test.

5.4.3 Locking of masts at fixed working position

HP's with extending structures which incorporate masts which must be tilted to a fixed working position for use shall be equipped with a device in accordance with 5.13 to ensure that the mast is locked in the working position before further movement is possible.

Verification: by functional test.

5.4.4 Crushing and shearing points between parts of the extending structure, the base and platform

Crushing and shearing points between parts of the extending structure, the base and platform shall be avoided by providing safe clearances in accordance with EN 349 or adequate guarding. For areas such as turntables crossing stabilizers/chassis and resting points for extending structures in the travel condition, where guarding is not possible but the areas can be seen from the control position, warning signs shall be fitted (see 7.2.13).

Crushing and shearing points need only be considered at those areas within reach of persons on the platform or at control positions or standing adjacent to the HP at ground level.

Verification: by visual examination.

5.4.5 Emergency evacuation means for the platform

5.4.5.1 Means for emergency evacuation

Means for emergency evacuation of the platform shall be provided (for example for cases such as flash over, explosion, collapsing of parts of a building or structure or in case of a failure of the normal platform drive system) allowing for the safe evacuation of the persons in the platform in a time as short as reasonably possible.

An acceptable means of emergency evacuation is a rescue ladder fixed in parallel to the extending structure, in accordance with 5.4.5.2.

The following alternatives can be used if the risk assessment carried out by the manufacturer shows that within the limits of their intended use they offer a level of safety comparable to that of a rescue ladder, or at least the best available safety level:

— a retractable type fall arrester in accordance with EN 360;

— an emergency system for lowering the platform;

— an escape chute.

5.4.5.2 Requirements for rescue ladders;

Rescue ladders shall be fitted with hand rails on each side. The height of the hand rails may be reduced where the hand rail is immediately adjacent to another structure (e.g. water pipe). In this case the structure shall fulfil the function of a handrail.

Rescue ladders shall conform to the dimensions given in Table 4, Figure 10 and Figure 11.

With the exception of any means of supplying water, the top ladder section shall allow free passage in accordance with the template shown below.

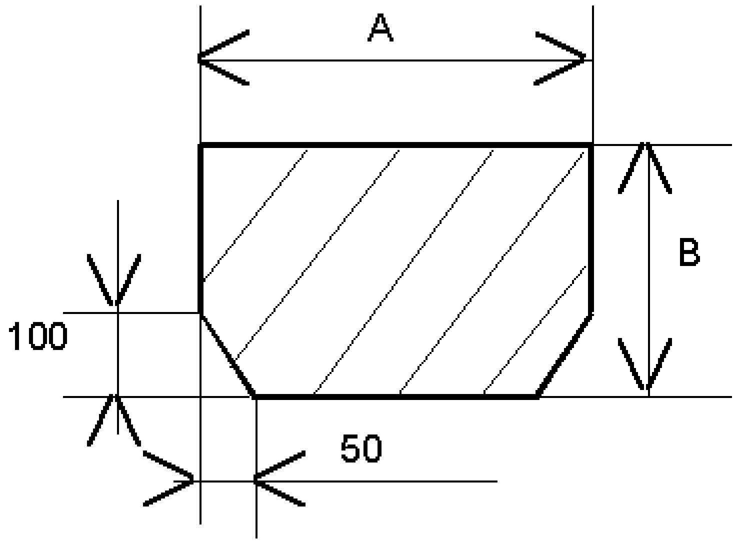
Table 4 — Dimensions of rescue ladder

Dimensions in millimetres

A	B	C [a]	D	E	F
≥ 450	≥ 280	≥ 280	20 ≤ D ≤ 50	250 ≤ E ≤ 300	20 ≤ F ≤ 60

[a] Minimum available length for the rung covering, not shown in Figure 10 and Figure 11.

Dimensions in millimetres

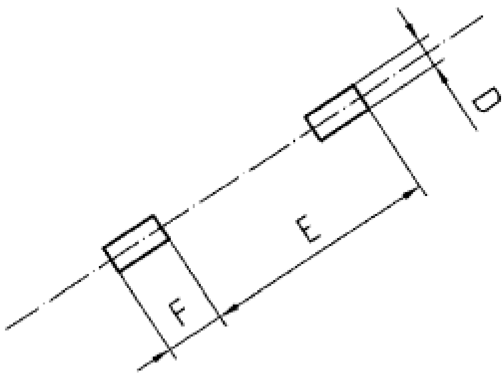


Key

A, B see Table 4

Figure 10 — Minimum dimensions of ladder sections

The rungs shall be manufactured from closed rectangular profiles. The distance between the rungs (E) shall be constant over the entire ladder.



Key

D, E, F see Table 4

Figure 11 — Rung spacing dimensions

Verification: With the exception of any means of supplying water, the last ladder section shall allow free passage in accordance with the template shown in Figure 10. A dimensional check of the ladder rung characteristics shall be carried out.

Ladder rungs shall be provided with a protective covering. The protection shall have the following properties:

a) be slip-resistant;

b) be weather-resistant;

c) be easy to replace;

d) shall not retain water;

e) be non-porous;

f) provide good grip;

g) shall not cause injuries, notably to hands, e.g. no sharp edges.

Verification: by visual examination and functional test.

5.4.6 Operator seat

A seat shall be provided for the operator which shall follow the rotating movement. The seat shall enable the operator to maintain a stable position and be designed with due regard to ergonomic principles. The seat mountings shall withstand all stresses to which they can be subjected. Where there is no floor beneath the operator's seat, the operator shall have footrests covered with a slip resistant material.

Verification: by visual examination and functional test.

5.4.7 Supporting of extending structure in transport position

The extending structure shall be supported in the transport position in such a way as to avoid harmful vibrations during transport (see 5.2.5.3.3).

Verification: By design check and visual examination

5.5 Extending structure drive systems

5.5.1 General

5.5.1.1 Drive systems shall be designed and constructed with brakes, automatic locks or self-sustaining devices to prevent any inadvertent movements of the HP. They shall also ensure that the platform, loaded with the rated load(s) + 20 %, can be stopped and held at any position under all possible conditions of operation.

Verification: by design check and functional test in 6.1.6.1.3.

5.5.1.2 If the power source is capable of producing higher forces than the extending structure and/or platform can withstand, the structure and/or platform shall be protected against excessive forces, for example by a pressure limiting device. The use of friction couplings is not permitted to fulfil the requirement.

Verification: by design check.

5.5.1.3 Transmission chains or belts shall only be used in drive systems provided inadvertent movements of a platform are automatically prevented if failure of a chain or belt occurs. This can be achieved by a self-sustaining gear box or monitoring the chain/belt by a safety device in accordance with 5.13.

Verification: by design check.

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

Verification: by design check and visual examination.

5.5.1.5 If powered and manual drive systems are provided for the same movement, interlocks shall prevent both systems from being engaged at the same time if this would create a hazard. This shall not apply to controls used only for emergency operation.

Verification: by design check.

5.5.2 Wire rope drive systems

5.5.2.1 Load carrying ropes shall be made from galvanized steel or stainless steel and have the following characteristics:

a) diameter:min. 6 mm;

b) number of wires: min. 114;

c) tensile grade of the wires: min. 1 570 N/mm^2; max. 2 160 N/mm^2.

In other respects they shall comply with ISO 2408.

The minimum breaking force of ropes shall be shown on a certificate in the technical file.

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

Verification: by design check.

5.5.2.2 Wire rope, drum and pulley diameters shall be calculated according to normative Annex D, assuming that all the load is taken on one wire rope system.

Wire rope drive systems shall have a separate system which, in the event of a rope failing, limits the vertical movement of the fully loaded platform to 0,2 m. This requirement is met, for example, by:

a) a second wire rope system designed according to the first system, and with a device to equalize the tension in the two systems, doubling the coefficient of utilization;

or

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

or

c) a second wire rope system according to a) but with larger drum and pulley diameters to increase the fatigue life of the second system.

Failure of the first system shall be self-revealing.

See Figure 12 to Figure 14 for examples.

Each rope shall have its own anchorage.

Verification: by design check and visual examination.

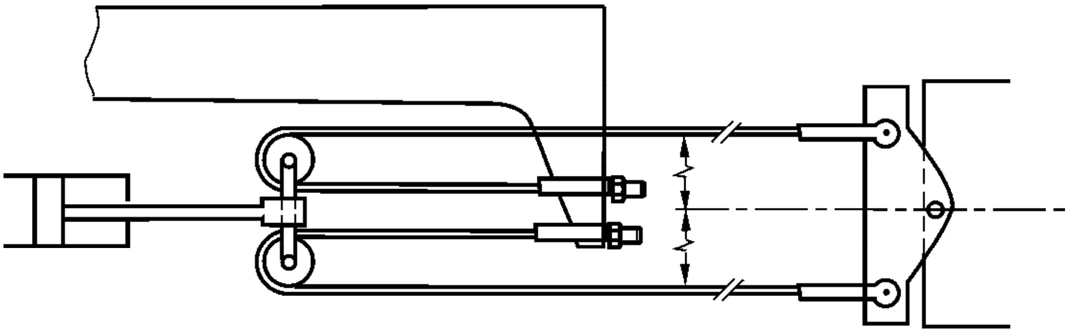


Figure 12 — Example of wire rope drive systems according to 5.5.2.2, a)

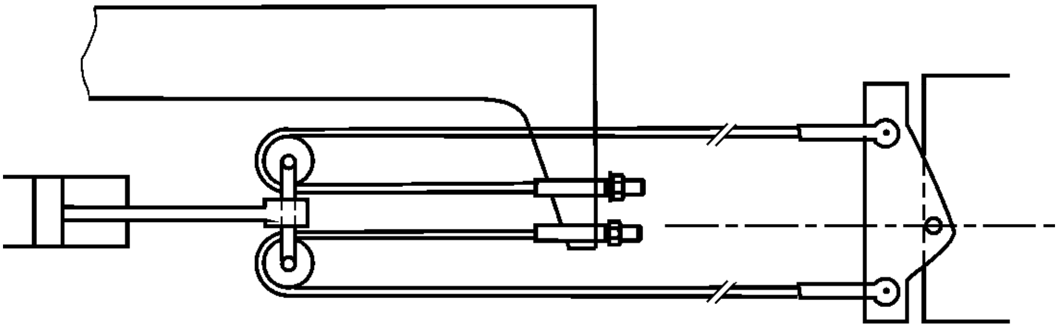


Figure 13 — Example of wire rope drive systems according to 5.5.2.2, b)

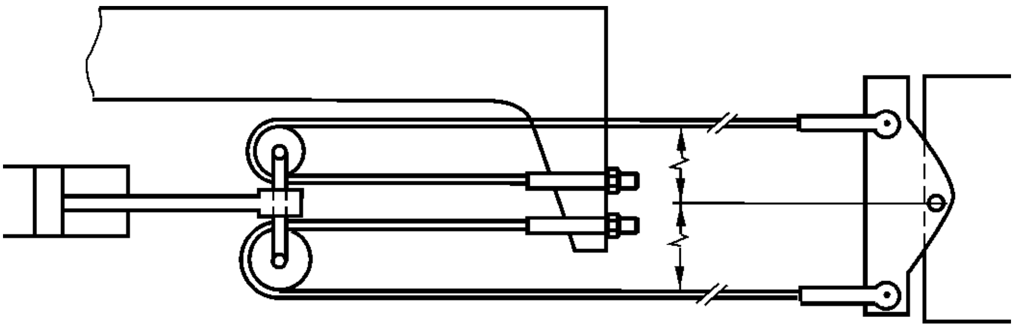


Figure 14 — Example of wire rope drive systems according to 5.5.2.2, c)

5.5.2.3 Rope terminations (end fastenings) shall have a breaking force of at least 80 % of the minimum breaking force of the rope. U-bolt grips shall not be used as rope terminations.

Verification: by design check.

5.5.2.4 It shall be possible to re-tension ropes.

Verification: by design check and visual examination.

5.5.2.5 Visual examination of ropes and rope terminations shall be possible without the removal of the ropes or major disassembly of the structural components of the HP. Suitably positioned inspection openings fulfil this requirement.

If this is not possible manufacturers shall provide detailed instructions for the method and frequency of examining ropes and rope terminations for wear and/or damage.

Ropes according to 5.5.2.2 shall be replaced when the criteria of wear indicated in ISO 4309 are detected in any one of those ropes.

Verification: instruction handbook.

5.5.2.6 Wire rope drive systems shall be equipped with a safety device in accordance with 5.13 which interrupts any movement causing slack rope conditions. Movement in the opposite direction shall be possible. If no slack rope condition can develop this device is not necessary.

Verification: by design check and visual examination.

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

Verification: by visual examination.

5.5.2.8 Only one layer of rope shall be wound on the drum unless a special spooling system is used.

Verification: by visual examination.

5.5.2.9 At least two turns of rope shall remain on the drum with the extending structure and/or the platform in the most extreme position.

Verification: by functional test and visual examination.

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

Verification: by design check and visual examination.

5.5.2.11 Means shall be provided to prevent unintentional displacement of ropes from pulleys, even under slack rope conditions.

Verification: by design check and visual examination.

5.5.2.12 The cross-section of the bottom of the grooves in rope drums and pulleys shall be circular over an angle of not less than 120° with a radius of 0,525 of the nominal rope diameter.

Verification: by design check.

5.5.3 Chain drive systems

5.5.3.1 The minimum breaking force of the chain shall be shown on a certificate contained in the technical file. Round link chains shall not be used.

Verification: by design check.

5.5.3.2 Chain drive systems with a single chain drive shall have a minimum coefficient of utilization of 5 assuming that all the load is taken on that system.

Chain drive systems shall have a separate system which, in the event of a chain failing, limits the vertical movement of the fully loaded platform to 0,2 m. This requirement is met, for example, by:

a) a second chain drive system designed according to the first system but each system having a minimum coefficient of utilization of 4, giving a total coefficient of utilization of 8, with a device to equalize the tension in the two systems;

   or

b) a second chain drive system designed according to the first system, but with a minimum coefficient of utilization of 4 (a total of 9 minimum) and with a device to ensure that the second system takes less than half the load in the operating condition, but is able to take the full load if the first system fails.

Failure of the first system shall be self-revealing.

Each chain shall have their own anchorage.

Verification: by design check and visual examination.

5.5.3.3 Chain terminations (end fastenings) shall have a breaking force of at least 100 % of the minimum breaking force of the chain.

Verification: by design check.

5.5.3.4 It shall be possible to re-tension chains.

Verification: by design check and visual examination.

5.5.3.5 Visual examination of chains and chain terminations shall be possible without the removal of the chains or major disassembly of structural components of the HP. Suitably positioned inspection openings fulfil this requirement.

If this is not possible, manufacturers shall provide detailed instructions for the method and frequency of examining chains and chain terminations for wear and/or damage.

Chains according to 5.5.3.2 shall be replaced when the chain manufacturers limits of wear are detected in any one of those chains.

Verification: by design check, visual examination and check of information for use.

5.5.3.6 Chain drive systems shall be equipped with a safety device in accordance with 5.13 which interrupts any movement causing slack chain conditions. Movement in the opposite direction shall be possible. If no slack chain condition can develop this device is not necessary.

Verification: by design check and visual examination.

5.5.3.7 Chain sprockets and pulleys shall be provided with devices to prevent the chain from riding off the sprocket or pulley, even under slack chain conditions.

Verification: by design check and visual examination.

5.6 Platform

5.6.1 The platform levelling systems shall not allow the level of the platform to vary by more than ± 5° during movements of the extending structure, or due to loads and forces during operation, excluding the effects of any residual slope.

Verification: by measurement during the functional test in 6.1.6.1.2.

5.6.2 All levelling systems shall include provisions to limit the level of the platform to a max. ± 10°, in the event of a failure within the levelling system.

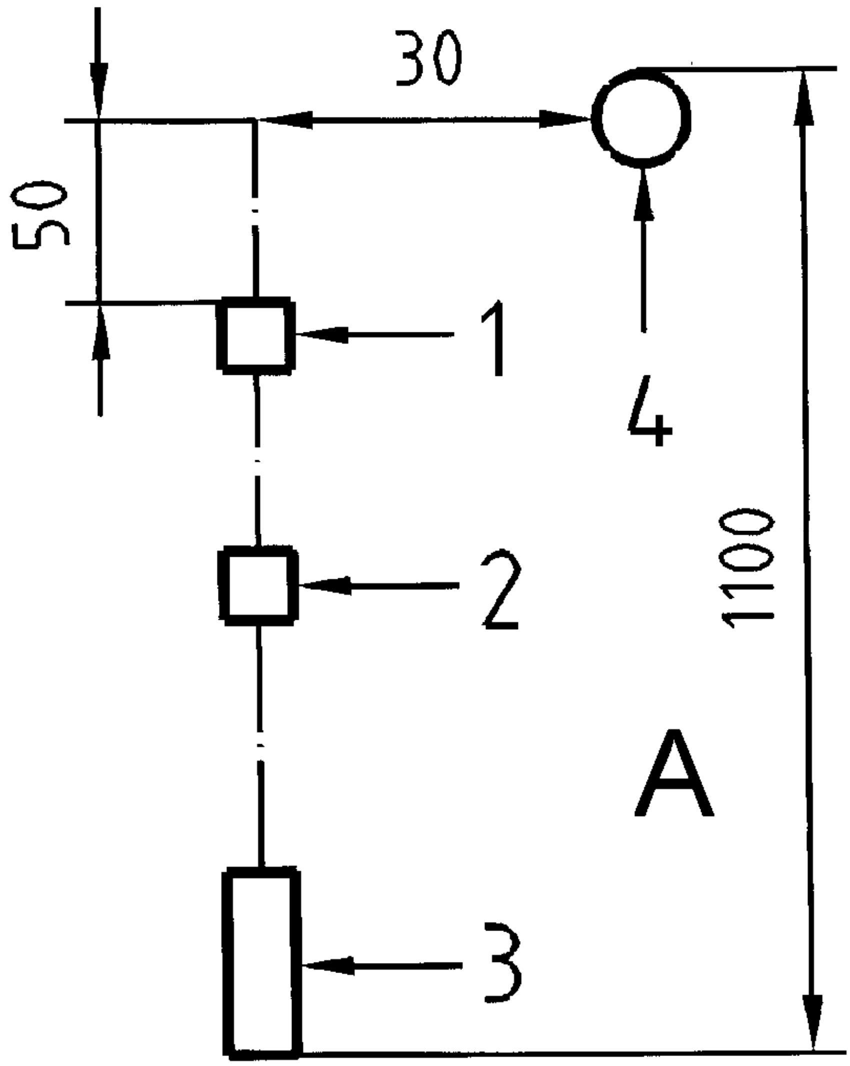
Hydraulic levelling systems are taken to be mechanical systems. Hydraulic cylinders in hydraulic levelling systems shall also comply with 5.11.

Verification: by simulating the failure condition and/or by design calculations in the technical file.

5.6.3 Protection shall be provided on all sides of each platform to prevent persons and materials falling out. The protection shall be securely fastened to the platform floor and shall, as a minimum, consist of top guardrails/handrails at least 1,1 m high, toeguards at least 0,15 m high and intermediate guardrails not further than 0,55 m from either guardrails or toeguards. Chains or ropes shall not be used as guardrails or access gates. At points of access to the platform the height of the toeguards may be reduced to 0,1 m.

An example of relative positions of hand and guard-rails are given in Figure 15.

Dimensions in millimetres



Key

A inside the cage
1 top guard rail
2 intermediate guard rails
3 toeguard
4 handrail (see 5.6.9)

Figure 15 — Example of relative positions of hand and guardrails

Verification: A dimensional check shall be carried out.

Anchoring points for the allowed number of persons in the cage for personal protective equipment against falling shall be fitted in the platform (rated force min. 900 N per person). Alternatively to the anchoring points, the structures of the platform can also be used to provide anchorage points provided that they achieve at least the same level of security. The anchoring points or structures are to be marked appropriately.

Verification: by measurement.

5.6.4 The top guardrails/handrails shall be constructed to withstand concentrated loads of at least 500 N per person in case of up to four persons in the cage applied at the least favourable positions in the least favourable direction at 0,5 m intervals without causing permanent deformation.

In case of more than four persons in the cage the top guardrails/handrails shall be constructed to withstand concentrated loads of at least 2 000 N in total applied at the least favourable positions in the least favourable direction at 0,5 m intervals without causing permanent deformation.

The basic structure of the platform shall be made of non-flammable material(s).

Verification: by visual examination after the static overload test in 6.1.4 and of the material specification in the technical file.

5.6.5 As a general rule side doors in the platform fencing shall open inwards. If necessary for rescue purposes access doors may open outward or be sliding doors with the top handrail permanently fixed or opening inwards or upwards. Opening sections of top handrails shall not open outwards.

Door locking devices shall be designed in such a way that the lock is automatically engaged when the door is closed. Incorrect locking of the door shall be detectable by the operator.

The design of the doors shall prevent their inadvertent or unintentional opening. For this reason the locking device shall present no protruding parts by which it can be disengaged by parts of the body or by clothing.

Verification: by visual examination and functional test.

5.6.6 The floor of the platform shall be slip-resistant, e.g. made of chequer plate or expanded metal, and be self-draining. Any opening in the floor or between the floor and toe-guards or access gates shall be dimensioned so as to prevent the passage of a sphere of 15 mm diameter.

Verification: by visual examination and measurement.

The floor shall be able to take the rated load distributed according to 5.2.3.1.

Verification: by design check.

5.6.7 When the distance between the access level and the floor of the platform in the access position exceeds 0,4 m, the HP shall be equipped with an access ladder.

The steps or rungs shall be not more than 0,3 m apart and, if needed, shall divide equally the distance between the bottom step or rung and the floor of the platform. The bottom step/rung shall be not more than 0,4 m above the access level. Each step or rung shall be at least 0,3 m wide with a tread depth of at least 25 mm and shall be slip-resistant according to EN 1846-2:2009, 5.1.2.3.4. The front of the steps or rungs shall be at least 0,15 m horizontally away from the supporting structure or any other components of the HP.

The access ladder shall be symmetrical with the access gate.

Handholds, handrails or similar adequate devices shall be provided in accordance with EN ISO 14122-3 and EN ISO 14122-4 to facilitate climbing any access ladder to the platform. They shall be arranged to avoid the use of controls and piping for handholds or footsteps.

Verification: by visual examination and measurement.

5.6.8 Trapdoors in platform floors shall be securely fastened to the floor so that no inadvertent opening is possible. It shall not be possible for trapdoors to open downwards or slide sideways. Their strength shall be in accordance with 5.6.6.

Verification: by visual examination.

5.6.9 Protection shall be provided to prevent injury to the hands of persons when a platform is moving in close proximity to other objects in particular when operating the controls (see EN 349).

Verification: by visual examination.

5.6.10 HP's shall be provided with communication between the platform and the main control stand.

Verification: by visual examination and test.

5.6.11 The movements (rotation, extension, etc.) of platforms shall be limited by mechanical stops. The ends of hydraulic cylinders, if properly constructed for the purpose, shall fulfil this requirement.

Verification: by calculation.

5.6.12 A device shall be provided to stop all aggravating movements on sustaining impact.

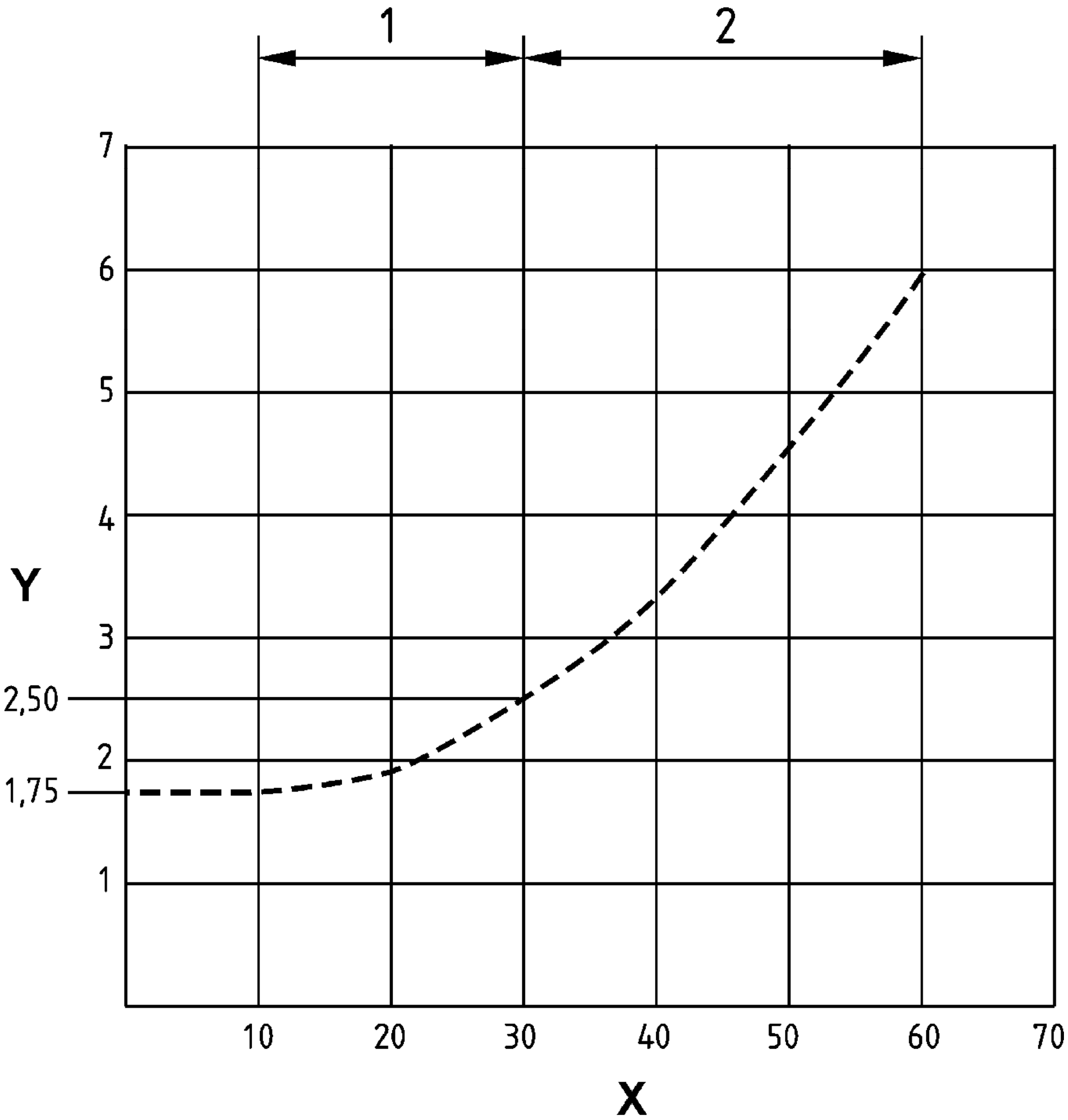
Verification: by visual examination and test.

5.7 Controls

5.7.1 HP's shall be provided with controls such that all movements can only take place whilst the controls are being actuated. Elevating structure control devices shall be situated at the main control stand on the base and at the platform. The controls, when released, shall automatically return to the neutral position. The travel controls do not need to be of this type, nor does the emergency system (see 5.7.11) if the subsequent use of the normal controls does not produce any inadvertent movement. All controls, particularly foot-operated controls, shall be constructed to prevent inadvertent operation. Foot controls shall have slip-resistant surfaces and be easy to clean. Controls shall also be provided with lighting and weather protection as necessary.

Verification: by functional test and visual examination.

5.7.2 The control system shall have sufficient control of fine positioning, simultaneous operation, speed, acceleration and deceleration to enable the operating times in Figure 16 to be achieved safely.



Key

X rescue height in metres (m)
Y operating time in minutes (min)
1 up to 30 m rescue height obligatory – required max. permissible operating time
2 above 30 m rescue height recommended max. permissible operating time

Figure 16 — Operating times

Manufacturers shall take the dynamic effects of acceleration and deceleration into account in the stability and structural calculations (see 5.2 and Annex B).

Verification: by functional tests and the technical file.

5.7.3 Control systems shall be designed with weather protection as necessary and to allow the operating time to be achieved at the ambient temperatures in the country of use after travelling 15 km or standing 2 h in the open.

Verification: by functional test.

5.7.4 The direction of all movements of the HP shall be clearly indicated on or near the controls preferably by symbols in accordance with CEN/TS 15989. All controls shall be arranged with the same logical operation, where possible, on both control panels.

Verification: by visual examination.

5.7.5 The design of controls shall be in accordance with EN 894-3 to allow safe use by persons wearing personal protective clothing e.g. gloves, boots, etc.

Verification: by visual examination and functional test with protective equipment.

5.7.6 The main control stand shall be arranged so that the operator:

a) can over-ride the controls at the platform;

b) has the widest possible view of the elevating structure;

c) can operate the controls without hindrance or danger from movements of the extending structure;

d) is not in danger of falling;

e) has access facilities as in 5.3.18.

Verification: by functional test and visual examination.

5.7.7 HP's shall be provided with emergency stop controls according to EN ISO 13850 at the control position at the main control stand and in the platform.

There shall be a procedure for resuming control of the extending structure from the main control stand, and to use the emergency system referred to in 5.7.11, without disengaging the emergency stop control at the platform.

The jacking control consoles shall have an additional stop control to stop the jacking movements independently of the main control system for these movements.

Operation of any emergency stop of the extending structure shall be indicated at all control position(s).

These procedures shall be described in the instruction manual and be included in any operator training with particular reference to any effect on the operation of safety devices.

Verification: by circuit diagram and functional test in 6.1.6.1.2 using each control position.

5.7.8 At the main control stand there shall be an indicator to show that the main power supply is operative.

An engine restart control shall be provided at the main control stand.

In case of failure of the power supply, on starting, or restoration of the power after failure of the power supply, no inadvertent movement shall occur.

Verification: by functional test in 6.1.6.1.2.

5.7.9 Pilot operated control valves shall be so designed and installed such that they fail to safety, e.g. they stop any further movement, in the event of power failure.

Verification: by checking that no movements occur when the pilot circuit is disconnected.

5.7.10 Controls at the work platform shall be protected against unintended actuation of the control devices caused by contact with external objects and movement by persons on the platform.

Verification: by visual examination.

5.7.11 An emergency system, e.g. a hand pump or secondary power supply, shall be provided to return the HP to the access position if the main power supply should fail.

A device shall be provided to ensure that the speed of movement of the platform is restricted to a maximum of 1,4 times normal speed even under emergency procedure.

Verification: by functional test of the emergency procedure.

5.7.12 Any simultaneous operations not acceptable for correct functioning of the HP, e.g. travel, movement of the extending structure, fire-pump drive, etc., shall be prevented by interlocks or equivalently effective means.

Verification: by functional test.

5.7.13 It shall not be possible to switch off the safety and indicating devices whilst the extending structure is in operation.

Verification: by functional test in 6.1.6.1.2.

5.7.14 If failure of any system or safety device, e.g. extending structure working envelope limit measuring devices/systems, platform hydraulic levelling systems, requires operation of the extending structure by an emergency procedure which could create a dangerous situation the instructions for the emergency procedure shall be clearly displayed at the emergency control position and shall include warning of the hazard. The emergency procedure shall also be detailed in the instruction manual.

Verification: by functional test in 6.1.6.1.2.

5.7.15 To protect persons at control positions, pipes and hoses in working cabs and other permanent working places outside of cabins should be avoided. If pipes and hoses at these places are closer than 1 m to the operator and contain fluids that are dangerous, e.g. because their pressure is greater than 5 000 kPa or because their temperature is greater than 60 °C, guards shall be provided.

Verification: by visual examination and measurement.

5.7.16 Cableless controls shall comply with EN 60204-1:2006, 9.2.7.

Verification: by design check and functional test.

5.8 Electrical systems

Design and selection of the electric and electronic components shall comply with the requirements of EN 60204-1.

Electrical/electronic circuits as well as controls shall have a level of protection which is adapted to the requirements and the environment to avoid malfunctions due to an inadequate protection type. The minimum degree of protection shall be IP 54 for all electric/electronic components according to EN 60529.

Electrical circuits shall be protected against damage on to connections and lines by short circuits.

Fuses shall be marked in a suitable way according to the maximum capacity permitted in the electrical circuit of an installation.

If electrical circuits of higher voltage (e.g. 230 V) are installed together with the electrical circuits of the vehicle in the same terminal box, the terminals or junction points of the circuits with the higher voltage shall be marked with the value of the maximum voltage. The requirements of EN 60204-1:2006, 13.1.3 shall also be fulfilled.

Cables and individual lines shall be marked by means of colours or numbers to avoid confusions.

The cables and conductors shall be flexible and of a type with many stranded fine copper conductors. They shall resist all foreseeable environmental conditions (temperature, humidity, light, ultraviolet, chemical and mechanical stress) and shall be installed in a suitable way.

In case of high mechanical loads acting from the outside on cables and lines, protective tubes shall be used.

High tractive forces on cables and lines shall be avoided by means of the design of the traction equipment. The minimum radii indicated by the manufacturers for the cables and lines used shall be observed during installation and for mobile arrangements.

Verification: by visual, functional and design check.

5.9 Pneumatic control systems

5.9.1 Pneumatic control systems shall fulfil the requirements of EN 983 and the requirements given in 5.9.2 to 5.9.8.

NOTE The special safety requirements for pneumatic cylinders operating load-carrying components are not covered in this document.

5.9.2 Pipes and their connections which may be subjected to the maximum pressure permitted by a pressure limiting device shall be designed to withstand at least twice that pressure without permanent deformation (Rp 0,2).

If, in normal operation, they may be subjected to a higher pressure than permitted by the pressure limiting device, they shall be designed to withstand at least twice that higher pressure without permanent deformation (Rp 0,2), but see 5.11.1 for failure conditions affecting cylinders.

5.9.3 The bursting pressure of hoses and bellows including fittings, which in normal operation may be subjected to the maximum pressure permitted by any pressure limiting device, or any higher pressure, shall be not less than three times that pressure.

5.9.4 All other parts of the pneumatic system, e.g. pumps, motors and valves, shall withstand at least the maximum pressure to which they will be subjected, including any temporary pressure setting increase necessary for carrying out the static overload test in 6.1.4.

5.9.5 The pneumatic system shall be provided with a pressure limiting device fitted before the first control valve. If different maximum pressures are used in the pneumatic system, more than one device shall be provided.

Pressure limiting valves shall be safeguarded against tampering by unauthorized persons.

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

5.9.7 The pneumatic system shall be equipped with a moisture reduction device/system. Systems intended for use below + 10 °C shall be designed to prevent ice formation, i.e. by use of additives.

5.9.8 Any incorrect connection of pneumatic piping and hoses causing a hazard e.g. to reverse the direction of movement of a pneumatic cylinder shall be avoided by following means:

a) by design or, failing this;

b) by information given on the elements to be connected and, where appropriate, on the means of connection.

Verification of 5.9.1 to 5.9.8: by design check on the pneumatic circuit diagram, functional test and visual examination.

5.10 Hydraulic drive systems

5.10.1 Hydraulic systems shall fulfil the requirements of EN 982 and the requirements given in 5.10.2 to 5.10.11.

5.10.2 Pipes and their connections which may be subjected to the maximum pressure permitted by a pressure limiting device during normal operation shall be designed to withstand at least twice that pressure without permanent deformation (Rp 0,2). If, in normal operation, they may be subjected to a higher pressure than permitted by the pressure limiting device, they shall be designed to withstand at least twice that higher pressure without permanent deformation (Rp 0,2), but see 5.11.1 for failure conditions.

5.10.3 The bursting pressure of hoses, including fittings, which in normal operation may be subjected to the maximum pressure permitted by any pressure limiting device, or any higher pressure, shall be not less than three times that pressure.

5.10.4 All other parts of the hydraulic system, e.g. pumps, motors and valves, shall withstand at least the maximum pressure to which they will be subjected, including any temporary pressure setting increase necessary for carrying out the static overload test in 6.1.4.

5.10.5 The hydraulic system shall be provided with a pressure limiting device fitted before the first control valve. If different maximum pressures are used in the hydraulic system, more than one pressure limiting device shall be provided.

Pressure limiting valves shall be safeguarded against tampering by unauthorized persons.

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

5.10.7 The hydraulic system shall enable any entrapped air to be vented.

5.10.8 Any hydraulic tank open to atmosphere shall be equipped with an air inlet filter. This air inlet filter shall filter air entering the tank to a cleanliness level compatible with the system requirements, taking into consideration the environmental conditions in which the system is to be installed.

5.10.9 Hydraulic tanks shall be equipped with devices for drainage and for indicating the minimum and maximum fluid levels when the HP's are in the travel condition.

5.10.10 If the hydraulic accumulator liquid pressure is required by design to be retained when the system is shut off, complete information for safe servicing shall be given on or near the accumulator in a visible location. Information shall include the combination of product safety label with a hazard severity panel according to ISO 3864-2:2004, 6.4 or ISO 3864-2:2004, 6.6 with the hazard signal word "Caution" and the text information "Pressurised vessel - Discharge prior to disassembly". Duplicate information shall be provided in the instruction book (see 7.1.7, d)) on the circuit diagram.

5.10.11 Any incorrect connection of hydraulic piping and hoses causing a hazard, e.g. to reverse the direction of movement of a hydraulic cylinder shall be avoided by following means:

a) by design; or, failing this,

b) by information given on the elements to be connected and, where appropriate, on the means of connection.

Verification of 5.10.1 to 5.10.11: by design check of the hydraulic circuit diagram, functional test and visual examination.

5.11 Hydraulic cylinders

5.11.1 Structural design

The structural design of load supporting cylinders shall be based on an analysis of the maximum pressures, loads and forces during normal operation and failure conditions, e.g.

a) During normal operating conditions:

1) Buckling:

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

2) Constructional detail:

The design of welded joints shall conform to the design standards given in 5.2.5.2. Load-carrying threaded joints shall comply with relevant standards, and stress calculations shall take into account the reduced shear areas due to manufacturing tolerances and the elastic deformation caused by hydraulic pressures. The design of threaded joints subjected to varying tensile loads shall take into account the effects of fatigue and prevent inadvertent separation (unscrewing);

3) Conditions causing pressure above normal pressure limits (see Figure 17 to Figure 21):

i) e.g. the effect of speed control devices which reduce the speed of cylinders below the speed which could result from the full supply to the cylinders, causing internal pressure loading additional to the normal pressure due to externally applied compressive loads. The pressure can also be multiplied by the ratio

$$\frac{D^2}{D^2 - d^2} \quad (2)$$

where

D is the diameter of the piston;

d is the diameter of the piston rod;

when a cylinder is in tension and the speed control device acts on the annulus. The speed control devices may take the form of restrictors or the control valve being partially open (or closed);

ii) and the effect of thermal expansion of fluid confined in the cylinder when at rest;

b) During failure conditions:

1) the normal generated pressure can increase by the ratio

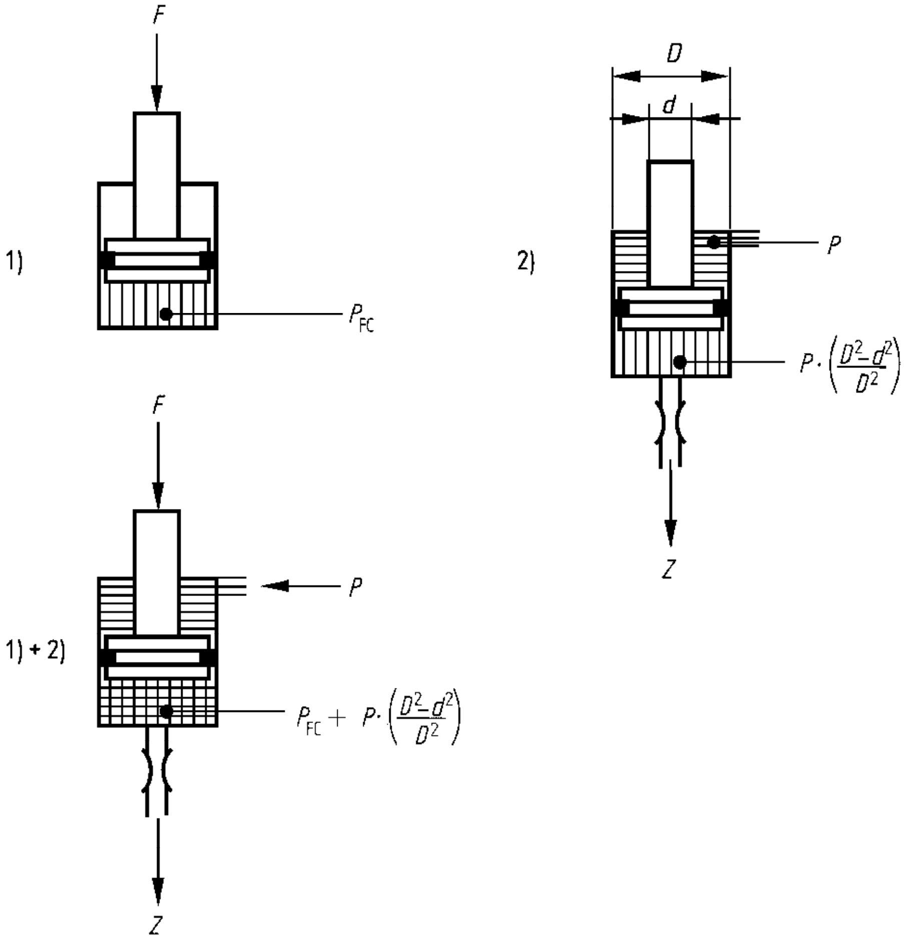
$$\frac{D^2}{d^2} \quad (3)$$

due to hydraulic fluid leaking past piston seals in double acting cylinders under compressive loads (see Figure 17 to Figure 19). This affects particularly the stresses in the cylinder tube and the head, and these shall not exceed the minimum yield stress (Rp 0,2). This ratio is the minimum safety factor for valves, hoses and pipes which are at the same pressure as the cylinder, unless the pressure increase is limited by other hydraulic components;

2) when more than one cylinder operates the same mechanism, consideration shall be given to the effect of one cylinder being blocked and taking or causing greater loads. In the case of double acting

cylinders this includes the force(s) generated by the other cylinder(s) or the force required to move the other cylinder (see Figure 20 and Figure 21).

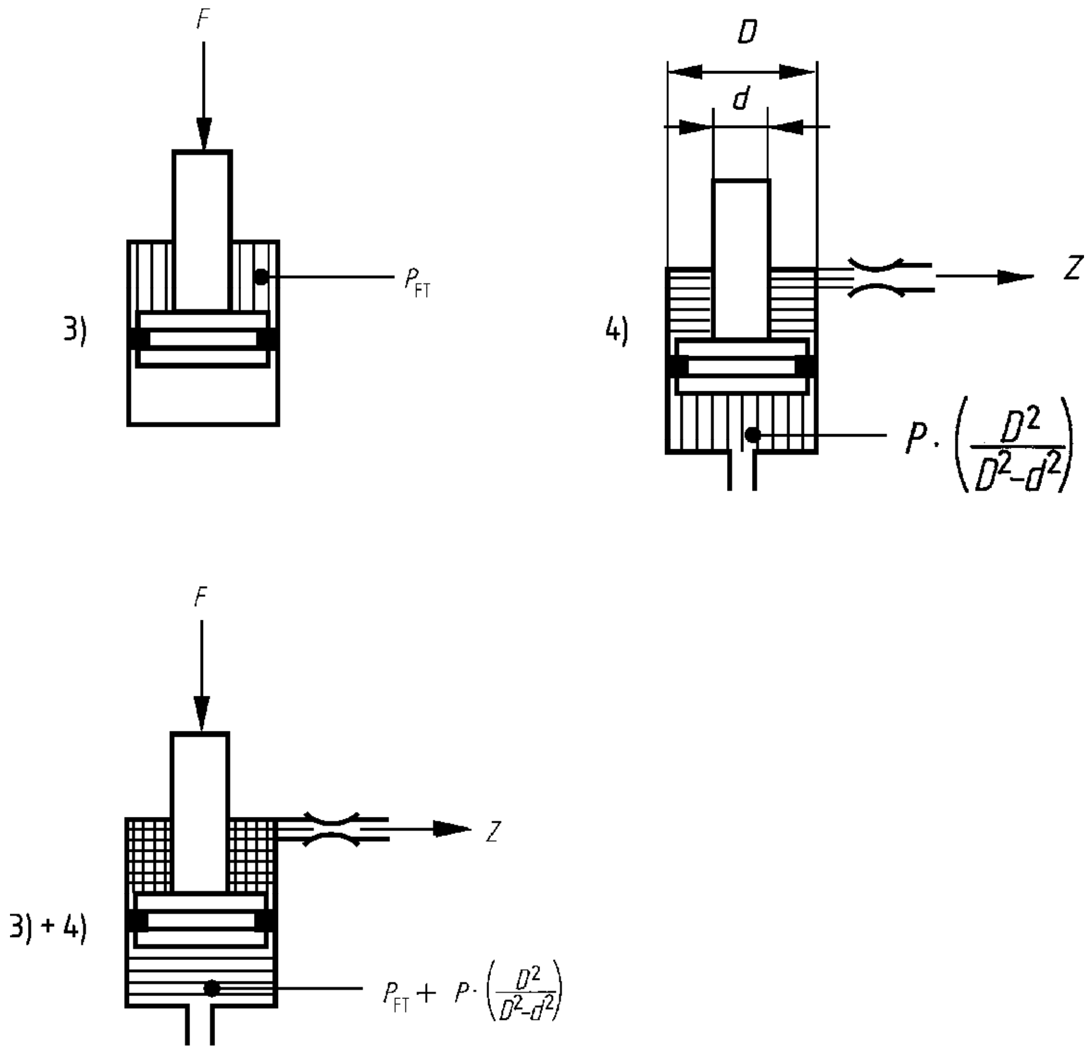
Under failure conditions the calculated maximum stress shall not exceed the minimum yield stress of the material (Rp 0,2).



Key

F	load
p	system pressure
p_{FC}	normal pressure
Z	restricted flow
d	diameter of the piston rod
D	diameter of the piston

Figure 17 — Cylinder pressures, normal operation (Cylinder in compression)



Key

F load

p_{FT} normal pressure

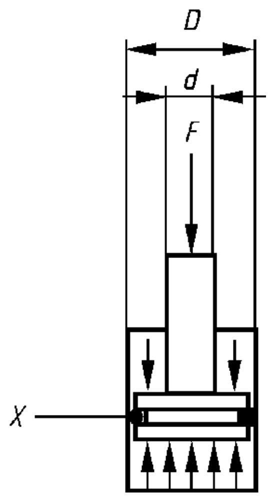
p system pressure

Z restricted flow

d diameter of the piston rod

D diameter of the piston

Figure 18 — Cylinder pressures, normal operation (Cylinder in tension)

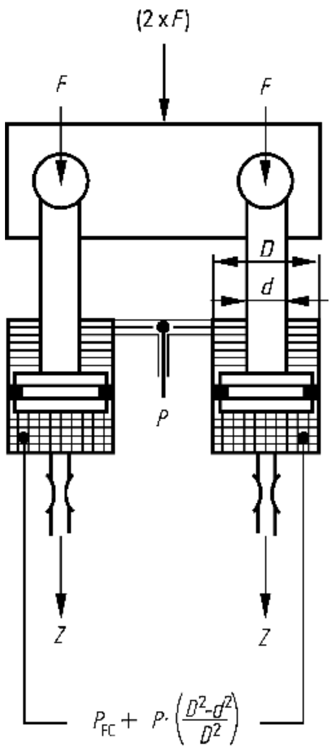


Key

F load
X failed seal
d diameter of the piston rod
D diameter of the piston

NOTE
— Equal pressure on top and bottom of the piston;
— load is supported by the area of the rod $\pi d^2/4$ instead of the area of the piston $\pi D^2/4$;
— the normal pressure p_{FC} increases by the ratio D^2/d^2.

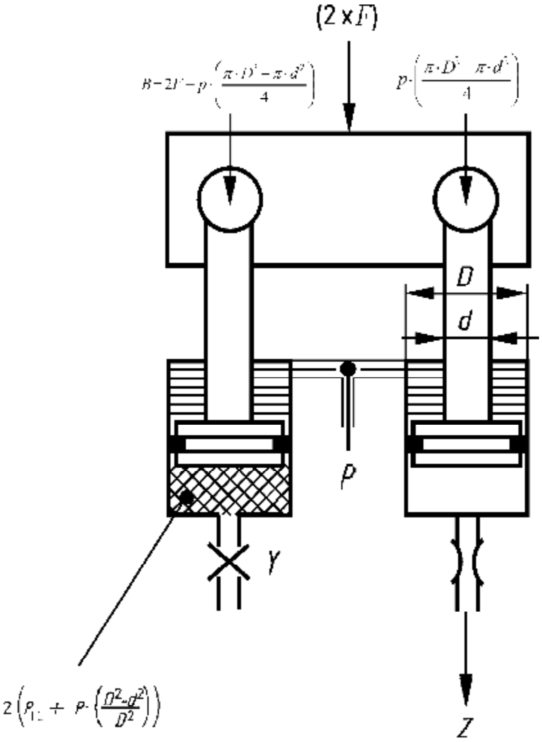
Figure 19 — Cylinder pressures: seal failure



Key

F load
p system pressure
p_{FC} normal pressure
Z restricted flow
d diameter of the piston rod
D diameter of the piston

Figure 20 — Twin cylinders in compression: normal operation



Key

B buckling load
F load
p system pressure
p_{FC} normal pressure
Y line blocked
Z restricted flow
d diameter of the piston rod
D diameter of the piston

Figure 21 — Twin cylinders, in compression: one line blocked

5.11.2 Prevention of unintended movement of the cylinder

Load holding cylinders shall be equipped with a device in accordance with 5.13 which prevents unintended movement of the cylinder even in the case of a pipe failure (excluding those pipes in this clause) until the device is released by an external force. These requirements shall be deemed to fulfil the requirements in 5.5.1.1, accepting that there is internal leakage (see 7.1.2, p)).

If lock valves are used for this purpose, they shall be either:

a) integral with the cylinder;

b) or directly and rigidly flange-mounted;

c) or placed close to the cylinder and connected to it by means of rigid pipes, as short as possible, having welded or flanged or threaded connections and being calculated in the same way as the cylinder. Other types of connection such as compression or flared pipe fittings are not permitted between the cylinder and the lock valve.

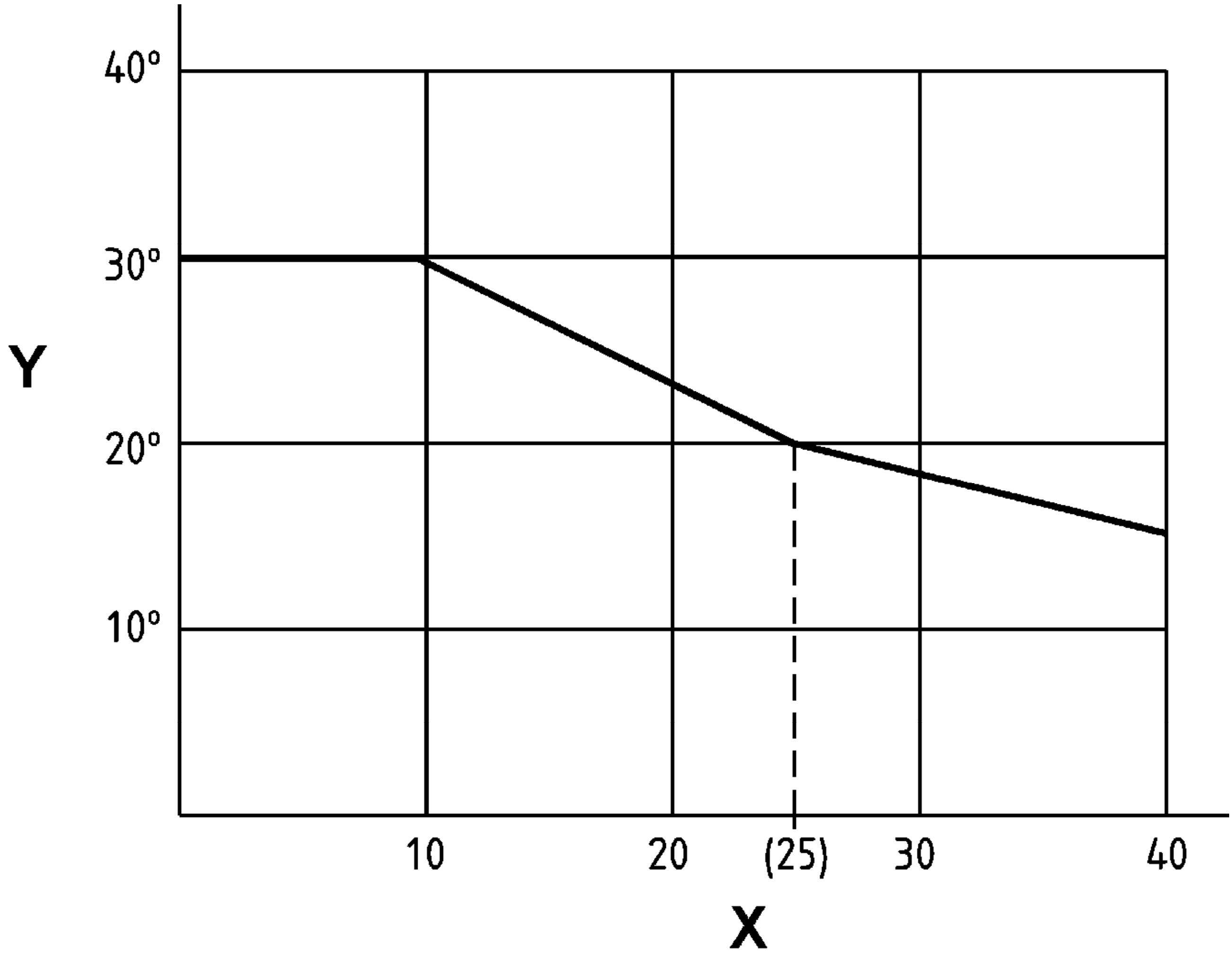
5.11.3 Verification of requirements on hydraulic cylinders

Verification: by design check on the hydraulic circuit diagram, structural calculations and visual examinations.

5.12 Static tilt angle δ

The static tilt angle δ of HP's of gross laden mass GLM according to EN 1846-2 up to 25 t shall be not less than the minimum values shown in Figure 22.

NOTE Above 25 t the static tilt angle δ in Figure 22 is a recommendation.



Key

X gross laden mass of vehicle in metric tonnes (t)
Y static tilt angle δ

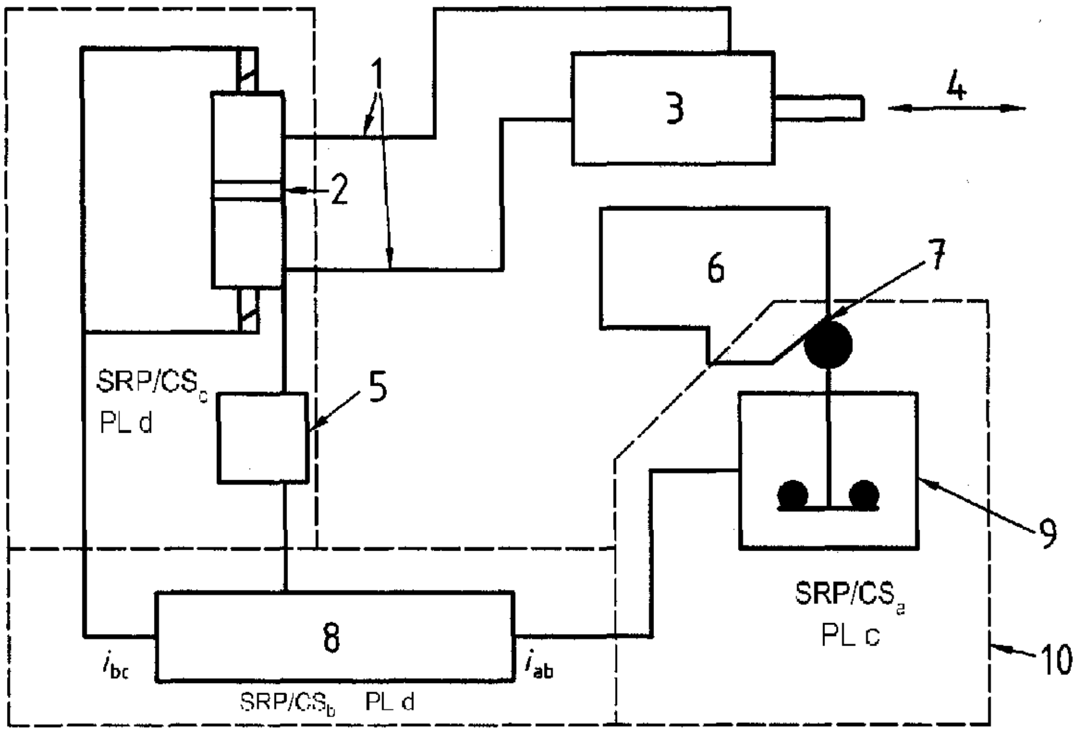
Figure 22 — Static tilt angle δ for motor vehicle mounted HP's

Verification: by static tilt test in 6.1.6.2.

5.13 Safety devices

5.13.1 In this document, wherever reference is made to this clause, the performance of safety-related parts shall, in the event of failures, conform to the Performance level (PL) (taken from EN ISO 13849-1) that are given in Table 5.

5.13.2 The validation of the safety functions and Performance level (PL) in 5.13.1 is given in EN ISO 13849-2. As shown in Figure 23, taken from CR 954-100 and adapted, a safety function can be achieved by a combination of a number of components of different technologies (e.g. mechanical, hydraulic, pneumatic, electronic), selection of the Performance level (PL) of each component taking into account the technology used. It is to be noted, as an example, that a Performance level (PL) d safety function may be achieved by an appropriate combination of Performance level (PL) c components.



Key

1	output signal	6	guard
2	fluidic directional valve	7	input signal
3	fluidic actuators	8	electronic control logic
4	hazardous movement	9	position device
5	checking function	10	scope of EN ISO 13849-1

PL c, PL d	Performance level according to EN ISO 13849-1
SRP/CS_a	Safety-related part of control system, input
SRP/CS_b	Safety-related part of control system, logic/processing
SRP/CS_c	Safety-related part of control system, output/power control elements
i_{ab}, i_{bc}	Interconnecting means (e.g. electrical, optical)

NOTE The stop and the start functions have been omitted to keep the example simple.

Figure 23 — Example to explain the use of Performance level (PL)

Figure 23 is a schematic diagram of the safety-related parts to provide one of the functions to control a machine actuator. This is not a functional/working diagram and is included only to demonstrate the principle of combining Performance level (PL) and technologies in this one function.

The control is provided through an electronic control logic and a fluidic directional valve checked at suitable intervals (see EN ISO 13849-1:2008, 6.2.5). The risk is reduced by an interlocking guard which prevents access to the hazardous situation when the guard is closed and prevents start-up of the fluidic actuator when the guard is open.

For this example, the combined safety-related parts of the control system begins at point 7 and ends at point 1 in Figure 23.

The safety-related parts which provide the safety function are: guard cam, position device, electronic control logic, fluidic directional valve and the interconnecting means.

These combined safety-related parts provide a stop function (see EN ISO 13849-1:2008, 5.2.1) as a safety function (for definition see EN ISO 13849-1:2008, 3.1.20). As the guard opens, the contacts in the position device open and the electronic control logic provides a signal to the fluidic directional valve to stop the fluidic flow as the output of the safety related parts of the control system. At the HP, this stops the hazardous movement of the actuator.

This combination of safety-related parts creates a safety function to demonstrate the categorisation based on the requirements of EN ISO 13849-1:2008, Clause 6. It considers the possibility and the probability of the faults that can occur which may affect the ability of those combined parts to perform the safety function. Using these principles, the safety-related parts shown in Figure 23 can be categorised as follows:

a) Performance level (PL) c for the electro-mechanical position device

   To reduce the probability of faults this device is comprised of well-tried components applied using well-tried safety principles, e.g. positive opening operation, over-dimensioning (see EN ISO 13849-1:2008, Clause 3 and EN ISO 13849-1:2008, 6.2.4);

b) Performance level (PL) d

   1) for the electronic control logic

      To increase the level of safety performance of this electronic control logic, the structure of this safety related part of the control system is designed so that it is able to detect most single faults, e.g. redundancy (see EN ISO 13849-1:2008, 6.2.6);

   2) for the checked fluidic directional valve

      To achieve the required level of safety performance, this safety-related part uses components which are periodically checked, e.g. monitoring, in order to detect the faults which have not been avoided using well tried safety principles (see EN ISO 13849-1:2008, 6.2.5).

The position, size and layout of the interconnecting means have also to be taken into account.

The overall objective is that each of the safety-related parts achieves a similar level of safety performance so that the contribution of the safety-related parts of the control system provides the required reduction in risk. Therefore the reliability and structure within the safety-related parts of the control system have both to be considered.

5.13.3 The combined effect of correct use by a trained operator, the control system, the operating system and the safety system shall be to achieve a Performance level (PL) of safety as shown in Table 5.

It shall only be possible to over-ride a safety device listed in Table 5 in a safe manner by using a separate device of the same Performance level (PL) or better.

Performance levels (PL), other than those shown in Table 5, can be used (see EN ISO 13849-1:2008, 6.3), but the intended system behaviour in case of fault(s) shall be maintained. Reasons for deviating from Table 5 shall be given. These reasons, to select other than the Performance level (PL) shown in Table 5, can be the use of different technologies, e.g. well-tried hydraulic or electro-mechanical components (Performance level (PL) c) in combination with electrical or electronic systems (Performance level (PL) d or Performance level (PL) e).

The manufacturer may use a safety device of a lower Performance level (PL) than shown in Table 5 provided that the decision is based on a risk assessment and the approval of a Notified Body is obtained.

Table 5 — Performance level (PL) for safety devices

Clause/subclause in this document	Performance level (PL) of EN ISO 13849-1
5.3.1	c
5.3.2	c
5.3.3	d
5.3.4	d
5.3.11	c
5.4.1.4	d
5.4.1.5.3	d
5.4.1.6	d
5.4.1.9	d
5.4.3	c
5.5.1.3	d
5.5.2.6	c
5.5.3.6	c
5.6.1	d
5.6.2	d
5.7.6	c
5.11.2	c

For safety devices which incorporate mechanical parts only, no specific Performance level (PL) is required.

6 Verification

6.1 Type tests

6.1.1 General

The tests described in 6.1 shall be carried out for verification of the design of the model on the first HP of any design intended for series production and on any unique HP.

6.1.2 Static test to verify the stability calculation

The HP shall be set up on the maximum allowable inclination of the supporting surface allowed by the manufacturer plus 0,5° with any stabilizers used to produce the maximum residual slope permitted by the manufacturer.

The test may be carried out on level ground if the test loads are re-calculated to include the effects of the maximum allowable inclination of the supporting surface and the maximum residual slope defined by the manufacturer, plus 0,5°.

The test load may be applied at any suitable strong point, if necessary to avoid over-stressing any part of the HP, provided they reproduce the distortions, play and elastic deflections in 5.2.4.1.6. The test is to be repeated in all the most unfavourable extended and/or retracted positions. Examples are shown in Table 2 and Figure 5 to Figure 7.

Test loads shall be applied to represent all the least favourable load and force combinations specified in 5.2.4.1.1 to 5.2.4.1.5 (see also 5.4.1.7, b)).

The HP is stable if it can come to a stationary condition without overturning while supporting the test load(s).

6.1.3 Residual load test

The HP is stable if it can come to a stationary condition without overturning while supporting the test load(s) with a minimum residual load of 6 % of the unladen mass of the vehicle (minus the driver's and loose equipment's mass and at minimum fuel tank level) shall be achieved on the unloaded side in the least favourable position (i.e. maximum horizontal position) of extending structure.

The test load shall be 1,0 × rated load.

6.1.4 Static overload test

With a test load of 125 % of the rated load, distributed evenly over the half of the platform creating the greatest stress in the specific test case, the HP shall be put into each position which creates maximum stress in any load carrying part. In the case of HP's which are required to meet the enhanced overload criteria of 5.4.1.8 (system 3 and system 4 in 5.4.1.1), the test load shall be 150 % of the rated load.

Temporary adjustment of brakes, pressures etc. shall be allowed if necessary for stopping and holding the test loads. After removing the test loads the HP shall show no permanent deformation.

Additionally it shall be demonstrated that, following application of the manual force according to 5.2.3.5 in any position of the platform, the platform shows no sign of permanent deformation.

All movements with the test load between each test position (see first paragraph of 6.1.4) shall be carried out at accelerations and decelerations appropriate with safe control of the load. Where several movements with the test load have to be carried out (i.e. lifting, lowering, slewing, travelling) the intended movements shall be carried out separately and with care taking into due account the least favourable positions and when vibrations associated with preceding movements have subsided.

When, due to various combinations of rated loads and free standing areas, tests with different test loads are necessary, all movements shall be carried out with appropriate test loads except where the least favourable conditions can be sufficiently simulated by one test.

The test load shall be applied gradually (to limit any dynamic effects) according to the calculation for a duration of 10 min. Verify that according to 5.4.1.8, b), 10 min after unloading, the height difference for HP's:

a) with a rescue height up to 30 m is less than 100 mm;

b) with a rescue height greater than 30 m is less than the value specified by the manufacturer.

6.1.5 Ladder type tests

Ladders on or forming part of the extending structure and their supports shall be tested in the same position twice, with static test loads equal to the design loads specified in 5.2.5.4. After removing the test loads the second time, the ladders, their supports and the extending structure shall show no permanent deformation when compared with measurement after the first loading.

6.1.6 Dynamic tests

6.1.6.1 General

6.1.6.1.1 Introduction

The HP shall be subjected to dynamic tests with the test loads distributed evenly over the half of the platform creating the greatest overturning moment in the specific test case.

6.1.6.1.2 Functional test

The HP shall be operated through its full working envelopes(s) carrying the rated load(s) to demonstrate that maximum permitted speeds, accelerations and decelerations are within the manufacturer's tolerances, and that all safety devices work correctly.

6.1.6.1.3 Dynamic overload test

The test in 6.1.6.1.2 shall be repeated carrying 110 % of the rated load(s) to demonstrate that the HP can operate smoothly throughout its working envelopes without permanent deformation or other patent defect.

NOTE For HP's with load sensing systems, the load sensing system may be overridden for the test.

6.1.6.2 Static tilt test

6.1.6.2.1 The HP at gross laden mass GLM as defined in EN 1846-2, shall be inclined along its longitudinal axis, as defined in EN 1846-2, and the overturning limit (loss of stability) shall be measured and recorded.

The test shall be repeated by inclining the vehicle both to the right and to the left.

6.1.6.2.2 The height of any stop used to prevent the wheels from slipping sideways during this test shall be maximum 50 % of the minimum vertical height in horizontal starting position between the surface on which the vehicle stands and the wheel rim.

NOTE During this test precautions should be taken to prevent complete loss of vehicle stability, for which purpose a form of temporary restraint may be used.

6.1.7 Tests of vertical load sensing and total moment sensing systems

6.1.7.1 Load sensing systems

The test load of 120 % of the rated load (see 5.4.1.4) shall be positioned along each side of the platform in turn. The centres of the test load shall be according to Figure 3 and Figure 4. The tests shall be repeated for any extended or rotated position of the platform. Each position of the test load shall produce the signal that stops further movement of the extending structure.

The test shall be repeated with the platform in each position of the extending structure which creates maximum height or reach, to prove that the accuracy is not affected by the position of the extending structure.

In the case of HP's with more than one rated load, the test shall be repeated for each combination of rated load and working envelope. Where there is more than one rated load, the load sensing system shall be capable of reacting to each rated load value.

6.1.7.2 Total moment sensing systems

The test in 6.1.7.1 shall be carried out but with a test load of 100 % of the rated load (see 5.4.1.6).

6.1.7.3 Moment sensing system with enhanced safety requirements (if applicable)

The test load on the platform is 100 % of the rated load (number of persons on the platform multiplied by 90 kg plus loose equipment). Verify that a minimum residual load of 6 % of the unladen mass of the vehicle (minus the driver's and loose equipment's mass and at minimum fuel tank level) is achieved on the unloaded side after turning off the moment sensing system in the least favourable position (i.e. maximum horizontal position of extending structure).

The test shall be carried out for all combinations of rated load and working envelope.

Where the width of the stabilizer is adjustable, the test shall be carried out for the shortest and largest stabilizer width.

6.1.8 Type test on noise

Noise emission values shall be determined using the noise test code in EN 1846-2:2009, Annex F.

6.2 Acceptance tests

The manufacturer shall perform, or have performed, the following tests on every HP before it is put into use:

a) the dynamic overload test according to 6.1.6.1.3;

b) the functional test according to 6.1.6.1.2. During this test all the appropriate verifications shall be made;

c) the tests of vertical load sensing and total moment sensing systems according to 6.1.7;

d) static overload test according to 6.1.4.

7 Information for use

7.1 Instruction handbook

7.1.1 General

Each HP shall be accompanied by an instruction handbook in accordance with EN ISO 12100-2:2003, 6.5, and with the requirements of this clause.

The instruction handbook shall at least include the information given in 7.1.2 to 7.1.10.

7.1.2 Operating instructions

a) Characteristics and description of the HP and intended uses;

b) location, purpose and use of all normal controls and any emergency stop controls;

c) information about setting up the HP, correct use of stabilizers, operation on sloping ground, limitations of full operation on excessive slopes, the use of wheel chocks on steep slopes, the necessary bearing strength of the ground, maximum supporting surface loads for wheels and stabilizers, guidelines for assessing adequacy of the ground, e.g. by driving the wheels of the vehicle over the ground, inspection of the ground surface to be covered before elevated operation, for soft ground, pot-holes, etc.;

d) prohibition of overloading the platform, avoidance of adding excessive loads when in the extended position, guidance for assessing the load on the platform and any ladders;

e) prohibition of use as a crane in unapproved ways;

f) important daily checks on the safe condition of the machine, oil leaks, loose electrical fittings/connections, chafed hoses/cables, condition of tyres/brakes/batteries, collision damage, obscured instruction plates, special safety devices, etc.;

g) avoidance of contact with the vehicle cab, other fixed objects (buildings, etc.), moving objects (vehicles, cranes, etc.) and live electrical conductors;

h) prohibition of any increase in reach or working height of the HP by use of additional equipment (e.g. ladders);

i) prohibition of any addition that would increase loads and wind loading on the HP, e.g. notice boards (for exceptions see 5.2.3.6);

j) ambient limitations (e.g. wind speed, temperature range);

k) information concerning vibrations transmitted by the machinery to the hand-arm system and to the whole body:

   1) the vibration total value to which the hand-arm system is subjected, if it exceeds 2,5 m/s^2. Where this value does not exceed 2,5 m/s^2, this shall be mentioned;

   2) the highest root mean square value of weighted acceleration to which the whole body is subjected, if it exceeds 0,5 m/s^2. Where this value does not exceed 0,5 m/s^2, this shall be mentioned;

   3) the uncertainty of measurement (whenever values are indicated).

   The values indicated shall be either those actually measured for the machinery in question or those established on the basis of measurements taken for technically comparable machinery which is representative of the machinery to be produced. The vibration shall be measured using the most appropriate measurement code for the machinery concerned and the operating conditions during measurement and the measurement codes used shall be described;

l) working conditions in which the use of a safety harness is recommended;

m) the importance of operation only by trained operators and an indication of the training required;

n) the responsibilities of operators;

o) procedures for frequent checks on the proper functioning of automatic safety devices;

p) hazards arising from leaving machines elevated and unattended for long periods, due to movement caused by internal hydraulic/pneumatic leakage;

q) precautions if travelling with the work platform elevated;

r) information on noise emission values (noise declaration) obtained using the noise test code in EN 1846-2:2009, Annex F;

s) the operating method to be followed in the event of accident or breakdown;

t) information concerning the radiation emitted for the operator and exposed persons where machinery is likely to emit non-ionising radiation which can cause harm to persons, in particular persons with active or non-active implantable medical devices;

u) information concerning the correct use of the anchorage points in the cage intended to avoid falling from the cage.

7.1.3 Transport, handling and storage information

a) Any special provisions for securing parts of the HP's for travel between operation sites;

b) the method of loading onto other vehicles/vessels for transport between operation sites, including lifting points, weight, centre of gravity, etc. for lifting purposes;

c) precautions to be taken before periods of storage indoors or out of doors;

d) checks to be made prior to use after periods of storage, exposure to extremes of ambient conditions − heat, cold, moisture, dust, etc.

7.1.4 Information on commissioning

a) Checks to be made on power supply, hydraulic oils, lubricants, etc. on first use, after long periods of storage or changes in environmental conditions (winter, summer, changed geographical location, etc.);

b) tests to be carried out before first use;

c) test report, where appropriate, detailing the static and dynamic tests carried out by or for the manufacturer or his authorised representative.

7.1.5 HP details

Principal operating features. Description, with diagrams where appropriate, of:

a) power source;

b) power circuits;

c) control circuits;

d) actuators;

e) purpose, location and function of automatic safety devices;

f) operational range of machine movements.

7.1.6 Maximum permitted loads on the platform

a) rated load;

b) wind loads;

c) side forces;

d) additional loads and forces;

e) maximum permitted wind speeds.

7.1.7 Maintenance information for use by trained personnel

a) Technical information on the HP including electrical/hydraulic/pneumatic circuit diagrams;

b) consumable items requiring regular/frequent checks or attention (lubricants, hydraulic oil level and condition, batteries, etc.);

c) safety features to be checked at specified intervals including safety devices, load holding actuators, emergency lowering controls, any emergency stops;

d) measures to be taken to ensure safety during maintenance;

e) checking structural and load-supporting components for any dangerous deterioration (corrosion, cracking, abrasion, etc.);

f) criteria for repair/replacement of parts, e.g. wire ropes and chains and the specifications of the spare parts to be used, when these affect the health and safety of operations;

g) the specifications of the spare parts to be used, when these affect the health and safety of operators;

h) the advisability of obtaining manufacturer's approval of any alteration which might affect stability, strength or performance;

i) parts requiring adjustment, including setting details;

j) any necessary tests/checks after maintenance to ensure a safe operating condition;

k) precautions to be taken when servicing machines fitted with pressure accumulators.

7.1.8 Special working methods or conditions

The instructions for use shall advise the user to obtain the guidance and approval of the manufacturer for any special working methods or conditions which are outside those intended by the manufacturer (see 7.1.2, a)) and shall also take into account any reasonably foreseeable misuse thereof.

7.1.9 Operating instructions for emergency

The instruction handbook shall contain location, purpose and use of emergency operation and any emergency stop controls.

7.1.10 Periodical examinations and tests

The instruction handbook shall contain the frequency and extent of periodical examinations and tests based on manufacturer's instructions, operating conditions and the frequency of use. It is normally not necessary to dismantle parts at periodical examinations, unless there are any doubts in relation to reliability and safety. The removal of covers, the exposure of observation apertures, and bringing the HP to the travel condition are not considered to be dismantling.

NOTE Periodical examinations and tests may consist of:

a) a visual examination of the structure with special attention to corrosion and other damage of load bearing parts and welds;

b) an examination of the mechanical, hydraulic, pneumatic and electrical systems with special attention to safety devices;

c) a test to prove the effectiveness of brakes and/or overload devices;

d) functional tests according to 6.1.6.1.2;

e) static overload test according to 6.1.4.

7.2 Marking

7.2.1 The marking shall be in accordance with EN 1846-2:2009, 6.4 and with 7.2.2 to 7.2.17.

7.2.2 One or more durable manufacturer's plate(s) giving the following indelible legible information shall be permanently attached to the HP in an easily visible place:

a) the business name and full address of the manufacturer and, where applicable, his authorised representative;

b) designation of the machinery;

c) designation of series or type;

d) mandatory marking[1)];

e) Serial or fabrication number;

f) the year of construction, that is the year in which the manufacturing process is completed;

g) nominal power expressed in kilowatts (kW);

h) mass of the most usual configuration, in kilograms (kg);

i) unladen mass in kilograms (kg);

j) maximum rated load in kilograms (kg);

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1) For machines and their related products intended to be put on the market in the EEA, CE marking as defined in the applicable European Directive(s), e.g. Machinery.

k) maximum rated load given as the allowable number of persons and mass of equipment in kilograms (kg) (in calculating the allowable number of persons, a figure other than 90 kg per person may be used if there are significantly different local physical characteristics);

l) maximum allowable manual force in newtons (N);

m) maximum allowable wind speed in metres per second (m/s);

n) maximum allowable slope of the supporting surface;

o) hydraulic supply information if an external hydraulic power supply is used;

p) pneumatic supply information if an external pneumatic power supply is used;

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

r) operating instructions for the emergency operation system.

Parts of this information may be repeated at other appropriate places on the HP (see 7.2.3 and 7.2.8).

7.2.3 The following information shall be permanently and clearly marked on each platform in an easily visible place:

a) the rated load in kilograms (kg) including, if applicable, the effects of additional loads and forces according to 5.2.3.6;

b) the rated load given as allowable number of persons and mass of equipment in kilograms (kg);

c) the maximum allowable manual force in newtons (N);

d) the maximum allowable wind speed in metres per second (m/s);

e) allowable special loads and forces, if applicable.

If more than one rated load is designated, they shall be tabulated in relation to the configuration of the HP.

7.2.4 HP's with a platform which can be extended, enlarged or moved relative to the platform or extending structure shall be marked with the rated load which can be carried in all positions and configurations of the platform.

7.2.5 HP's with main and secondary platforms shall be marked with the total rated load as well as with the rated loads of each platform.

7.2.6 HP's which are designated for operation in enclosed premises only (e.g. no wind) shall be permanently and clearly marked in an easily visible place to that effect.

7.2.7 Points for connection of external power supplies shall be permanently and clearly marked with the essential power supply information (see 7.2.2).

7.2.8 Parts which may be detached for functional reasons (e.g. platforms, outriggers) shall be permanently and clearly marked in an easily visible place with:

a) manufacturer's or supplier's name;

b) model designation of the HP;

c) serial or fabrication number of the HP.

7.2.9 An abridged version of the operating instructions for using the HP shall be permanently and clearly affixed in a suitable position. This abridged version shall refer the operator to the instruction handbook.

7.2.10 HP's shall be finished in clearly visible colours and all projecting extremities shall be marked with hazard colours.

7.2.11 Each stabilizer shall be permanently and clearly marked in an easily visible place with the maximum load it may be required to support during operation of the HP.

7.2.12 The pressure for pneumatic tyres shall be indicated on the HP.

7.2.13 Where safe clearances or adequate guarding are not possible warning signs shall be fitted (see 5.3.12 and 5.4.4).

7.2.14 HP's according to 5.3.3 requiring the use of stabilizers shall be provided with warning notices at the control positions informing the operator of conditions requiring the operation of the stabilizers.

7.2.15 Each ladder on or forming part of the extending structure shall be marked with the maximum number of persons allowed on the ladder, and whether it is an access ladder or a rescue ladder.

7.2.16 Hydraulic fluid power systems with accumulators shall have a warning label "Caution - De-pressurise system before maintenance".

7.2.17 Instructions for use of the emergency system shall be fitted near its controls.

7.3 Safety signs

Safety signs shall be in accordance with ISO 3864-1, ISO 3864-2 and ISO 3864-3.

NOTE 92/58/EEC deals with the minimum requirements for the provision of safety signs and/or health signs at work.

Annex A
(informative)

Special loads and forces — Use of HP's in wind speeds greater than Beaufort Scale 6 (see 5.2.3.4.1)

NOTE This information is reproduced from EN 280 but updated editorially regarding the references.

The original WG 1 of CEN/TC 98 adopted Beaufort Scale 6 after discussing a number of previously existing standards and the experience of users of Mobile Elevating Work Platforms (MEWPs). A significant reaction from users was that it represented a natural limit; at that level of wind speed operators became aware of the effects and were reluctant to use the machines.

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

It was agreed that higher wind speeds could be dealt with:

— by the manufacturers specifying that higher wind speeds were acceptable (see 7.2.2, m)); or

— by measures such as a reduction of the number of persons allowed on the work platform in those conditions. Most manufacturers used this procedure, giving appropriate details in their operating instruction manual. This approach is consistent with the requirement of training for operators in the Use of Work Equipment Directive (89/655/EEC Article 7) and CEN Guide 414:2004, 6.10.2 (Clause "Information for use – Signals and warning devices").

Annex B
(informative)

Dynamic factors in stability and structural calculations

NOTE This information is reproduced from EN 280:2001, Annex B with the amendment that item c) of EN 280:2001, Annex B is deleted.

Different methods of determining stability, used in existing standards, were discussed e.g.:

a) application of a factor to the rated load. It was eventually agreed that this was inadequate, particularly for large machines with large structural masses;

b) application of various factors to rated load, structural masses, etc. applied vertically. These factors varied from one standard to another and in no case were they substantiated by experiments or calculations.

It was concluded that the method to be used must take into account not only structural masses, rated load, wind forces, manual forces, etc., but their dynamic effects, where applicable, expressed as a factor acting in the direction of movement. It was also agreed that the calculation method must be checked by a static stability type test representing the calculated overturning moment - something not required by other standards.

However, this still left open the factor figure to be used for the dynamic effects, and it was agreed that this must be determined experimentally. The method chosen was to strain gauge the stabilizers, during operation of the extending structure with the rated load in the work platform, on the basis that the load on the stabilizers determines the stability.

Taking the static stresses as unity, the stress fluctuations, when reversing the controls to produce the most violent oscillations possible, varied between a minimum of 0,9 and a maximum of 1,2, over a curve similar to a sine wave. It was considered that dynamic forces producing this result could be represented by a static test calculated using the mean value. The mean figure, 1,05, was rounded up to 1,1 to give a substantial safety margin and various manufacturers made calculations to compare the resulting test loads with their existing test methods.

Compared with existing test methods (which varied considerably) the new method showed slightly lower test loads for some small machines (under 10 m) similar figures for medium sized machines (up to 20 m) and substantially higher figures for the largest machines (up to 70 m) due to their higher centres of gravity.

The figure of 1,1 (1,0 vertically plus 0,1 angularly) was accepted as giving a more reliable test over the whole range of machine types and sizes than previous methods. It would, typically, give type-test loads of 1 1/2 to 8 times the rated load, when taking into account the maximum possible combinations of loads and forces and working conditions. The increase from 1,05 to 1,1 was considered to provide an adequate extra margin of safety, particularly when considering the improbability of all the worst conditions occurring simultaneously. The oscillations produced during the tests were much more severe than those produced by even accidental misuse at normal maximum operating speeds indicating that the results were related more to the energy-absorbing flexibility and natural frequency of the structure than to operating speeds.

Structural calculations

Clearly, under the same type of misuse the stress fluctuations at the upper end of the extending structure would be much greater. "Experience under known service conditions is the most valuable and reliable basis for design" (see BS 2573-2) but manufacturers are advised to make similar strain gauge tests to check that the peak stresses are within the maximum permissible stress limits for the particular design details. Being of a very intermittent nature they would not normally need to be taken into account in fatigue calculations.

Annex C
(informative)

Major alterations and repairs

Alterations and repairs to an HP should be supported by the relevant structural and/or stability calculations of this document. It is advisable that such alterations should be made with the approval of the manufacturer, or his authorised representative established in the European Community. The verification procedures in Clause 6 should be repeated on completion.

For the purpose of this document "major alterations" or "major repair" are modifications of the whole or part of an HP which affect stability, strength or performance.

Annex D
(normative)

Design of wire rope drive systems for the extending structures and platform levelling systems

NOTE This information is reproduced from DIN 15020-1.

D.1 General

A "wire rope drive" within the meaning of this document comprises the wire ropes running on rope drums and on or over rope pulleys, as well as the associated rope drums, rope pulleys and compensating pulleys.

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

This annex does not apply to rope drives with friction pulley drive. Wire ropes which do not run on rope drums and/or over rope pulleys (carrying ropes and tensioning ropes) and sling ropes are not dealt with in this document.

D.2 Calculation of rope drive

When calculating the rope drives, the following factors which influence the service life of a wire rope must be taken into consideration:

a) mode of operation (drive group);

b) wire rope diameter (coefficient c);

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

d) rope grooves.

Mode of operation (drive group)

The mechanical components shall be graded according to their mode of operation into a "drive group" in accordance with Table D.1, in order to achieve an adequately long service life. The grading is made according to running time categories, which take the average running time of the rope drive into account. As regards the grading into running time categories, the mean running time per day, related to one year, is the determining factor.

D.3 Calculation of rope diameter (coefficient c)

The rope diameter d (in millimetres (mm)) is determined in accordance with the equation below, from the calculated traction force on the rope S (in newtons (N)):

$$d_{\min} = c \times \sqrt{S} \tag{D.1}$$

The values of coefficient c (in mm/$\sqrt{N}$) are given in Table D.2 for the various drive groups. These values apply equally to bright and to galvanized wire ropes. The calculated rope traction S is determined from the static traction force in the wire rope taking into consideration the acceleration forces and the efficiency of the rope drive (see D.5).

Items which need not be taken into consideration include: Acceleration forces up to 10 % of the static traction forces.

Table D.1 — Drive groups according to running time categories

Running time category	Symbol			V_{006}	V_{012}	V_{025}	V_{05}	V_1	V_2	V_3	V_4	V_5
	Mean running time per day in hours (h), related to 1 year			up to 0,125	over 0,125 up to 0,25	over 0,25 up to 0,5	over 0,5 up to 1	over 1 up to 2	over 2 up to 4	over 4 up to 8	over 8 up to 16	over 16
Load collective	No	Term	Explanation	Drive group								
	1	light	maximum load occurs only infrequently	$1E_m$	$1E_m$	$1D_m$	$1C_m$	$1B_m$	$1A_m$	2_m	3_m	4_m
	2	medium	low, average and maximum loads occur with roughly equal frequency	$1E_m$	$1D_m$	$1C_m$	$1B_m$	$1A_m$	2_m	3_m	4_m	5_m
	3	heavy	maximum loads occur almost continuously	$1D_m$	$1C_m$	$1B_m$	$1A_m$	2_m	3_m	4_m	5_m	5_m
If the duration of an operating cycle is 12 min or longer, the rope drive may be graded one drive group lower than the drive group grading determined from the running time category and from the load collective.												

Table D.2 — Coefficients *c*

Drive group	c (in mm/$\sqrt{N}$) for conventional transports and wire ropes which are not non-twisting. Nominal strength of the individual wires in newtons per square millimetre (N/mm^2)			
	1 570	1 770	1 960	2 160[a]
$1E_m$	–	0,067 0	0,063 0	0,060 0
$1D_m$	–	0,071 0	0,067 0	0,063 0
$1C_m$	–	0,075 0	0,071 0	0,067 0
$1B_m$	0,085 0	0,080 0	0,075 0	0,070 0
$1A_m$	0,090 0	0,085 0		–
2_m	0,095 0			–
3_m	0,106			–
4_m	0,118			–
5_m	0,132			–
[a] Wire ropes of 2 160 N/mm^2 nominal strength in particular shall be of a design which makes them entirely suitable for the special application concerned here.				

D.4 Calculation of the diameters of rope drums, rope pulleys and compensating pulleys [coefficient ($h_1 \times h_2$)]

The diameter D of rope drums, rope pulleys and compensating pulleys, related to the centre of the wire rope, is calculated from the minimum rope diameter d_{min} determined in accordance with D.3, using the following equation:

$$D_{min} = h_1 \times h_2 \times d_{min} \quad \text{(D.2)}$$

where

h_1 and h_2 are non-dimensional coefficients.

The factor h_1 is dependent on the drive group and on the rope design, and is listed in Table D.3; the factor h_2 is dependent on the arrangement of the rope drive and is listed in Table D.4.

Thicker wires ropes (up to 1,25 times the calculated rope diameter) may be laid on rope drums, rope pulleys and compensating pulleys having the diameters calculated in accordance with Table D.3 and Table D.4 for the same rope traction force and without any impairment of the service life, on condition that the permissible groove radius in accordance with 5.5.2.12 is observed. Larger rope drum, rope pulley and compensating pulley diameters will increase the service life of the wire rope.

Table D.3 — Coefficients h_1

Drive group	rope drums and wire ropes which are not non-twisting	rope pulley and wire ropes which are not non-twisting	compensating pulley and wire ropes which are not non-twisting
$1E_m$	10	11,2	10
$1D_m$	11,2	12,5	10
$1C_m$	12,5	14	12,5
$1B_m$	14	16	12,5
$1A_m$	16	18	14
2_m	18	20	14
3_m	20	22,4	16
4_m	22,4	25	16
5_m	25	28	18

For the determination of h_2 the rope drives are classified according to the number w of alternating bending stresses which the most unfavourably stressed portion of the rope has to run through during one working cycle (lifting and lowering of the load) for one working stroke. w is entered as the sum of the following individual values for the elements of the rope drive:

Rope drum: $\omega = 1$

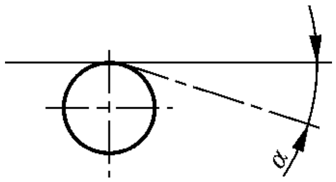
Rope pulley for deflection in the same direction, $\alpha > 5°$: $\omega = 2$

Rope pulley for deflection in the opposite direction, $\alpha > 5°$: $\omega = 4$

Rope pulley, $\alpha \leq 5°$ (see Figure D.1): $\omega = 0$

Compensating pulley: $\omega = 0$

End attachment of rope: $\omega = 0$

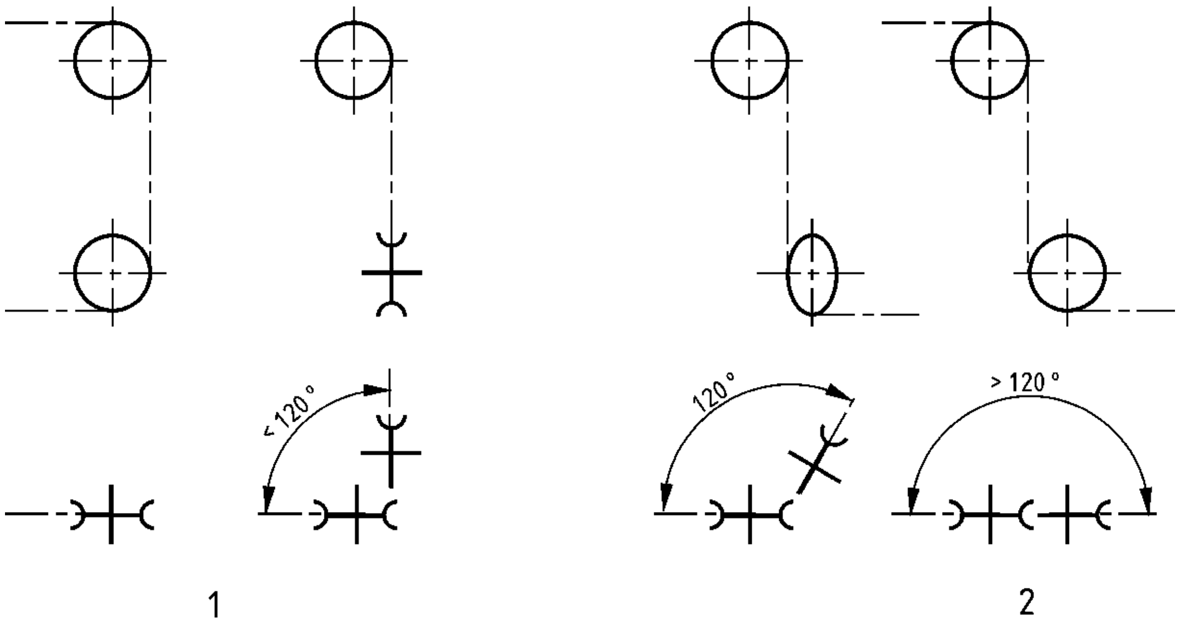


Key

α angle of deflection

Figure D.1 — Angle of deflection

Deflection in the opposite direction must be taken into consideration if the angle between the planes of two adjacent rope pulleys (traversed by the rope in succession) amounts to more than 120° (see Figure D.2 and Table D.4).



Key

1 deflection in the same direction

2 deflection in the opposite direction

Figure D.2 — Deflection in the same direction and in the opposite direction

Table D.4 — Coefficients h_2

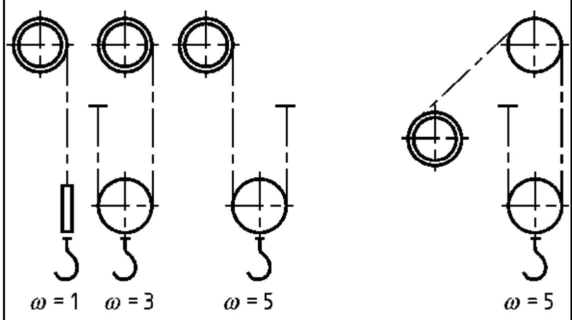
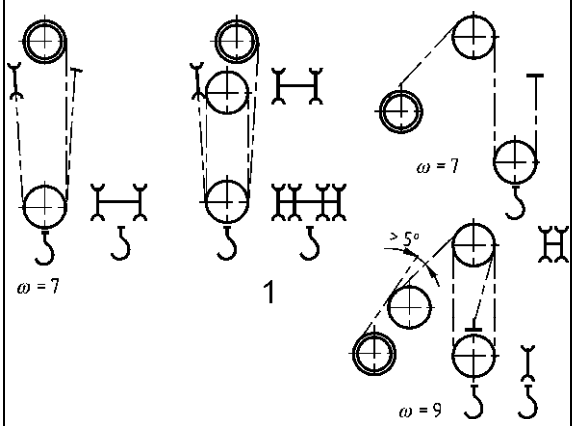
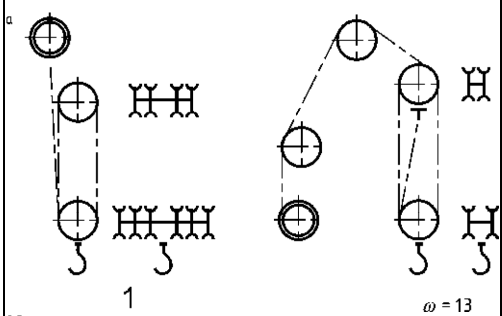
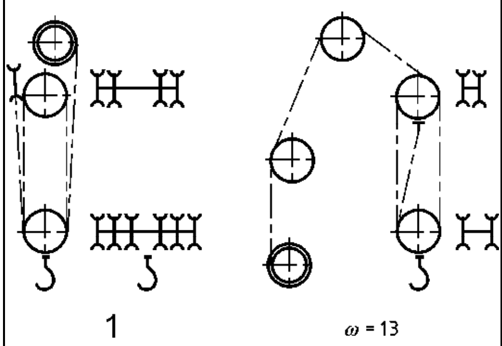
Examples for arrangements of rope drives			h_2[a] for	
Description	Examples of application (drums illustrated in double lines)	ω	rope drums, compensating pulleys	rope pulleys
Wire rope runs on rope drum and over no more than two rope pulleys with deflection in the same direction or one rope pulley with deflection in opposite direction	 **Key** ω number of reversed bending	up to 5	1	1
Wire rope runs on rope drum and over no more than four rope pulleys with deflection in the same directions or two rope pulleys with deflection in the same direction and one rope pulley in the opposite direction or two rope pulleys with deflection in the opposite direction	b  **Key** ω number of reversed bending 1 two pulley blocks each ω = 7	6 up to 9	1	1,12

Table D.4 — Coefficients h_2 *(concluded)*

Examples for arrangements of rope drives		ω	h_2[a] for	
Description	Examples of application (drums illustrated in double lines)		rope drums, compensating pulleys	rope pulleys
Wire rope runs on rope drums and over at least five rope pulleys with deflection in the same direction or three rope pulleys with deflection in the same direction plus one rope pulley with deflection in the opposite direction or	 **Key** ω number of reversed bending 1 two pulley blocks each ω = 11	10 and over	1	1,25
one rope pulley with deflection in the same direction plus two rope pulleys with deflection in the opposite direction or three rope pulleys with deflection in the opposite direction	 **Key** ω number of reversed bending 1 two pulley blocks each ω = 11			

[a] The correlation of w and h_2 in respect of the description and of the examples of application is only valid on condition that, one segment of rope runs through the entire arrangement of the rope drive during one working stroke. For the determination of h_2, only the values of w which occur at the most unfavourable segment of the rope need to be considered.

[b] Compensating pulley.

D.5 Efficiency of rope drives

The efficiency of a rope drive, for calculation of the rope traction force in accordance with D.3 is determined in accordance with the following equation:

$$\eta_s = (\eta_R)^i \times \eta_F = (\eta_R)^i \frac{1}{n} \times \frac{1-(\eta_R)^n}{1-\eta_R} \tag{D.3}$$

where

i is the number of fixed rope pulleys between the rope drum and the pulley block or load (e.g. in the case of lifting gear of jib cranes);

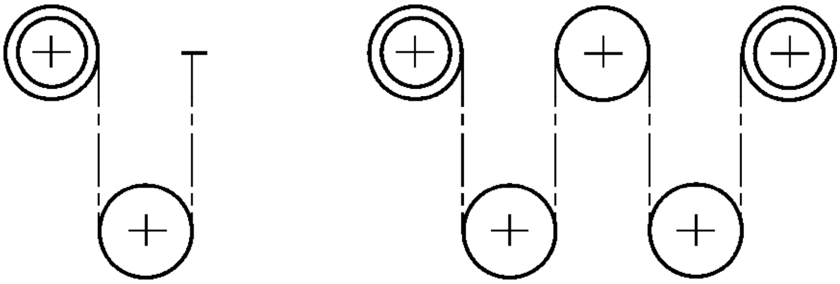
n is the number of rope plies in one pulley block. One pulley block consists of the sum total of all the rope plies and rope pulleys for one rope winding onto a rope drum (see Figure D.3);

η_F is the efficiency of the pulley block;

$$\eta_F = \frac{1}{n} \times \frac{1-(\eta_R)^n}{1-\eta_R} \tag{D.4}$$

η_R is the efficiency of one rope pulley;

η_S is the efficiency of the rope drive.



a) Pulley block two ply n = 2

b) Twin pulley block four ply, consisting of two pulley blocks, each two ply 2 × (n = 2)

Figure D.3 — Pulley blocks

The efficiency of a rope pulley is dependent on the ratio of the rope pulley diameter to the rope diameter (D:d), on the rope design and on the rope lubrication, in addition to being dependent on the type of bearing arrangement of the pulley (plain bearings or anti-friction bearings). Insofar as more accurate values have been proved by means of trials, the following shall be assumed for calculations:

— for plain bearings η_R = 0,96;

— for anti-friction bearings η_R = 0,98.

The efficiencies in Table D.5 are calculated on the basis of the above values.

No efficiency needs to be taken into consideration in the case of compensating pulleys.

Table D.5 — Efficiencies of pulley blocks

n		2	3	4	5	6	7	8	9	10	11	12	13	14
η_F	Plain bearing	0,98	0,96	0,94	0,92	0,91	0,89	0,87	0,85	0,84	0,82	0,81	0,79	0,78
	Anti-friction bearings	0,99	0,98	0,97	0,96	0,95	0,94	0,93	0,92	0,91	0,91	0,90	0,89	0,88

Annex E
(informative)

Calculation example of Annex D for wire rope, drum and pulley diameters

NOTE This information is adapted from EN 280.

E.1 Notes

a) Light intermittent duty according to EN 280 is interpreted as large machines with large rated loads, often operating with less than the full rated load and used intermittently.

b) Heavy duty according to EN 280 is interpreted as smaller machines with low rated loads, regularly carrying the full rated load, and used regularly.

c) Medium term (see Table D.1) is considered the most severe working case for extending structures in this document, as their load varies during the operating cycle. Heavy Term would only apply to levelling systems on machines with low rated loads, e.g. one person, carried during the whole of every cycle. This does not apply to HP's but would still give the same drive group used in the example.

The worst possible case has been taken, e.g. a single rigid boom moving through an arc to reach maximum height. In practice, as this movement is achieved by the use of more than one boom, the mean running time would be divided by the number of booms and would be further reduced by the higher operating speeds of telescopic movements.

For the purpose of this analysis a load cycle starts when the platform is loaded in the access position, and finishes when it is unloaded in the access position after being extended to a working position.

E.2 Annex D method summarised

a) D.2: Use the number of load cycles and operating speeds from Table D.1 to determine the drive group.

b) D.3: Calculate the minimum theoretical rope diameter d_{min} using the coefficient c for this drive group from Table D.2, in the following equation:

$$d_{min} = c \times \sqrt{S} \quad \text{(E.1)}$$

where

S is the calculated traction force in the rope.

This completes the Annex D process for calculating the wire rope diameter. However, the coefficient of utilization may be calculated by dividing the breaking force figures from ISO 2408 corrected if necessary for different wire strengths, by the calculated traction force in the rope.

c) D.4: Calculate the diameters of drums and pulleys from the equation

$$D_{min} = h_1 \times h_2 \times d_{min}, \quad \text{(E.2)}$$

where

— the coefficient h_1 for the drive group is taken from Table D.3; and

— the coefficient h_2 is determined by the total number of alternating stresses in the most unfavourably stressed portion of the rope using Table D.4.

E.3 Example

E.3.1 General

The following example illustrates the process. The load figures have been chosen to give an exact 9 mm diameter for the wire rope, so the coefficients in the table are minima.

E.3.2 Drive group — See D.2 and Table D.1

Case 1: Light intermittent duty (EN 280)

40 000 cycles over ten years = $\frac{40\,000}{365 \times 10}$ = 10,96 cycles/day.

Worst case, 25 m boom moving through 180° (360° total) at 0,4 m/sec (see Figure E.1).

Mean running time/day in hours (h), relating to one year (see Table D.1).

$$\frac{\pi \times 50}{0,4} = 393 \text{ s/cycle} \quad \frac{10,96 \times 393}{60 \times 60} = \begin{matrix} 1,12 \text{ h/day} \\ (1-2 \text{ h/day}) \end{matrix} = \text{class } V_1$$

Table D.1 gives $1A_m$ drive group for Class V_1, medium duty.

Case 2: Heavy duty (EN 280)

100 000 cycles over ten years = $\frac{100\,000}{365 \times 10}$ = 27,4 cycles/day.

Worst case, 10 m boom moving through 90° (180° total) at 0,4 m/sec (see Figure E.2).

Mean running time/day in hours (h) relating to one year (see Table D.1).

$$\frac{\pi \times 20}{2 \times 0,4} = 78,5 \text{ s/cycle} \quad \frac{27,4 \times 78,5}{60 \times 60} = \begin{matrix} 0,6 \text{ h/day} = \text{class } V_{05} \\ (0,5\text{-}1 \text{ h/day}) \end{matrix}$$

Table D.1 gives $1A_m$ drive group for Class V_{05} heavy duty.

Conclusion: $1A_m$ drive group is adopted as appropriate for all HP's complying with this document.

E.3.3 Calculation of minimum rope diameter — See D.3

$$d_{min} = c \times \sqrt{S} \qquad \text{(E.3)}$$

where

S is the calculated load in the rope in newtons (N).

Using drive group $1A_m$, Table D.2 gives coefficient c:

— for ropes (not non-twisting) with a nominal strength of 1 570 N/mm²: c = 0,090;

— for ropes (not non-twisting) with a nominal strength of 1 770 N/mm²: c = 0,085;

— for ropes (not non-twisting) with a nominal strength of 1 960 N/mm²: c = 0,085;

— for ropes (not non-twisting) with a nominal strength of 2 160 N/mm²: c is not applicable for drive group $1A_m$ according to Table D.2.

For S = 10 000 N and c = 0,090 and S = 11 211 N and c = 0,085: d_{min} = 9 mm.

Coefficients of utilization:

EXAMPLE Wire ropes 6 × 19: From ISO 2408:2004, Table C.6 and Table C.7 the minimum breaking force F_{min} of 9 mm diameter wire ropes 6 × 19 with wire strength 1 770 N/mm² is:

— with fibre core: F_{min}= 47 300 N;

— with steel core: F_{min}= 51 000 N.

Wire strength:	Coefficients of utilization: Fibre core:	Coefficients of utilization: Steel core:	Equation:
1 570 N/mm² (S = 10 000 N)	$\frac{43\,300 \times 1\,570}{10\,000 \times 1\,770} = 4{,}20$	$\frac{51\,000 \times 1\,570}{10\,000 \times 1\,770} = 4{,}52$	$\frac{F_{min}}{S} \times \frac{1570}{1\,770}$
1 770 N/mm² (S = 11 211 N)	$\frac{47\,300}{11\,211} = 4{,}22$	$\frac{51\,000}{11\,211} = 4{,}55$	$\frac{F_{min}}{S}$
1 960 N/mm² (S = 11 211 N)	$\frac{4{,}22 \times 1\,960}{1\,770} = 4{,}67$	$\frac{4{,}55 \times 1\,960}{1\,770} = 5{,}04$	$\frac{F_{min}}{S} \times \frac{1960}{1\,770}$

E.3.4 Calculation of the diameters of rope drums, pulleys and static pulleys — See D.4

Using the equation

$$D_{min} = h_1 \times h_2 \times d_{min} \quad \text{(E.4)}$$

the coefficients h_1 for drive group 1*A*m are taken from Table D.3.

The coefficients h_2 are determined by the total number, ω_t, of alternating stresses, ω, in the most unfavourably stressed portion of the rope using Table D.4 and have been used for the last two columns of Table E.1. Figure E.3 shows that the value h_2 for HP's is normally 1.

Table E.1 — *D*/*d* ratio

	ω	ω_{t1} = 0 to 5	ω_{t1} = 6 to 9	ω_{t1} = equal or greater than 10
Drum	1	16	16	16
Pulley deflecting more than 5° in the same direction	2	18	20,25	22,5
Pulley deflecting more than 5° in the opposite direction	4	18	20,25	22,5
Pulley deflecting less than 5° in any direction and static pulley (e.g. end attachment of rope)	0	14	14	14

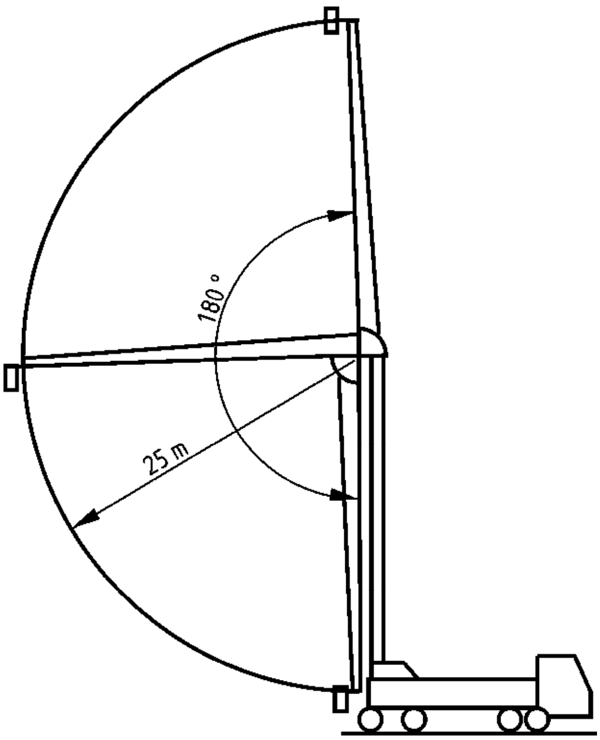


Figure E.1 — Wire rope systems — Case 1: Light intermittent duty

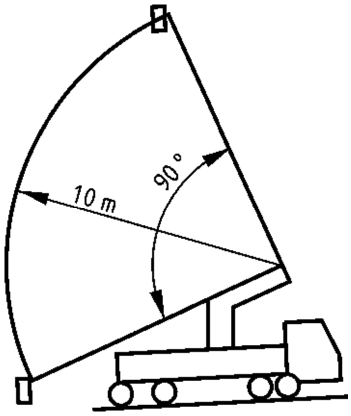
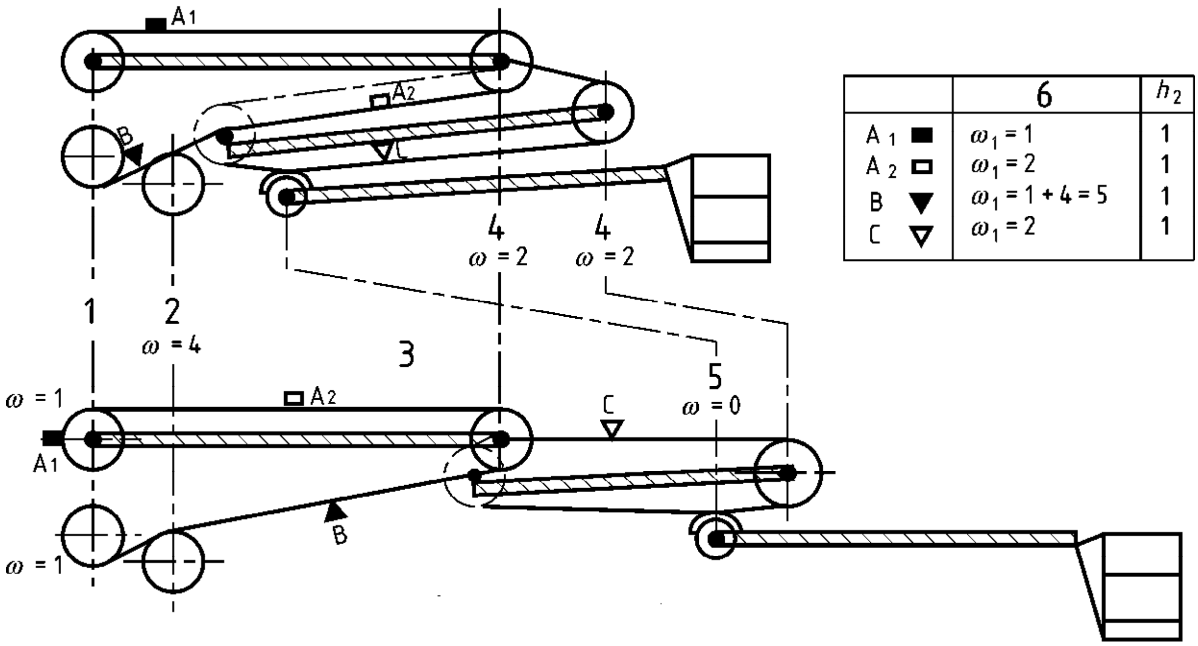


Figure E.2 — Wire rope systems — Case 2: Heavy duty

Extending structure retracted



Extending structure extended

Key

ω alternating stress

1 double rope drive

2 rope pulley (deflection in the opposite direction)

3 rope pulley (deflection in the same direction)

4 rope pulley (deflection in the opposite direction)

5 end attachment of rope

6 number of alternating bending stresses

A_1, A_2, B, C rope

Figure E.3 — Determination of the number of alternating bending stresses in individual wire ropes, for determination of pulley and drum diameters − Example of wire-rope-driven extending structure

Annex ZA
(informative)

Relationship between this European Standard and the Essential Requirements of EU Directive 2006/42/EC

This European Standard has been prepared under a mandate given to CEN by the European Commission and the European Free Trade Association to provide one means of conforming to Essential Requirements of the New Approach Directive Machinery 2006/42/EC.

Once this standard is cited in the Official Journal of the European Union under that Directive and has been implemented as a national standard in at least one Member State, compliance with the normative clauses of this standard except subclause 5.3.6 confers, within the limits of the scope of this standard, a presumption of conformity with the relevant Essential Requirements of that Directive and associated EFTA regulations.

WARNING — Other requirements and other EU Directives may be applicable to the products falling within the scope of this standard.

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