Draft

Australian/New Zealand Standard™

Public Comment is invited for:

DR AS/NZS 1418.10:2023, Cranes, hoists and winches, Part 10: Mobile elevating work platforms

During their development process, Australian/New Zealand Standards are available in draft form during the public consultation period to allow any interests concerned with the application of the proposed Standard to review the draft and submit their comments.

This draft is liable to alteration. It is not to be regarded as an Australian/New Zealand Standard until finally issued as such by Standards Australia/Standards New Zealand.

Upon successful conclusion of the Public Comment period it is proposed to publish this Standard as AS/NZS 1418.10:202X.

NOTE

This public comment draft is for New Zealand consultation, and New Zealand stakeholders only. This draft was previously released for Australian consultation through Standards Australia. Any comments received from stakeholders outside of New Zealand will be marked for future work, unless previously resolved.

STANDARDS Australia

STANDARDS NEW ZEALAND
TE MANA TAUTIKANGA O AOTEAROA

Preface

This Standard was prepared by the Joint Standards Australia/Standards New Zealand Committee ME-005, Cranes, to supersede AS/NZS 1418.10:2011.

The objective of this document is to specify requirements for mobile elevating work platforms (MEWPs) in general and, in addition, those intended for specific applications such as use near live electrical conductors or operation in orchards where specific design requirements are necessary to address the risks associated with the intended use. Additional requirements are also specified for portable MEWPs.

In the preparation of this document, cognizance was taken of ISO 16368, Mobile Elevating Work Platforms—Design, Calculations, Safety Requirements and Test Methods.

The major changes in this edition are as follows:

(a) Clause 2.1.6 now includes the limit states method for determining structural capacity of the MEWP as an alternative to the permissible stress method.

(b) Clause 3.6.3.1.4 now includes platform deflection criteria to determine the stability of Group A MEWPs rated for 1 person indoor use.

(c) Clause 2.6 now includes a normative reference to AS 5247 (ISO 21455 MOD) for operator controls, actuation, displacement, location and method of operation.

DRAFTING NOTE: AS 5247:202X is currently under development and is expected to publish concurrently with AS/NZS 1418.10.

The terms “normative” and “informative” have been used in this document to define the application of the appendix to which they apply. A “normative” appendix is an integral part of a Standard, whereas an “informative” appendix is only for information and guidance.

At the time of publication of this document, technical solutions to meet the requirements of Clauses 2.3.1.2, 2.3.1.4 and 2.3.4 may not be available for certain classes of MEWP.

The respective jurisdictional authority may specify the requirements of Clauses 2.3.1.2, 2.3.1.4 and 2.3.4 for uninsulated/insulated MEWPs, including effective dates.

Australia and New Zealand have different requirements for insulated MEWPs (see Section 7).

This Standard includes a commentary on some of the clauses. The commentary directly follows the relevant clause, is designated by ‘C’ preceding the clause number and is printed in italics in a box. The commentary is for information and guidance and does not form part of the document.

Contents

Australian/New Zealand Standard

Cranes, hoists and winches

Part 10: Mobile elevating work platforms

1 Scope and general

1.1 Scope

This document specifies requirements for mobile elevating work platforms (MEWPs) in general and, in addition, those intended for specific applications such as use near live electrical conductors or operation in orchards where specific design requirements are necessary to address the risks associated with the intended use. It does not apply to passenger and goods lifts, hoists, fixed elevating work platforms, suspended scaffolding or mast climbing platforms.

Section 5 of this document provides variations of requirements for MEWPs that are specifically designed for use in orchards.

Section 6 of this document provides variations of requirements for portable MEWPs.

Section 7 of this document provides additional requirements for insulated MEWPs.

This document does not apply to any matter relating to firefighting equipment or to any matter relating to the vehicles upon which elevating work platforms are mounted, except to a vehicle which, while stationary, is a stable support for the extending structure.

NOTE 1 Appendix A provides a list of typical hazards associated with MEWPs.

NOTE 2 Appendix B provides explanatory notes on the changes to MEWP insulation that have been introduced in this revision.

1.2 Normative references

DRAFTING NOTE: AS 5247:202X, referred to below, is currently under development and is expected to publish concurrently with AS/NZS 1418.10.

The following documents are referred to in the text in such a way that some or all of their content constitutes requirements of this document.

NOTE Documents referenced for informative purposes are listed in the Bibliography.

AS 1418.1, *Cranes, hoists and winches, Part 1: General requirements*

AS 1657, *Fixed platforms, walkways, stairways and ladders—Design, construction and installation*

AS 1824.2, *Insulation coordination (phase-to-earth and phase-to-phase, above 1 kV), Part 2—Application guide*

AS 1931.1, *High-voltage test techniques, Part 1: General definitions and test requirements*

AS 2067, *Substations and high voltage installations exceeding 1 kV a.c*

AS 2549, *Cranes, hoists and winches — Glossary of terms*

AS 2550.10, *Cranes, hoists and winches—Safe use, Part 10: Mobile elevating work platforms*

AS 4024.1501, *Safety of machinery, Part 1501: Design of safety related parts of control systems—General principles for design*

AS 4024.1601, *Safety of machinery, Part 1601: Design of controls, interlocks and guarding—Guards—General requirements for the design and construction of fixed and movable guards*

AS 4024.1604, *Safety of machinery, Part 1604: Design of controls, interlocks and guarding — Emergency stop — Principles for design (ISO 13850:2015 (ED.3.0) MOD)*

AS 4024.1801, *Safety of machinery, Part 1801: Safety distances to prevent danger zones being reached by upper and lower limbs*

AS 4024.1803, *Safety of machinery, Part 1803: Safety distances and safety gaps — Minimum gaps to prevent crushing of parts of the human body*

AS 5224, *Cranes — Proof of competence of steel structures (ISO 20332:2016, MOD)*

AS 5227 (all parts), *Cranes — Requirements for mechanisms*

AS 5247, *Mobile elevating work platforms — Operator's controls — Actuation, displacement, location and method of operation (ISO 21455:2020, MOD)*

AS 60068.2.64, *Environmental testing, Part 2.64: Tests—Test Fh: Vibration. broad-band random (digital control) and guidance*

AS/NZS 4024.1204, *Safety of machinery — Electrical equipment of machines, Part 1204: General requirements (IEC 60204-1:2016 (ED. 6.0) MOD)*

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

AS 62061, *Safety of machinery — Functional safety of safety-related electrical, electronic and programmable electronic control systems (IEC 62061:2005+AMD1:2012+AMD2:2015 CSV (ED.1.2)/COR1:2015 MOD)*

ISO 2408, *Steel wire ropes — Requirements*

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

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

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

ISO 18893, *Mobile elevating work platforms — Safety principles, inspection, maintenance and operation*

ISO 20381, *Mobile elevating work platforms — Symbols for operator controls and other displays*

ISO 22877, *Castors and wheels — Vocabulary, symbols and multilingual terminology*

IEC 61057, *Live working — Insulating aerial devices for mounting on a chassis*

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

ANSI/SAIA A92.2, *Vehicle-mounted elevating and rotating aerial devices*

ASTM D635, *Standard test method for rate of burning and/or extent and time of burning of plastics in a horizontal position*

UL 94, *Tests for flammability of plastic materials for parts in devices and appliances*

IEC TS 62073, *Guidance on the measurement of hydrophobicity of insulator surfaces*

1.3 Terms and definitions

For the purposes of this document, the terms and definitions given in ISO 18893 and AS 2549 and the following apply.

1.3.1
access position
configuration of the MEWP for access to and from the work platform

Note 1 to entry: The access, stowed, lowered travel and transport positions can be identical.

1.3.2
boom insulation
boom insert
dielectric component consisting of an insulated insert designed to electrically insulate the platform from all portions of the extending structure lying below the insert

1.3.3
basket
enclosed work platform made from dielectric materials used on insulated MEWPs

1.3.4
non-ductile material
material that is not ductile

Note 1 to entry: “Ductile” is defined in 1.3.11.

1.3.5
chain drive system
system that comprises one or more chain(s) running on chain sprockets and on or over chain sheaves as well as any associated chain sprockets, chain sheaves and compensating sheaves

1.3.6
chassis
base of the MEWP

Note 1 to entry: The chassis may be pulled, pushed, self-propelled, and the like.

Note 2 to entry: See Figure 1.3 for an illustration of the chassis.

1.3.7
chassis insulation
dielectric component consisting of an insert or cover or both, positioned between the chassis and the extending structure, designed to electrically insulate the chassis should any portion of the extending structure below the boom insert contact energized electrical apparatus

1.3.8
critical component
load-supporting element that supports or stabilizes the work platform or the extending structure

Note 1 to entry: Critical components are usually subject to fatigue or wear and normally require routine inspection or replacement during the service life of the MEWP.

1.3.9
competent person
person who has acquired, through education, training, qualification or experience or a combination of these, the knowledge and skill enabling that person to perform the task required

Note 1 to entry: Different types of MEWP (e.g. self-propelled boom lift, scissor lift, vehicle-mounted or insulated-vehicle-mounted MEWPs) require different competencies. Appropriate training and qualifications should demonstrate competencies in the applicable type of MEWP under consideration.

1.3.10
disruptive discharge
phenomena associated with the failure of insulation under electric stress, in which the discharge completely bridges the insulation under test, reducing the voltage between the electrodes to zero or nearly to zero

Note 1 to entry: The term applies to discharges in solid, liquid and gaseous dielectrics and to combinations of these.

Note 2 to entry: A disruptive discharge in a solid dielectric produces permanent loss of dielectric strength (non-self-restoring insulation); in a liquid or gaseous dielectric, the loss may be only temporary (self-restoring insulation).

Note 3 to entry: The term "sparkover" is used when a disruptive discharge occurs in a gaseous or liquid dielectric.

Note 4 to entry: The term "flashover" is used when a disruptive discharge occurs over the surface of a solid dielectric in a gaseous or liquid medium.

Note 5 to entry: The term "puncture" is used when a disruptive discharge occurs through a solid dielectric.

1.3.11
ductile material
material that has a minimum elongation before failure of 10 % and has adequate notch impact strength at the lowest operating temperature for which the MEWP is rated

1.3.12
electrical apparatus
apparatus including overhead lines and underground cables, the conductors of which are live or can be made live

1.3.13
elevated travel position
configuration of the MEWP for travel on a work site out of the lowered travel position

1.3.14
extending structure
A structure that is connected to the chassis to support the work platform and allow movement of the work platform to its required position

Note 1 to entry: It may be, for example, a single or a telescoping or an articulating boom or ladder, or a scissor mechanism or any combination of them, and may or may not slew on the base.

Note 2 to entry: See Figure 1.3 for an illustration of the extending structure.

1.3.15
fall-arrest system
system designed to arrest a fall of a person

1.3.16
FEA model
finite element analysis model
computerized method of idealizing a real model for the purposes of performing structural analysis

1.3.17
gradeability
Maximum gradient in percent that the MEWP is rated to ascend in the lowered travel position

1.3.18
height
the maximum vertical distance of the work platform floor above the supporting surface when the extending structure is fully elevated

1.3.19
instability
condition of a MEWP in which the sum of the moments tending to overturn the unit exceeds the sum of the moments tending to resist overturning

1.3.20
insulated line maintenance MEWP
vehicle-mounted MEWP used by or for an electricity utility in the construction, operation and maintenance of the electricity distribution network, and where the equipment and stores associated with the work are carried on the vehicle body

1.3.21
load cycle
cycle starting from a position, carrying out work and returning to the same position

1.3.22
load-sensing system
system of monitoring the vertical load and vertical forces on the work platform

Note 1 to entry: The system includes the measuring device(s), the method of mounting the measuring device(s), the signal processing systems, indicators, displays and warning systems.

1.3.23
lowered travel position
configuration(s) of the MEWP for travel on the work site where the chassis inclination limits and maximum travel speeds associated with the elevated travel position do not apply

1.3.24
MEWP classifications
1.3.24.1
Group A
MEWPs where the vertical projection of the centre of the area of the platform, in all platform configurations at the maximum chassis inclination specified by the manufacturer, is always inside the tipping lines

1.3.24.2
Group B
MEWPs that are not in Group A

1.3.25
MEWP types
1.3.25.1
Type 1 MEWP
MEWP for which travelling is only allowed with the MEWP in its stowed position

1.3.25.2
Type 2 MEWP
MEWP for which travelling with work platform in elevated travel position is controlled from a point on the chassis

Note 1 to entry: Types 2 and 3 may be combined.

1.3.25.3
Type 3 MEWP
MEWP for which travelling with work platform in elevated travel position is controlled from a point on the work platform

Note 1 to entry: Types 2 and 3 may be combined.

1.3.26
mobile elevating work platform
MEWP
mobile machine that is intended to move persons to working positions where they are carrying out work from the work platform with the intention that persons are getting on and off the work platform at access positions at ground level or on the chassis and which consists as a minimum of a work platform with controls, an extending structure and a chassis

1.3.27
moment-sensing system
system of monitoring the moment acting about the tipping line tending to overturn the MEWP

Note 1 to entry: The system includes the measuring device(s), the method of mounting the measuring devices and the signal processing system.

1.3.28
operating modes
1.3.28.1
mode 1
normal operating mode usually under the control of the operator

1.3.28.2
mode 2
mode employed in the event of failure of the main power supply to retrieve the elevated MEWP

Note 1 to entry: This mode is usually under the control of the operator or ground personnel and is the primary emergency recovery mode (see Clause 2.6.10).

1.3.28.3
mode 3
mode intended to be employed by trained personnel for the purpose of maintenance, testing or as a secondary emergency recovery mode

1.3.29
orchard MEWP
MEWP intended to raise workers to a position to maintain and harvest trees, vines on trellises or other plants cultivated for the production of fruit, nuts, seeds, flowers or plant extracts

1.3.30
oscillating axle
supporting structure that allows mainly vertical movement of the end wheel assemblies independently or in relation to each other

1.3.31
pedestrian-controlled MEWP
MEWP whose controls for powered travel can be operated by a person walking close to the MEWP

1.3.32
rail-mounted MEWP
MEWP whose travel is guided by rails

1.3.33
rated capacity
maximum load, expressed in kg, for which the MEWP has been designed for normal operation

Note 1 to entry: Rated capacity includes persons, tools and material acting vertically on the work platform.

Note 2 to entry: A MEWP can have more than one rated capacity depending on different configurations.

1.3.34
reach
maximum horizontal distance measured from a plumbline at the outer extremity of the work platform to the centre of slew or to the front of the tyres for non-slewing MEWPs

1.3.35
rotation
circular movement of the work platform about a vertical axis

Note 1 to entry: See Figure 1.3 for an illustration of rotation.

1.3.36
safety function
function of a machine whose failure can result in an immediate increase of the risks(s) to the safety of persons

Note 1 to entry: A safety function may be composed of safety devices (e.g. actuators, sensors, logic units and switching components) and software as well as interconnecting means.

1.3.37
secondary work platform
platform attached to the work platform or the extending structure, and able to be moved separately

1.3.38
self-propelled MEWP
MEWP provided with its own source of tractive power rather than requiring an external means of propulsion

1.3.39
manually propelled MEWP
MEWP that is not self-propelled

1.3.40
slab-type MEWP
MEWP intended only for use on a substantially level hard surface

1.3.41
slewing
circular movement of the extending structure about a vertical axis

Note 1 to entry: See Figure 1.3 for an illustration of slewing.

1.3.42
stability
condition of a MEWP in which the sum of the moments that tend to overturn the unit is equal to or less than the sum of the moments that tend to resist overturning

1.3.43
stowed position
configuration of the MEWP in which the extending structure is lowered and retracted and stabilizers/outriggers are retracted

Note 1 to entry: The access, stowed, lowered travel, and transport positions can be identical.

1.3.44
totally manually powered MEWP
MEWP in which movement is powered only by manual effort

1.3.45
trailer-mounted MEWP
MEWP incorporating a chassis which is exclusively designed to be transported by towing

1.3.46
transport position
configuration of the MEWP for transport

Note 1 to entry: The access, stowed, lowered travel, and transport positions can be identical.

1.3.47
transport
delivery of the MEWP to or from the work site

1.3.48
travelling
movement of the chassis except transporting

Note 1 to entry: See Figure 1.3 for an illustration of travelling.

1.3.49
type test
test on a representative model of a new design or one incorporating significant changes to an existing design

1.3.50
vehicle-mounted MEWP
MEWP installed on a vehicle chassis that is not expressly designed and manufactured as part of the MEWP

Note 1 to entry: This does not include trailer-mounted MEWPs.

1.3.51
wire rope drive system
system that comprises one or more wire rope(s) running on rope drums and on or over rope sheaves as well as any associated rope drums, rope sheaves and compensating sheaves

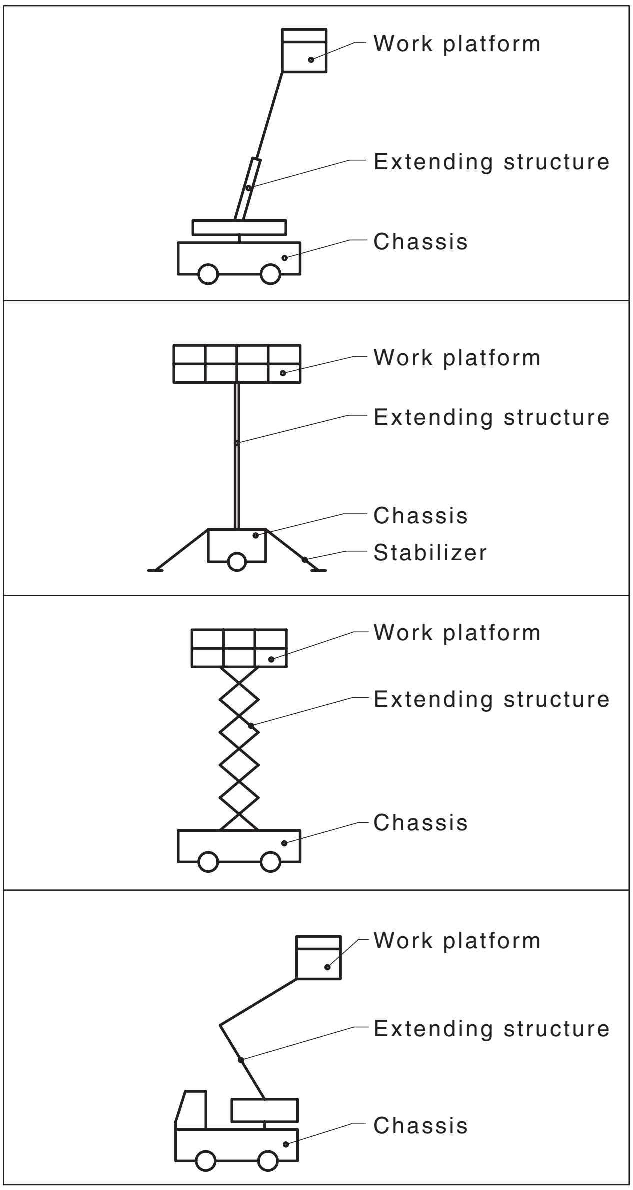
1.3.52
wireless control
means by which an operator's commands are transmitted without any physical connection for at least part of the distance between the control console and the MEWP system

1.3.53
working envelope
space in which the work platform is designed to work, under normal operating conditions

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

1.3.54
work platform
movable component of the MEWP, other than the chassis, intended for carrying personnel (with or without material), e.g., cages, buckets and baskets

1.3.55
working coefficient
ratio of the minimum breaking load to the working load



Work platform
Extending structure
Chassis
Work platform
Extending structure
Chassis
Stabilizer
Work platform
Extending structure
Chassis
Work platform
Extending structure
Chassis

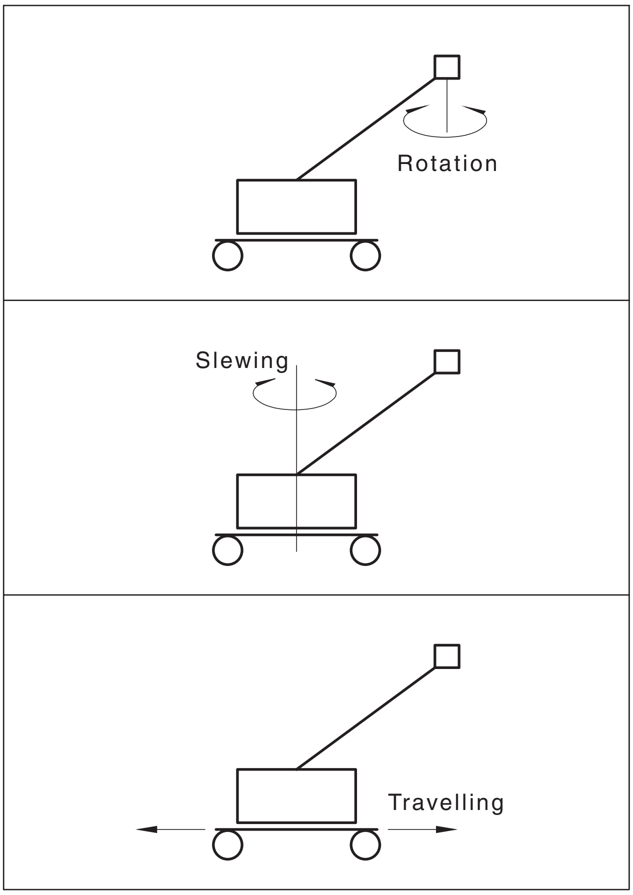


Figure 1.3 — Illustration of some definitions

1.4 New designs, innovations and design methods

This document does not prevent the use of materials, methods of assembly, procedures and the like that do not conform with the specific requirements of this document, or are not mentioned in it, provided the minimum dimensional and performance requirements specified herein are met.

NOTE Where an example of a safety measure has been given in this document, it should not be considered the only possible solution. Any other solution leading to an equivalent level of safety is permissible.

2 Design requirements

2.1 Structural and stability calculations

2.1.1 Calculations

The following calculations shall be performed:

(a) Structural calculations to evaluate the individual loads and forces in their positions, directions and combinations that produce the highest stresses in the components.

(b) Stability calculations to identify the various positions of the MEWP and combinations of loads and forces which together create conditions of minimum stability.

Verification of the requirements of Clause 2.1 shall be carried out by design check, static tests and overload tests.

2.1.2 Rated capacity

The rated capacity (equivalent to a mass *m*) shall be determined from the following equation:

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

where

m_p = 80 kg (mass of a person)

m_e = ≥ 40 kg (minimum mass of tools and materials)

n = the permitted number of persons on the work platform

The minimum capacity shall be no less than 120 kg.

2.1.3 Forces acting on the MEWP structure

The following loads and forces shall be taken into account:

(a) Forces created by rated capacity and structural masses (see Clause 2.1.4.1).

(b) Wind forces (see Clause 2.1.4.2).

(c) Manual forces (see Clause 2.1.4.3).

(d) Special loads and forces (see Clause 2.1.4.4).

2.1.4 Determination of forces acting on the MEWP structure

2.1.4.1 Forces created by rated capacity and structural masses

2.1.4.1.1 Gravitational and dynamic forces

Gravitational forces created by the rated capacity (mass) and structural masses shall be taken to act vertically downwards at the component centres of mass. The forces shall be calculated by multiplying the component masses by 1.0 *g*. The factor *g* represents the acceleration due to gravity (9.81 m/s^2).

Dynamic forces created by acceleration and deceleration of structural masses and rated capacity (mass) shall be represented by forces acting in the line of motion of the component centres of mass, as follows:

(a) The dynamic forces created by extension or retraction of the extending structure shall be calculated by multiplying the structural masses by 0.1 *g*.

NOTE 1 For information on dynamic factors in stability and structural calculations, see Appendix C.

(b) The dynamic forces created by travelling movements of Type 2 and 3 MEWPs shall be calculated by multiplying the component masses by *z* times *g*. The factor *z* shall be a minimum of 0.1 unless determined by calculation or tests. The product of *z* and *g* represents the acceleration/deceleration of the MEWP due to travel and the angular acceleration/deceleration of the MEWP due to travel over ground obstacles such as occurs during the kerb test (see Clause 3.6.3.2.2).

NOTE 2 For information on dynamic factors in stability and structural calculations, see Appendix C.

NOTE 3 an example of the calculation of z is included in Appendix D.

2.1.4.1.2 Load distribution on the work platform

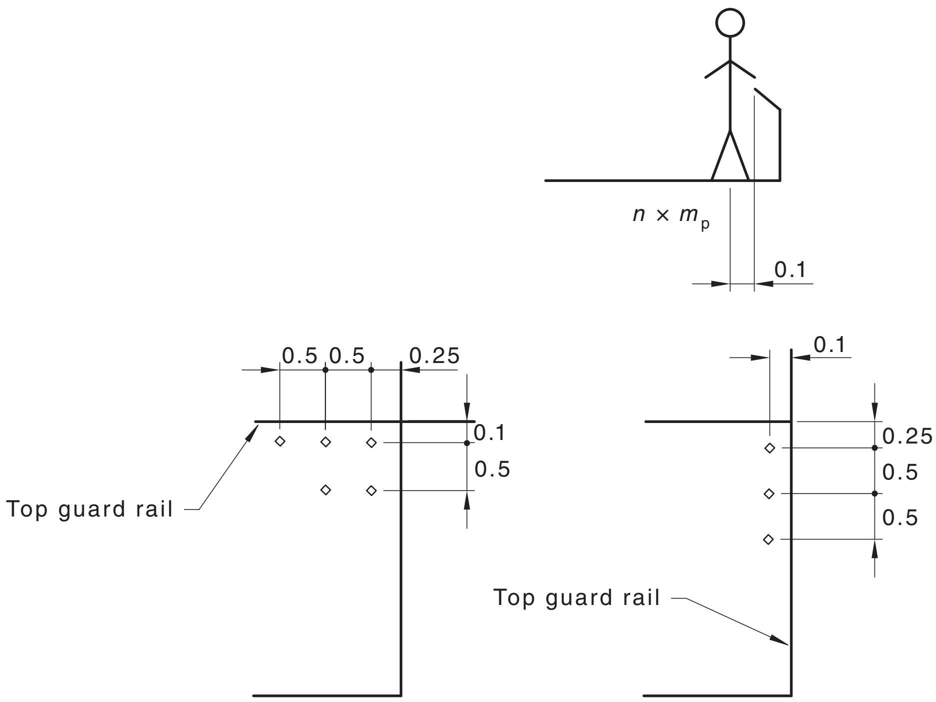
Each person is assumed to act as a point load on the work platform and any platform extension at a horizontal distance of 100 mm from the upper inside edge of the top guardrail. The distance between the point loads shall be 500 mm. The width of a person shall be taken to be 500 mm (see Figure 2.1.4.1.2).

Equipment is assumed to act as an evenly distributed load on 25 % of the floor of the work platform. If the resulting pressure exceeds 3 kN/m^2, the value of 25 % may be increased to give a pressure of 3 kN/m^2.

Personnel point loads shall be superimposed onto equipment (distributed) loads.

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

Dimensions in metres



Key:

1 Top guard rail

Figure 2.1.4.1.2 — Rated capacity — person

2.1.4.2 Wind forces

2.1.4.2.1 Outdoor MEWPs

All MEWPs that may be exposed to wind shall be regarded as being affected by wind at a pressure of 100 N/m^2, equivalent to a wind speed of 12.5 m/s (Beaufort Scale 6).

NOTE Wind speeds and pressures as a function of elevation are given in Appendix P.

Wind forces are assumed to act horizontally at the centre of surface of the parts of the MEWP, and of persons and equipment on the work platform. They shall be taken to be dynamic forces.

This does not apply to MEWPs intended for non-wind conditions only [see Clause 4.2.2(d)].

2.1.4.2.2 Shape factors applied to surfaces exposed to wind

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

(a)	L-, U-, T-, I-sections	1.6
(b)	Box sections	1.4
(c)	Large flat areas	1.2
(d)	Circular sections, according to size	Refer to AS 5222
(e)	Persons directly exposed	1.0

NOTE If additional information is needed, especially concerning shielded structural areas, refer to AS 5222 (see also Clause 2.1.4.2.3).

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

The full surface area of one person shall be 0.7 m^2 (0.4 m average width × 1.75 m height) with the centre of area 1.0 m above the work platform floor.

The exposed surface area of one person standing on a work platform behind an imperforate (not perforated) section of fencing 1.1 m high shall be 0.35 m^2, with the centre of area 1.45 m above the work platform floor.

The number of persons directly exposed to wind shall be calculated as —

(a) the length of the side of the work platform exposed to wind, rounded to the nearest 0.5 m and divided by 0.5 m; or

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

If the number of persons allowed on the work platform is greater than that calculated in Item (a), a shape factor of 0.6 shall be applied to the extra number of persons.

2.1.4.2.4 Tools and equipment on the platform exposed to wind

The wind force on exposed tools and materials on the work platform shall be calculated as 3 % of their mass, acting horizontally at a height of 0.5 m above the work platform floor.

2.1.4.3 Manual force

The minimum value for the manual force (M) shall be taken as 200 N for MEWPs designed to carry only one person, and 400 N for MEWPs designed to carry more than one person, applied at a height of 1.1 m above the work platform floor. Any greater force permitted shall be specified in the operator's manual.

2.1.4.4 Special loads and forces

Special loads and forces are created by special working methods and conditions of use of the MEWP, such as objects carried on the outside of the work platform, wind forces on large objects carried on the work platform and forces imposed by winches or material handling devices.

NOTE For information on the use of MEWPs in wind speeds greater than 12.5 m/s, see Appendix E.

If a user asks for such special working methods and/or conditions of use, the resulting loads and forces shall be taken into account as a modification to the rated capacity, structural load, wind load and/or manual forces, as appropriate.

2.1.5 Stability calculations

2.1.5.1 Forces created by structural masses and rated capacity

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

NOTE Examples are provided in Figures 2.1.5.5(A) and 2.1.5.5(B).

The maximum allowable inclination of the chassis, as defined by the manufacturer, shall be increased by 0.5 degrees to allow for inaccuracy in setting up the MEWP.

2.1.5.2 Wind forces

Wind forces shall be multiplied by a factor of 1.1 and taken to be acting horizontally.

2.1.5.3 Manual forces

Manual forces applied by persons on the work platform shall be multiplied by a factor of 1.1 and taken to be acting in the direction creating the greatest overturning moment.

NOTE Examples are provided in Figures 2.1.5.5(A) and 2.1.5.5(B).

2.1.5.4 Special loads and forces

Special loads and forces shall be included in the calculation.

2.1.5.5 Calculation of overturning and stabilizing moments

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

Tipping lines shall be determined as shown in Appendix F. For solid and foam-filled tyres, the tipping lines may be taken at a distance from the outside edge of a quarter of the ground contact width.

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

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

NOTE Examples are shown in Tables 2.1.5.5(A) and 2.1.5.5(B), and in Figures 2.1.5.5(A) and 2.1.5.5(B).

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

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

(a) Tolerances in the manufacture of the components.

(b) Play in the connections of the extending structure.

(c) Elastic deformations due to the effects of forces.

(d) Failure of any one tyre in the case of MEWPs supported by pneumatic tyres in the working position.

(e) Performance characteristics (accuracy) of the load-sensing system, moment-sensing system and position control. These may be affected by —

(i) peaks caused by short-term dynamic effects;

(ii) hysteresis;

(iii) slope of the MEWP;

(iv) ambient temperature; and

(v) different positions and distribution of the load on the work platform (see Clause 2.1.3).

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

Table 2.1.5.5(A) — Examples of load and force directions and combinations for stability calculations — Load sensing[a]

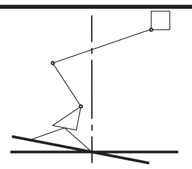
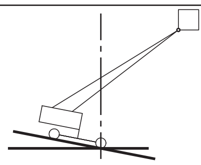
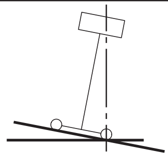
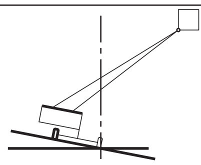
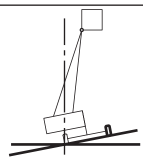
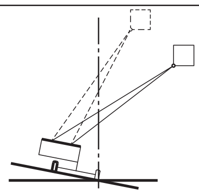
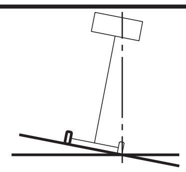
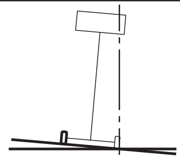
Example	Working condition	Rated capacity		Structural force Sn		Manual force M		Wind force W		Diagram
		x 1.0	x 0.1 x *z* (S)	x 1.0	x 0.1 (A) x *z* (S)	x 1.0	x 0.1	x 1.0	x 0.1	
1	Raising (lowering)	V	A	V	A	—	—	H	H	
2	Travelling	V	S	V	S	—	—	H	H	
3	Travelling	V	S	V	S	—	—	H	H	
4	Forwards stability, stationary on slope	V	—	V	—	A	A	H	H	
5	Backwards stability, stationary on slope	80 kg V 0 kg	— —	V V	— —	A —	A —	H H	H H	
6	With limited reach, forward stability, stationary on slope, lowering	V	A	V	A	—	—	H	H	

Table 2.1.5.5(A) *(continued)*

Example	Working condition	Rated capacity		Structural force *Sn*		Manual force *M*		Wind force *W*		Diagram
		x 1.0	x 0.1 x *z* (S)	x 1.0	x 0.1 (A) x *z* (S)	x 1.0	x 0.1	x 1.0	x 0.1	
7	On slope, stationary	V	—	V	—	A	A	H	H	
8	Level ground, stationary. (Load always inside the tipping line)	80 kg V	—	V	—	—	—	H	H	
		0 kg V	—	V	—	—	—	H	H	

Key

V = Vertical

H = Horizontal

A = Angular

S = At slope angle. S represents the mass of the structural component *n*

[a] See Figure 2.1.5.5(A) for further guidance.

NOTE This table is not exhaustive.

Table 2.1.5.5(B) — Examples of load and force directions and combinations for stability calculations — Using enhanced overload and stability criteria[a]

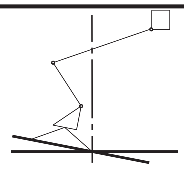
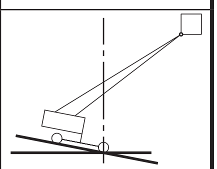
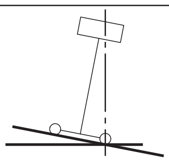
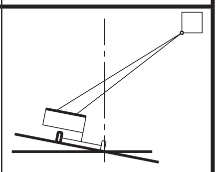
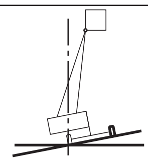
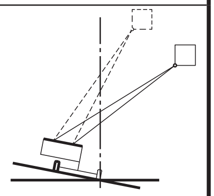
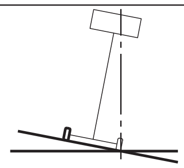
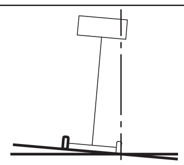
Example	Working condition	Rated capacity		Structural force *Sn*		Manual force *M*		Wind force *W*		Diagram
		x 1.5	x 0.15 x *z* (S)	x 1.0	x 0.1 (A) x *z* (S)	x 1.0	x 0.1	x 1.0	x 0.1	
1	Raising (lowering)	V	A	V	A	—	—	H	H	
2	Travelling	V	S	V	S	—	—	H	H	
3	Travelling	V	S	V	S	—	—	H	H	

Table 2.1.5.5(B) *(continued)*

Example	Working condition	Rated capacity		Structural force *Sn*		Manual force *M*		Wind force *W*		Diagram
		x 1.5	x 0.15 x *z* (S)	x 1.0	x 0.1 (A) x *z* (S)	x 1.0	x 0.1	x 1.0	x 0.1	
4	Forwards stability, stationary on slope	V	—	V	—	A	A	H	H	
5	Backwards stability, stationary on slope	80 kg V 0 kg	— —	V V	— —	A —	A —	H H	H H	
6	With limited reach, forward stability, stationary on slope, lowering	V	A	V	A	—	—	H	H	
7	On slope, stationary	V	—	V	—	A	A	H	H	
8	Level ground, stationary. (Load always inside the tipping line)	80 kg V 0 kg V	— —	V V	— —	— —	— —	H H	H H	

Key

V = Vertical

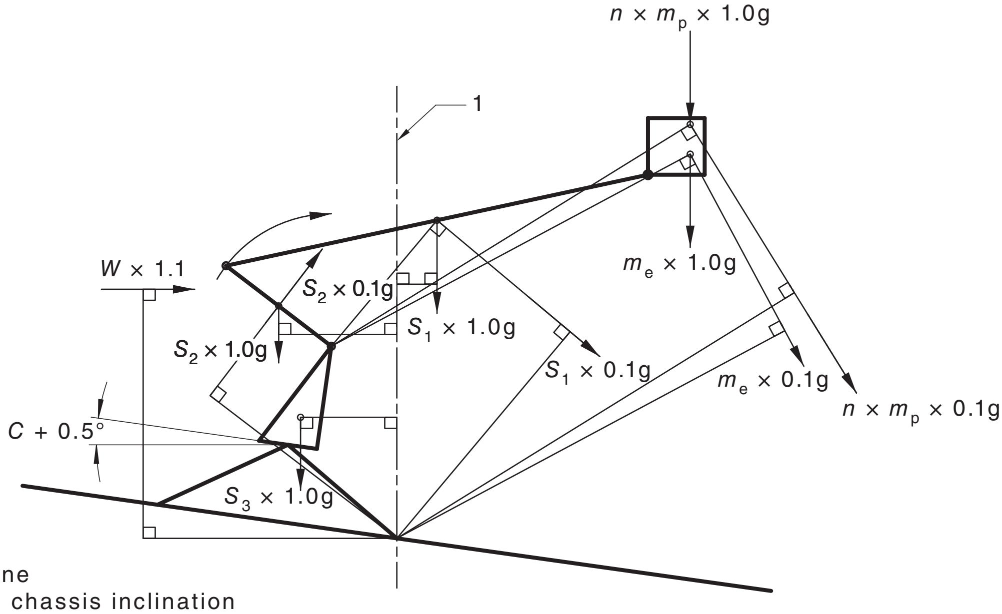
H = Horizontal

A = Angular

S = At slope angle. S represents the mass of the structural component *n*

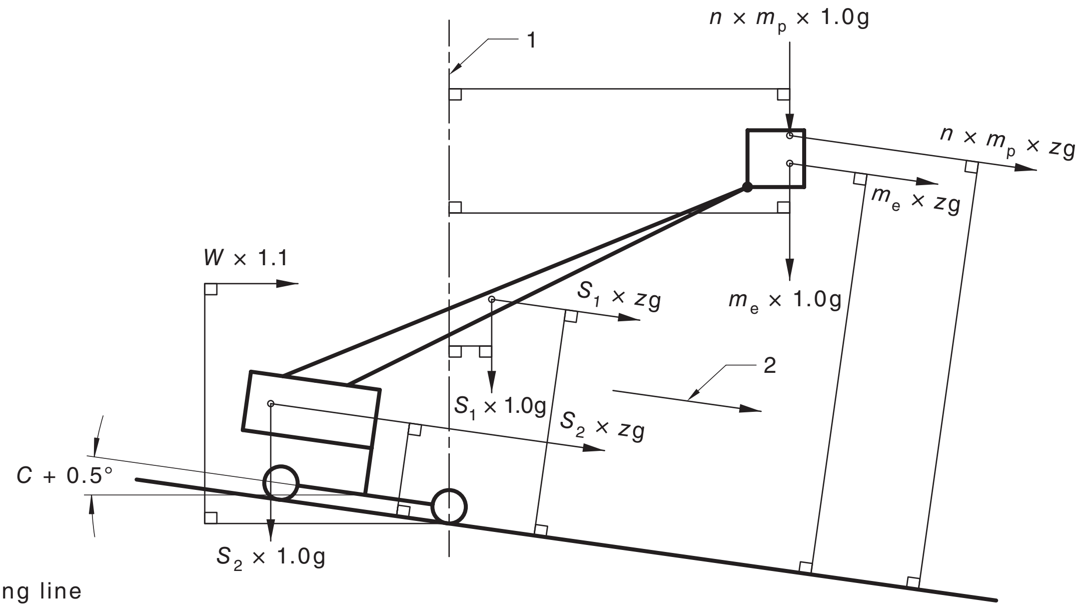
[a] See Figure 2.1.5.5(B) for further guidance.

NOTE This table is not exhaustive.



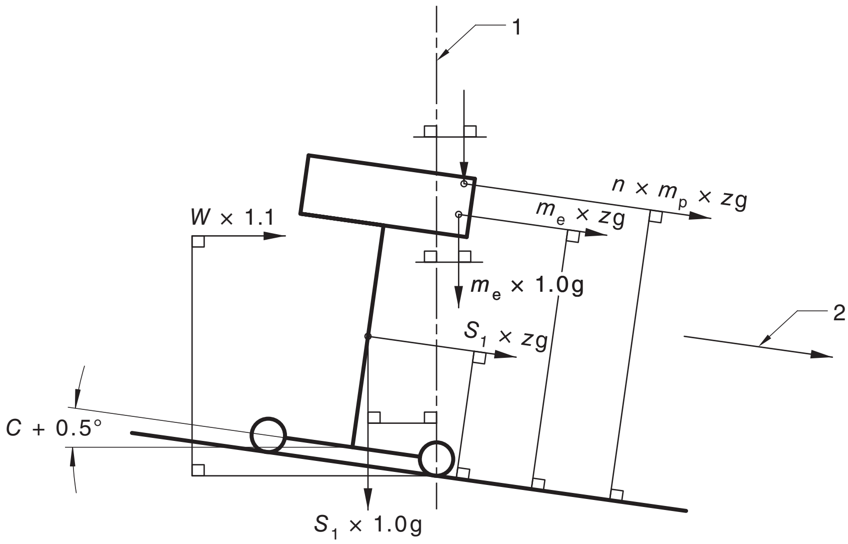
Key
1 Tipping line
C Maximum chassis inclination

(a) Example 1



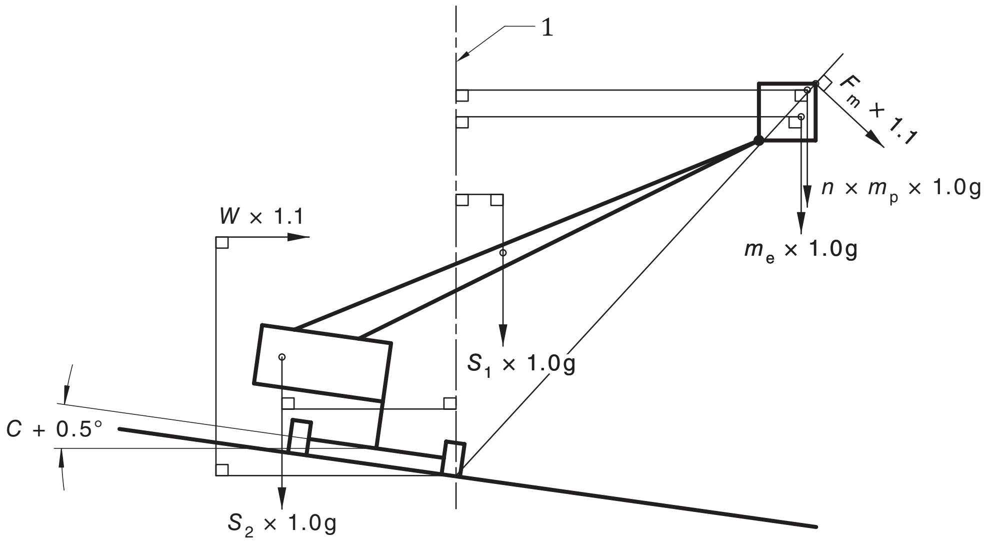
Key
1 Tipping line
2 Direction of travel
C Maximum chassis inclination

(b) Example 2



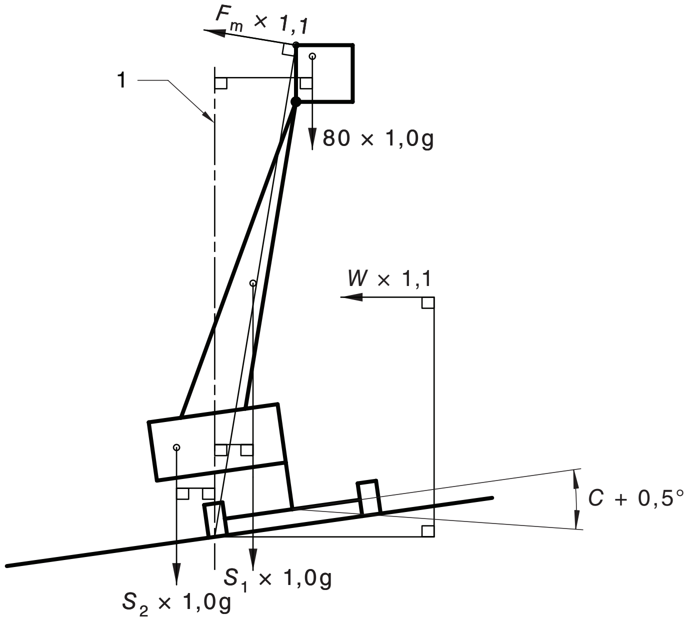
Key
1 Tipping line
2 Direction of travel
C Maximum chassis inclination

(c) Example 3



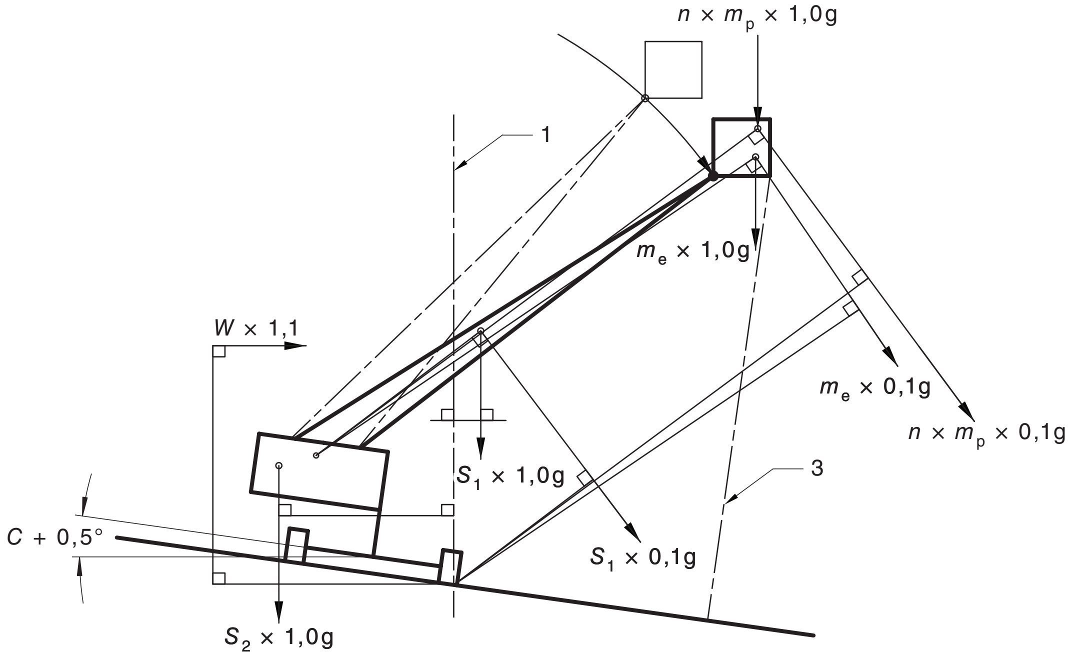
Key
1 Tipping line
C Maximum chassis inclination

(d) Example 4



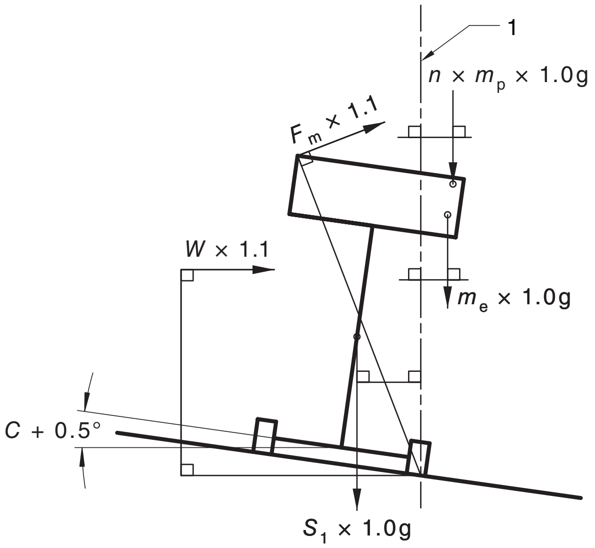
Key
1 Tipping line
C Maximum chassis inclination

(e) Example 5



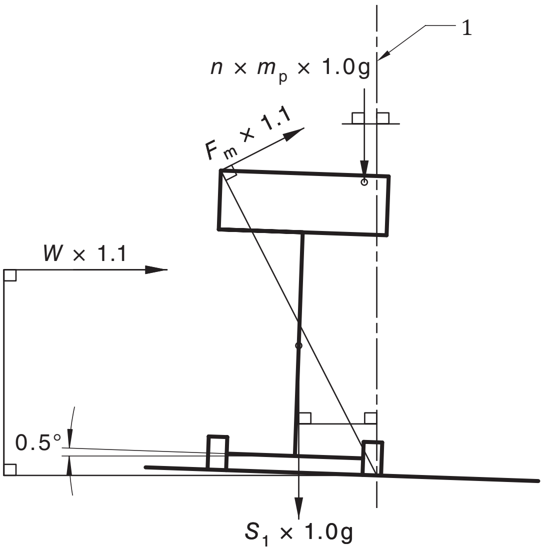
Key
1 Tipping line
3 Limited reach
C Maximum chassis inclination

(f) Example 6



Key
1 Tipping line
C Maximum chassis inclination

(g) Example 7



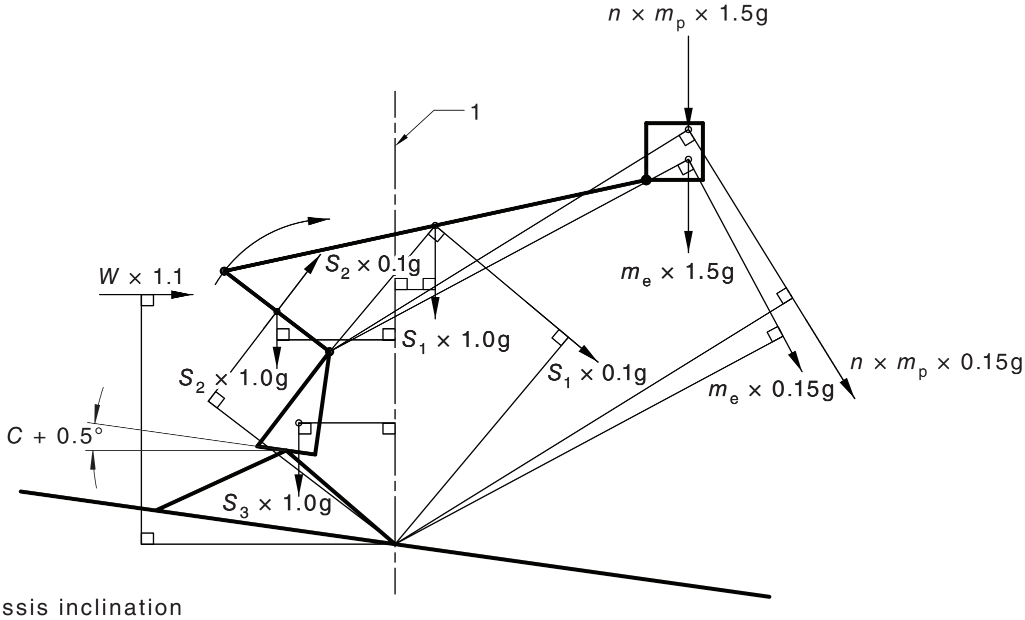
Key
1 Tipping line

(h) Example 8

NOTE 1 For number of persons (n) see Clause 2.1.2; mass of one person (m_p) see Clause 2.1.2; mass of equipment (m_e) see Clause 2.1.2; wind force, see Clause 2.1.4.2; manual force, see Clause 2.1.4.3; and travelling acceleration factor, see Clause 2.1.4.1.1.

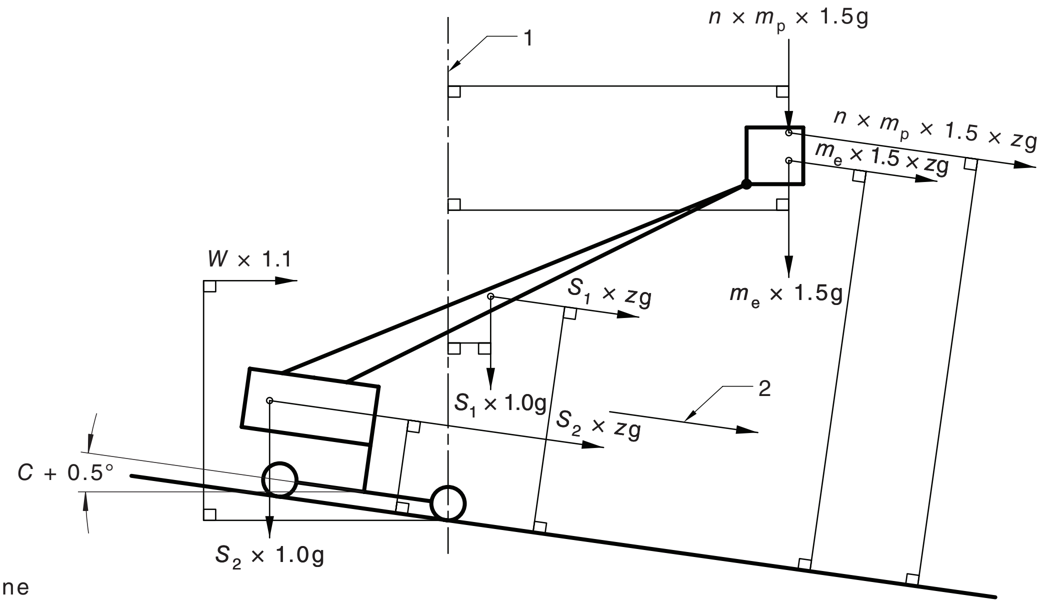
NOTE 2 See Table 2.1.5.5(A) for further guidance.

Figure 2.1.5.5(A) — Examples of maximum overturning load and force moment combination — Load sensing



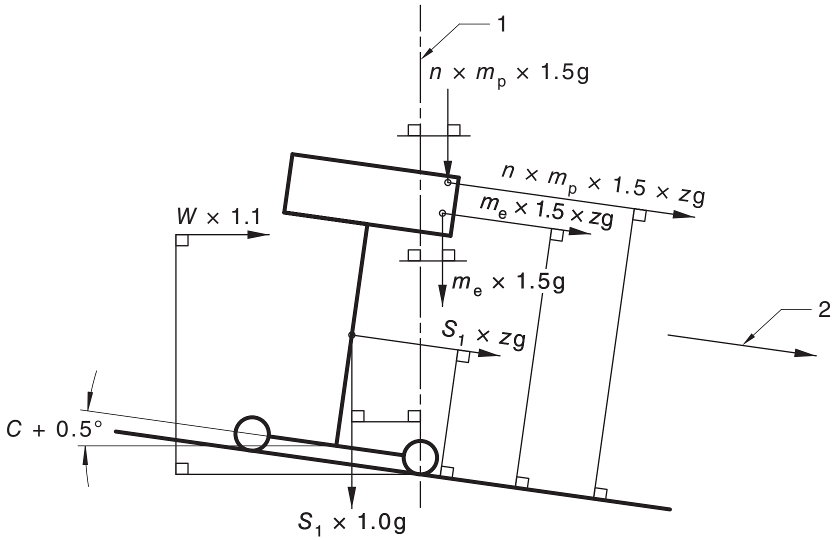
Key
1 Tipping line
C Maximum chassis inclination

(a) Example 1



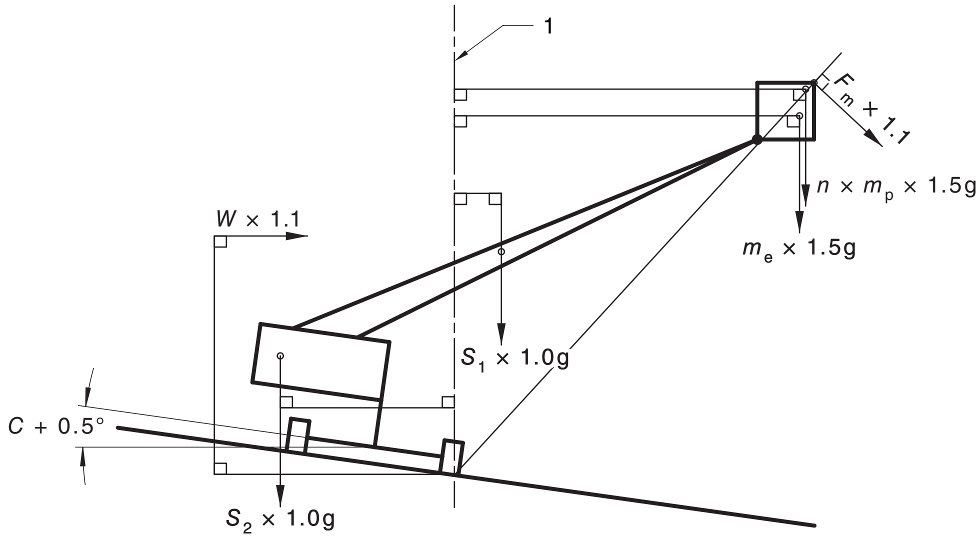
Key
1 Tipping line
2 Direction of travel
C Maximum chassis inclination

(b) Example 2



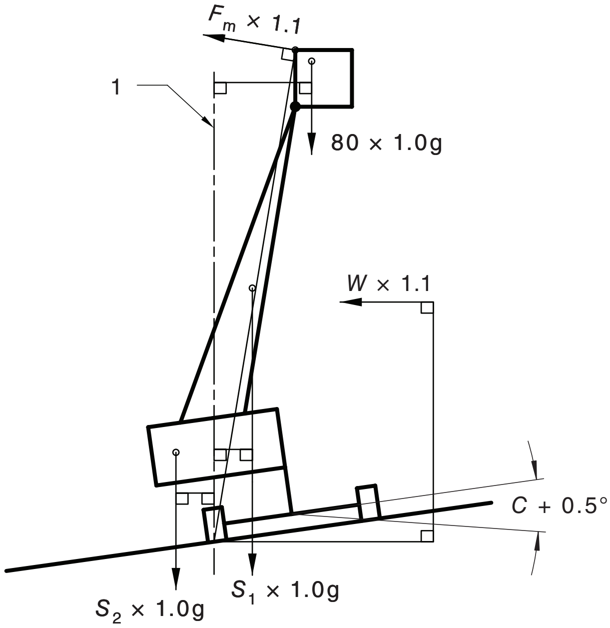
Key
1 Tipping line
2 Direction of travel
C Maximum chassis inclination

(c) Example 3



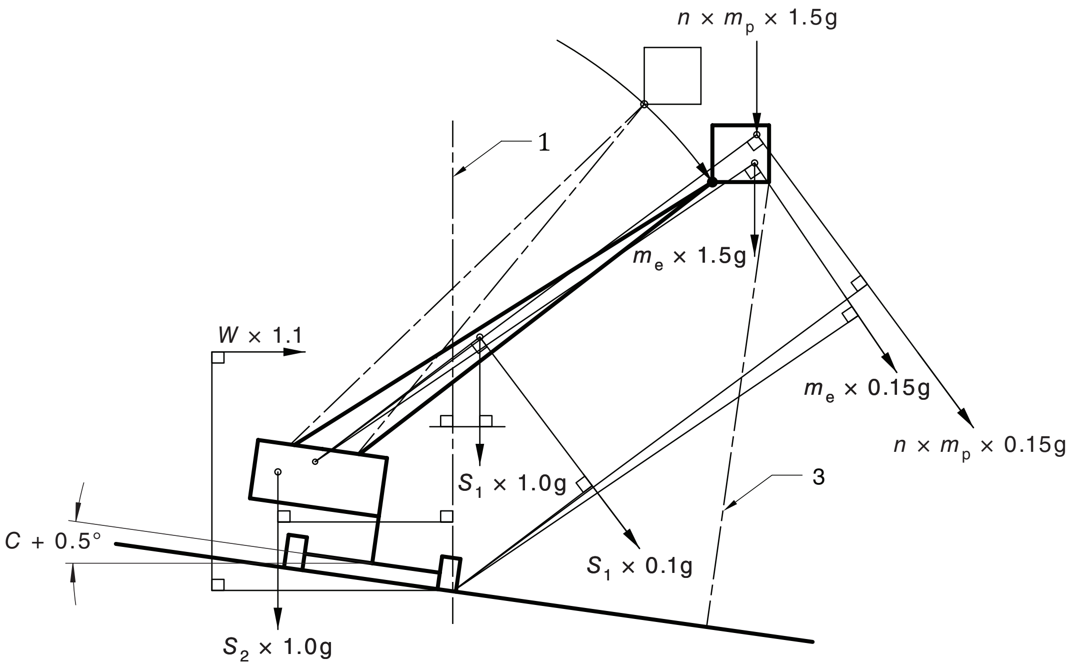
Key
1 Tipping line
C Maximum chassis inclination

(d) Example 4



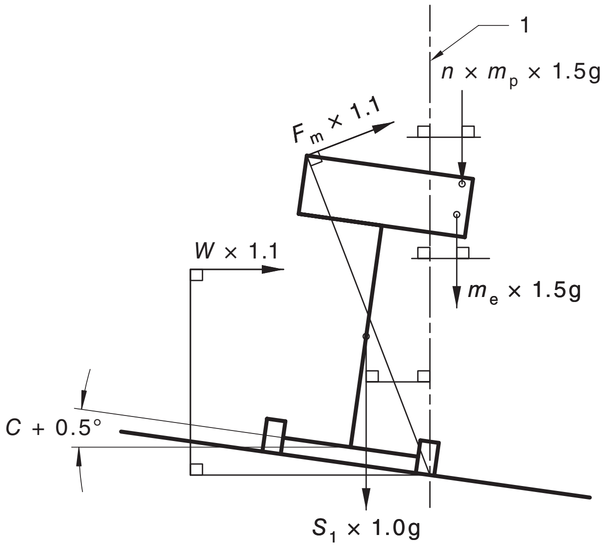
Key
1 Tipping line
C Maximum chassis inclination

(e) Example 5



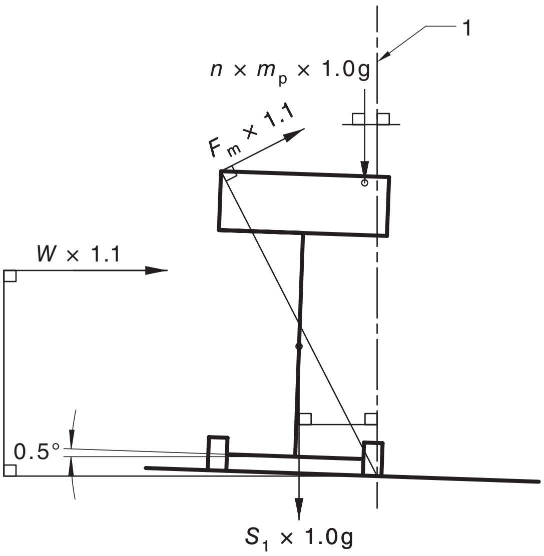
Key
1 Tipping line
3 Limited reach
C Maximum chassis inclination

(f) Example 6



Key
1 Tipping line
C Maximum chassis inclination

(g) Example 7



Key
1 Tipping line

(h) Example 8

NOTE 1 For number of persons (n) see Clause 2.1.2; mass of one person (m_p) see Clause 2.1.2; mass of equipment (m_e) see Clause 2.1.2; wind force, see Clause 2.1.4.2; manual force, see Clause 2.1.4.3; and travelling acceleration factor, see Clause 2.1.4.1.1.

NOTE 2 See Table 2.1.5.5(B) for further guidance.

Figure 2.1.5.5(B) — Examples of maximum overturning load and force moment combination — Using enhanced overload and stability criteria

2.1.5.6 Dynamic stability

The MEWP shall remain stable when subjected to braking tests (Clause 3.6.3.2.3) and kerb and depression tests (Clause 3.6.3.2.2).

NOTE For a calculation example, see Appendix D.

2.1.6 Structural calculations

2.1.6.1 General

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

The requirements given in Clauses 2.1.3 and 2.1.5 shall be taken into account in the determination of loads and forces to be used in the calculations.

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

For all loadbearing components and joints, the required information on stresses or safety factors shall be included in the calculations in a clear and 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.

2.1.6.2 Calculation methods

The method of calculation shall conform wherever possible with the requirements of structural Standards applicable to the materials used in the design. Calculations shall include fatigue-stress calculation methods and elastic buckling. The elastic deformations of slender components shall be taken into account.

The requirements given in Clauses 2.1.4 and 2.1.5 shall be taken into account in the determination of loads and forces to be used in the calculations.

The analysis shall be made for the worst-case load combinations. The calculated stresses shall not exceed the permissible values.

NOTE 1 For typical load combinations, see AS 1418.1.

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.

2.1.6.3 Analysis

2.1.6.3.1 General stress analysis

The general stress analysis shall be used to analyse failure by yielding, buckling, and fracturing. General stress analysis shall be carried out for all loadbearing components and joints.

The required information on stresses or safety factors shall be included in the analysis in a clear and easily verifiable form. Details of the main dimensions, cross-sections and materials for the individual components and joints shall be given.

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

Stress analysis shall be performed by one of the methods described in Clause 2.1.6.3.2. When using the criteria for enhanced overload methods in Clause 2.3.1.6, the rated load shall be replaced by 150 % of the rated load.

2.1.6.3.2 Stress analysis methods

2.1.6.3.2.1 Permissible stress method

Stresses imposed by the load and force combinations defined in Clause 2.1.3 shall not exceed 66.7 % of either the minimum yield strength or the buckling strength of the ductile materials.

Non-ductile structural elements of the MEWP shall have a design stress of no more than 20 % of the minimum ultimate strength of the material.

2.1.6.3.2.2 Limit states method

Loads can be either regular or occasional.

Regular loads occur frequently under normal operation. Regular loads include the following:

(a) Rated load.

(b) Dead weights.

Occasional loads occur infrequently and are usually neglected in fatigue assessment. Occasional loads include the following:

(i) Loads due to in-service wind.

(ii) Manual force.

These loads are combined into two load combinations, load combination A comprising only regular loads and load combination B comprising both regular and occasional loads. The static strength of the structure shall be assessed for both load combinations A and B. The loads and forces defined in Clause 2.1.3 shall be multiplied by the partial safety factors γ_p given in Table 2.1.6.3.2.2.

Table 2.1.6.3.2.2 — Partial safety factors

Clause	Loading	Partial safety factors γ_p	
		Load combination A	Load combination B
2.1.2	Rated capacity	1.34	1.22
2.1.4.1	Structural masses	1.22	1.16
2.1.4.2	Wind forces (loads)	-	1.22
2.1.4.3	Manual force	-	1.22

Dead weights that are acting favourably (for example, counterweights that reduce forces and stresses) in some load-carrying parts shall be assigned the value $\gamma_p = 1$ when calculating the stresses on those load-carrying parts.

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

The strength of load bearing steel structures shall be calculated and proofed in accordance with AS 5224. When AS 5224 is not applicable, for example when calculating the fatigue strength of welded connections with plates thinner than 3 mm, the calculation and proof of the load bearing structures shall follow the principles of AS 5224 and appropriate limits states shall be obtained from relevant sources.

Non-ductile structural elements of the MEWP shall have a design stress of no more than 20 % of the minimum ultimate strength of the material.

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

2.1.6.3.3 Elastic stability analysis

Elastic stability analysis shall be carried out for all loadbearing components subject to compressive stress. Elastic stability analysis is the proof against failure by elastic instability (e.g. buckling, crippling).

2.1.6.3.4 Fatigue-stress analysis

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

The number of load cycles for determining the life of a MEWP shall be either of the following and shall be declared in the fatigue calculations:

(a) *Light intermittent duty* — 4×10^4 cycles (e.g. 10 years, 40 weeks per year, 20 h per week, 5 load cycles per hour).

(b) *Heavy duty* — 10^5 cycles (e.g. 10 years, 50 weeks per year, 40 h per week, 5 load cycles per hour).

For the proof, the different parts of the load bearing structure shall be assigned to S classes in accordance with Clause 6.3 of AS 5224:2021 (see also Clause R.2). The S classes may be established either —

(i) by direct selection from Clause R.2;

(ii) by directly applying the formulae in AS 5224:2021 (see also Clause R.3.2);

(iii) in the simplified way described in Clause R.3.3; or

(iv) by experience with technical justification.

NOTE For the design of wire rope drive systems, see Appendix S.

2.1.6.4 Effects of ambient temperature

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

2.2 Chassis and stabilizers/outriggers

2.2.1 Automatic safety device

An automatic safety device in accordance with Clause 2.10 shall be fitted to prevent the travel of pedestrian-controlled MEWPs and power-driven Type 1 MEWPs when the work platform is out of the transport or stowed position.

Verification shall be carried out by design check and functional test.

2.2.2 Chassis inclination

2.2.2.1 General

2.2.2.1.1 Chassis inclination indicator

MEWPs shall have a device to indicate when the inclination of the chassis exceeds the specified limits.

2.2.2.1.2 Prevention of elevation

A system shall be provided to prevent elevation when the chassis inclination is beyond the specified limit for that configuration. This system shall be automatic and in accordance with the requirements of Clause 2.10.

2.2.2.2 Type 1 MEWPs

For Type 1 MEWPs, the indicator in Clause 2.2.2.1.1 may be replaced by a spirit level. For those MEWPs with power-driven stabilizing devices, the indication shall be clearly visible from each stabilizing device control position. The requirements of Clause 2.2.2.1.2 do not apply once the MEWP is out of the access position.

2.2.2.3 Type 2 MEWPs

2.2.2.3.1 Vehicle-mounted

When travelling in the elevated travel position, an audible warning shall sound at each control position before reaching the specified limit. The warning shall continue to sound while the limit is exceeded. Further elevation shall be prevented upon reaching the chassis inclination limit for that configuration.

> ***C2.2.2.3.1*** *Travel is not prevented on vehicle-mounted MEWPs designed for road travel due to the braking systems employed. The alarm will therefore sound before the limit is reached.*

2.2.2.3.2 Non-vehicle-mounted

When travelling in the elevated travel position, upon reaching the specified limit, the device shall prevent the MEWP from travelling further in the selected direction and an audible warning shall sound. Travel may only be resumed provided that stability is maintained or improved.

2.2.2.4 Type 3 MEWPs

For Type 3 MEWPs, when travelling in the elevated travel position, upon reaching the specified limits, the device shall prevent the MEWP from travelling further in the selected direction and an audible warning shall sound. Travel may only be resumed provided that stability is maintained or improved.

2.2.2.5 Vehicle-mounted MEWPs

For vehicle-mounted MEWPs supported entirely or partly on pneumatic tyres when elevated, an inclination-indicating device should be fitted to each end of the vehicle in close proximity to the points of support.

Vehicle-mounted MEWPs that do not fulfil this requirement shall be tested in accordance with Clause 3.6.3.1.3.

2.2.2.6 Protection

Protection shall be provided against damage and accidental or unauthorised change of setting(s) to all chassis inclination and limiting devices listed in Clause 2.2.2.

Adjustment shall require the use of tools.

2.2.2.7 Platform lowering

Controls which enable return of the work platform to the stowed position shall remain active.

2.2.2.8 Verification

Verification of the requirements of Clause 2.2.2 shall be carried out by means of a design check and functional testing.

Chassis inclination requirements are summarized in Table 2.2.2.8.

Table 2.2.2.8 — Chassis inclination requirement summary

Requirement	Clause(s)	Group A			Group B		
		Type 1	Type 2	Type 3	Type 1	Type 2	Type 3
Chassis inclination indicator	2.2.2.1.1	R	R	R	R	R	R
Prevent elevation when beyond chassis inclination limit	2.2.2.1.2	R	R	R	R	R	R
Spirit level as an indicator	2.2.2.2	[a]	O	O	[a]	O	O
Audible warning when approaching inclination limits	2.2.2.3.1	NA	R	NA	NA	R	NA
Travel cut-out when limits are reached	2.2.2.3.2 and 2.2.2.4	NA	[b]	R	NA	[b]	R

Key

R = Required

O = Optional

[a] For Type 1 MEWPs a spirit level indicator may be used to fulfil the requirement for a chassis inclination indicator.

[b] Not required on vehicle-mounted MEWPs.

2.2.3 Locking pins

Locking pins shall be secured against unintentional disengagement (e.g. using a spring pin) and loss (e.g. using a chain).

Verification shall be carried out by visual examination.

2.2.4 Control bars

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

Verification shall be carried out by visual examination.

2.2.5 Control bars held in vertical position

If control bars and tow bars, when not in use, are raised to the vertical position, an automatic device (i.e. self-latching device) shall be provided to hold the bars in this position.

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

Verification shall be carried out by visual examination, test and measurement.

2.2.6 Support points

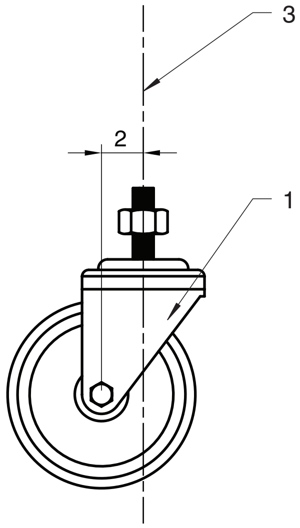
2.2.6.1 Stabilizer/outrigger feet

Stabilizer/outrigger feet shall be constructed to accommodate ground unevenness of at least 10 degrees.

Verification shall be carried out by visual examination and measurement.

2.2.6.2 Wheels and castors

Castor wheels with an offset, as defined in ISO 22877, are not permitted unless rotation about the vertical axis is automatically prevented when the work platform is raised out of the lowered travel position. (see Figure 2.2.6.2). These requirements do not apply to self-propelled MEWPs.



Key

1 Castor wheel

2 Offset

3 Vertical axis

Figure 2.2.6.2 — Castor wheel with offset

Verification shall be carried out by visual examination and test.

2.2.7 Permitted work platform positions

2.2.7.1 MEWPs with stabilizing devices or systems

Except for totally manually powered MEWPs (see Clause 2.2.8), every MEWP with devices or systems that are required to be deployed to satisfy the stability tests specified in Clause 3.6.3 shall be fitted with a safety device in accordance with Clause 2.10. The safety device shall prevent the work platform from operating outside permitted positions unless the devices or systems are set in accordance with the operating instructions. The safety system shall function without the need for operator intervention or connection.

NOTE Stabilizing devices or systems include stabilizers, outriggers, extendible axles, axle lockouts and pothole protection.

Verification shall be carried out by design check and functional test.

2.2.7.2 MEWPs that operate in a limited range with alternate stabilizing devices

MEWPs that are constructed for operation without stabilizers/outriggers, or with alternate stabilizing devices in a limited range of operation, shall be equipped with safety devices in accordance with Clause 2.10, which shall prevent operation outside that limited range.

The safety devices shall operate without the need for operator intervention or connection.

Verification shall be carried out by design check and functional test.

2.2.8 Totally manually powered MEWP

The requirements of Clause 2.2.7 are not mandatory for MEWPs that are totally manually powered and have a work platform floor height not exceeding 5 m above base level.

Totally manually powered MEWPs are also exempted from all safety requirements that cannot be met without power supply.

Verification shall be carried out by design check.

2.2.9 Oscillating axle lock or control systems

2.2.9.1 General

MEWPs equipped with one or more oscillating axles, in systems that lock or control the oscillating axle(s) to maintain stability, shall satisfy the following requirements:

(a) On Type 1 MEWPs, a safety device shall be fitted in accordance with Clause 2.10, which shall prevent deployment of the extending structure until oscillation of the axle(s) is locked or controlled.

(b) On Type 2 and Type 3 MEWPs that have a means of locking or controlling the oscillating axle(s), except mechanical hydraulic locking mechanisms, safety devices in accordance with Clause 2.10 shall be incorporated.

Where hydraulic cylinders are used as positional locking or control devices, these shall conform to Clause 2.9.

2.2.9.2 Prevention of powered stabilizer/outrigger or chassis levelling system movement

MEWPS with powered stabilizers/outriggers or a chassis levelling system shall be fitted with a safety device in accordance with Clause 2.10, to prevent movements of the stabilizers/outriggers or chassis levelling system, unless the extending structure and the work platform are in the stowed or transport position or within the limited range specified in Clause 2.2.7.

When the extended structure and the work platform are inside the limited range, as specified in Clause 2.2.7, the operation of the stabilizers/outriggers or chassis levelling system shall not create an unstable situation.

Verification shall be carried out by design check and functional test.

2.2.10 Manually operated stabilizers/outriggers

Manually operated stabilizers/outriggers shall be designed to prevent unintentional movement.

Verification shall be carried out by design check and functional test.

2.2.11 Self-propelled MEWP brakes

2.2.11.1 General

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

2.2.11.2 Elevated travel position

When in the elevated travel position, the brakes shall be able to stop the MEWP in accordance with Clause 2.2.15 and to maintain the stopped position.

2.2.11.3 Lowered travel position

When in the lowered travel position, the brakes shall hold the MEWP on the maximum slope it is capable of climbing, subject to adequate traction on the braking wheels.

2.2.11.4 Maximum rated speeds

The MEWP shall be able to stop from maximum rated speeds when descending the maximum slope that it is capable of climbing, subject to adequate traction on the braking wheels.

Verification shall be carried out by design check and functional test.

2.2.12 Movement of stabilizers/outriggers

The movements of stabilizers/outriggers shall be limited by mechanical stops that include hydraulic cylinders if designed for that purpose.

Mechanical means shall be provided to prevent uncontrolled movements of stabilizers/outriggers from the transport position.

Powered stabilizers/outriggers meeting the requirements of Clauses 2.2.10 and 2.9 are deemed to meet the above requirement. This requirement applies to MEWPs with permanently attached stabilizers/outriggers that increase the width or length of the MEWP and to all vehicle-mounted and trailer-mounted MEWPs.

Manually operated stabilizers/outriggers shall be locked in the transport position by two separate locking devices for each stabilizer/outrigger, at least one of which operates automatically (e.g. a gravity-locking pin plus a detent). Removable stabilizers/outriggers (vertical lifts) do not require mechanical stops, as these types need to be removed and stowed to transport the MEWP.

Verification shall be carried out by design check.

2.2.13 Unauthorized use

MEWPs shall be equipped with a device to prevent unauthorized use (e.g. lockable switch).

Verification shall be carried out by functional test.

2.2.14 Maximum travel speeds in elevated travel position of Type 3 MEWPs

Type 3 MEWPs shall be fitted with a safety device in accordance with Clause 2.10 to prevent the travel speed in the elevated travel position exceeding the following values:

(a) 1.5 m/s for vehicle-mounted MEWPs.

(b) 3.0 m/s for rail-mounted MEWPs.

(c) 0.4 m/s for all other Type 3 MEWPs.

All travel speed restrictions for self-propelled MEWPs, when the work platform is out of the lowered travel position, shall be automatic.

Verification shall be carried out by design check and functional test.

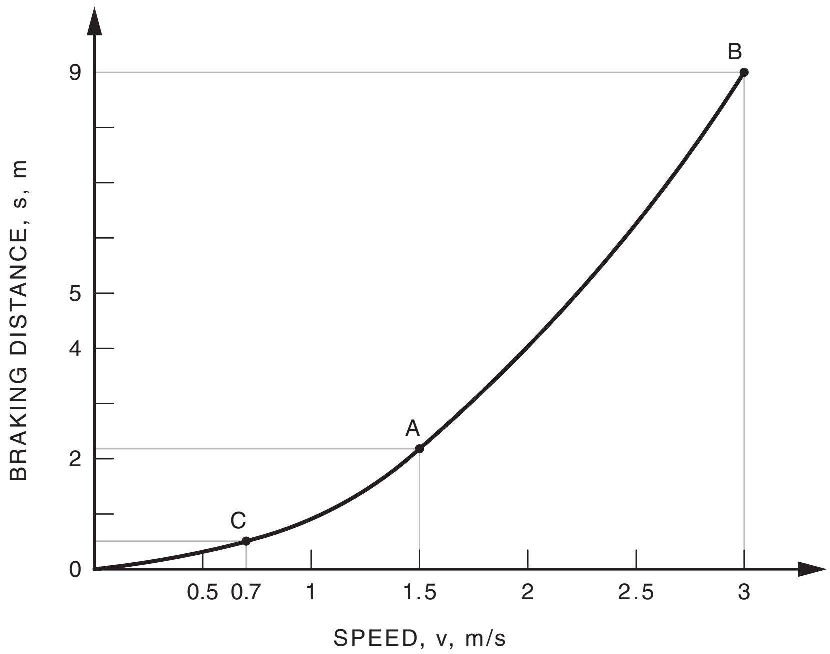
2.2.15 Stopping distances

MEWPs travelling at the maximum speeds given in Clause 2.2.14 on the maximum specified slope shall be capable of being stopped at distances not greater than those given in Figure 2.2.15.

NOTE 1 Figure 2.2.15 is based on an average deceleration of 0.5 m/s^2 and does not include the operator's reaction time.

NOTE 2 Minimum braking distances depend on factor *z* (see Clause 2.1.4.1.1).

Verification shall be carried out by functional test.



Key

A For vehicle-mounted MEWPs

B For rail-mounted MEWPs

C For all other MEWPs

Figure 2.2.15 — Maximum braking distance for Type 2 and 3 MEWPs

2.2.16 Maximum travel speed of pedestrian-controlled MEWPs

The maximum travel speed of pedestrian-controlled MEWPs with the work platform in the transport or stowed position shall not exceed 1.4 m/s.

Verification shall be carried out by measurement.

2.2.17 Guards to protect persons at control positions

Except in the case of Group A MEWPs (see Clause 2.3.4), guards shall be provided to prevent persons at control positions, or standing adjacent to the MEWP at ground level or at other points of access, from touching hot parts or dangerous parts of drive systems. Opening or removal of these guards shall only be possible using devices located in fully enclosed and lockable enclosures (e.g. cabs, compartments) or by the use of tools or keys provided with the MEWP. When it is foreseen that the fixed guards will be removed regularly (e.g. for routine maintenance), the fastenings shall remain attached to the guards or to the MEWP.

This requirement does not apply to the exhaust systems of vehicles conforming to road traffic regulations unless they are located near the control or access position.

Verification shall be carried out by visual examination.

2.2.18 Engine exhaust

The exhaust from internal combustion engines shall be directed away from control positions and from all electrical insulation.

Verification shall be carried out by visual examination.

2.2.19 Filling points for fluids

The filling points for flammable fluids shall be positioned to minimize the risk of fire from spillage onto hot parts (e.g. engine exhausts).

Verification shall be carried out by visual examination.

2.2.20 Battery constraint

Batteries and battery containers of all MEWPs shall be constrained to prevent displacement. Means shall be provided so that, in the event of overturning, the battery assembly will be constrained to avoid the risk of injury to the operator due to the battery being displaced or electrolyte being ejected.

Suitable ventilation holes shall be provided in the battery container, compartment or cover to prevent dangerous accumulation of gases in places occupied by operators.

NOTE Experience has indicated that when openings are positioned such that gases can escape freely, ventilation apertures are usually satisfactory if they provide a cross-section (in m^2) of (0.5 × the number of cells × the 5 h rated capacity, in ampere-hours). This level is not intended to cover the charging condition.

Verification shall be carried out by visual examination.

2.2.21 Derailment prevention

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

Verification shall be carried out by functional test.

2.2.22 Vehicle-mounted MEWP chassis selection

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

2.2.23 Vehicle-mounted MEWP transport position indicators

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

2.3 Extending structure

2.3.1 Methods to avoid overturning and exceeding permissible stresses

2.3.1.1 General

In addition to the provisions of Clause 2.1.5.5, the MEWP shall either be provided with control devices or conform to the methods outlined in this clause which reduce the risk of overturning and the risk of exceeding permissible stresses using one of the equivalent solutions indicated in Table 2.3.1.1 by a cross.

Verification of all requirements of Clause 2.3.1 shall be carried out by design check and tests (see Clauses 3.4 and 3.6).

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

Table 2.3.1.1 — Control devices

Group[a]	Load-sensing system and position control[b]	Load- and moment sensing system[c]	Moment-sensing system with enhanced overload criteria[d]	Position control with enhanced overload and stability criteria[e]
A	X			X
B	X	X	X	X

[a] See Clause 1.3 for further guidance.

[b] See Clauses 2.3.1.2 and 2.3.1.3 for further guidance.

[c] See Clauses 2.3.1.2 and 2.3.1.4 for further guidance.

[d] See Clauses 2.3.1.4 and 2.3.1.6 for further guidance.

[e] See Clauses 2.3.1.3, 2.3.1.5 and 2.3.1.6 for further guidance.

2.3.1.2 Load-sensing system

Where provided, the load-sensing system shall operate in the following way:

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

(b) While the load-sensing system is triggered, it shall give a visual and audible signal conforming to IEC 61310-1 which can be seen and heard from each control position.

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

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

For Type 1 MEWPs in Group A, it is permitted for the load-sensing system to be effective only when raising the extending structure from the lowest position. In this case, for the overload test specified in Clause 3.6.4, the test load shall be 150 % of the rated load.

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

The load-sensing system shall be in accordance with Clause 2.10.

The safety function override system (see Clause 2.6.10) shall remain active at all times, including those times when the load-sensing system is activated.

2.3.1.3 Position control

2.3.1.3.1 General

To avoid overturning of the MEWP or exceeding the permissible stresses in the structure of the MEWP, the permissible positions of the extending structure shall be limited automatically by mechanical stops (see Clause 2.3.1.3.2), non-mechanical limiting devices (see Clause 2.3.1.3.3) or electrical safety devices (see Clause 2.10).

2.3.1.3.2 Mechanical limiting devices

Where permissible positions are limited by mechanical stops, these shall be designed to resist the maximum forces exerted without permanent deformation.

NOTE Hydraulic cylinders fulfil this requirement if designed for this purpose.

2.3.1.3.3 Non-mechanical limiting devices

Where non-mechanical limiting devices are used, permissible positions of the extending structure shall be limited by a device that measures the positions of the extending structure and is operated through the control systems to limit movements to the working envelope. This device shall be backed up by a safety device in accordance with Clause 2.10.

2.3.1.4 Moment-sensing system

Where provided, the moment-sensing system shall operate such that when the overturning moment due to rated load and dead weights is reached, a visual and audible warning is given and further movements are prevented, except those movements that reduce the overturning moment.

The control system for the moment-sensing system shall conform to the requirements of Clause 2.10.

2.3.1.5 Criteria for enhanced stability for limited work platform dimensions

As an alternative to a load- and moment-sensing system, MEWPs for up to two persons may follow “enhanced stability requirements”.

To meet these enhanced stability requirements, the MEWP shall be designed according to the following criteria:

(a) Inside dimensions of the work platform at any horizontal section shall be as follows:

  (i) For one person, a sectional area not more than 0.6 m^2 with no side more than 0.85 m long.

(ii) For two persons, a sectional area not more than 1.1 m^2 with no side more than 1.5 m long.

(b) For the static stability test described in Clause 3.6.3.1, the test loads shall be calculated using 150 % of the rated capacity as identified in Clause 2.1.2. The other load and force combinations specified in Clauses 2.1.4.1, 2.1.4.2, 2.1.4.3, and 2.1.4.4 shall remain as specified.

2.3.1.6 Criteria for enhanced overload for limited work platform dimensions

As an alternative to a load-sensing system, MEWPs for up to two persons may follow “enhanced overload requirements”.

To meet these enhanced overload requirements, the MEWP shall be designed according to the following criteria:

(a) Inside dimensions of the work platform at any horizontal section shall be as follows:

(i) For one person, a sectional area not more than 0.6 m^2 with no side more than 0.85 m long.

(ii) For two persons, a sectional area not more than 1.1 m^2 with no side more than 1.5 m long.

(b) For the overload test described in Clause 3.6.4, the test load shall be 150 % of the rated capacity.

2.3.1.7 Variable working envelope with more than one rated capacity

MEWPs with more than one rated capacity and more than one working envelope shall have an indicator of the selected combination that is visible from the work platform. The indicator may be a physical change (e.g. platform extension) to the configuration of the platform that affects its rated capacity. An indicator is not required for MEWPs on which the working envelope is limited by a moment-sensing system.

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

MEWPs with enhanced stability for two persons shall require activation of a load-sensing system when selecting the extended working envelope(s).

2.3.1.8 Variable working envelope with one rated capacity

For MEWPs with one rated capacity and a variable working envelope (e.g. MEWPs with variable positions of stabilizers/outriggers) where selection is by manual means, selection shall only be possible with the extending structure in the access position (see Clause 2.2.10).

2.3.2 Sequencing of the extending structure

When a telescopic structure needs to be extended or retracted in a specific sequence, this sequence shall be automatic.

Verification shall be carried out by design check and functional test.

2.3.3 Tilting chassis or superstructure

MEWPs equipped with a tilting chassis or superstructure in which the stability of the machine, when operating, is dependent on control or locking of the tilting mechanism shall satisfy the following requirements:

(a) On Type 1 MEWPs, a safety device in accordance with Clause 2.10 shall prevent deployment of the extending structure until tilting of the chassis or superstructure is positively controlled or locked.

(b) On Type 2 and 3 MEWPs, it shall be shown by demonstration that the inclinations of the superstructure remain within the limits specified by the manufacturer when the inclination of the chassis is at the maximum permitted value.

Safety devices that control or lock the tilting shall be in accordance with Clause 2.10.

Hydraulic cylinders shall conform to Clause 2.9.

2.3.4 Trapping and shearing

Trapping and shearing points between moving parts that are within reach of persons on the work platform or standing adjacent to the MEWP at ground level shall be avoided by providing safe clearances in accordance with AS 4024.1801 or AS 4024.1803, or guarding in accordance with AS 4024.1601, as applicable.

For Group A MEWPs, when this is not practicable, clearly visible warnings with instructions to keep clear shall be permanently attached in the area of the hazard. Motion (lowering) alarms shall sound over at least the last 2 m of lowering to warn persons in the vicinity of a lowering platform.

Verification shall be carried out by measurement and visual examination.

2.3.5 Supporting the extending structure for routine inspection and maintenance

When the work platform of a MEWP needs to be raised for inspection or maintenance purposes, a means shall be provided to enable the extending structure to be held in the required position This means shall be capable of supporting an unloaded work platform and of being operated from a safe position. It shall not cause damage to any part of the MEWP (see Clause 4.2.14).

Verification shall be carried out by visual examination and functional test.

2.3.6 Speeds of the extending structure

MEWPs shall not exceed the following speeds:

(a) *For raising and lowering the work platform* — 0.4 m/s.

(b) *For telescoping the boom* — 0.4 m/s.

(c) *For slewing or rotation (horizontal speed at the outer edge of the work platform, measured at maximum range)* — 0.7 m/s.

Verification shall be carried out by functional test.

2.3.7 Support in the transport position

Provision shall be made to enable the extending structure to be supported in the transport position to limit vibrations during transport.

Verification shall be carried out by design check and visual examination.

2.4 Extending structure drive systems

2.4.1 General

2.4.1.1 Inadvertent movements

Drive systems shall be designed and constructed to prevent any inadvertent movements of the extending structure.

Verification shall be carried out by design check and functional test.

2.4.1.2 Protection of the extending structure from power sources

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

NOTE Protection may be achieved by using a pressure-limiting device.

The use of friction couplings does not fulfil this requirement.

Verification shall be carried out by design check.

2.4.1.3 Failure of transmission chain or belt

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

NOTE This may be achieved by using a self-sustaining gearbox or by monitoring the chain or belt with a safety device in accordance with Clause 2.10.

Flat belts shall not be used.

Verification shall be carried out by design check and functional test.

2.4.1.4 Kickback of handles

Manual drive systems shall be designed and constructed to prevent kickback of handles.

Verification shall be carried out by design check and visual examination.

2.4.1.5 Powered and manual drive systems for the same function

If both powered and manual drive systems are provided for the same function (e.g. to override an emergency system), and if there is a risk of injury from engaging both systems at the same time, this shall be prevented.

Verification shall be carried out by design check and functional test.

2.4.1.6 Braking system for all drives

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

The braking system shall ensure that the work platform, loaded with 1.1 times the rated capacity, can be stopped and held at any position in all configurations of operation. The braking system shall be protected against inadvertent release.

Verification shall be carried out by design check and functional test.

2.4.2 Wire rope drive systems

2.4.2.1 Wire rope drive system safety

2.4.2.1.1 General

Wire rope, drum and sheave diameters shall be calculated according to AS 5227 or Appendix S, assuming that the entire load is taken on one wire rope system. Traction drive systems shall not be used.

Wire rope drive systems shall have a device or system that, in the event of a wire rope drive system failure, limits the vertical movement of the fully loaded work platform to 200 mm.

This requirement shall be met by either a mechanical safety device (see Clause 2.4.2.1.2) or an additional wire-rope drive system (see Clause 2.4.2.1.3).

An example calculation for wire rope drive systems is given in Appendix T.

2.4.2.1.2 Mechanical safety device

Mechanical safety devices shall operate by engaging with the extending structure. These safety devices shall gradually bring the work platform plus the rated load to a stop and hold it in the event of the wire rope drive system failure. The average deceleration shall not exceed 1.0 g. Any spring operating this device shall either be a guided compression spring with secured ends, or have a wire diameter of more than half the pitch in the operating condition, to limit the shortening of the spring should it fail.

2.4.2.1.3 An additional wire rope drive system

Where an additional wire rope drive system is used, it shall be one of the following:

(a) A wire rope drive system designed according to the first system, with a device to give approximately equal tension in the two wire rope systems, thus doubling the working coefficient.

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

(c) A wire rope drive system designed according to Item (a), with larger drum and sheave diameters to increase the fatigue life of the second system to at least twice the calculated lifetime of the first system.

Failure of the first system shall be self-revealing.

Verification shall be carried out by design check and visual examination.

2.4.2.2 Load-carrying wire ropes

Load-carrying wire ropes (refer to ISO 2408) shall be made from galvanized steel wires or equivalent and shall have the following characteristics:

(a) Minimum diameter 8 mm.

(b) Minimum number of wires 114. Tensile grade of the wires, minimum 1570 MPa, and maximum 2160 MPa.

(c) Fatigue life suitable for the application.

(d) Corrosion resistance equivalent to that of galvanized steel.

(e) Ratio of sheave diameter to wire diameter meeting the requirements of AS 1418.1 and appropriate to the design classification.

The minimum breaking load of the wire ropes shall be shown on a certificate. Wire ropes that are used directly for lifting or supporting the work platform shall not include any splicing, except at their ends.

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

Verification shall be carried out by design and visual examination.

2.4.2.3 System of multiple wire ropes

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

Verification shall be carried out by design check and visual examination.

2.4.2.4 Re-tensioning wire ropes

It shall be possible to re-tension wire ropes.

Verification shall be carried out by design check and visual examination.

2.4.2.5 Terminations of wire ropes

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

(a) Splices.

(b) Aluminium pressed ferrules.

(c) Non-ageing steel pressed ferrules.

(d) Wedge-socket anchorages.

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

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

Verification shall be carried out by design check and visual examination.

2.4.2.6 Visual examination of wire rope terminations

Visual examination of wire rope terminations shall be possible.

NOTE The visual examination should not require the removal of the wire ropes or major disassembly of the structural components of the MEWP.

If it is not practicable to use inspection openings, means for examination shall be specified in the manufacturer's instructions.

Verification shall be carried out by design check and visual examination.

2.4.2.7 Safety device for MEWPs raised and lowered by wire ropes

MEWPs with work platforms that are raised and lowered by means of wire ropes, and where a slack rope condition can develop, shall be equipped with a safety device in accordance with Clause 2.10 that interrupts movements causing slack rope conditions. Movements in the opposite direction shall be possible.

NOTE For the purpose of this clause, a slack rope condition can occur where a rope pulls a mechanism in one direction and the mechanism is returned by gravity or an external force. A slack rope condition does not occur with a double-acting system where a rope pulls the mechanism in both directions.

Verification shall be carried out by design check and functional test.

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

Power-driven rope drums shall be grooved. Means shall be provided to prevent the wire rope from leaving the ends of the drum.

NOTE Means of prevention may be by using flanges extending to a height of at least twice the wire rope diameter above the highest layer.

Verification shall be carried out by visual examination.

2.4.2.9 Layers of rope

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

Verification shall be carried out by visual examination.

2.4.2.10 Turns of rope

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

Verification shall be carried out by functional test and visual examination.

2.4.2.11 Fastening rope to drum

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

Verification shall be carried out by design check and visual examination.

2.4.2.12 Unintentional displacement of rope

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

Verification shall be carried out by design check and visual examination.

2.4.2.13 Cross-section of drum grooves

The cross-section of the bottom of the grooves in wire rope drums and sheaves shall be circular over an angle of not less than 120 degrees.

Verification shall be carried out by design check and visual examination.

2.4.3 Chain drive systems

2.4.3.1 General

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

There shall be on record a certificate on chains, from the chain manufacturer, showing the minimum design breaking load of chains.

2.4.3.2 Limit of vertical movement in case of failure

2.4.3.2.1 General

Chain drive systems shall have a device or system that limits the vertical movement of the fully loaded work platform to 200 mm in the event of a chain drive system failure. This requirement shall be met by either of the drive systems described in Clause 2.4.3.2.2 and Clause 2.4.3.2.3.

2.4.3.2.2 Single-chain drive systems

Single-chain drive systems shall have a working coefficient of at least 5, plus a mechanical safety device that operates by engaging with the extending structure. This safety device shall gradually bring the work platform plus the rated capacity to a stop and hold it in the event of a drive system failure. The average deceleration shall not exceed 1.0 g. Any spring operating this device shall either be a guided compression spring with secured ends, or have a wire diameter of more than half the pitch in the operating condition, to limit the shortening of the spring if it should fail.

2.4.3.2.3 Two-chain drive systems

Two-chain drive systems shall meet either one of the following requirements:

(a) *Equal tension* — Each chain of a two-chain drive system shall either have a working coefficient of at least 4 (a total minimum coefficient of 8) and be provided with a device to give approximately equal tension in the two chain systems or conform to Item (b) below. Failure of a chain shall be self-revealing.

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

Verification shall be carried out by design check and visual examination.

2.4.3.3 Multiple chains attached to a point

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

Verification shall be carried out by design check and visual examination.

2.4.3.4 Tensioning chains

It shall be possible to re-tension chains.

Verification shall be carried out by design check and visual examination.

2.4.3.5 Strength of junction between chain and termination

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

Verification shall be carried out by design check.

2.4.3.6 Visual examination of chains and terminations

Visual examination of chains and chain terminations shall be possible. It should not require the removal of the chains or major disassembly of structural components of the MEWP.

If it is not possible to provide inspection openings, detailed instructions for examination shall be specified in the manufacturer's instructions.

NOTE See Clause G.2.5 for further details.

Verification shall be carried out by design check and visual examination.

2.4.3.7 Safety device for MEWPs raised and lowered by chains

MEWPs with work platforms that are raised and lowered by means of chains, and where a slack chain condition can develop, shall be equipped with a safety device, in accordance with Clause 2.10, that interrupts movements causing slack chain conditions. Movements in the opposite direction shall be possible.

NOTE For the purpose of this clause, a slack chain condition can occur where a chain pulls a mechanism in one direction and the mechanism is returned by gravity or an external force. A slack chain condition does not occur with a double-acting chain drive system where a chain pulls the mechanism in both directions.

Verification shall be carried out by design check and functional test.

2.4.3.8 Unintentional displacement of chain

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

Verification shall be carried out by design check and visual examination.

2.4.4 Lead-screw drive systems

2.4.4.1 Lead-screw and nut design stress and material

The design stress of lead-screws and nuts shall not be more than one-sixth of the ultimate tensile stress of the material used. The lead-screw material shall have a higher abrasion resistance than the loadbearing nut.

Verification shall be carried out by design check.

2.4.4.2 Separation of lead screw from work platform

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

Verification shall be carried out by visual examination.

2.4.4.3 Loadbearing nut and safety nut

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

Verification shall be carried out by design check and visual examination.

2.4.4.4 Detection of wear on loadbearing nuts

It shall be possible to detect the wear of the loadbearing nuts without disassembly.

2.4.5 Rack and pinion drive systems

2.4.5.1 Design stress of racks and pinions

The design stress of racks and pinions shall be not greater than one-sixth of the ultimate tensile stress of the material used.

Verification shall be carried out by design check.

2.4.5.2 Safety device and overspeed governor

Rack and pinion drives shall have a safety device in accordance with Clause 2.10, actuated by an overspeed governor. This safety device shall gradually bring the work platform plus rated capacity to a stop and hold it in the event of the lifting mechanism failing. The average deceleration shall not exceed 1.0 g. If this safety device is actuated, the power supply shall be interrupted automatically.

Verification shall be carried out by design check and functional test.

2.4.5.3 Devices to prevent pinion disengagement

In addition to the normal work platform guide rollers, positive and effective devices shall be provided to prevent any driving or safety-device pinion from coming out of engagement with the rack. These devices shall ensure that axial movement of the pinion is limited so that a minimum of two-thirds of the tooth width is always in engagement with the rack.

They shall also restrain radial movement of the pinion from its normal meshing position to no more than one-third of the tooth depth. Verification shall be carried out by visual examination.

2.4.5.4 Visual examination of pinions

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

Verification shall be carried out by visual examination.

2.5 Work platform

2.5.1 Level of work platform

After the initial levelling (if applicable) of the platform, the level of the work platform shall not vary by more than 5 degrees from the initial setting during movements of the extending structure.

The levelling system, except hydraulic levelling systems, shall incorporate a safety device conforming to Clause 2.10 that, in the case of a failure within the system, will maintain the work platform level within a further 5 degrees.

Verification shall be carried out by means of a design check and functional test.

NOTE Mechanical levelling systems fulfil this requirement if designed to take at least twice the load imposed on them. For wire ropes and chains, see Clause 2.4.2 and Clause 2.4.3. For the purpose of this clause, the enhanced overload criteria do not apply.

Verification shall be carried out by means of a design check.

Hydraulic cylinders in hydraulic levelling systems shall conform to Clause 2.9.2.

Verification shall be carried out by means of functional testing.

2.5.2 Platform level adjustment

Manually controlled adjustment of the level of the platform is permissible in all positions of the work platform. When the work platform is not in the lowered travel position or transport position, the speed of the platform levelling shall not exceed 0.3 rad/s (17 °/s).

2.5.3 Work platform materials

The structural components of the work platform shall be made of non-flammable material(s), that is, materials that will not sustain a flame after the ignition source has been removed.

2.5.4 Guardrail (protection) systems

2.5.4.1 General

Protection shall be provided on all sides of each work platform to prevent the fall of persons and materials. Except for orchard MEWPs (see Section 5) and insulated MEWPs (see Section 7), the protection shall be securely fastened to the work platform and, as a minimum, shall consist of guardrails at least 950 mm high, toe guards at least 100 mm high and intermediate guardrails not further than 550 mm from either the guardrails or the toe guards.

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

Clear horizontal space between toe guard segments shall not exceed 15 mm.

The guardrails shall be constructed to withstand concentrated forces of 500 N per person, applied at the least favourable positions in the least favourable direction at 500 mm intervals, without causing permanent deformation of the guardrails.

Chains or ropes shall not be used as guardrails, midrails, or access gates.

Verification shall be carried out by visual examination.

2.5.4.2 Folding guardrails

Provisions shall be made for folding guardrails to be securely fastened to the work platform and shall be equipped with locking pins secured against unintentional disengagement and loss, or an equally effective means of locking. When in the operational position they shall meet the requirements of Clause 2.5.4.1.

2.5.4.3 Protection of hands

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

2.5.5 Anchorage(s)

Anchorage(s) for the connection of a fall-arrest system shall be provided for boom supported MEWPs. MEWPs other than boom-supported MEWPs may be fitted with a fall-arrest or fall-restraint anchorage.

When fitted with a fall-arrest anchorage, each anchorage shall be capable of withstanding a static force of 15 kN without reaching ultimate strength. For anchorages rated for two people, the strength requirement shall be increased to 21 kN. This strength requirement shall only apply to the anchorage and its attachment to the MEWP in all possible load directions. When fitted, the number of anchorages shall equal or exceed the allowable number of persons. Any anchors defined as fall-arrest anchorages shall be tested to the requirements of Clause 3.6.2.

Fall arrest anchorages shall be marked to indicate the number of persons that may be attached [see Clause 4.2.2(j)]. Their capacity shall not be shown.

When fitted with a fall-restraint anchorage, each anchorage shall be capable of withstanding a static force of 6 kN without reaching ultimate strength and shall be located no more than 750 mm above the floor. For anchorages rated for more than one person, the strength requirements shall be multiplied by the number of persons. This strength requirement shall only apply to the anchorage and its attachment to the MEWP in all possible load directions.

Fall-restraint anchorages shall be marked “Restraint Only”, with words or symbols, and shall indicate the number of persons that may be attached.

Verification shall be carried out by design check and visual examination.

2.5.6 Openings in guardrails for entrance and exit

Any part of the protection movable for the purpose of access to the work platform shall not fold or open outwards. The gate shall be designed to either return automatically to the closed and latched position or be interlocked in accordance with Clause 2.10 to prevent operation of the MEWP until it is closed and latched. Inadvertent opening shall be prevented.

Sliding or vertically opening intermediate guardrails that return automatically to their protective position do not need to be latched or interlocked. Sliding or vertically opening intermediate guardrails shall be capable of being held in the open position with one hand while a person enters or leaves the platform.

The minimum opening width for the purpose of access to the work platform shall be 420 mm.

On work platforms with fixed top guardrails, the opening shall be not less than 800 mm high and 420 mm wide.

NOTE Wherever reasonably practicable, the minimum opening dimensions should be 920 mm high and 645 mm wide.

Verification shall be carried out by visual examination.

2.5.7 Floor of work platform

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

The floor of the work platform and any trapdoor shall be able to take the rated capacity distributed according to Clause 2.1.4.1.2.

Verification shall be carried out by design check.

NOTE Except for insulated MEWPs (see Section 7), non-conductive work platforms may have drain holes or access openings.

2.5.8 Access systems

When the distance between the access level and the upper edge of the toe guard (or the work platform floor if the toe guard opens with the access gate) in an access position exceeds 500 mm, the MEWP shall be equipped with an access ladder.

The steps or rungs should be spaced equally over the distance between the bottom step or rung and the floor of the work platform. Each step or rung shall be slip resistant. The access ladder shall be symmetrical with the access gate. The access system shall conform to the relevant requirements in Appendix O.

For vehicle-mounted MEWPs, the access system to the traydeck shall conform to this clause and Appendix O.

A ladder cage conforming to AS 1657 shall be provided where a person could fall more than 6 m from a rung-type ladder.

Verification shall be carried out by design check and visual examination.

2.5.9 Handholds and handrails

Handholds, handrails or similar devices shall be provided for both hands while climbing or descending the access ladder to the work platform. They shall be arranged to avoid the use of controls and piping as handholds or footsteps.

Verification shall be carried out by visual examination.

2.5.10 Trapdoors

Trapdoors in work platforms shall be designed so that inadvertent opening is not possible. It shall not be possible for trapdoors to open downward or to slide sideward.

Verification shall be carried out by visual examination.

2.5.11 Audible warning device

Type 3 MEWPs shall be equipped with an audible warning device (e.g. a horn) that is operated from the work platform.

Verification shall be carried out by functional test.

2.5.12 Means of communication

Type 2 MEWPs shall be provided with an appropriate means of communication between the persons on the work platform and the driver.

Verification shall be carried out by visual examination and functional test.

2.5.13 Mechanical stops

The movements of work platform(s) relative to the extending structure shall be limited by mechanical stops.

NOTE Hydraulic cylinders fulfil this requirement if designed for this purpose.

Verification shall be carried out by design check and functional test.

2.5.14 Support in transport position

The work platform of vehicle- and trailer-mounted MEWPs shall be supported in the transport position in such a way as to minimize the effects of harmful vibrations during transport (see Clause 2.1.6.3.4).

Verification shall be carried out by design check and visual examination.

2.6 Controls

2.6.1 General

Controls on MEWPs shall meet the requirements of AS 5247.

DRAFTING NOTE: AS 5247:202X is currently under development and is expected to publish concurrently with AS/NZS 1418.10.

2.6.2 Activation and operation

2.6.2.1 General

Except for vehicle travel controls of vehicle-mounted MEWPs, controls shall be provided such that all movements of the MEWP can only take place while the controls are being actuated. Control devices that control any movement of the MEWP shall automatically return to the “off” or “neutral” position when released. They shall be protected against unintentional activation. Controls shall be positioned to avoid danger to the operator from moving parts of the MEWP.

When the MEWP transitions from the elevated travel position to the lowered travel position, the travel speed shall always start in the slowest speed. Selection of a higher speed shall only occur with a separate operator input.

Any increase in speed shall only occur by a separate operator input.

2.6.2.2 Sustained involuntary operation protection

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

C2.6.2.2 *Sustained involuntary operation refers to the inability of the operator to disengage the activated control device, for example when forced against the controls by an external object which prevents the operator from releasing the controls.*

Verification shall be carried out by functional test and visual examination.

2.6.3 Work platform controls: location, accessibility and protection

Control devices shall be situated on the work platform. They shall be readily accessible to the operator. Platform control boxes not permanently attached shall have their normal location and orientation clearly marked on the platform and the control box.

All control devices shall be protected against activation other than that initiated by the operator.

All motion control devices shall have a function enable control in accordance with AS 5247.

If wireless control systems are used, they shall conform to Appendix H.

A position shall be provided to house the controls in the work platform.

Verification shall be carried out by means of functional testing and by visual examination.

2.6.4 Duplicate controls: location, accessibility, protection and selection

2.6.4.1 General

Duplicate controls for all powered functions of the extending structure shall be provided and readily accessible from the base or ground level. Control boxes not permanently attached shall have their normal location and orientation clearly marked.

2.6.4.2 Emergency stop control

The base or ground-level controls of Clause 2.6.4.1 shall override the platform emergency stop control.

2.6.4.3 Selector mechanism

A selector mechanism shall be provided such that movement is possible from only one pre-selected control station. The mechanism shall be located at the base or ground level controls. The mechanism shall be a safety device that conforms to Clause 2.10.

2.6.4.4 Selector mechanism key

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

2.6.4.5 MEWPs with insulating components

On MEWPs with non-conductive (insulating) components, the lower controls shall be located such that an operator is not placed in the electrical path between the aerial device and the ground.

2.6.4.6 Travel controls

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

Verification shall be carried out by functional test and visual examination.

2.6.5 Emergency stops

MEWPs shall be provided with emergency stop controls according to AS 4024.1604 or ISO 13850 at each control position.

All emergency stop actuators at all control locations other than at the platform (see Clause 2.6.4) shall remain active in all operating modes, see Note 2. They shall be of the normally closed, positive-break type.

Verification shall be carried out by design check and functional test.

NOTE 1 For MEWPs that employ mechanically activated gravity lowering control(s), the lowering control may remain active after initiation of the emergency stop.

NOTE 2 Operating mode 1 is the normal operating mode, mode 2 is the operating mode in the event of loss of the primary power supply, and mode 3 is the operating mode intended to be employed by trained personnel for the purpose of maintenance, testing or as a secondary emergency recovery mode.

2.6.6 Electrical switches

Electrical switches controlling safety functions shall be selected according to the function they perform and the requirements specified in Clause 2.10.

Verification shall be carried out by design check.

2.6.7 Pilot and solenoid valves

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

Verification shall be carried out by design check and functional test.

2.6.8 Restoration of power after failure of power supply

On starting or on restoration of power after failure of the power supply, no movement shall occur unless there is a deliberate action by the operator.

Verification shall be carried out by functional test.

2.6.9 Auxiliary system

MEWPs shall be fitted with an auxiliary system to provide a backup in the event of failure of the primary power (e.g. out of fuel, flat battery).

NOTE When an auxiliary system is in operation it is considered to be operating mode 2.

The auxiliary system shall be capable of returning the work platform from anywhere in the working envelope to an access position. The auxiliary system controls shall be located in a position easily accessible from the ground. The system may also be operable from the work platform.

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

Where hand pumps are used, the maximum actuating force shall not exceed 50 N. The total time required to lower the platform from full height shall not exceed 3 min.

Verification shall be carried out by design check and functional test.

> ***C2.6.9*** *A manual lowering system is not required to be duplicated in the work platform for MEWPs which employ such a system.*

2.6.10 Overriding of functions

2.6.10.1 Overriding of safety functions or devices

Where overriding of safety functions or devices is permitted as described in this document, it shall be done by use of a control that —

(a) is located at the base or ground level;

(b) conforms to Clause 2.10;

(c) is of the hold-to-run type; and

(d) allows one motion at a time.

NOTE 1 Overriding of functions may be performed using either the primary power unit or the auxiliary system.

NOTE 2 The overriding system is operating mode 3, which is intended to be employed by trained personnel for the purpose of maintenance, testing or as a secondary emergency recovery mode.

Controls for overriding safety functions or devices shall be marked in accordance with Clause 4.2.5.

An additional overriding device to override safety functions or devices may be located at the work platform controls.

2.6.10.2 Overriding of the emergency stop function

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

Duplicate controls located at the base or ground level shall remain active when the emergency stop device located on the work platform is activated.

During the overriding of the emergency stop function —

(a) work platform controls shall remain deactivated; and

(b) all the other safety functions and devices shall remain active.

NOTE It is possible for load sensing system override and emergency stop function override to occur at the same time.

During overriding of functions, it is permissible to use either the main power supply or the auxiliary system.

The location of the controls shall be clearly identified with a label. The colour of the actuator shall contrast to the surrounding area and background so that it is clearly visible.

Verification shall be carried out by design check and functional testing.

2.6.11 Speed restriction

A device shall be provided to limit the speed of movement of the work platform to 1.4 times normal speed, even under emergency operations.

Verification shall be carried out by functional check.

2.6.12 Automatic or programmed operation

Automatic or programmed operation that is performed with the joystick, lever or switch released is permissible if appropriate safety measures are employed.

NOTE An example of such a safety measure is a warning device alerting the operator that the machine is "under operation" with a continuously operated switch the release of which interrupts the movement.

2.6.13 Winch control on vehicle-mounted MEWPs

If equipped with a powered material handling winch, a vehicle-mounted MEWP shall have winch controls at both upper and lower control locations.

2.6.14 Control systems using encoded data techniques

Control systems using encoded data techniques shall conform to the requirements of Clause 2.6 and the additional requirements of Appendix H.

2.7 Electrical equipment

2.7.1 General

Electrical equipment of MEWPs shall conform to the relevant Standards, specifically to the requirements of AS/NZS 4024.1204.

The necessary safety measures or operating limitations shall be specified in the operator’s manual where deviations from the specified safety measures are necessary due to special conditions relating to —

(a) d.c. supplies;

(b) ambient air temperature;

(c) altitude; and

(d) connection to moving elements of the machine.

The relevant electromagnetic compatibility requirements shall be observed.

Verification shall be carried out by design check and visual examination.

2.7.2 Main switch

A main switch shall be fitted in an easily accessible and identified position. It shall be possible to secure it in the disconnected position with a locking device to prevent operation.

Verification shall be carried out by design check and visual examination.

2.7.3 Cables

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

Verification shall be carried out by design check and visual examination.

2.7.4 Battery protection

Batteries shall be protected against damage by short circuits and against mechanical damage. If batteries are the primary power source, the disconnection (isolation) of the battery, that is breaking one pole of the electrical supply (e.g. when charging), shall be easily possible without the use of a tool.

Verification shall be carried out by visual examination.

2.7.5 Ingress of water

When necessary to prevent ingress of water, the minimum degree of protection provided by enclosures shall be IP 54 in accordance with AS 60529. Account shall be taken of any foreseeable conditions of use (for example, fluids other than water necessitating higher degrees of protection and pressure cleaning of the MEWP).

Verification shall be carried out by design check and visual examination.

2.7.6 Electromagnetic compatibility (EMC)

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

2.7.7 Hourmeter

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

An hourmeter is not required for totally manually powered MEWPs.

2.8 Hydraulic systems

2.8.1 Pressure-limiting device

The hydraulic system shall include the pressure-limiting device (e.g. pressure-relief valve) before the first control valve. If different maximum pressures are used in the hydraulic system, more than one pressure-limiting device shall be provided.

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

Verification shall be carried out by design check and visual examination.

2.8.2 Strength of pipes and connections

Pipes and their connections that may be subjected to the maximum pressure permitted by any pressure-limiting device shall be designed to withstand at least twice that pressure without permanent deformation. If, in normal operation, components may be subjected to higher pressures than permitted by the pressure-limiting device, they shall be designed to withstand at least twice that higher pressure without permanent deformation.

NOTE For failure conditions, see Clause 2.9.1.3.

Verification shall be carried out by design check.

2.8.3 Bursting strength of hoses and fittings

All fittings and hoses shall have a minimum bursting strength of three times the operating pressure for which the relevant circuit is designed. Verification shall be carried out by design check.

2.8.4 Pressure rating of other components

All components of the hydraulic system, other than those specified in Clauses 2.8.2, 2.8.3 and 2.9, shall be rated for at least the maximum pressure to which they will be subjected, including any temporary increase in pressure setting necessary for carrying out the overload test (see Clause 3.6.4).

Verification shall be carried out by design check.

2.8.5 Gauge connections

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

Verification shall be carried out by design check and visual examination.

2.8.6 Venting of air

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

Verification shall be carried out by design check.

2.8.7 Inlet filter

Hydraulic fluid reservoirs open to atmosphere shall be equipped with an air-inlet filter.

Verification shall be carried out by visual examination.

2.8.8 Fluid level indicators

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

Verification shall be carried out by visual examination and functional test.

2.8.9 Fluid cleanliness

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

Verification shall be carried out by design check.

2.8.10 Gas-loaded accumulators

In hydraulic systems incorporating gas-loaded accumulators, means shall be provided to vent the liquid pressure automatically or to positively isolate the accumulator when the system is in the unpressurized state. When the accumulator is able to be isolated in the pressurized state, a relief valve shall be fitted.

If the gas-loaded accumulator pressure is required by design to be retained when the system is shut off, complete information for safe servicing shall be given on or near the accumulator in a visible location. Information shall include the following statement:

CAUTION — PRESSURIZED VESSEL.

The same information shall be provided in the instruction manual on the circuit diagram.

There shall be a caution label on the gas-loaded accumulator stating the following:

CAUTION — PRESSURIZED VESSEL.

DISCHARGE PRIOR TO DISASSEMBLY.

Verification shall be carried out by design check and visual examination.

2.8.11 Incorrect connection of hoses

Hydraulic hoses shall be designed, identified or located to avoid any incorrect connection causing a hazard (e.g. to reverse the direction of movement of a hydraulic cylinder).

Verification shall be carried out by visual examination and functional test.

2.9 Hydraulic cylinders

2.9.1 Structural design

2.9.1.1 General

The design of load-supporting cylinders shall be based on an analysis of the pressure, imposed loads, and forces during normal operation and failure conditions (see Clause 2.9.1.3). Cylinders acting as mechanical stops shall be designed to withstand twice the imposed load.

Verification of the requirements of Clause 2.9 shall be carried out by design check, functional test and visual examination.

2.9.1.2 Normal operating conditions

2.9.1.2.1 Buckling

Operating conditions that produce combinations of extended length, pressure, deflections and externally applied loads and forces creating the maximum buckling conditions shall be identified.

2.9.1.2.2 Constructional details

The design of welded joints shall conform to Clause 2.1.6.2. Load-carrying threaded joints shall conform to relevant Standards. 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 that are subjected to varying tensile loads shall take into account the effects of fatigue and prevent inadvertent separation (unscrewing).

2.9.1.2.3 Conditions causing pressure above pressure-limiting device pressures

See Figures 2.9.1.2.3(A) to 2.9.1.2.3(E) for guidance on conditions causing pressure above pressure-limiting device pressures.

Conditions that cause increases in pressure above those of the pressure-limiting device shall be taken into account.

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

(a) The effect of devices that reduce the speed of cylinders below the speed that could result from the full fluid supply to the cylinders, causing internal pressure loading additional to the normal pressure due to externally applied loads. This additional pressure may be determined by the ratio

$$D^2 \big/ \left(D^2 - d^2\right)$$

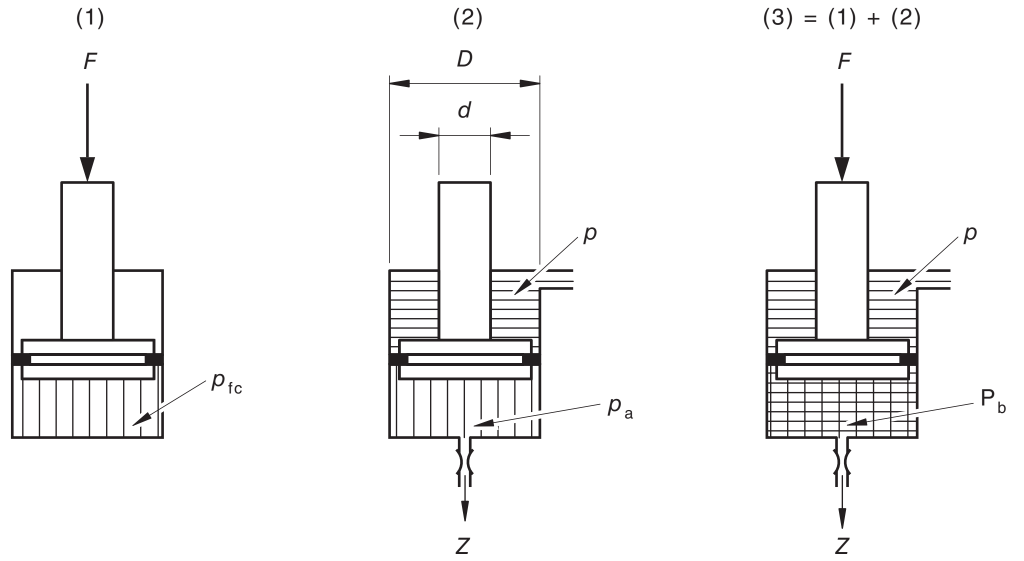
where

D = diameter of the piston

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

The speed control device may take the form of the control valve being partially open or closed.

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



Key:

F Load

P System pressure

p_{fc} Normal load pressure

Z Restricted flow

D Diameter of the piston

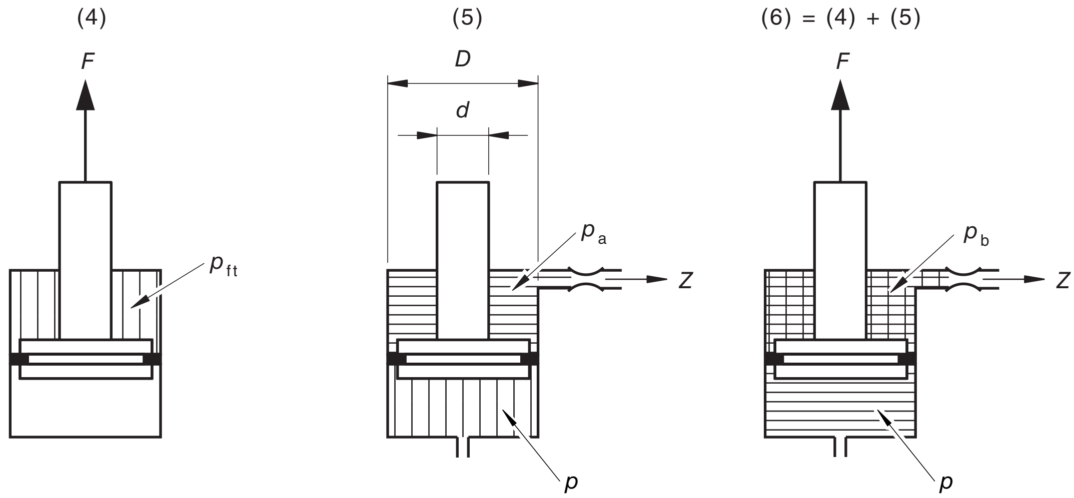
d Diameter of the piston rod, when a cylinder is in tension and the speed control device acts on the annulus

$$P_{fc} = \left[\frac{F \times 4}{\pi \left(D^2 \right)} \right]$$

$$P_a = p \left[\frac{D^2 \times d^2}{D^2} \right]$$

$$Pb = p_{fc} \left[\frac{D^2 \times d^2}{D^2} \right]$$

Figure 2.9.1.2.3(A) — Cylinder pressure under normal operation (cylinder in compression)



Key:

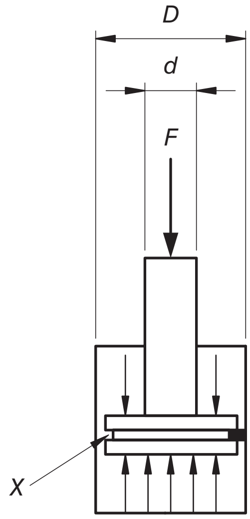
F Load
P System pressure
p_{fc} Normal load pressure
Z Restricted flow

$$p_{ft} = \left[\frac{4F}{\pi\left(D^2 - d^2\right)} \right]$$

$$p_a = p\left[\frac{D^2}{D^2 - d^2} \right]$$

$$p_b = p_{fc} + p\left[\frac{D^2}{D^2 - d^2} \right]$$

Figure 2.9.1.2.3(B) — Cylinder pressure under normal operation (cylinder in tension)



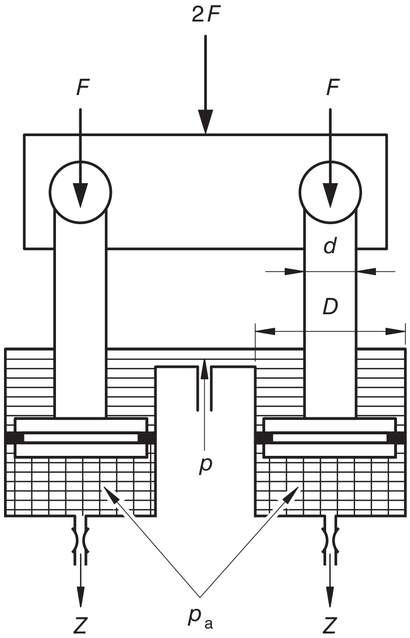
Key:

F Load

X Failed seal

NOTE The pressure on top is equal to that at the bottom of the piston. The load is supported by the area of the rod $\frac{\pi D^2}{4}$ instead of the area of the piston $\frac{\pi D^2}{4}$. The normal pressure (p_{fc}) increases by the ratio $\frac{D^2}{d^2}$.

Figure 2.9.1.2.3(C) — Cylinder pressures at seal failure



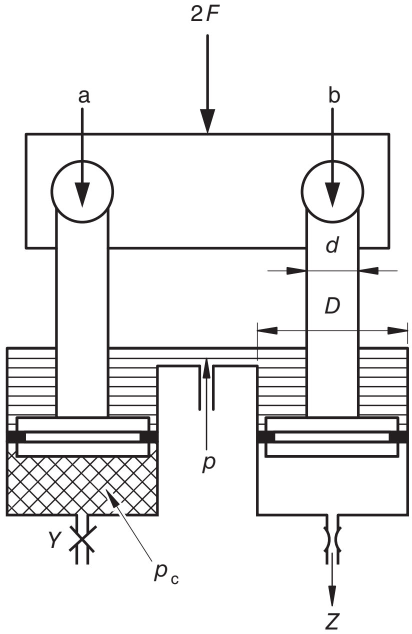
Key:

F	Load
P	System pressure
p_{fc}	Normal load pressure
Z	Restricted flow

$$p_{fc} = \left[\frac{F \times 4}{\pi\left(D^2\right)}\right]$$

$$p_a = p_{fc} + p\left[\frac{D^2 - d^2}{D^2}\right]$$

Figure 2.9.1.2.3(D) — Twin cylinders under normal compression in normal operation



Key:

F Load
P System pressure
p_{fc} Normal load pressure
Y Line blockage
Z Restricted flow

$$p_{fc} = \left[\frac{F \times 4}{\pi\left(D^2\right)} \right]$$

$$p_a = p_{fc} + p\left[\frac{D^2 - d^2}{D^2} \right]$$

$$p_a = 2\left[p_{fc} + p\left(\frac{D^2 - d^2}{D^2} \right) \right]$$

Figure 2.9.1.2.3(E) — Twin cylinders under compression — One line blocked

2.9.1.3 Failure conditions

2.9.1.3.1 Oil leaking past piston seals

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

2.9.1.3.2 Several cylinders operating the same mechanism

When more than one cylinder operates the same mechanism [see Figures 2.9.1.2.3(D) and 2.9.1.2.3(E)], 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.

Under failure conditions, the calculated maximum stress shall not exceed the yield stress of the material.

2.9.2 Prevention of unintended movement of load-holding cylinders

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

The effects of thermal expansion in load-holding cylinders and manufacturing tolerances shall be accounted for.

Such devices shall be either —

(a) integral with the cylinder;

(b) directly and rigidly flange-mounted; or

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

Other types of fittings, such as compression fittings or flared pipe fittings, shall not be used between the cylinder and the lock valve.

NOTE These requirements fulfil those of Clause 2.4.1.6.

> ***C2.9.2*** *Compression and flared pipe fittings rely on friction to form a mechanical joint and may not provide a reliable hydraulic seal when under mechanical loading.*

2.10 Safety devices

In this document, wherever reference is made to this clause, the performance of safety-related parts, in the event of faults, shall conform to the performance levels (taken from ISO 13849-1) or SILs (taken from AS 62061) that are given in Table 2.10.

NOTE For an example of the application of control system categories, see Appendix N.

For operating modes 1 and 2, it shall only be possible to override a safety device listed in Table 2.10 in a safe manner by using a separate device of the same category or better. For operating mode 3, where it is required to override a safety device, hazard warnings and instructions shall be provided in the manual on how this may be performed in a safe manner.

The safety-related parts of control systems of MEWPs shall be designed in accordance with the requirements of AS 62061 or ISO 13849-1. In addition, as a minimum, MEWPs shall be fitted with the safety devices specified in Table 2.10.

Table 2.10 — Description of safety function/device of the MEWP and required reliability levels

Clause No.	Description of safety function/device of the MEWP	SIL of AS 62061	Performance (PL) of ISO 13849-1
Clause 2.2.1	Prevents a Type 1 MEWP from travelling when work platform is out of the transport position	1	c
Clause 2.2.2	Level indicator (e.g. spirit level) indicates whether the inclination of the MEWP chassis is within the limits permitted by the manufacturer. On Type 2 and Type 3 MEWPs, prevents continuation of travel in the selected direction. For vehicle-mounted MEWPs of Type 2, the cut-out function may be replaced with an audible alarm	1	c
Clause 2.2.7.1	Prevents work platform from operating outside permitted positions unless the stabilizers/outriggers are set in accordance with the operating instructions	1	c
Clause 2.2.7.2	Prevents MEWPs (which are designed to operate in a limited range without stabilizers/outriggers) from operating outside that range without stabilizers/outriggers engaged	2	d
Clause 2.2.9	Oscillating axle lock or control system	1	c
Clause 2.2.10	Interlocks powered stabilizers/outriggers in the required extended position, unless the MEWP is in transport mode or within a limited and “stable” range	2	d
Clause 2.2.14	Limits the speed of travel with the manned work platform out of the lowered travel position on Type 3 MEWPs	1	c
Clause 2.3.1.2	Load-sensing system provides visual and audible warning, and stops the work platform, when certain rated load situations have been exceeded	2	d
Clause 2.3.1.3	Control system limits the work platform to the working envelope, when the envelope is not limited exclusively by mechanical stops	2	d
Clause 2.3.1.4	Moment-sensing system provides visual warning when overturning moment is reached and prevents further movements, except movements that reduce the overturning moment	2	d
Clause 2.3.3	Prevents movement of tilting chassis or superstructure unless the work platform is in its access position	1	c
Clause 2.4.1.3	Automatically prevents inadvertent movements of the work platform in the event of a failure of a chain or belt system in the drive system of the MEWP	1	c

Table 2.10 *(continued)*

Clause No.	Description of safety function/device of the MEWP	SIL of AS 62061	Performance (PL) of ISO 13849-1
Clause 2.4.2.7	Prevents movement of the work platform in the event of a slack rope condition (applicable for MEWPs with work platforms that are raised and lowered by means of a wire rope)	1	b
Clause 2.4.3.7	Prevents movement of work platform in the event of a slack chain condition (applicable for MEWPs with work platforms that are raised and lowered by means of a chain)	1	c
Clause 2.4.5.2	Overspeed device on rack and pinion drives to stop and hold the work platform (plus rated load) in the event of drive failure. The acceleration shall not exceed 1.0 g	1	c
Clause 2.5.1	Platform levelling system that limits the variation of the work platform (basket) inclination to a maximum of ± 5 degrees. The levelling system shall incorporate a safety device that prevents the inclination of the platform (basket) exceeding a further 5 degrees inclination if failure occurs within the system	2, (1)	d, c
Clause 2.5.6	Prevents operation of the MEWP until the gate is closed and fastened (locked) in position (if gates are not designed to automatically close and lock). Outward opening gates are not permitted	1	c
Clause 2.6.4	Interlocks controls so that control of MEWP can only be done at one preselected station	1	c
Clause 2.9.2	Prevents unintended movement of load holding cylinders, in the event of failure of a hose or pipe	1	c

3 Verification of the safety requirements or measures or both

3.1 General

Examinations and tests to ensure that MEWPs conform to this document shall be completed in accordance with this section.

The results of examinations and tests, and the name and address of the person(s) carrying them out, shall be recorded in a signed report.

3.2 Type tests of MEWPs

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

(a) Design check (see Clause 3.4).

(b) Manufacturing checks (see Clause 3.5).

(c) Tests (see Clause 3.6).

Vehicle-mounted MEWPs installed onto a different vehicle shall be subject to the applicable tests specified in Clause 3.6. If the vehicle is of the same make and model as that for which the MEWP was originally designed and fitted, it is not necessary to perform the tests in accordance with Clauses 3.6.2, 3.6.3.1.2 and 3.6.3.1.3 where the following applies:

(i) The vehicle manufacturer's full model code is identical to the original vehicle.

(ii) The tare mass has not been reduced.

(iii) The tare mass distribution has not been altered.

(iv) The wheelbase has not been altered.

3.3 Production tests

MEWPs shall undergo the following production tests before being placed in service:

(a) Overload test (see Clause 3.6.4).

(b) Functional tests (see Clause 3.6.5).

(c) In addition, each vehicle-mounted MEWP shall undergo the static stability test in accordance with Clause 3.6.3.1.1.

A production system shall be implemented to provide assurance that the materials, components, assembly and function of the MEWP conform to the design and manufacturing specifications.

3.4 Design check

The design check required by Clause 3.2(a) shall verify that the MEWP is designed in accordance with this document. It shall include verification of the following documents:

(a) Drawings containing the main dimensions of the MEWP.

(b) Description of the MEWP, including necessary information about its capabilities.

(c) Information on the materials used.

(d) Diagrams of the electrical, hydraulic and pneumatic circuits and control systems.

(e) Instruction manual.

(f) Calculations.

(g) Validation reports of the systems that incorporate those safety devices referred to in Clause 2.10.

The documents shall include all the necessary information to enable the calculations to be checked.

3.5 Manufacturing check

The manufacturing check required by Clause 3.2(b) shall verify that —

(a) the MEWP is manufactured in accordance with the documents referenced in Clause 3.4;

(b) the components are in accordance with the drawings;

(c) test certificates are available for all loadbearing ropes and chains, hydraulic or pneumatic hoses, electrical insulation and flame-retardant materials (as applicable);

(d) the quality of welds, particularly in loadbearing components, is in accordance with appropriate standard(s); and

(e) the construction and installation of parts are in accordance with the design specifications.

3.6 Tests

3.6.1 General

Tests shall be made as required by Clauses 3.2 and 3.3 to verify that —

(a) the MEWP is stable;

(b) the MEWP is structurally sound; and

(c) all functions work correctly and safely.

NOTE Special aids may be required to allow these tests to be carried out safely.

3.6.2 Fall-arrest overturning test

MEWPs designed for use with a fall-arrest system shall successfully complete the following test:

(a) The MEWP while positioned on a level surface shall sustain the force of a 136 kg test mass free-falling as follows:

(i) The test mass origin shall be placed with the centre of gravity 0.46 m outside of the top rail of the work platform in a direction that creates the most adverse stability condition.

(ii) The test mass shall be attached by a lanyard, without a shock absorber fitted, to a lanyard anchorage point nearest the test mass origin. The lanyard shall be routed over the top rail of the work platform such that the overturning force is applied to the top rail.

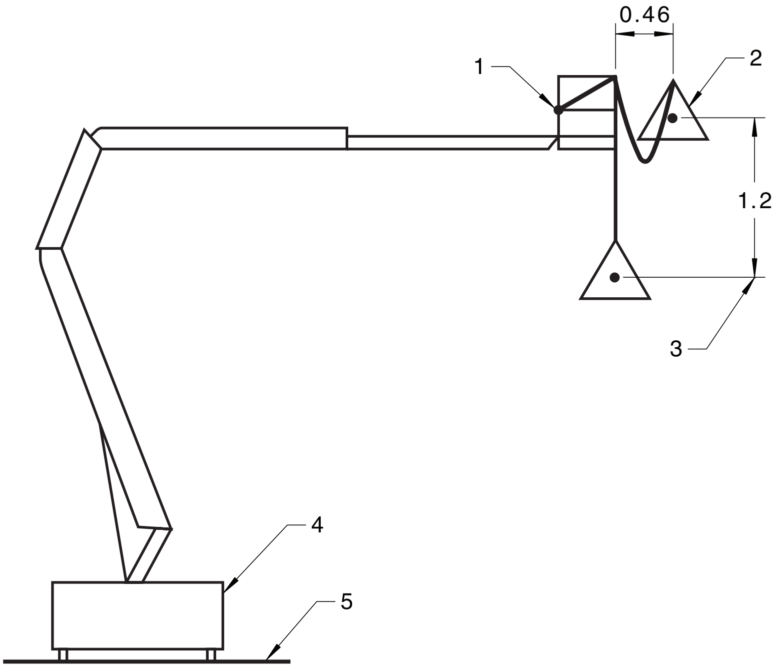
(iii) The test mass shall free-fall a minimum vertical distance of 1.2 m without interference, obstruction, or hitting the floor/ground during the test.

(b) The MEWP shall be loaded to the most adverse stability condition during the test. This condition may be with or without the remaining load required to achieve capacity, including the 136 kg test mass. Any additional load shall be placed such that it is evenly distributed on the platform.

The MEWP shall not overturn as a result of this test. Permanent deformation of any part is acceptable, provided that the test mass is not released during the test (see Figure 3.6.2).

NOTE For the purpose of this test, the enhanced stability criteria do not apply.

Dimensions in metres



Key:

1 Anchorage
2 136 kg test mass
3 Free fall distance
4 MEWP
5 Level surface

Figure 3.6.2 — Fall-arrest anchorage test

3.6.3 Stability tests

3.6.3.1 Static tests

3.6.3.1.1 General

The MEWP shall be set up on the maximum allowable chassis inclination plus 0.5 degrees. If provided, stabilizers/outriggers shall be used as specified. Test load(s) shall be applied to represent the entire least favourable load and force combinations specified in Clauses 2.1.5.1, 2.1.5.2, 2.1.5.3 and 2.1.5.4.

For MEWPs following the criteria for enhanced stability (see Clause 2.3.1.5), the test load associated with the rated capacity (see Clause 2.1.4.1) shall be modified in accordance with Clause 2.3.1.5. For insulated vehicle-mounted electrical line maintenance MEWPs following the enhanced stability criteria, the load on the vehicle during the test may be modified according to Clause 7.8.2.

For MEWPs following the enhanced stability criteria, load cells placed under the outriggers/stabilizers may be used to measure the residual stabilizing moment when the MEWP is subjected to a test load of 150 % of the rated capacity. The effect of deflection shall be considered.

The test may be carried out with the chassis level provided the test loads are recalculated to include the effects of the maximum allowable chassis inclination, plus 0.5 degrees.

The test load(s) may be applied at any suitable strong point, if necessary, to avoid overstressing any part of the MEWP.

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

NOTE Examples of positions are shown in Tables 2.1.5.5(A) and 2.1.5.5(B) and Figures 2.1.5.5(A) and 2.1.5.5(B).

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

Additionally, following application of manual forces according to Clause 2.1.4.3 in any position of the work platform, it shall be demonstrated that the work platform shows no permanent deformation.

3.6.3.1.2 MEWPs supported on pneumatic tyres

In addition to the test specified in Clause 3.6.3.1.1, if the MEWP is supported in the working position by pneumatic tyres and is not protected by a low tyre pressure warning system, the MEWP shall be set up on the maximum allowable chassis inclination plus 0.5 degrees. The test shall be conducted by deflating a single tyre and applying test load(s) to represent the all of the least favourable load and force combinations specified in Clauses 2.1.5.1, 2.1.5.2, 2.1.5.3 and 2.1.5.4. The test shall be repeated for all tyres that support the MEWP, whose deflation adversely affects the stability of the MEWP. For the purpose of this test, the enhanced stability criteria need not be applied.

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

3.6.3.1.3 Vehicle-mounted MEWPs

In addition to the tests specified in Clauses 3.6.3.1.1 and 3.6.3.1.2, where a vehicle-mounted MEWP is supported partly or wholly on a flexible suspension when elevated, the MEWP shall be placed on a slope equal to the manufacturer's rating plus 5.0 degrees.

When equipped with one pair of outriggers/stabilizers, the chassis may be levelled to the manufacturer's rating using the outriggers/stabilizers. Where the rated inclination cannot be achieved because of insufficient travel of the outriggers/stabilizers, additional dunnage shall be used. For the purpose of this test, the enhanced stability criteria do not apply.

Where an alarm system that warns when the vehicle axles are on an incline greater than that permitted is provided, the test shall be performed on that incline plus 0.5 degrees.

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

3.6.3.1.4 Platform deflection test

The following test is only required for single person indoor only Group A MEWPs.

Position the MEWP on a level surface. Place an 80 kg mass on the platform floor, representing the mass of one person, in accordance with Clause 2.1.4.1.2. All masses and loads shall be taken to act in the location and direction that will produce the least stable outcome. The MEWP shall not overturn when a horizonal load is applied to the top rail resulting in a horizontal displacement of 0.3 m of the platform top rail or when the applied horizontal load reaches 300 N. If the maximum applied horizontal force is less than 300 N, the load required to sustain the platform top rail deflection at 0.3 m shall be 70 N or greater. The MEWP is stable if it can maintain a stationary condition without overturning while supporting the load(s). Lifting of multiple wheels or stabilizers/outriggers alone does not indicate a condition of instability.

Calculations may be used to demonstrate conformance to this requirement. Calculations shall be based on empirical data.

A sample calculation is included in Appendix Q.

> ***C3.6.3.1.4*** *This test is particularly relevant to MEWPs where manual force is the dominant load causing overturning because the magnitude of the manual force applied is not readily established by the operator. This test is intended to give the operator reasonable opportunity to detect an unsafe side load situation, and take corrective action, prior to reaching the point of instability.*

3.6.3.2 Dynamic tests on Type 2 and 3 MEWPs

3.6.3.2.1 General

Type 2 and 3 MEWPs shall be subjected to kerb tests and braking tests, with the rated capacity distributed evenly over the half of the work platform to create the greatest overturning moment in the specific test case.

Kerb and depression tests are not required for rail-mounted MEWPs. For Type 2 and 3 MEWPs in Group A that have platform extension(s) with rated loads different from the main work platform rated load, and that do not have specific load control of the extension platform(s), the tests shall be carried out with the loads distributed in the same way and at the same time on both the main work platform and the extension platform [see Figure 3.6.3.2.1(A)].

The rated load m_{ext} is defined by

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

where

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

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

m_p = 80 kg (mass of a person)

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

The rated load *m*work is defined by

$$m_{work} = (m_{p,work} - m_{p,ext} - m_p) + (m_{e,work} - m_{e,ext})$$

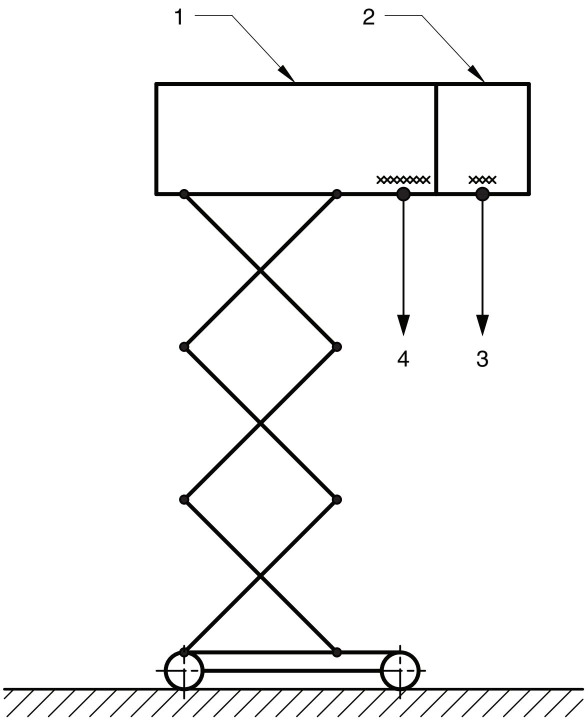
where

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

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

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

NOTE 1 See Clause 2.1.2 for further guidance.



Key

1 Main work platform

2 Extension platform (fully extended)

3 Rated load (extension platform), m_{ext}

4 Rated load (main platform), m_{work}

Figure 3.6.3.2.1(A) — Dynamic tests on Type 2 and 3 MEWPs

Tests shall also be carried out with only the extension load, distributed in the same way on the extension. In addition, the main platform loads that increase the overturning moments shall be taken into account in accordance with Clause 2.1.4.1.2. An example of where these loads would need to be taken into account is given in Figure 3.6.3.2.1(B).

The rated load m_{ext} is defined by

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

where

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

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

m_p = 80 kg (mass of a person)

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

The rated load *m*work is defined by

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

where

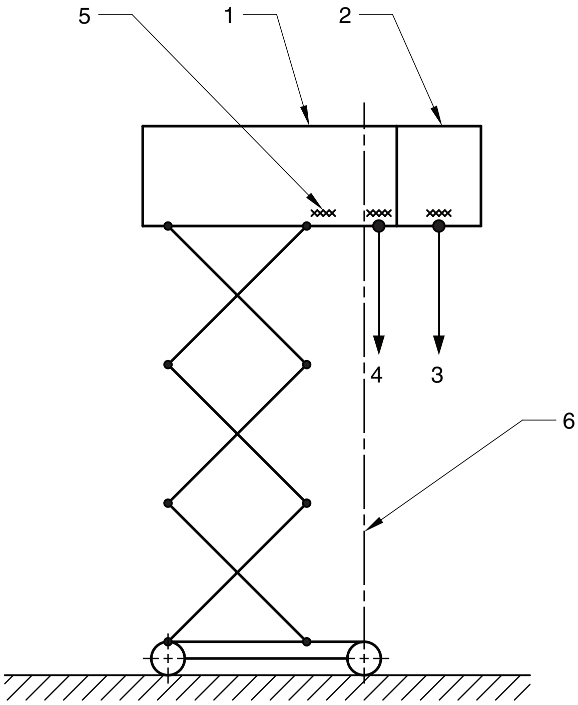
$m_{p,work}$ = $n_{p,work} \times m_p$

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

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

f = proportion of the main work platform load outside the tipping line

NOTE 1 See Clause 2.1.2 for further guidance.



Key

1 Main work platform

2 Extension platform (fully extended)

3 Rated load (extension platform), m_{ext}

4 Rated load (main platform), m_{work}

5 Removal of the stabilizing portion of the main work platform load

6 Tipping line

Figure 3.6.3.2.1(B) — Dynamic tests on Type 2 and 3 MEWPs with load locations

3.6.3.2.2 Kerb (obstruction) and depression tests

The tests shall be repeated driving in both forward and reverse directions, in each extended position of the MEWP and, if different travel speeds are allowed for different heights, at each of those heights at the maximum permitted speeds for those heights. In all cases, the steering wheels shall be parallel to the length of the machine.

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

The tests shall be carried out as follows:

(a) For tests running into a kerb, Type 2 and 3 MEWPs shall be driven on level ground in order —

(i) to bring each leading wheel or track in turn into contact with a kerb with a height of 100 mm perpendicular to the kerb; and

(ii) to bring both leading wheels or tracks simultaneously into contact with the same kerb. The drive control shall be maintained at maximum until the MEWP comes to a stop or both leading wheels or tracks climb the kerb.

(b) For depression tests of Type 2 and 3 MEWPs intended for use on other than level hard surfaces, the MEWP shall be driven on level ground in order —

(i) to drive each leading wheel/track in turn off the edge of a depression of 0.1 m, with the test machine approaching the depression perpendicular to the depression and being driven until the leading wheel is in the depression, and

(ii) to drive both leading wheels or tracks simultaneously off the same depression. Maximum speed shall be maintained until both leading wheels or tracks are driven into or over the depression.

(c) For depression tests for slab-type Type 2 and 3 MEWPs, the MEWP shall be driven on level ground in order to drive each leading wheel or track in turn into a 600 mm square depression with a vertical drop of 100 mm with one front wheel or track aligned across (perpendicular to) the edge of the test hole. The test wheel or track shall enter the hole at all locations along the edge of the depression. Only one leading wheel or track shall be driven into the depression for each approach.

The drive control shall be maintained at maximum until the MEWP comes to a complete stop in the depression or traverses the depression in its entirety.

The MEWP shall not overturn during the tests.

3.6.3.2.3 Braking tests

Type 2 and 3 MEWPs shall be stopped as rapidly as the controls allow, in both forward and reverse directions, in each MEWP position and combination of slope, loads and forces which together create conditions of minimum stability and, if different travel speeds are allowed for different heights, at each of those heights at the maximum permitted speeds for those heights.

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

The MEWP shall not overturn during the above tests. The stopping distance shall conform to Clause 2.2.15.

3.6.4 Overload test

The test load shall be 125 % of the rated capacity for power-operated MEWPs, and 150 % of the rated capacity for manually powered MEWPs and those MEWPs where the enhanced overload criteria apply.

All movements with the test loads shall be carried out at accelerations and decelerations appropriate with safe control of the load. If 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, when vibrations associated with preceding movements have subsided, and with care, taking into due account the least favourable positions.

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

During the overload test, the MEWP shall be on level ground and the extending structure put into each position that creates maximum stress in any loadbearing part of the MEWP.

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

During the overload test, the braking systems shall be capable of stopping and sustaining the test load(s).

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

3.6.5 MEWP functional tests

Functional tests shall demonstrate that —

(a) the MEWP can operate smoothly for all motions at the rated speeds;

(b) all safety devices work correctly;

(c) maximum design speeds are not exceeded; and

(d) markings are fitted.

4 Information for use

4.1 Manuals

4.1.1 General

Manuals shall be made available with each MEWP. Where notation is used, it shall be in SI units.

4.1.2 Maintenance manual

The maintenance manual shall include the following additional information:

(a) Commissioning information.

(b) The specified examinations or tests based on the number of operating hours.

(c) Total number of designed operating hours or load cycles or both for the entire MEWP and for individual critical components.

(d) For vehicle-mounted MEWPs, the characteristics of the vehicle that are necessary to ensure the stability of the MEWP (e.g. weight, wheelbase, chassis stiffness, etc.).

(e) Parts detachable for functional reasons (see Clause 4.2.9).

(f) For foam-filled tyres, the tyre weight.

(g) Care, maintenance and test procedures for the electrical insulation (if applicable).

(h) Instructions relating to the maintenance of hydraulic systems, including necessary precautions.

(i) Information for preparing the MEWP for service after extended periods of storage or non-use.

(j) The MEWP type.

(k) The MEWP classification.

(l) The axial clearance of the slew bearing (if applicable).

(m) Maintenance information for use by trained personnel – instructions for maintenance operations to be carried out only by specialist maintenance personnel shall be separate from the operating instructions.

NOTE Examples of elements for this type of information are given in Appendix G.

4.1.3 Operator's manual(s)

The operator's manual(s) shall also include the following:

(a) General safety precautions.

(b) Operating instructions which give details for safe use.

(c) Pre-operational inspection requirements and checks.

(d) A warning that pre-operational inspections are to be conducted at the beginning of each new shift or change of operators.

(e) Operator maintenance information.

(f) Transport, handling and storage information.

(g) Any special provisions for securing parts of the MEWP for transport between places of use.

(h) Lift points, mass, centre of gravity for lifting purposes and points to use for securing on the transport vehicle.

(i) Precautions to be taken before periods of storage indoors or outdoors.

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

(k) Information regarding placing the MEWP into service.

(l) Tests before placing the MEWP into service.

(m) The manufacturer's recommended periodical examinations or tests.

(n) Refuelling information.

(o) Emergency procedures, including methods for recovery of the work platform.

(p) Auxiliary lowering instructions (see Clause 2.6.9).

(q) Instructions on how to use the overriding system (see Clause 2.6.10).

(r) Cautions and restrictions of operation.

(s) The load distribution (in kilograms) and ground loading pressure (in kilopascals) on the wheels/stabilizers/outriggers under the most onerous loading conditions on hard concrete surfaces.

(t) Information on available accessories and options.

(u) Parts that are detachable for functional reasons.

(v) A list of MEWP functions, features, operating characteristics, limitations and devices to be included in familiarisation.

(w) Information about setting up the MEWP (for example, maximum permitted slope(s) for operation and travelling) and the applied forces created by the stabilizing devices or wheels.

(x) Location, purpose and use of all normal controls, auxiliary controls and emergency stop equipment.

(y) Prohibition of overloading the work platform.

(z) Prohibition of use as a crane.

(aa) Traffic regulations (where applicable).

(bb) Keeping clear of live electrical conductors.

(cc) Avoidance of contact with fixed objects (for example, buildings) or moving objects (for example, other vehicles, cranes).

(dd) Prohibition of any increase in reach or working height of the MEWP by use of additional equipment (for example, ladders).

(ee) Prohibition of any addition that would increase the wind loading on the MEWP.

(ff) Maximum allowable wind speed, in metres per second, or where the MEWP is designed for use in non-wind conditions, a warning to that effect.

(gg) Installation of removable guardrails (where applicable).

(hh) Precautions for getting on and off the work platform when elevated.

(ii) Precautions for travelling with elevated work platform.

(jj) Precautions for travelling with crawler machines.

(kk) Guidance on personal fall protection systems.

(ll) Specifications including the following:

  (i) Rated capacity.

  (ii) Allowable number of persons.

  (iii) Allowable manual force.

  (iv) Maximum allowable wind speed, in metres per second, or, where the MEWP is designed for use in non-wind conditions, a warning to that effect.

  (v) Maximum permissible chassis inclinations.

  (vi) MEWP mass.

  (vii) For electrically powered MEWPs, supply voltage.

  (viii) Allowable special loads and forces.

  (ix) Insulation rating (where applicable).

  (x) Gradeability.

  (xi) Maximum platform height.

  (xii) Tyres.

  (xiii) The MEWP classification.

(mm) Allowable ambient temperature range.

4.2 Marking

4.2.1 Manufacturer's plate

Symbols used for marking shall conform to ISO 20381.

One or more durable plate(s), indelibly marked and permanently attached to the MEWP in an easily visible place, shall give the following information:

(a) Manufacturer's or supplier's name.

(b) Country of manufacture.

(c) Model designation.

(d) Serial number on a fixed component on the MEWP.

(e) Year of manufacture.

(f) Unloaded mass, in kilograms.

(g) For insulated line vehicle MEWPs, the additional mass of tools and equipment required to be stored on the vehicle to satisfy the enhanced stability requirements (see Clause 7.8.2).

(h) Rated capacity, in kilograms.

(i) Allowable number of persons.

(j) Maximum allowable manual force, in Newtons.

(k) Maximum allowable wind speed, in metres per second, or, where the MEWP is designed for use in non-wind conditions, advice to that effect.

(l) Maximum allowable chassis inclination.

(m) Hydraulic supply information, if an external hydraulic power supply is used.

(n) Pneumatic supply information, if an external pneumatic power supply is used.

(o) Electrical supply information, if an external electrical power supply is used.

(p) Installer of a vehicle-mounted MEWP's name (if applicable).

(q) For insulated MEWPs, the electrical insulation rating (see Section 7).

(r) Statement of conformance to this document.

(s) The rated capacity, including platform capacity and lifting attachment capacity (if applicable).

(t) Gradeability.

(u) Height, in metres.

(v) MEWP classification.

The plate shall have provision to include the MEWP's date of commissioning.

The capacity rating in either case shall be designated with boom or booms and load-carrying attachments extended to the position of maximum overturning moment attainable throughout the full range of motion. Capacities of the MEWP in other positions shall be specified separately. All applicable ratings shall be stated in the manual and on placards affixed to the MEWP.

4.2.2 Work platform

Symbols used for marking shall conform to ISO 20381. Information shall be presented in plain English and SI units.

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

(a) The rated capacity, in kilograms.

(b) The allowable number of persons.

(c) The maximum allowable manual force, in Newtons.

(d) Maximum allowable wind speed, in metres per second, or, where the MEWP is designed for use in non-wind conditions, advice to that effect.

(e) Allowable special loads and forces, if applicable (see Clause 2.1.4.4).

(f) Whether the MEWP is “electrically insulated”, and the level of insulation.

(g) The safe approach distances to overhead powerlines.

(h) Information related to the use and load rating of the equipment for material handling.

(i) Information related to the use and load rating of the MEWP for multiple configurations.

(j) The location of the lanyard anchorage point and the allowable number of occupants connected.

4.2.3 Multiple rated capacities

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

4.2.4 Auxilliary systems

The location and instructions for operating the auxilliary system(s) shall be marked on the MEWP near the relevant controls.

4.2.5 Overriding of functions

The location and instructions, including precautions for operating the controls required to override functions (see Clause 2.6.10), shall be marked on the MEWP near the relevant controls.

4.2.6 Work platform rated capacities

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

4.2.7 Orchard use

MEWPs designed for orchard use only (see Section 5) shall be permanently and clearly marked with the following:

ORCHARD OPERATION ONLY not for general industrial application

4.2.8 External power supply connections

Points for connection of external power supplies shall be permanently and clearly marked with the essential power supply information (see Clause 4.2.1).

4.2.9 Detachable parts

Parts which may be detached for functional reasons (e.g. work platforms, stabilizers/outriggers) shall be permanently and clearly marked in a prominent place with —

(a) the manufacturer's or supplier's name and address;

(b) the model designation of the MEWP; and

(c) the part number.

4.2.10 Projecting extremities

The extremities of moving components that can project outside the chassis base of MEWPs shall be marked to warn of potential hazards using yellow and black coloured bands of equal width, inclined at an angle of approximately 45°.

NOTE For information on safety signs, refer to ISO 3864-1.

4.2.11 Wheel/stabilizer/outrigger load

The maximum point load that each stabilizer/outrigger/wheel applies to the ground during operation of the MEWP under most onerous conditions of loading shall be permanently and clearly marked in a prominent place.

The maximum ground contact loading pressure (in kPa) under the most onerous operating conditions shall be permanently and clearly marked next to the supports or wheels (see Clause 4.1.3).

4.2.12 Tyre pressure

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

4.2.13 Clearances

Where safe clearances or adequate guarding are not reasonably practicable, warning notices shall be fitted (see Clause 2.3.4).

4.2.14 Maintenance

A notice shall be fitted to the MEWP warning persons not to enter the space beneath a raised work platform and extending structure during maintenance unless a means of structure support is in place.

4.2.15 Stabilizer/outrigger use

MEWPs requiring the use of stabilizers/outriggers shall be provided with a warning notice at the operator's position to alert the operator of the need to position the stabilizers/outriggers.

4.2.16 Levelling instructions

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

NOTE For examples, see Figure 4.2.16.

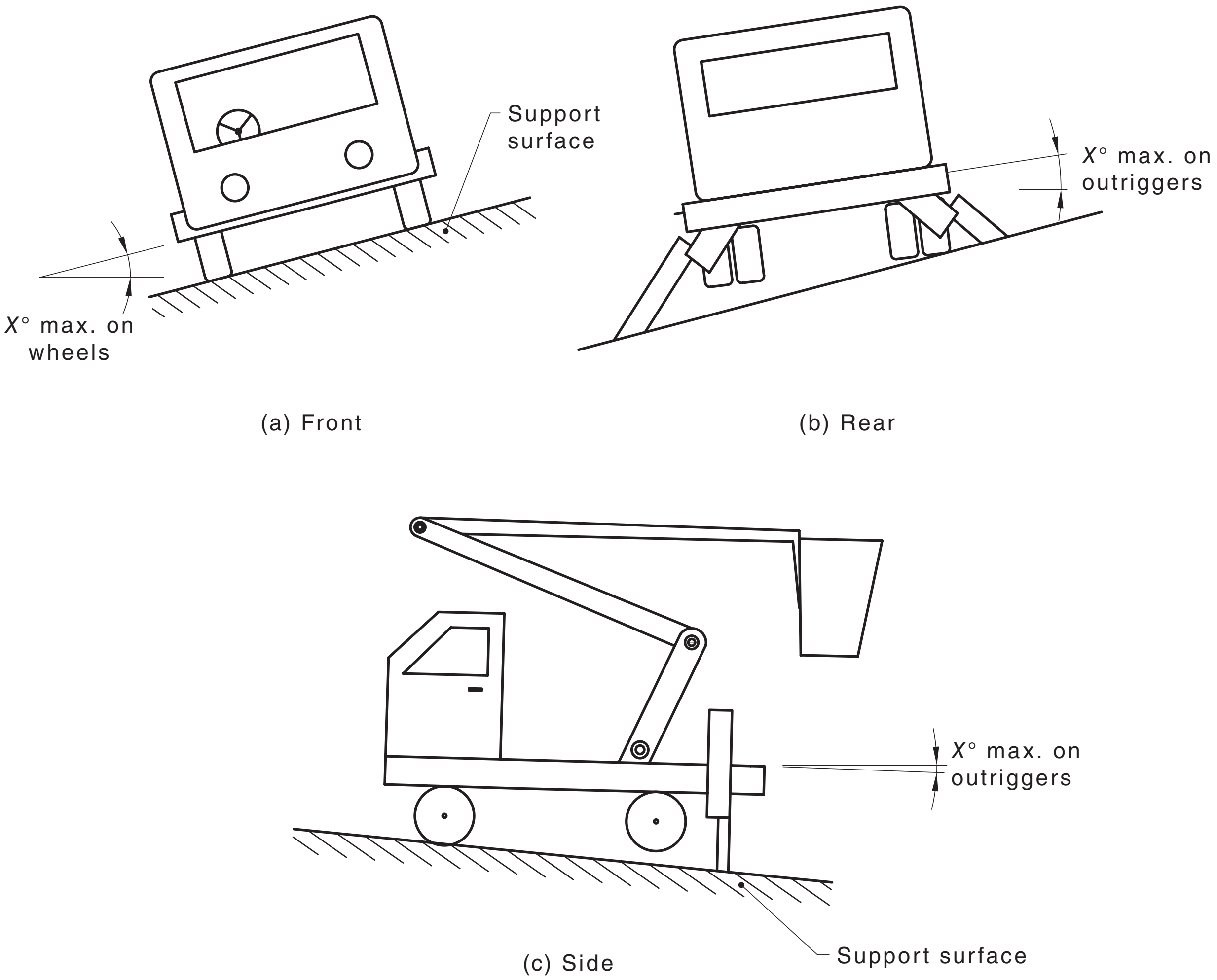


Figure 4.2.16 — Examples of levelling criteria

4.2.17 Pressurized vessel

Hydraulic systems with a gas-charged accumulator shall have a caution label on the gas-charged accumulator stating the following:

CAUTION — PRESSURIZED VESSEL.

DEPRESSURIZE PRIOR TO DISASSEMBLY.

NOTE See Clause 2.8.10.

5 Orchard MEWPs

5.1 General

This section sets out design safety requirements for a class of MEWPs used in orchards to lift personnel to a working position for picking fruit, maintaining orchard trees, and erection and maintenance of ancillary orchard structures, e.g. growing trellises and shade structures.

The requirements for orchard MEWPs covered by this section apply only to single operator boom-type MEWPs with limited operator platform dimensions.

NOTE 1 The rated capacity of orchard MEWPs is typically 170 kg to 200 kg.

The requirements supplement or modify the general provisions for MEWPs provided in this document. Unless specified otherwise within this section, the general provisions for MEWPs in this document shall apply.

Recognition of orchard MEWPs as a class is not intended to limit the use of other MEWPs in orchards if the orchard topography, access paths, and work procedures are suited to their use and appropriate risk management controls are in place.

Where an example of a safety measure has been given in this section for clarity, it shall not be considered as the only possible solution. Any other solution leading to an equivalent level of safety is permissible.

NOTE 2 A commentary on orchard MEWPs is provided in Appendix I.

5.2 Safety requirements and measures for orchard MEWPs

5.2.1 Rated capacity

See Clause 2.1.2 for guidance on rated capacity.

The rated capacity of an orchard MEWP, equivalent to a mass (m), shall be determined from the following equation:

$$m = \left(m_{\mathrm{p}} + m_{\mathrm{e}} + m_{\mathrm{b}}\right)$$

where

m_{p} = 100 kg (minimum for a single operator)

m_{e} = maximum fruit load (minimum 45 kg)

m_{b} = mass of the empty fruit carry bag

5.2.2 Fatigue stress analysis

See Clause 2.1.6.3.4 for guidance on fatigue stress analysis.

The design load cycles for orchard MEWPs shall be a minimum of 1×10^5 cycles. The load spectrum factor shall be 1.

5.2.3 Chassis inclination

See Clause 2.2.2 for guidance on chassis inclination.

For orchard MEWPs, the requirements of Clause 2.2.2 shall be replaced by the requirements of this clause.

For orchard MEWPs travelling outside the lowered travel position, an audible alarm shall be given at the operator’s control position before the specified maximum chassis inclination has been reached.

5.2.4 Brakes

See Clause 2.2.11 for guidance on brakes.

Non-slewing orchard MEWPs with lift height up to 4 m limited to slopes of maximum 5 degrees may be fitted with hydraulic retardation brakes only, provided the arrangement is designed to prevent the drive motors from losing braking effect during overrun. The creep rate shall not exceed 2 m/h when parked facing either uphill or downhill on a 5 degree slope.

A warning shall be included in the instruction manual and displayed on the MEWP stating that the MEWP drive wheels are required to be chocked if parked on a slope, to prevent the MEWP from creeping.

5.2.5 MEWP speed

5.2.5.1 Maximum travel speed in the elevated position

See Clause 2.2.14 for guidance on maximum travel speed in the elevated position.

Travel speeds for orchard MEWPs with the operator platform in the elevated travel position shall be limited to the following:

(a) 1.5 m/s at a platform floor height of 4.0 m or below.

(b) 1.0 m/s at a platform floor height above 4.0 m and below 6.5 m.

(c) 0.7 m/s at a platform floor height above 6.5 m.

Where MEWPs are designed to employ variable speed limits based on the height ranges above, the speed limiting mechanism shall be automatic and shall be fitted with a safety device in accordance with Clause 2.10.

5.2.5.2 Maximum travel speed in the lowered travel position

Where the maximum travel speed in the lowered travel position exceeds the maximum travel speed in the elevated position, the MEWP shall satisfy the requirements of the kerb and depression test (Clause 3.6.3.2.2) at the lowered travel position, with the height of the kerb (obstruction) increased to 150 mm. An additional requirement to be demonstrated during the test is that the MEWP is designed so that the operator is not at risk of injury by impact with the guardrail or at risk of being catapulted from the platform.

5.2.5.3 Speeds of the extending structure

Orchard MEWPs shall not exceed the following speeds:

(a) *For raising and lowering the work platform* — 0.8 m/s.

(b) *For telescoping the boom* — 0.8 m/s.

(c) *For slewing or rotation (horizontal speed at the outer edge of the work platform, measured at maximum range)* — 1.4 m/s.

5.2.6 Stopping distances

See Clause 2.2.15 for guidance on stopping distances.

Orchard MEWPs travelling at the maximum speeds given in Clauses 5.2.5.1 and 5.2.5.2, on the maximum specified slope, shall be capable of being stopped at distances not greater than those given in Figure 2.2.15.

5.2.7 Load- and moment-sensing systems

To meet the criteria for “enhanced overload and stability”, orchard MEWPs shall be designed and tested according to the following alternative criteria to that of Clauses 2.3.1.5 and 2.3.1.6:

(a) The horizontal cross-sectional area inside the work platform at any height shall be contained within an area not exceeding 700 mm × 700 mm.

(b) The picking bag attached to the platform shall not exceed 0.15 m^3, with horizontal internal cross-section not exceeding 0.3 m^2.

(c) Orchard MEWPs that rely on the enhanced stability criteria shall complete the static stability test (Clause 3.6.3.1) as modified by Clauses 2.3.1.5(b) and 2.3.1.6(b).

Where the orchard MEWP is fitted with a castor wheel assembly, the assembly shall be positioned during the test such that it results in the least stability of the MEWP.

5.2.8 Operator platform level control

The requirements of Clause 2.5.1 shall be modified as follows:

(a) The work platform shall be permitted to operate off level up to the maximum rated slope set by the manufacturer for safe operation.

(b) The maximum rated slope shall be validated by successful completion of the stability tests (Clause 3.6.3).

(c) Orchard MEWPs that incorporate mechanical levelling systems shall conform to the option given in Clause 2.5.1 requiring that the levelling system be designed to take twice the imposed load.

The levelling systems shall incorporate maintenance-free pins and bearings, and a mechanism to prevent the pins or bearings becoming dislodged should the primary securing mechanism fail.

5.2.9 Guardrail (protection) system

Protection shall be provided on all sides of the work platform to prevent a person on the platform from falling. The protection shall be securely fastened to the work platform. As a minimum, the protection shall consist of the following:

(a) A guardrail, minimum 900 mm from the top of the rail to the floor, profiled to reduce impact hazards to the operator when travelling over rough terrain, with horizontal cross-section measured inside the top rail contained within an area not exceeding 650 mm × 650 mm.

(b) A lower barrier 100 mm above the floor to resist the operator’s feet slipping from the work platform, with internal horizontal cross-section contained within an area not exceeding 700 mm × 700 mm, and openings to facilitate clearing of orchard debris from the platform (horizontal gaps in the barrier shall not to exceed 120 mm).

(c) An intermediate barrier commencing at a maximum height of 550 mm above the lower barrier with internal horizontal cross-section contained within an area not exceeding 700 mm × 700 mm. Vertical posts may be used instead of an intermediate guardrail, provided the clear horizontal distance between the posts is no more than 180 mm. Clear space between guardrail segments shall not exceed 120 mm.

Openings in platform guardrails for entrance and exit are permitted provided they conform to the requirements of Clause 2.5.6.

The guardrail system shall meet the strength requirements of Clause 2.5.4.

5.2.10 Controls

5.2.10.1 General

See Clause 2.6 for guidance on controls.

5.2.10.2 Foot-operated controls designed for hands-free operation

Foot-controlled orchard MEWPs designed for hands-free operation shall meet the requirements of Clause 2.6.2 (to guard the controls and protect control devices against unintentional activation) by employing the following alternative solutions:

(a) Foot controls shall be unguarded where the presence of a guard would introduce the risk of the control failing to return to "off" when released by the operator, or the operator being unable to release the control because of plant debris becoming wedged between the guard and the foot control.

(b) Unguarded foot controls shall be arranged such that the operator stands continuously on the controls when occupying the platform to manage the risk of the controls being actuated other than by the operator.

NOTE 1 For foot-controlled MEWPs, where the risk of inadvertent operation is eliminated by limited platform dimensions and constant positioning of the operator standing on the controls, a separate continuously activated control is not required.

(c) Where foot controls meeting the above requirements are unguarded, the motion controls shall be automatically deactivated when the operator leaves the platform. The controls shall be reactivated only by a separate hand control. Stopping the MEWP drive engine automatically when the operator steps off the platform is an acceptable solution.

NOTE 2 This requirement is intended to manage the risk of a person unintentionally activating the controls when stepping on the platform.

(d) Mechanically actuated hydraulic control valves controlling any motions of the MEWP shall be full-flow with spring return to "off" to manage the risks of unintended motion. Electronic controls shall be designed to minimum reliability Category 1 as specified in Clause 2.10.

5.2.10.3 Duplication of controls at the base

The overriding emergency system described in Clause 2.6.10 shall be accessible from both the work platform and the base.

NOTE The objective of Clause 2.6.4 may be met by control handles acting directly on flow control valves mounted at the base, provided that —

(a) a motion can be overridden by the base control even if the corresponding control in the platform is jammed "on"; and

(b) further motion can be prevented by operating the emergency stop.

5.2.10.4 Simultaneous use of controls

Travel controls are permitted to operate simultaneously with other controls.

5.2.11 Boom lift systems

The following shall apply:

(a) The boom lift system of an orchard MEWP shall be designed to provide for the operator platform being lowered under influence of gravity.

NOTE Double-acting hydraulic systems are able to force the platform down and can destabilize the MEWP if the platform is inadvertently lowered on to an obstacle that prevents further lowering.

(b) Non-slewing orchard MEWPs, with 4 m lift or less and a rated slope of 5 degrees or less, shall be exempt from the requirement in Clause 2.9.2 to fit a device to prevent unintended movement caused by failure of a hydraulic line, provided the descent speed is limited to normal descent speed.

5.2.12 Marking

Orchard MEWPs designed to conform to this section shall be permanently and clearly marked with the following:

ORCHARD OPERATION ONLY not for general industrial application

Orchard MEWPs with hydraulic retardation brakes only shall be marked with the following:

WHEEL CHOCKS SHALL BE USED WHEN PARKED

6 Portable MEWPs

6.1 General

This section provides variations to the requirements of Sections 1 to 4 for MEWPs incorporating all of the following features, and which are referred to herein as "portable MEWPs".

A portable MEWP is a work platform incorporating all of the following features:

(a) The capacity of the platform is limited to a maximum of one person at any time, with a maximum platform area no greater than 0.6 m^2 and with no side greater than 0.85 m.

(b) Load rating: minimum 120 kg, maximum 200 kg.

(c) The MEWP is portable, that is, it can be disassembled into modules (subcomponents) that weigh no more than 50 kg each, can be readily carried and quickly and safely assembled by the user.

(d) Maximum platform floor height of 10 m.

(e) Stationary or manually propelled.

Unless specified otherwise in this section, the general provisions for MEWPs in this document shall apply.

Portable MEWPs are intended for use in applications that historically have required the use of ladders. The requirements in this section are intended to provide for safeguarding persons and equipment against the risk of accidents associated with the use of portable MEWPs.

6.2 Specific requirements

6.2.1 Assembly

The subcomponents of the portable MEWP shall be so designed that they can only be assembled in the correct manner. Securing devices intended to lock the assembled components together shall be integral with the subcomponents; that is, loose fasteners or devices shall not be used. It shall be possible to verify the correct locked position of each device (e.g. by visual inspection or indicators).

The portable MEWP shall be so designed that the assembled subcomponents cannot separate under the action of any force (including infrequent forces arising from obstruction or collision) to which the portable MEWP may reasonably be exposed. Any locking device required to sustain infrequent forces shall be capable of carrying twice the normal locking force without failure.

The elevating mechanism shall be designed such that the maximum forces acting on the portable MEWP from the drive shall not result in the structural or mechanical failure of any subcomponent.

Subcomponents shall be equipped with sufficient wheels, handles or grip points to facilitate manual handling. Instructions for handling shall be provided.

Each subcomponent shall be individually marked with a model number identifying the portable MEWP on which it may be used.

6.2.2 Openings in guardrails for entrance and exit

Any part of the protection movable for the purpose of access to the work platform shall not fold or open outwards. The gate shall return automatically to the closed position.

Inadvertent opening shall be prevented.

The minimum opening width for the purpose of access to the work platform shall be 420 mm.

NOTE Consideration should be given to ease of entry and exit.

6.2.3 Controls

Elevating controls shall always be accessible from the platform. Controls at the base are optional and, if provided, shall be capable of overriding the controls in the platform. Two actions shall be required by the operator to cause the platform to lift or descend.

6.2.4 Manual descent and emergency retrieval

Means shall be provided to lower the platform in the event of failure of the normal power source, from the platform by the operator and from below in the event of an incapacitated operator.

Manual descent from the support surface may require additional auxiliary equipment.

Where required, auxiliary equipment shall be specified in the operator's manual or, where it is of a specialist nature, shall be provided.

6.2.5 Design for stability

6.2.5.1 General

A sample unit of each model in each of its intended configurations shall pass the tests outlined in Clauses 6.2.5.2, 6.2.5.3 and 6.2.5.4, as applicable. The requirements of Clause 3.6.3 need not apply.

6.2.5.2 Stability test

When raised to its maximum platform height, the portable MEWP shall be capable of withstanding, without overturning, a minimum horizontal test force of 222 N or 15 % of the rated capacity (whichever is greater), applied at the platform top rail, in the direction most likely to cause overturning, with the rated capacity distributed on the platform in accordance with the requirements of Clause 2.1.4.1.2.

NOTE Some movement relative to the support surfaces is permitted providing instability is not reached.

6.2.5.3 Platform deflection test

When the portable MEWP is set up in accordance with the manufacturer's specification and a vertical load of 80 kg is applied to the centre of the platform floor, the portable MEWP shall not overturn when a load applied horizontally at the handrail causes movement of the handrail of 0.3 m. The load required to sustain the deflection at 0.3 m shall be 70 N or greater. This test is intended to give the operator reasonable opportunity to detect an unsafe side load situation, and take corrective action, prior to reaching the point of instability.

6.2.5.4 Wind stability

A calculation shall confirm that the portable MEWP remains stable at a wind speed of 12.5 m/s, with the rated capacity in the platform. The side load from the operator shall be based on a 0.7 m^2 person at 1 m above floor level. The side load from the equipment shall be based on 3 % of the rated equipment capacity applied at 0.5 m above the floor.

6.2.6 Brakes

For devices equipped with wheels or castors, a braking means shall be provided with at least two points of contact with the support surface, which shall automatically apply braking whenever the load in the platform exceeds 30 kg.

6.2.7 Motion limits

Overtravel in the extreme limits of motion shall be prevented by limits or mechanical stops.

Where mechanical stops are used, both the drive mechanism and the stop shall be designed to resist the maximum force that can be applied by the drive.

7 Insulated MEWPs

7.1 General

7.1.1 Scope of section

This section sets out safety requirements for insulated MEWPs. The requirements supplement or modify the general provisions for MEWPs provided in this document. Unless otherwise specified in this section, the general provisions for MEWPs shall apply.

The requirements specified in this section apply to insulated MEWPs intended for use in Australia. For New Zealand, insulated MEWPS covered by this section shall conform to the requirements of ANSI/SAIA A92.2, IEC 61057 or this standard, or to local regulations or guides.

7.1.2 Risk considerations

Elevating work platforms with electrical insulation shall be designed to minimize risks to personnel —

(a) located in the basket; and

(b) on or adjacent to the vehicle.

The risks include the following:

(i) Electric shock due to step-and-touch potentials.

(ii) Electrical short-circuits.

NOTE 1 The insulation systems specified in this document are intended to minimize the electrical risk arising from inadvertent contact and are not designed as primary insulation components subject to continuous electrical stress.

NOTE 2 The insulation should be designed to be effective if contact is made with an overhead conductor located at or above the prescribed conductor height when the MEWP is sited at ground level with stabilizers/outriggers extended to lift the wheels 25 mm clear of the ground.

7.1.3 Use

This document does not address the requirements for MEWPs used for high-voltage live work in rain, mist, fog, snow or sleet.

MEWPs designed in accordance with this document shall not be used in proximity to electrical networks with a system highest voltage exceeding 145 kV a.c.

NOTE 1 Reference should be made to IEC 61057 or ANSI/SAIA A92.2 for MEWPs that are designed to be used on higher system voltages.

Insulated MEWPs shall be categorized as follows:

(a) Category A MEWPs that are designed and manufactured for work in which the boom is considered primary insulation (bare-hand work) shall have all conductive components at the platform end bonded together to accomplish equipotential of all such components.

This document does not cover Category A MEWPs.

NOTE 2 Refer to ANSI/SAIA A92.2 for further information on Category A MEWPs.

(b) Category B MEWPs that are designed and manufactured for work in which the insulated boom is not considered primary insulation but secondary, such as work using insulating (rubber) gloves. Isolation or bonding of the conductive components at the platform end is not a requirement.

Category B MEWPs shall be equipped with a lower test electrode system.

NOTE 3 A Category B MEWP in this document is not equivalent to a Category B MEWP referenced in ANSI/SAIA A92.2.

(c) Category C MEWPs that are designed and manufactured for work in which the insulated boom is not considered primary insulation but secondary, such as that using insulating (rubber) gloves. Isolation or bonding of the conductive components at the platform end is not a requirement.

NOTE 4 A Category C MEWP in this document is not equivalent to a Category C MEWP referenced in ANSI/SAIA A92.2. Category C MEWPs are not equipped with a lower test electrode system and are designed for 46 kV and below.

NOTE 5 For application of the various categories see Clause M.2.

7.1.4 Insulation rating

Insulated MEWPs shall be designed for the following nominal system voltages (refer to AS 1824.2):

(a) Low-voltage: < 1000 V a.c. or 1500 V d.c.

(b) High-voltage, including the following:

(i) 11 kV a.c.

(ii) 22 kV a.c.

(iii) 33 kV a.c.

(iv) 66 kV a.c.

(v) 132 kV a.c.

MEWPs shall be designed for work in “dry”, “wet”, or “rain” weather conditions in accordance with Appendix K.

NOTE 1 Table K(A) of Appendix K is included in recognition that MEWPs cannot generally be assumed to be dry. MEWPs may be used during rain, immediately following rain, or may pass through rain on transit to the work site.

NOTE 2 Appendix L lists the electrical hazards addressed in this document.

7.1.5 Materials and construction

Insulation components shall be designed to meet the strength requirements of Clause 2.1.6.

The insulation shall be protected against ingress of moisture, the effects of ultraviolet degradation and abrasion. Boom surfaces and associated components shall be hydrophobic, smooth and free of cavities, crevices and irregularities, which may promote capillary action or retain contaminants of water. The insulation components shall meet the performance requirements of Clause 7.9.

Insulating components may be constructed from any suitable non-hygroscopic insulating material. Where reinforced plastics are employed, such as glass-fibre-reinforced plastic, the reinforced matrix shall not contain cavities or delaminations, which may impair the dielectric strength of the component.

7.2 Design

7.2.1 Minimizing risks to operators

The following requirements apply:

(a) MEWPs rated for low-voltage work shall have cover insulation that conforms to the requirements of Clause 7.6. They shall be fitted with an insulated basket that conforms to Clauses 7.3.1 and 7.3.2 or an insulated platform that conforms to Clause 7.4.

(b) MEWPs rated for high-voltage work shall have a boom-insulating insert located between the basket and ground level in accordance with Clause 7.5. The insulating insert shall be located as close as practicable to the basket.

(c) All exposed metal fittings above the boom insulation or within the safety clearance specified in AS 2067, measured from the basket floor to the nearest exposed part of the boom, shall be provided with insulated covering in accordance with Clause 7.6.

(d) All MEWPs with a boom insulation rating above 33 kV shall be fitted with leakage test electrodes in accordance with Clause 7.7.5 unless —

  (i) a d.c. periodic test regime is established in accordance with Clause M.4.4.3; and

  (ii) the required test regime is stated in the operator’s and maintenance manuals.

7.2.2 Minimizing risks to personnel located at ground level

All insulated MEWPs, except those of Group A, Type 1, shall be provided with a chassis insulation system designed to protect personnel at ground level from electric shock. The minimum rating for the chassis insulation system shall be —

(a) 33 kV for MEWPs with a boom insulation rating of 33 kV and above; or

(b) equal to the boom insulation rating for MEWPs rated less than 33 kV.

NOTE The majority of distribution voltages are 33 kV or less. Additional risk controls will be necessary when working near electrical systems rated above the chassis insulation rating.

The insulation shall be located to protect against phase-to-earth faults for any portion of the MEWP capable of being raised more than 7.5 m above ground level.

All metallic portions of the MEWP between 4.5 m and the lower end of the chassis insulation shall be provided with cover insulation designed in accordance with Clause 7.6.

7.2.3 Minimizing the risk of inadvertent contact between objects at different potential

All exposed metal portions above the boom insulation of the MEWP shall be provided with cover insulation in accordance with Clause 7.6 to reduce the risk of contact with low-voltage conductors or earthed structures capable of creating a potential difference or short-circuit.

NOTE 1 Any area below the boom insulation of the MEWP that can be raised more than 4.5 m above the support surface (see Clause 7.1.2, Note 2) should be provided with a system to reduce the risk of short circuits.

NOTE 2 Hazards that should be addressed are illustrated in Appendix L.

NOTE 3 A system comprises design, warning devices and work procedure.

7.3 Insulated operator's baskets

7.3.1 Materials

Insulating components of baskets shall be manufactured from flame-retardant materials capable of meeting the requirements of ASTM D635 and shall be marked "flame retardant".

7.3.2 Construction

7.3.2.1 General

The outer surface of the basket and the associated ancillary equipment (e.g. control descent devices, tool baskets and hydraulic lines) should, as far as possible, be contoured to reduce the risk of the boom being entangled in overhead conductors.

Basket external surfaces and associated components, including hoses shall be hydrophobic and free of irregularities that may promote capillary action or retain contaminants or water.

The internal surface shall be free of obstructions and uneven surfaces that may cause injury to personnel.

Except for drain holes as referred to in Clause 7.3.2.2, the basket shall be fully enclosed.

Means shall be provided to facilitate access and egress, emergency egress and drainage and cleaning. MEWPs designed to have a high-voltage (HV) liner fitted shall be provided with a tilting mechanism to fulfil this purpose. A cover shall be provided to prevent accumulation of water when not in use.

The basket floor and step treads shall have a non-slip surface.

An external step shall be either bonded or moulded onto the basket as low as possible to provide an appropriate footing for an operator exiting the basket when using a controlled descent device (CDD) (see Figure 7.3.2.1).

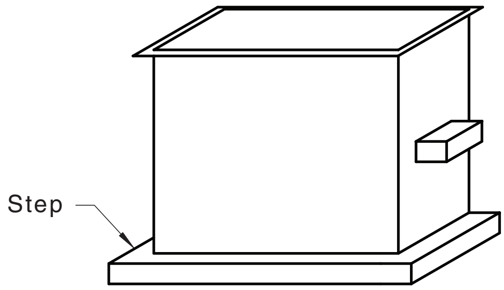


Figure 7.3.2.1 — External step for baskets equipped with CDD

7.3.2.2 Drain holes

Only baskets with a low-voltage (LV) inner to outer rating can be provided with drain holes. For baskets with higher ratings, other means of drainage shall be employed.

Where drain holes are provided, they shall be arranged such that a straight piece of 2 mm diameter rigid wire cannot be pushed through the hole without deformation.

The drain hole arrangement shall successfully pass the basket inner to outer test of Clause 7.9.8 and Table 7.9.14.3.

There shall be not more than two drain holes of 10 mm in diameter maximum.

7.3.3 Insulation criteria

The basket shall be designed to provide an insulation level of at least LV —

(a) between the interior and exterior; and

(b) between the top of the basket, including the operator's controls, harness attachment points and power tool outlets, and the bottom outer surface of the basket.

The construction of the basket shall provide clear separation between metal components at the top of the basket and the bottom of the basket.

NOTE HV insulation may be achieved by a basket or basket and liner combined.

The insulation shall be capable of meeting the performance requirements of Clauses 7.9.7 and 7.9.8, as applicable.

Baskets capable of being fitted with an HV insulated basket liner shall at minimum have a 33 kV dry vertical surface rated working voltage.

7.3.4 Insulating basket liners for HV live working

Liners shall be manufactured from flame-retardant materials capable of meeting the requirements of ASTM D635 or UL 94 Class H-B or V-2, and shall be marked "flame retardant". The material should be rugged enough to withstand wear and tear without pitting or scoring.

Liners shall, as far as possible, be designed to prevent water ingress between the liner and basket.

NOTE The provision of a rolled lip is desirable.

Liners shall be permanently marked with their serial number and manufacture date.

Liners shall be provided with a means to secure them within the basket in the event of the basket being tilted or inverted.

Liners shall be capable of meeting the performance requirements of Clause 7.9.9.

7.4 Low-voltage insulated platforms

In addition to the requirements of Clause 2.5, insulating components incorporated in low-voltage operators' platforms shall conform to the requirements of Clauses 7.5 and 7.6, as appropriate.

7.5 Insulation inserts

7.5.1 Length

7.5.1.1 General

The insert and all components (e.g. parts of a boom or booms at the end of the insert or a part of a boom and a test electrode formed in accordance with Clause 7.7.5 levelling rods and insulated hoses) that bridge the insert shall be arranged to meet the minimum requirements for creepage distance, withstand distance (puncture resistance) and air gap as shown in Figure 7.5.1.4.

7.5.1.2 Creepage distance (*C*)

The creepage distance is the shortest distance along any insulating surface between two conducting components that are different electrical potentials. This is the minimum distance to prevent flashover at the rated voltage.

The distance shall be not less than that required by AS 1824.2 for "light pollution severity" (i.e. 25 mm per kV r.m.s. of the line to ground nominal system voltage).

NOTE For example, if the nominal system voltage is 66 kV, then the creepage distance required is not less than:

$$\frac{66}{\sqrt{3}} \times 25 = 953m$$

7.5.1.3 Air gap (*A*)

Where insulation is obtained by the provision of an air gap (*A*) between two components at different potential, the air gap shall conform to the requirements of AS 2067.

NOTE The air gap (*A*) should be designed in accordance with AS 2067. For example, if the nominal rated system voltage is 66 kV, the rated voltage kV r.m.s. is 72.5 kV. From AS 2067, the minimum phase-to-earth clearance will be 630 mm.

7.5.1.4 Withstand distance (puncture resistance) (*B*)

Where insulation is achieved through the use of solid dielectric material, the withstand distance (puncture resistance) (*B*) shall be calculated for the material used. Failure of this insulation is puncture through the insulating material by the electric arc.

The design of this insulation may be achieved as follows:

(a) Determine the electric strength (kilovolts per millimetre) for the insulation to be used. This may be established from the manufacturer or by test.

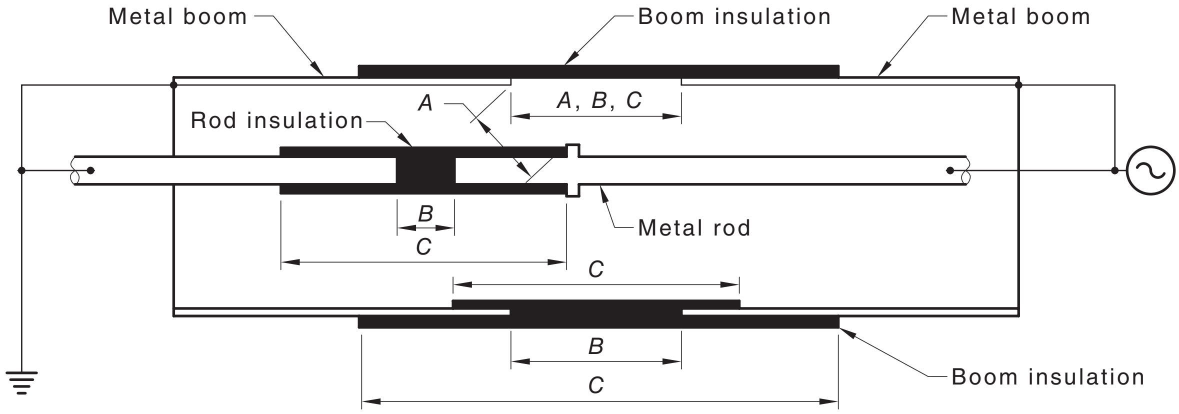
(b) Establish the maximum surge voltage applicable for the insulating rating. This should cover all the possibilities of test voltage, lightning surge and switching surge.

(c) Calculate the initial withstand distance for the surge voltage.

(d) Apply an adequate safety factor to this distance, as "puncture" will permanently damage the insulation.

The final design withstand distance should ensure that any failure of the insulation component due to surge voltage will occur as surface flashover and not puncture of the dielectric insulation.

The creepage distance or air gap may vary on elevating work platforms equipped with telescoping booms or mechanical levelling systems. In such systems, the insulation length shall be the minimum distance obtainable when any point of the boom or basket is raised more than 7.5 m above ground level.



Key

A Air gap

B Withstand distance

C Creepage distance

Figure 7.5.1.4 — Insulation distance

7.5.2 Construction

The outer surface of the booms shall be contoured to reduce the risk of the boom and associated actuators and links being entangled in overhead conductors.

All insulation surfaces shall be smooth with a hydrophobic gloss surface.

The insulation system shall be designed and constructed to facilitate access to all insulation surfaces to ensure satisfactory regular maintenance and periodic tests during the life of the MEWP.

Hydraulic hoses, levelling and control rods or links that bridge the insulating insert or that are connected to controls or fittings, either in the platform or within reach of persons on the platform, shall be constructed from materials with electrical insulating properties capable of meeting the performance requirements given in Clause 7.9.4.

Arrangements shall be made so that, in the event of breakage or failure of the rods or hoses, the operating controls or fittings in or within reach of the basket shall not be electrically connected to the earthed part of the structure.

7.6 Insulated covering

7.6.1 General

Guards and cover insulation shall be designed so that —

(a) routine pre-operational inspections can be performed;

(b) they are able to withstand a force of 500 N applied normal to any external surface and, when the force is applied, the resulting deflection does not impair the insulating performance;

(c) they are contoured to reduce the risk of the boom being entangled in overhead conductors; and

(d) they are hydrophobic and do not to contain crevices or irregularities that may promote capillary action or retain contaminants or water.

The insulated covering shall be capable of meeting the performance requirements of Clause 7.9.6.

7.6.2 Extent of cover insulation

The extent of cover shall be such that if a dry test voltage was to be applied to a simulated conductor with the conductor applied to the MEWP in accordance with Clause 7.6.3, the voltage would not result in disruptive discharge or puncture.

7.6.3 Application

The simulated conductor shall be fitted in a bow constructed in accordance with Figure 7.6.3.

The bow shall be applied in any orientation such that the only part of the bow that contacts the MEWP is that marked “contact zone”.

Enclosed areas (e.g. the area bounded by booms and a cylinder or link arms) shall be excluded if the simulated conductor can only contact the surface when the end of the bow is inserted into the enclosed area.

Dimensions in millimetres

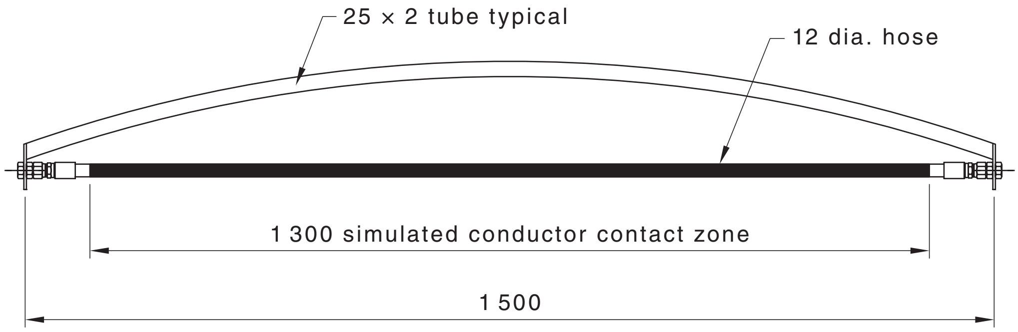


Figure 7.6.3 — Simulated conductor bow assembly

7.7 Electrical test points

7.7.1 General

All insulated MEWPs shall be provided with clearly labelled test points to facilitate electrical testing.

7.7.2 Upper test point

The upper test point shall be connected to metalwork above the boom insert. It shall be marked. It shall be accessible on removal of an appropriately insulated cover. Metalwork above the boom insert and that associated with the basket shall not be permanently bonded together. It may be temporarily bonded together during testing of the boom insert.

7.7.3 Intermediate test point

Where required, MEWPs shall be provided with an intermediate test point to facilitate independent testing of the boom and chassis insulating systems.

Where two insulation inserts are provided, the metallic portions of the boom between the boom insert and the chassis insulator, and hydraulic hoses or control rods that pass through or are located in this area, shall be electrically connected to the intermediate electrical test point. All hoses shall be sectioned in a manifold or via bulkhead fittings connected to the metalwork.

For Category C MEWPs where one continuous insert is provided and acts as both chassis and boom insulation, the intermediate test point may be provided by a temporary electrode fitted to the external surface of the insert only. The temporary electrode shall be placed at a location on the boom corresponding to a height of 7.5 m from the support surface when the boom is fully raised.

NOTE For details of the electrode location, see Clause 7.7.5.

7.7.4 Lower test point

The metallic portions of the boom below the chassis insulation insert and any metalwork associated with the hoses or control rods that pass through or are located in this area shall be electrically connected to the lower electrical test point located immediately below the chassis insulation.

7.7.5 Boom insulator surface leakage monitoring electrode(s)

A non-corrosive metal collector strip at least 20 × 2 mm, as shown in Figure 7.7.5, shall be permanently bonded onto the interior surface of the boom-insulating component. A non-corrosive 6 mm threaded insert shall protrude through and be solidly connected to the strip and the boom and shall form the main surface leakage current monitoring electrode.

An external band shall not be permanently attached unless required for a continuous monitoring circuit that may be used during HV live line work.

All solid operating links and rods shall be fitted with permanent conductive bands and individually connected to the common pick-up point.

All hollow tubes, including hydraulic, and pneumatic and fibre optic lines, shall be fitted with conductive couplings electrically connected to the exterior and interior surfaces of the tube and the pick-up point.

On fibre optic lines certified by test to be dielectrically sound and to not wick water, the conductive coupling may be connected to the outer sheathing only.

All covers or other components that bridge the insulating insert shall be fitted with an equivalent band on their interior surfaces. The band shall be capable of being connected to the pick-up point.

Each electrode shall be electrically isolated from the metal boom.

Means shall be provided to verify the integrity of the test point either by visual inspection or test. Where a test is required, the test procedure shall be included in the operator's and maintenance manuals.

Where required, a permanent capacitive shield may be fitted to reduce capacitive coupling effects and improve indication of resistive current (e.g. where a line-monitoring system is employed).

NOTE 1 The metal portion located between a boom-insulating insert and chassis-insulating insert may be used as the leakage-monitoring electrode provided that all lines and tubes that pass through the boom insert are terminated in accordance with this clause.

NOTE 2 This clause is optional for all MEWPs rated at or below 33 kV, or those intended to be d.c. tested.

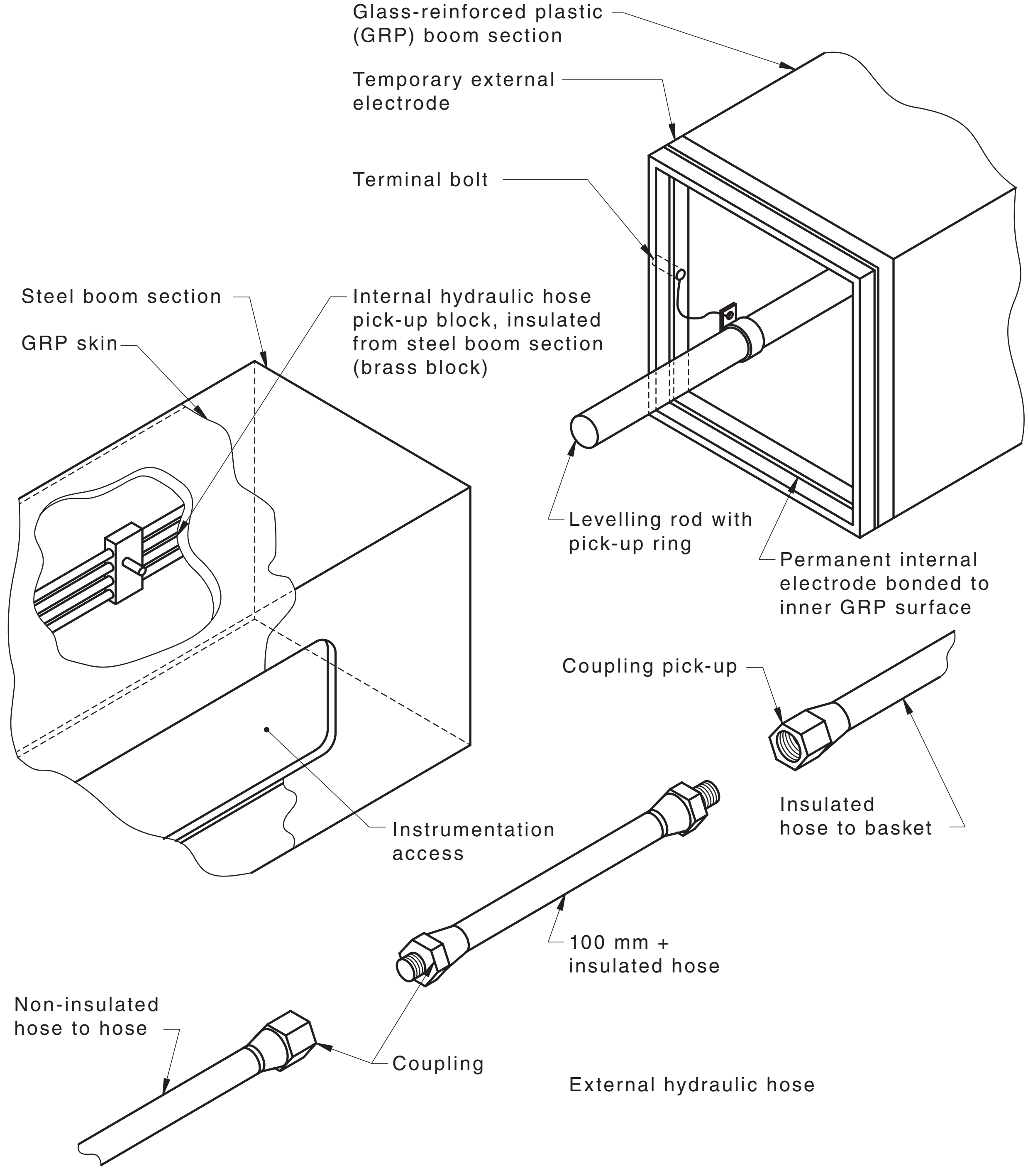


Figure 7.7.5 — General arrangement of instrumentation connections for insulated elevating work platforms

7.7.6 Gradient control devices

Where required, gradient control devices shall be installed on the basket end of the boom-insulating section. The gradient control device shall be connected to the upper test point.

7.8 Additional requirements

7.8.1 Load sensing

If a load-sensing system is fitted to an insulated MEWP, the requirements of Clause 2.3.1.2(d) shall not apply.

7.8.2 Criteria for enhanced stability for limited work platform dimensions

As an alternative to a load- and moment-sensing system, insulated MEWPs for up to two persons may follow "enhanced stability requirements" as specified in Clause 2.3.1.5.

For insulated line maintenance vehicles only, one of the following tests shall apply:

(a) A test carried out as described in Clause 3.6.3.1 (test load calculated using 100 % rated load) with all removable tools and stores removed from the vehicle.

(b) A test carried out as described in Clause 2.3.1.5(b) (test load calculated using 150 % rated load). For the purpose of this test, additional mass up to 50 % of the total mass of removable tools and stores normally carried on the vehicle may be applied to aid stability. The additional mass shall be limited to 10 % of the tare mass of the vehicle-mounted MEWP. The additional mass required shall be stated on the compliance plate.

For all other insulated MEWPs, the requirements of Clause 2.3.1.5(b) shall apply.

7.8.3 Criteria for enhanced overload for limited work platform dimensions

As an alternative to a load- and moment-sensing system, insulated MEWPs for up to two persons may follow "enhanced overload requirements" as specified in Clause 2.3.1.6.

For the overload test given in Clause 3.6.4, the test load shall be 150 % of the rated capacity.

7.8.4 Earthing terminal

A fault current rated earthing terminal shall be connected to the MEWP chassis or subframe. The terminal shall have a minimum diameter of 12 mm. The terminal shall be readily accessible and clearly labelled and located away from the vehicle fuel tank, fuel lines, access and ground control points.

The resistance between the lower test point and the earthing terminal shall be less than 0.1 Ω.

NOTE This resistance should be achieved preferably without the use of bonding conductors. If bonding conductors are used, they should be able to carry the prospective fault current of the system on which the MEWP is to be used.

7.8.5 Reduction of fire risk

The following applies:

(a) All hydraulic hoses shall be contained within the boom or within a continuous guard along the length of the boom. A guard that spans an insulation insert shall conform to Clauses 7.5 and 7.7, as applicable.

(b) Hydraulic tool outlets shall be arranged to point away from the operator. All hoses around the basket shall be provided with covers to protect occupants from direct spray in the event of hydraulic line failure.

7.8.6 Emergency shut-off

An emergency shut-off, designed to isolate all oil flow to the basket, shall be provided at the basket. This may be provided by an emergency stop control. Where provided, the upper emergency stop control shall be capable of being overridden at base level in order to retrieve the MEWP from any elevated position.

In addition, an emergency stop control that is readily accessible from the support surface shall be fitted (e.g. on the tray of the vehicle).

7.8.7 Emergency retrieval

The upper controls shall be capable of being isolated and overridden at base level in order to retrieve the MEWP from any elevated position.

7.8.8 Vacuum exclusion systems

For Category B MEWPs and MEWPs whose maximum height exceeds 15 m, means shall be provided so that the absolute pressure in the hoses that bridge an insulating insert, when measured at the top of the boom, shall be not less than 80 kPa.

7.8.9 Vertical boom deflection

The vertical deflection of a MEWP boom, measured at the basket at full rated capacity, shall not exceed 1 % of height plus 5 % of reach.

Height is measured from level ground to the bottom of the basket.

Reach is measured from a plumb line at the outer extremity of the basket to the centre of rotation.

The booms shall be in the position of maximum deflection. When the load is removed, the booms shall return to the initial position of ± 10 mm of height.

7.8.10 Lateral boom deflection

The MEWP shall be positioned so that the height to the basket floor is greater than 6.0 m above the support surface and the boom is extended to maximum reach. A horizontal force, as defined in Clause 2.1.4.3, shall be applied perpendicular to the boom axis at the boom tip.

The datum point is taken at the resulting deflection.

The horizontal force shall be relaxed and then applied in the opposing direction. The deflection is measured from the datum point to the resulting deflected point.

The resulting deflection shall not exceed 400 mm from the datum.

7.8.11 Pilot operated controls

The requirements of AS 5247:202X Clauses 7.6.4 and 7.6.5 do not apply to controls that employ manually operated pilot control valves, provided a hydraulic pressure filter without a by-pass is fitted to the pilot supply circuit.

> DRAFTING NOTE: AS 5247:202X is currently under development and is expected to publish concurrently with AS/NZS 1418.10.

7.9 Acceptance testing of electrical insulation

7.9.1 General

Test procedures shall be developed in accordance with Clause 7.9 and included in the maintenance manual.

MEWPs should be tested in a repeatable normal operating configuration with all accessories in place. To ensure results are repeatable and consistent, the configuration of the MEWP during testing should conform to the requirements of Clause 7.9.4.2 or be noted in the report.

Voltages for power frequency, withstand and leakage tests shall be 50 Hz alternating voltage and measured using a peak responding meter r.m.s. calibrated. All tests shall be carried out in accordance with AS 1931.1.

All electronic systems should be electrically isolated prior to applying test voltages.

7.9.2 Test schedule

An acceptance test shall be conducted —

(a) before the MEWP is first placed in service to verify that the insulation design and materials used in construction meet the requirements of this document;

(b) in accordance with Clause M.6; and

(c) on change of ownership, if the original acceptance test report is not available.

The electrical insulation testing schedule shall be compiled using the criteria in Tables K(A) and K(B). The insulation level specified for the MEWP shall determine the class from Table K(A). The tests required for each class shall be in accordance with Table K(B).

7.9.3 Withstand test

7.9.3.1 Dry insulated withstand test

The insulated insert withstand test is used to verify that the boom insert and chassis inserts are able to individually withstand a temporary over-voltage that may be imposed by the system on which they are used.

7.9.3.2 Test method

7.9.3.2.1 General

The test shall be conducted with the insulation inserts in a clean and dry condition. Inserts not under test shall be short-circuited. The vehicle chassis shall be earthed during the test.

Where the boom insulation and chassis insulation is formed by one continuous insert, an external temporary foil test electrode shall be applied to all portions of the boom insert between a height of 7.5 m from the support surface, when the boom is fully raised, and the upper electrode (boom tip). The foil shall be shaped into internal cavities of the insulation using the simulated conductor (as in Clause 7.6). If necessary, the electrode may be applied in successive sections not less than 100 mm wide to reduce capacitive currents.

Where chassis insulation is provided by cover insulation, either in part or in whole, an external temporary foil test electrode shall be applied to all portions of the boom exterior that lie between a height of 7.5 m measured from the support surface, when the boom is fully raised, and the extremity of the cover insulation. The foil shall be shaped into internal cavities of the insulation using the simulated conductor (as in Clause 7.6). If necessary, the electrode may be applied in successive sections not less than 100 mm wide to reduce capacitive currents.

7.9.3.2.2 Procedure

The procedure shall be as follows:

(a) Measure the insulation resistance at a minimum of 2.5 kV. The resistance after 1 min shall be greater than 1000 MΩ.

(b) Apply a 1 min dry power frequency withstand test voltage, at the test level specified in Table 7.9.14.3, between the upper test point and the vehicle chassis.

7.9.3.2.3 Pass criteria

There shall be no puncture or disruptive discharge.

NOTE The measurement of the insulation resistance is required to verify that the condition of the insulation is likely to be suitable for energizing at voltages up to the test level. Measurement of resistance alone is not a suitable means of verifying the performance of the electrical insulation.

7.9.3.3 Withstand test for low-voltage MEWPs

7.9.3.3.1 Purpose

The purpose of the withstand test is to verify that the low-voltage platform insulation has been adequately maintained, has no physical damage and is able to withstand a temporary over-voltage that may be imposed by the system on which it is used.

This test only applies to low-voltage rated MEWPs that do not have insulating insert(s).

7.9.3.3.2 MEWP set-up

The following applies:

(a) The MEWP should be set up as shown in Clause 7.9.4.

(b) The vehicle chassis shall be connected to earth.

(c) All parts of the platform cover insulation and controls shall be thoroughly wet with a minimum volume of 2l of water per square metre of basket floor area. Ensure water is applied to all internal cavities of the basket.

(d) An external temporary test electrode shall be applied to all portions of the platform surfaces. If necessary, the electrode may be applied in successive sections not less than 100 mm wide to reduce capacitive currents.

7.9.3.3.3 Test method

The procedure shall be as follows:

(a) Measure the insulation resistance between the electrode and the chassis at a minimum of 2.5 kV. After 1 min, the insulation resistance shall be greater than 1000 MΩ. The test shall not proceed further if these values are not achieved.

(b) Apply a 1 min, 5 kV test voltage between the test electrodes and the vehicle chassis.

7.9.3.3.4 Pass criteria

There shall be no puncture or disruptive discharge.

7.9.4 Total leakage current test

7.9.4.1 Purpose

The total leakage current test is used to quantify the value of total capacitive and resistive current of each insert.

7.9.4.2 MEWP set-up

The following applies:

(a) No capacitive shields shall be used.

(b) When required, electrical stress control devices may be temporarily installed to the metalwork immediately adjacent to the insulation being tested. The type and positioning of any temporary stress control device shall be noted in the record of test.

(c) The MEWP shall be set up outdoors and positioned at least 7.5 m from external buildings or structures.

(d) The stabilizing legs and wheels shall be placed on insulators. The insulation resistance of the chassis to earth shall be least 100 times the impedance of the current-measuring circuit. A low-voltage ohmmeter may be used.

(e) All metalwork at the platform shall be electrically bonded and connected to the upper test electrode.

(f) The vehicle chassis shall be connected to the current-measuring circuit and then to earth through a coaxial cable that has the screen earthed.

(g) All hydraulic lines bridging the insulation shall be completely filled with hydraulic oil from the MEWP's reservoir.

(h) The booms shall be aligned parallel to the longitudinal axis of the vehicle in plan view, with the basket to the rear of the vehicle.

(i) When under test, the booms shall be positioned according to the applicable test position depicted in Figure 7.9.4.5. The height from the ground level to the top of the basket shall be 7.5 m.

(j) Where the insulation rating varies according to the configuration of the boom (for example, in a dual-rated boom with different boom extensions), the boom shall be tested for each voltage rating at the corresponding minimum extended length as marked by the manufacturer.

(k) When in the test position and connected to the upper electrode, the high-voltage test supply lead shall be set at an angle of approximately 45 degrees to horizontal and in line with the MEWP axis.

(l) Inserts not under test shall be short-circuited.

(m) Where boom and chassis insulation is formed by one continuous insert, the external temporary foil test electrode shall be applied to all portions of the boom insert between a height of 7.5 m from the support surface, when the boom is fully raised, and the upper electrode (boom tip). The foil shall be shaped into internal cavities of the insulation using the simulated conductor (as in Clause 7.6). If necessary, the electrode may be applied in successive sections not less than 100 mm wide to reduce capacitive currents.

(n) Where chassis insulation is provided by cover insulation, either in part or in whole, an external temporary foil test electrode 25 mm wide shall be applied to the exterior surface at a height of 7.5 m, measured from the support surface when the boom is fully raised.

7.9.4.3 Test method

Apply a dry 1 min power frequency test voltage equivalent to the highest system voltage phase to earth, corresponding to the rated working voltage of the component under test at the test level specified in Table 7.9.14.3 between the upper test point and earth.

7.9.4.4 Pass criteria

When the chassis insulation is short-circuited, the leakage current measured in the current-measuring circuit shall be less than —

(a) 2.5 mA; or

(b) 10 μA/kV for Category C MEWPs.

NOTE The 10 μA/kV pass criteria for Category C MEWPs is designed to achieve sufficient sensitivity to verify the boom insulation during periodic tests.

The current shall not increase during the test.

When the boom insulation is short-circuited, the leakage current measured in the current-measuring circuit shall be less than 2.5 mA. The current shall not increase during the test.

7.9.4.5 Test record

The test report shall note the following:

(a) The specific test location of the booms in relation to the chassis and other metal structures.

(b) A photograph, sketch or reference to the relevant diagram in Figure 7.9.4.5 describing the test position.

(c) The test voltages applied and leakage current measured in each insert.

NOTE 1 In determining these maximum acceptable leakage currents, reference has been made to AS/NZS IEC 60479.1. In particular, an absolute requirement was laid down for the current through a MEWP's operator, making inadvertent contact with a live conductor, not to exceed 25 % of the maximum allowable current in "zone 2" (refer to AS/NZS IEC 60479.1) under the worst foreseeable conditions.

NOTE 2 This test should be carried out in conjunction with the withstand test specified in Clause 7.9.3 and the leakage current measured at the highest system voltage phase-to-earth during both increasing and decreasing voltages.

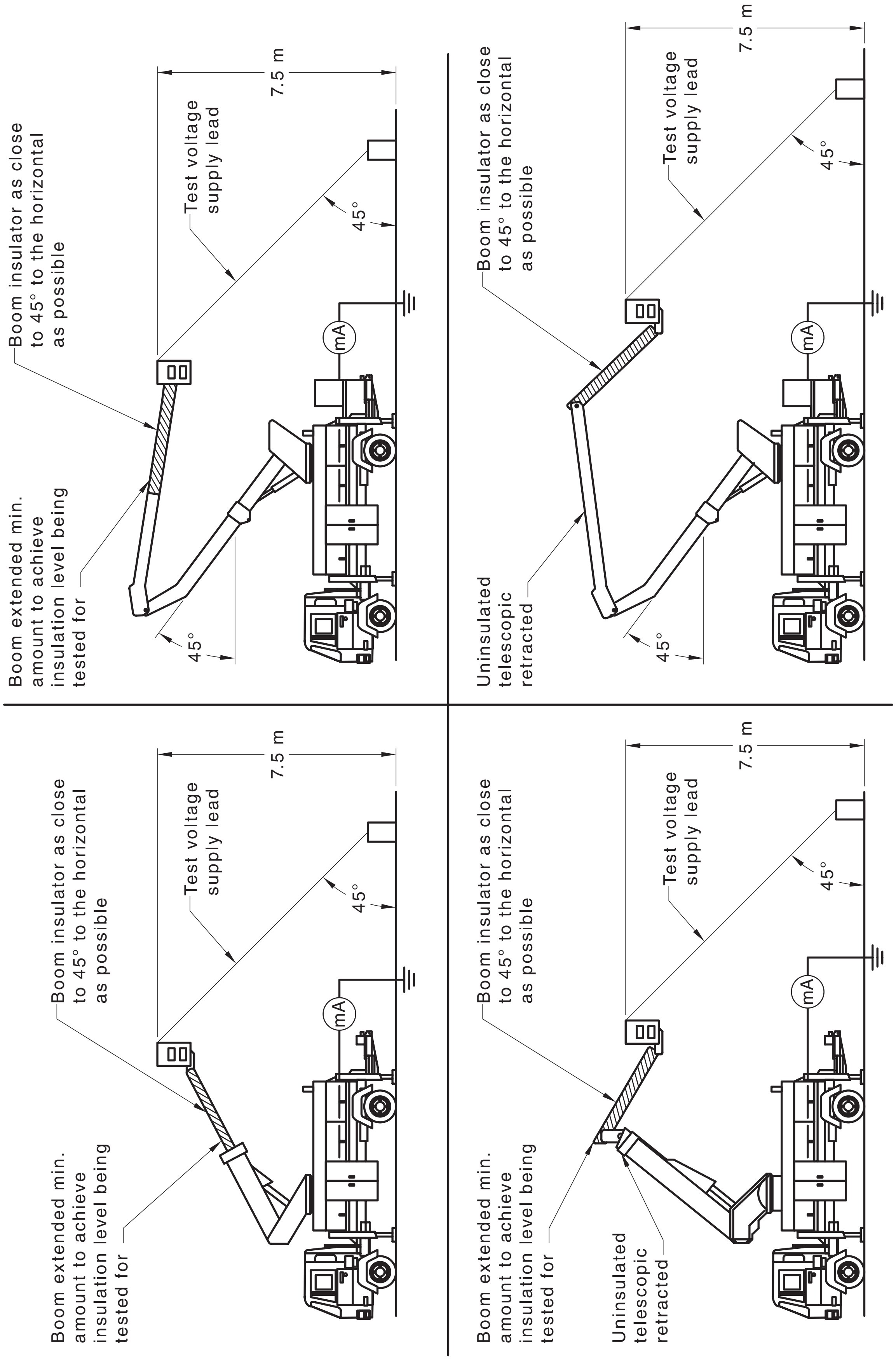


Figure 7.9.4.5 — MEWP test positions for acceptance and periodic tests

7.9.5 Boom insert surface leakage test for MEWPs fitted with test electrodes in accordance with Clause 7.7.5

7.9.5.1 Purpose

The surface leakage test is used to provide a benchmark to periodically monitor surface degradation by measuring the leakage across the surface of the boom insert.

Where surface leakage is intended to be monitored using d.c. test apparatus, the surface leakage test shall be performed in accordance with Clause M.4.4.3.

7.9.5.2 Test method

7.9.5.2.1 General

The vehicle chassis shall be earthed during the test.

The chassis insulation shall be short-circuited.

7.9.5.2.2 Procedure

The procedure shall be as follows:

(a) Connect the current-measuring circuit to the insulator surface leakage monitoring electrode (see Clause 7.7.5), and to a temporary external surface electrode, and wrap around the external surface of the insulator in line with the internal electrode. Fit the external electrode with a capacitive shield that is connected to earth (see Figure 7.9.5.4).

(b) Ensure that neither the capacitive shield nor shield insulation makes contact with the insulating insert surface located above the leakage current-monitoring electrode.

(c) With the capacitive shield in place, the insulation resistance of the insulator surface leakage current monitoring electrode shall be at least 100 times the impedance of the current-measuring circuit. Measure the insulation resistance at a minimum of 2.5 kV.

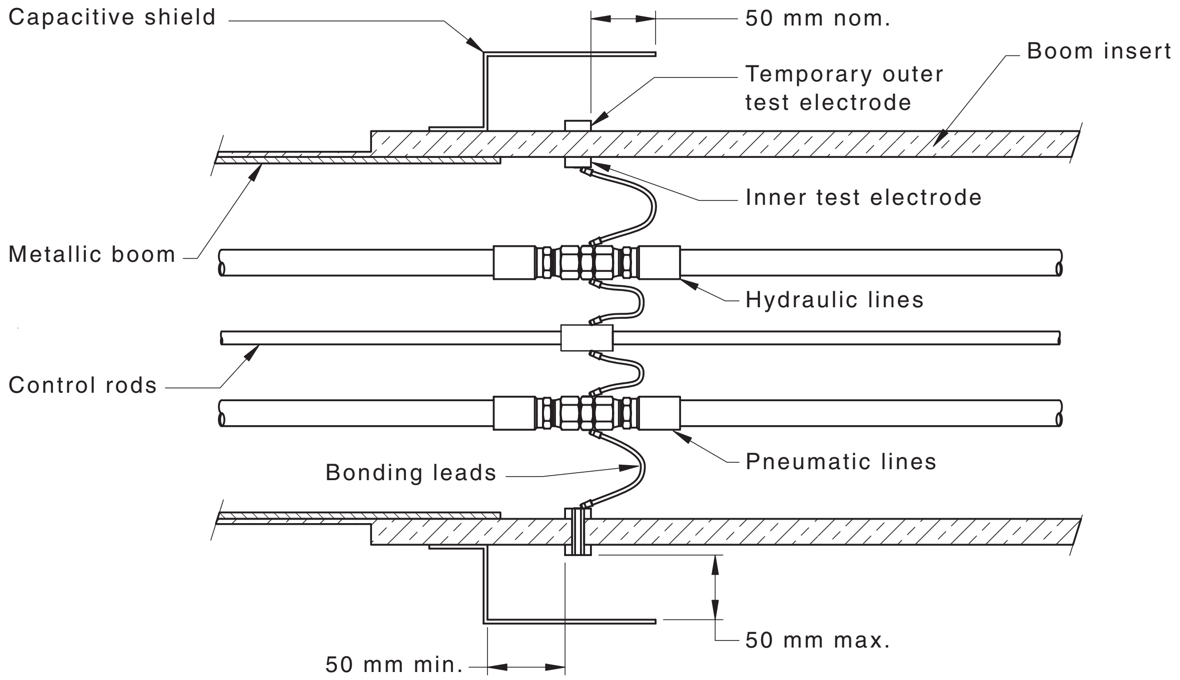
(d) Apply a dry 1 min power frequency withstand test voltage at the test level specified in Table 7.9.14.3 between the upper test point and the earth.

7.9.5.3 Pass criteria

The leakage current monitored shall be less than 1 μA/kV. It shall not increase during the test.

7.9.5.4 Additional test for boom inserts with multiple insulation ratings

A boom insert with additional insulation ratings marked along its length shall be tested in accordance with Clause 7.9.5.2 with the temporary external electrode applied at each marked change in insulation rating. The length between the upper end of the boom insert and each rating mark shall meet the requirements of Clause 7.5.1.



NOTE The design of actual shields may vary (drawing is illustrative only).

Figure 7.9.5.4 — Capacitive shield

7.9.6 Low-voltage insulating covering test (all MEWPs)

7.9.6.1 Purpose

The low-voltage insulating covering test is used to prove the integrity of boom insulating covering.

7.9.6.2 Test method

The procedure shall be as follows:

(a) Bridge all metalwork of the various parts of the booms and basket and connect to earth.

(b) Apply a temporary electrode in close contact with surfaces of covering or guards fitted to the booms in accordance with Clause 7.2.3.

(c) Apply a 1 min dry withstand test voltage, as per Table 7.9.14.3, to the temporary electrode.

7.9.6.3 Pass criteria

There shall be no puncture or disruptive discharge.

NOTE This test may be carried out in multiple sections if the test current due to capacitive leakage on the complete temporary electrode is likely to exceed the maximum current available from the test set.

7.9.7 Basket vertical withstand test

7.9.7.1 Purpose

The basket vertical withstand test is used to verify that the insulation rating of the basket, complete with all fittings and attachments installed (except for HV live work liner, which shall be removed for the test), is adequate to minimize the risk of short-circuit or transfer of potential in the vertical plane.

7.9.7.2 Test set-up

The test shall be set up as illustrated in Figure 7.9.7.4.

7.9.7.3 Test method

The procedure shall be as follows:

(a) Install a temporary upper (plate or foil) electrode in contact with the entire top horizontal lip of the basket.

(b) Bond the operator's controls, harness attachment points and power tool outlets, plus any exposed conductive components near the top of the basket, to the temporary upper electrode.

(c) Install a temporary lower (foil) electrode in contact with the external surface of the base of the basket. Shape the electrode into all contours of the external surface of the basket bottom and covers using the simulated conductor as described in Clause 7.6.

The electrode shall cover the surface lying below a horizontal plane located 50 mm above the level of the internal floor and extend to a vertical plane intersecting the boom pivot pin as shown in Figure 7.9.7.4.

(d) Position the basket to best simulate the most onerous likely working position when elevated to greater than 7.5 m.

(e) Apply a 1 min dry power frequency withstand test voltage at the level specified in Table 7.9.14.3 to the upper electrode with the lower electrode connected to earth.

NOTE 1 If radio remote controls are fitted in the basket, they should be replaced with dummy units wrapped in metallic foil, or similar material, for this test.

NOTE 2 This test may be carried out in multiple sections if required (the test current due to capacitive leakage on the complete temporary electrodes may exceed the maximum current available from the test set).

7.9.7.4 Pass criteria

There shall be no puncture or disruptive discharge during the application of the test voltage.

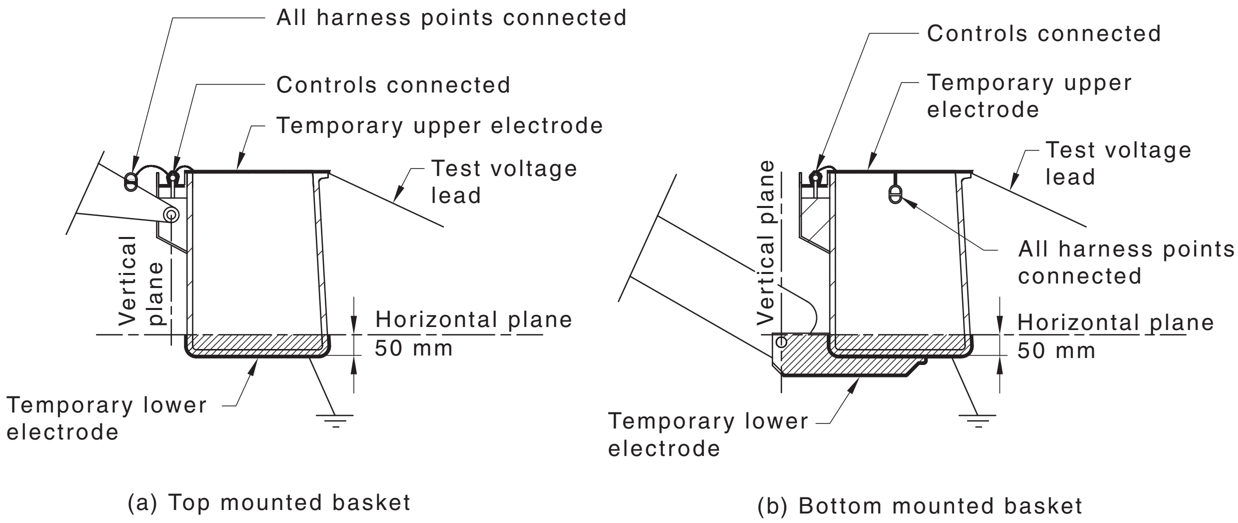


Figure 7.9.7.4 — Basket vertical withstand test set-up

7.9.8 Basket puncture test

7.9.8.1 Purpose

The basket puncture test is used to verify that the insulation rating of the basket, complete with all fittings and attachments (except for HV live work liner which shall be removed for the test), is adequate to minimize the risk of short-circuit or transfer of potential through the basket wall.

7.9.8.2 Test method

The test shall be set up as illustrated in Figure 7.9.8.3.

The testing procedure shall be as follows:

(a) Install a temporary foil in contact with the exterior surface of the basket, including the base. Shape the electrode into all contours using the simulated conductor described in Clause 7.6.

(b) Install a temporary inner electrode in close contact with the inner surface of the basket. Shape the electrode to all contours of the inner surface.

NOTE The inner electrode may be foil or tap water, or a combination of both.

(c) Extend the electrodes vertically to a position 150 mm from the top horizontal lip of the basket.

(d) Apply a 1 min dry power frequency withstand test voltage at the level specified in Table 7.9.14.3 to the inner electrode with the outer electrode connected to earth.

7.9.8.3 Pass criteria

There shall be no puncture or disruptive discharge during the application of the test voltage.

NOTE Where any metalwork causes excessive audible discharges, the test should be repeated with the metalwork connected to the nearest electrode.

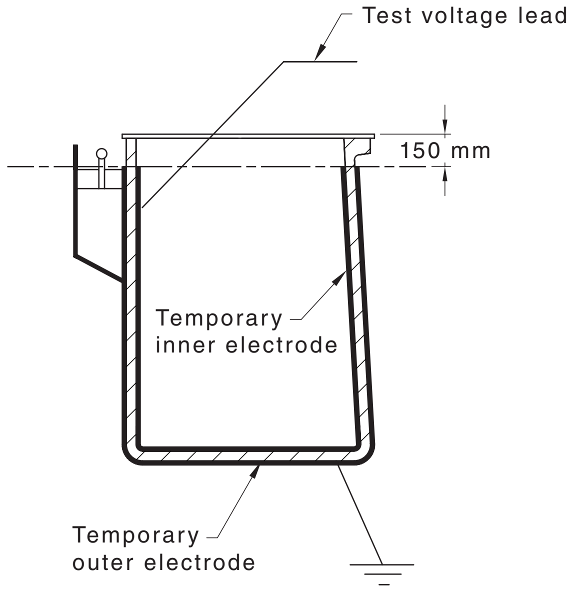


Figure 7.9.8.3 — Basket puncture test set-up

7.9.9 HV live work liner puncture test

7.9.9.1 Purpose

The liner puncture test is used to verify that the insulation rating of the liner is adequate to minimize the risk of short-circuit or transfer of potential and conform to the requirements of HV live work standards.

7.9.9.2 Test method

The procedure shall be as follows:

(a) Install a temporary exterior electrode in close contact with the exterior surface of the liner. Shape the electrode to all contours of the exterior surface.

NOTE The electrode may be foil or tap water, or a combination of both.

(b) Install a temporary inner electrode in close contact with the inner surface of the liner. Shape the electrode to all contours of the inner surface.

NOTE The electrode may be foil or tap water, or a combination of both.

(c) Extend the electrodes vertically to a position 150 mm from the top horizontal lip of the liner.

(d) Apply a 1 min dry power frequency withstand test voltage at the level specified in Table 7.9.14.3 to the inner electrode with the outer electrode connected to earth.

7.9.9.3 Pass criteria

There shall be no puncture or disruptive discharge during the application of the test voltage.

7.9.10 Hydrophobicity test for wet-rated MEWPs (reference only)

7.9.10.1 Purpose

The hydrophobicity test is used to verify that the insulation inserts and basket surfaces are hydrophobic.

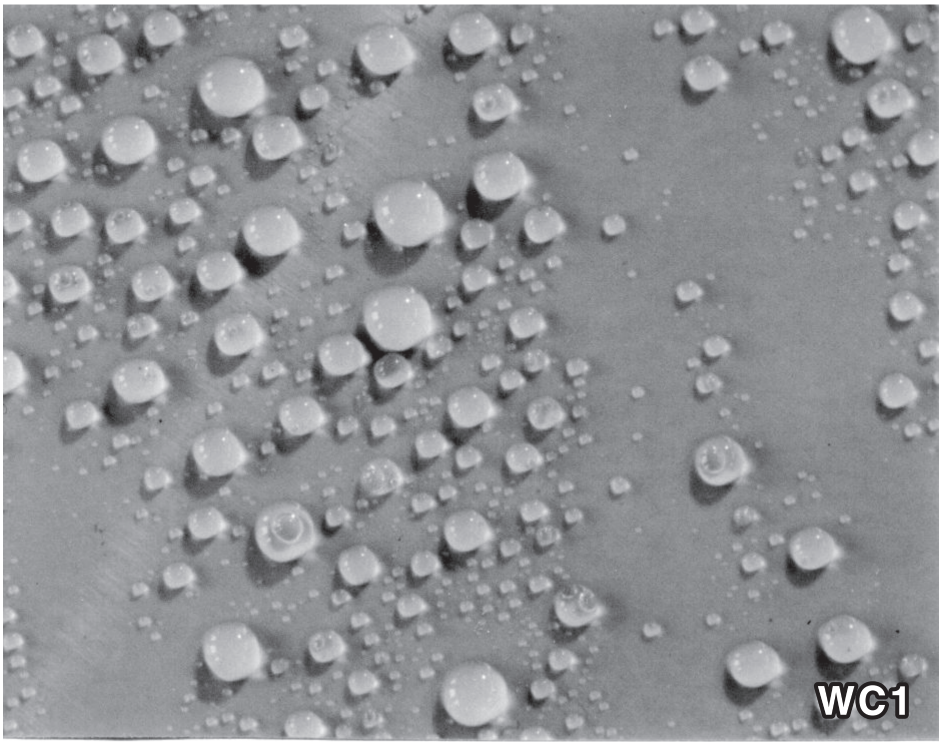
7.9.10.2 Test method

The hydrophobicity test shall be carried out on a sample of external and internal surfaces in accordance with IEC TS 62073:2016, Method C: The spray method.

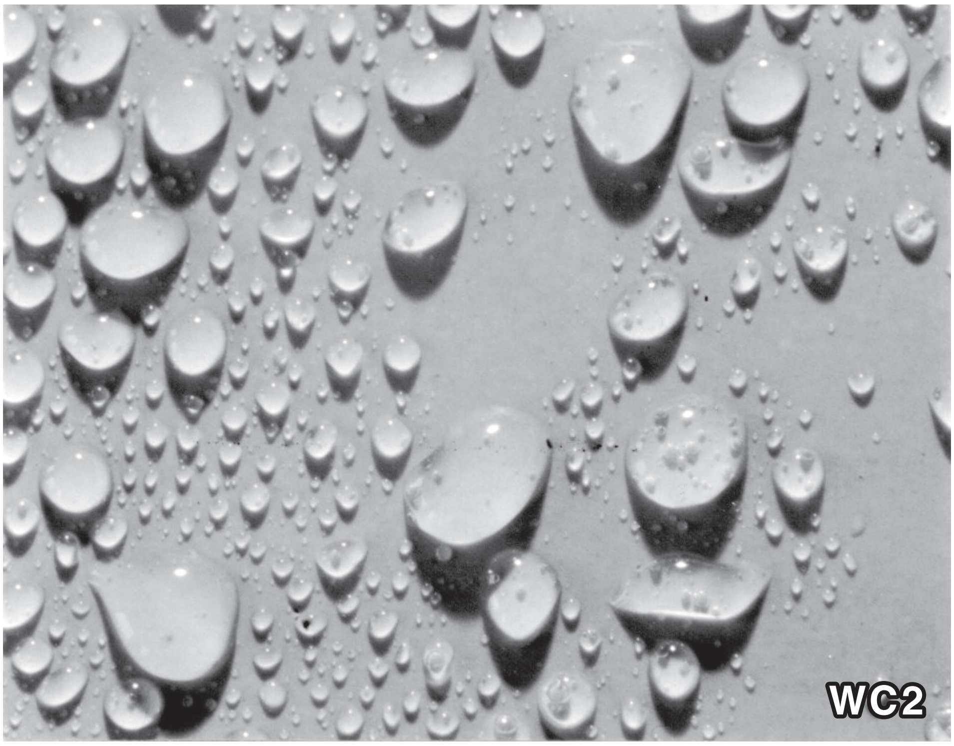
7.9.10.3 Pass criteria

The classification shall be WC1 or WC2 (see Figure 7.9.10.3).

Hydrophobicity classifications WC3 to WC6 are not recommended.

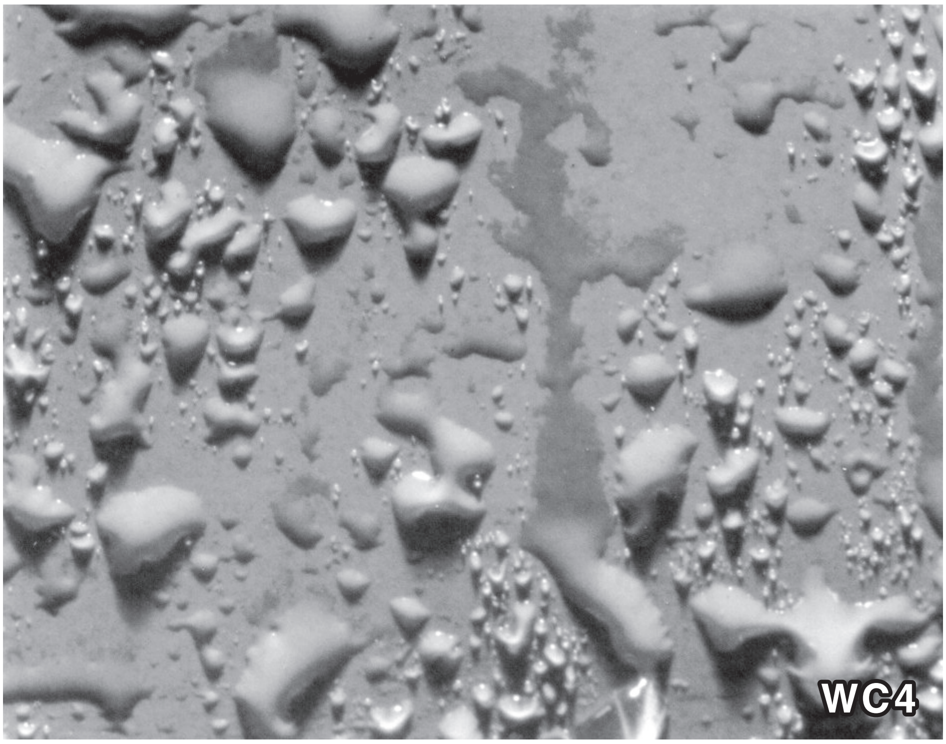


(a) WC1

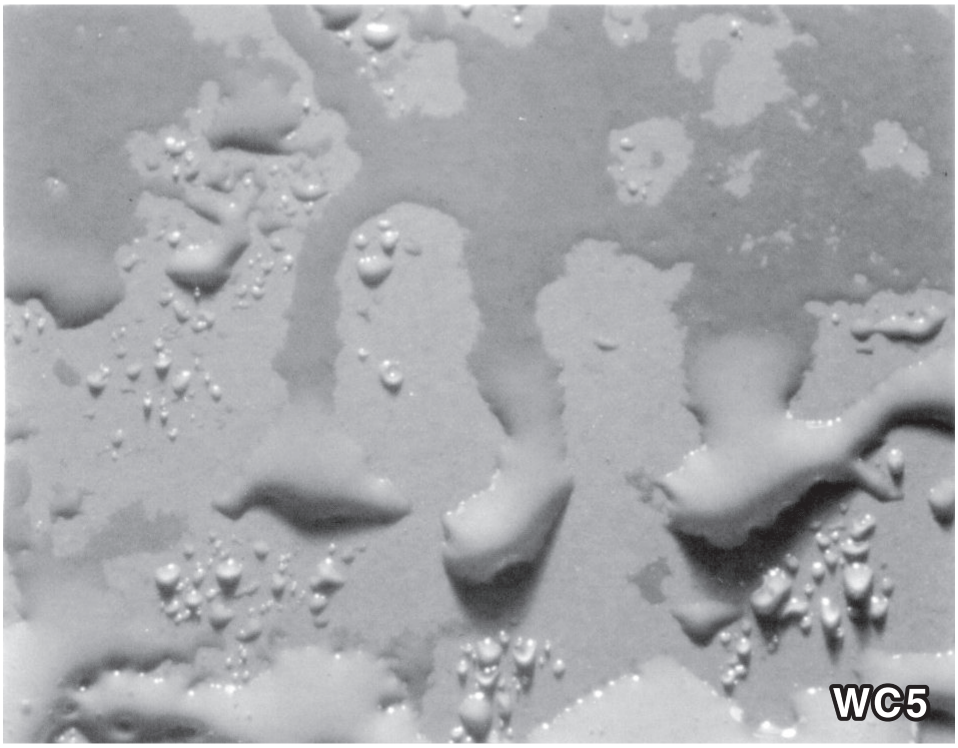


(b) WC2

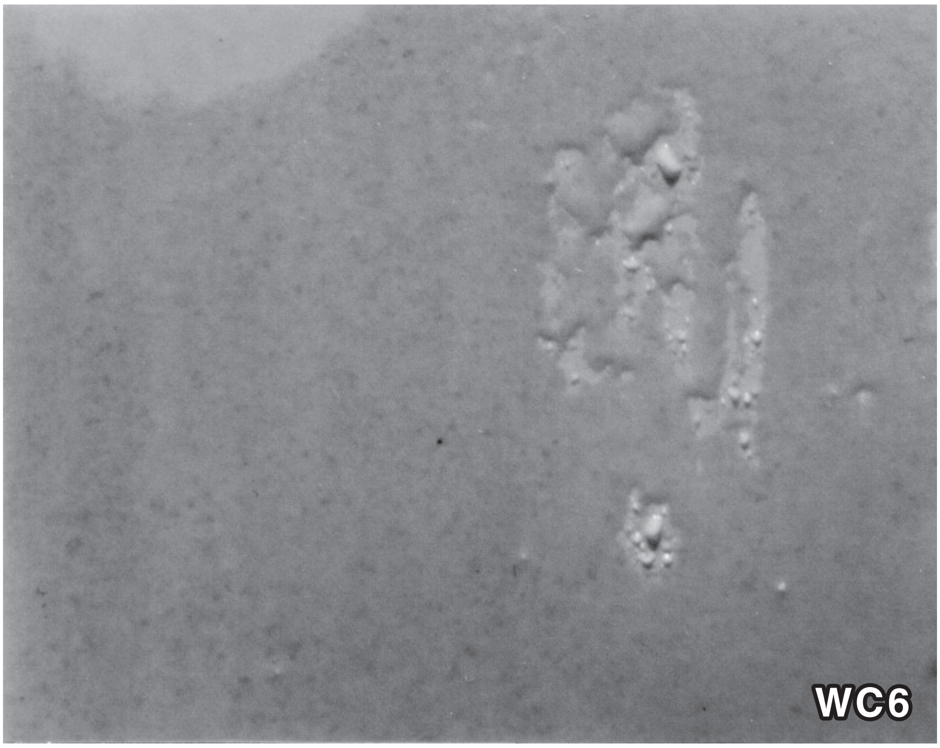
(c) WC3



(d) WC4



(e) WC5



(f) WC6

Figure 7.9.10.3 — Hydrophobicity classification

7.9.11 Wet insert withstand and leakage current test

7.9.11.1 Purpose

The wet insert leakage current test is used to verify that the dielectric properties of the MEWP boom insert and chassis insulating system are not unduly impaired after exposure to moisture.

7.9.11.2 Apparatus

The water used for wetting shall have a resistivity greater than 100 Ωm (less than 100 µS/cm).

7.9.11.3 MEWP set-up

The following applies:

(a) When under test, the MEWP shall be set up in the configuration specified in Figure 7.9.4.5.

(b) Throughout the tests, the insulation resistance of the chassis to earth shall be maintained at a value of at least 100 times the impedance of the current-measuring circuit, when measured with a low-voltage ohmmeter.

NOTE If required, the stabilizers/outriggers and wheels may be placed on low-voltage insulators.

(c) When required, electrical stress-control devices may be temporarily installed to the metalwork immediately adjacent to the insulation being tested.

(d) The vehicle chassis shall be connected to the current-measuring circuit and then to earth, through a coaxial cable that has the screen earthed.

(e) All hydraulic lines bridging the insulation shall be completely filled with hydraulic oil from the MEWP's reservoir.

(f) Transit covers shall be removed.

(g) The insert not under test shall be short-circuited.

7.9.11.4 Test method

The procedure shall be as follows:

(a) Completely wet all internal and external insert surfaces of the insert, to simulate worst likely wet conditions. The spray shall be directed inside each hollow insulator.

(b) Within 3 min of completion of wetting, measure the insulation resistance using a minimum of 5 kV d.c. for a period of 1 min. The minimum insulation resistance shall be not less than 2 MΩ/kV of the rated working voltage of the component for the insert under test. If this criterion is not met, the MEWP fails the test and the remainder of the test shall not be carried out.

(c) Apply a wet 1 min power frequency withstand test voltage corresponding to the rated working voltage of the component per Table 7.9.14.3 between the upper test point and earth.

(d) On both raising and reducing the test voltage as described in Item (c), measure the leakage current through the insulating component at a test voltage equivalent to the highest system voltage phase to earth and corresponding to the rated working voltage of the component.

7.9.11.5 Pass criteria

The following requirements apply:

(a) The resistance shall be not less than 2 MΩ/kV of the rated working voltage of the component.

(b) There shall be no puncture or disruptive discharge during the test.

(c) The leakage current in Item (b) shall be less than 2.5 mA.

(d) The leakage current trend shall not increase during the application of the test voltage.

7.9.12 Basket wet vertical withstand test

7.9.12.1 Purpose

The basket wet vertical withstand test is used to verify that the insulation rating of the basket, complete with all fittings and attachments installed (except for HV live work liner, which shall be removed for the test), is adequate to minimize the risk of short-circuit or transfer of potential in the vertical plane when wet.

7.9.12.2 Test method

The test shall be set up as described in Clause 7.9.7.

The testing procedure shall be as follows:

(a) After the satisfactory completion of the dry basket vertical withstand test [see Clause 7.9.7.3(d)], wet the basket using the apparatus as specified in Clause 7.9.11.2. Wet all internal and external surfaces of the basket completely, to simulate wet conditions.

(b) Within 3 min of wetting, apply a 1 min wet power frequency test voltage, at the level specified in Table 7.9.14.3, to the upper electrode, with the lower electrode connected to earth.

NOTE 1 If radio remote controls are fitted in the basket, they should be replaced with dummy units wrapped in metallic foil, or similar material, for this test.

NOTE 2 This test may be carried out in multiple sections if required (the test current due to capacitive leakage on the complete temporary electrodes may exceed the maximum current available from the test set).

7.9.12.3 Pass criteria

There shall be no puncture or disruptive discharge during the application of the test voltage.

7.9.13 Insulating inserts rain test for rain-rated MEWPs

7.9.13.1 Purpose

The insulating inserts rain test is used to verify that a MEWP's boom insert, chassis insulating system and basket(s) are "rain capable" and will not add to the hazards experienced during storm restoration work.

7.9.13.2 MEWP set-up

The MEWP shall be set up in accordance with Clause 7.9.11.3.

7.9.13.3 Test method

The procedure shall be as follows:

(a) Record the effect of the wetting apparatus on the total leakage current measured. The difference shall be added to the total leakage current measured for the rain test to give the corrected leakage current.

(b) After the satisfactory completion of the total leakage current test on the boom and chassis insulation system in accordance with Clause 7.9.4, pre-wet the insulation in accordance with Clause 7.9.11.4.

(c) After pre-wetting, subject the insulation to a simulated rain at a rain rate of 150 mm per hour for 15 min as required in AS 1931.1 (see Note 1). Other equivalent methods or spray systems may be used (see Note 2). The actual position of the MEWP in relation to the spray system shall be illustrated with photographs or described in the test report.

NOTE 1 Water will enter hollow booms or insulating components in the course of the normal operation of the MEWP. Therefore, the test should be carried out with the ends of the boom or insulation system exposed to wetting.

NOTE 2 A combination of commercially available full jet sprays angled at 45 degrees to the horizontal and set up to spray from a single direction is acceptable for this purpose provided it can be demonstrated that —

(a) the rain rate of precipitation is satisfactory;

(b) there is consistent coverage; and

(c) the water resistivity is satisfactory.

(d) At the end of the wetting period, apply a 1 min test voltage equivalent to the highest system voltage phase-to-earth and corresponding to the rated working voltage of the component per Table 7.9.14.3 between the upper test point and earth. During the application of the test voltage, the insulation shall be also subjected to the continuous simulated rain.

7.9.13.4 Pass criteria

The following requirements apply:

(a) There shall be no flashover or puncture during the test.

(b) The leakage current shall be measured at the start and finish of the test. It shall be less than 2.5 mA.

(c) The leakage current trend shall not increase during the test.

7.9.14 Basket rain vertical withstand test (for rain-rated MEWPs only)

7.9.14.1 Purpose

The basket rain vertical withstand test is used to verify that the insulation rating of the basket, complete with all fittings and attachments installed (except for HV live work liner, which shall be removed for the test), is adequate to minimize the risk of short-circuit or transfer of potential in the vertical plane when raining.

7.9.14.2 Test method

The test shall be set up as described in Clause 7.9.7.

The testing procedure shall be as follows:

(a) After the satisfactory completion of the dry basket vertical withstand test (see Clause 7.9.7), set up the rain test apparatus in accordance with AS 1931.1 (see Note), such as to subject at least 3 faces of the basket (top and two sides) to simulated rain.

(b) Pre-wet the basket in accordance with Clause 7.9.12.2(a).

(c) After pre-wetting, subject the insulation to simulated rain at a rate of 150 mm per hour as required in AS 1931.1 for 15 min. The water used shall have a resistivity greater than 100 Ωm (less than 100 µS/cm).

(d) At the end of the 15 min period and while still applying simulated rain, apply a 1 min wet withstand test voltage, at a level specified in Table 7.9.14.3, to the upper electrode with the lower electrode connected to earth.

NOTE A combination of commercially available full jet sprays angled at 45 degrees to the horizontal and set up to spray from a single direction is acceptable for this purpose provided it can be demonstrated that —

(a) the rate of precipitation is satisfactory;

(b) there is consistent coverage; and

(c) the water resistivity is satisfactory.

7.9.14.3 Pass criteria

The following criteria apply:

(a) There shall be no puncture or disruptive discharge during the application of the test voltage.

(b) The test current trend shall not increase during the test. This current may be measured at the test set.

Table 7.9.14.3 — MEWP insulation — Acceptance tests

Insulation component	Rated working voltage of component (Nominal system voltage—U)	Dry withstand test voltage (DWTV) (Power frequency 1 min)	Wet withstand test voltage (Power frequency 1 min)	Highest system voltage (HSV), phase-to-earth $\frac{Um}{\sqrt{3}}$	Maximum leakage current			
	kV a.c. (r.m.s.)	kV a.c. (r.m.s.)	kV a.c. (r.m.s.)	kV a.c. (r.m.s.)	Dry boom		Dry chassis	Wet boom and chassis
					Cat C @ HSV Total leakage[b]	Cat B @ HSV Surface leakage[a]	@ HSV Total leakage	@ HSV Total leakage
Inserts (and when chassis insulation is achieved by cover)	132	278	145	84	N/A	275 µA	N/A	2.5 mA
	66	140	72	42	N/A	140 µA	2.5 mA	
	33	70	36	21	210 µA	70 µA	2.5 mA	
	22	50	24	14	140 µA	50 µA	2.5 mA	
	11	28	12	7	70 µA	28 µA	2.5 mA	
	LV	5	5	N/A	N/A	N/A	N/A	

Table 7.9.14.3 *(continued)*

Insulation component	Rated working voltage of component (Nominal system voltage—U)	Dry withstand test voltage (DWTV) (Power frequency 1 min)	Wet withstand test voltage (Power frequency 1 min)	Highest system voltage (HSV), phase-to-earth $\frac{Um}{\sqrt{3}}$	Maximum leakage current			
					Dry boom		Dry chassis	Wet boom and chassis
	kV a.c. (r.m.s.)	kV a.c. (r.m.s.)	kV a.c. (r.m.s.)	kV a.c. (r.m.s.)	Cat C @ HSV Total leakage[b]	Cat B @ HSV Surface leakage[a]	@ HSV Total leakage	@ HSV Total leakage
Cover insulation	33 22 11 LV	35 25 14 5	N/A	N/A	N/A			
Basket, vertical surface	33 LV	50 5	38 5					
Basket puncture	HV LV	50 5	N/A					
HV live work liner	33	50	N/A					

[a] Surface leakage current is measured at dry withstand test voltage for acceptance tests.

[b] Total leakage current is measured at the highest system voltage phase-to-earth.

NOTE The test voltage for high-voltage live work liners and the basket vertical surface test are derived from ANSI/SAIA A92.2.

7.9.15 Certification notices

A distinctive label shall be placed in a clearly visible location in the cabin of the MEWP vehicle. The label shall indicate —

(a) that the insulation has passed the test requirements of this document;

(b) the rated working voltages to which components have been tested;

(c) the date of test;

(d) the next due test date;

(e) the MEWP serial number; and

(f) identification of the test authority.

7.9.16 Insulation marking system

7.9.16.1 Purpose

The insulation marking system provides a consistent marking method for MEWPs conforming to this document, and which shall be used on or near live exposed electrical apparatus.

7.9.16.2 Insulation rating

The insulation rating of the MEWP shall be indicated on the identification plate (see Table 7.9.16.2). The rating system shall indicate the insulation levels of each component and the category in accordance with Appendix K.

The booms of the MEWP shall be marked to show the rated working voltage levels of the insulating components. Change of locations of the various levels of this insulation shall be clearly indicated. Marking shall be clearly visible from the operator's basket and ground level. Where the insulation rating varies with the configuration of the booms, indicators shall be provided on the booms to indicate the configuration and the rating.

NOTE For insulation markings, AS 1319 and AS 2700 may be used.

The minimum height of lettering should be 50 mm to ensure that it is visible from 10 m.

Labels shall be located in accordance with the requirements of Clause 7.9.17 and as illustrated in Figure 7.9.16.2.

Where labels are used, they shall be UV stable, coloured adhesive labels similar to those illustrated in Figure 7.9.16.2. They shall not compromise the MEWP insulation integrity.

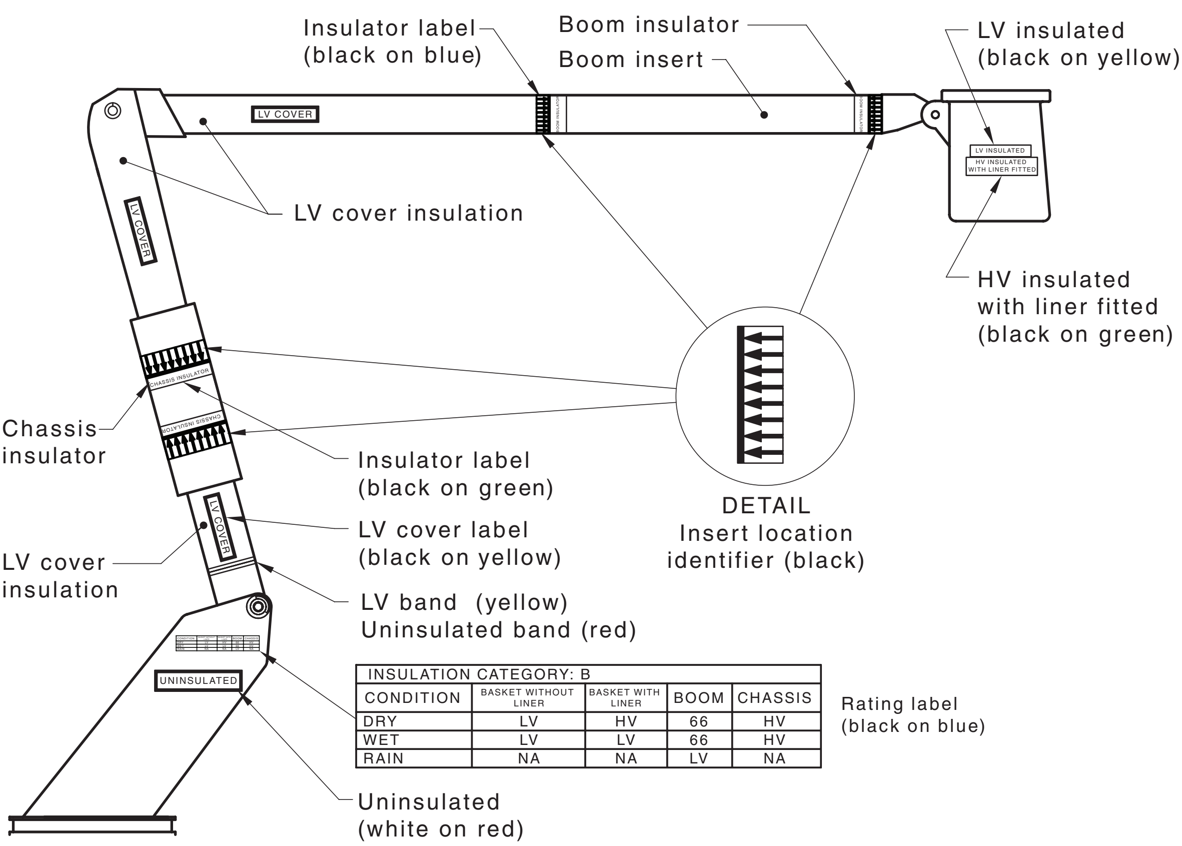


Figure 7.9.16.2 — MEWP marking

Table 7.9.16.2 — Example of MEWP insulation rating identification plate

Insulation category B				
Condition	**Boom, kV**	**Chassis, kV**	**Basket without liner, kV**	**Basket with liner, kV**
Dry	132	33	LV	HV
Wet	33	33	LV	HV

Table 7.9.16.2 *(continued)*

Insulation category B				
Condition	**Boom, kV**	**Chassis, kV**	**Basket without liner, kV**	**Basket with liner, kV**
Rain	11	11	LV	—

7.9.17 Labels

7.9.17.1 Insulation rating labels

A label with black lettering, clearly visible from ground level, shall be applied in close proximity to the identification plate. The label shall indicate the rated working voltages of the boom insulation, chassis insulation and basket.

Baskets shall be labelled as follows:

(a) For an uninsulated basket: “UNINSULATED”.

(b) For an insulated basket that passes the test specified in Clause 7.9.8 (LV): “LV INSULATED”.

(c) For a basket intended for high-voltage live work when a liner, conforming to Clause 7.9.9, is fitted and passes the vertical surface withstand test (Clause 7.9.7) and puncture test (Clause 7.9.8) (minimum LV): “LV INSULATED/HV INSULATED WITH LINER FITTED”.

(d) For HV insulated baskets that pass the requirements of Clauses 7.9.7 and 7.9.9: “HV INSULATED”.

7.9.17.2 Insulator location identifiers

Insulator location identifying bands shall be applied around the boom at both ends of each insulating insert and indicate the minimum creepage length of the insulator. Markings on these bands shall consist of a black line approximately 15 mm wide with 15 mm long arrows projecting out from one side pointing towards the insulator. The terms “boom insulator” or “chassis insulator” shall be written adjacent to the band arrows.

7.9.17.3 Insulation covering labels

Coloured insulation labels shall be applied to areas with insulation covering. A yellow band, nominally 20 mm wide, shall be placed around the boom at the point where the low-voltage insulation covering starts.

7.9.17.4 Uninsulated label

A red band, nominally 20 mm wide, shall be placed around the boom below the yellow band described above. A red label, indicating the “uninsulated” section, shall be placed below the band.

7.9.17.5 Colours

Colours shall conform to the requirements of Table 7.9.17.5.

Table 7.9.17.5 — Label/band colours

Location	As label colour	Lettering colour
Certification notices MEWP rating labels	Sky blue	Black
Insulator location identifiers Upper boom insulator	Sky blue	Black

Table 7.9.17.5 *(continued)*

Location	As label colour	Lettering colour
Chassis insulator HV Basket with liner	Bright green	Black
LV cover insulation LV Basket/Basket without HV liner	Safety yellow	Black
Uninsulated	Spectrum red	White

7.9.18 Electrical test reports

A test report shall be provided and, as a minimum, shall contain the information specified in Appendix J.

Appendix A
(informative)

Typical hazards associated with MEWPs

This appendix sets out the hazards that have been identified by the risk assessment procedure (see Table A.1).

A hazard that is not significant and for which, therefore, no relevant clause is given in this document is designated as NS (not significant).

Table A.1 — List of hazards

Hazards		Relevant clause in this document
1	**Mechanical hazards**	
1.1	Crushing hazard	Clauses 2.1, 2.2.4, 2.2.5, 2.2.22, 2.3.4, 2.5.10, 2.6.1, 4.2.13, 5.2.9, H.5
1.2	Shearing hazard	Clauses 2.3.4, 2.6.1, 4.2.13
1.3	Cutting or severing hazard	NS
1.4	Entanglement hazard	Clauses 2.2.18, 4.2.13
1.5	Drawing-in or trapping hazard	Clauses 2.2.18, 4.2.13
1.6	Impact hazard	Clauses 2.2.5, 5.2.9, G.2.1(h), Appendix G
1.7	Stabbing or puncture hazard	NS
1.8	Friction or abrasion hazard	Clause G.2.5(e), Appendix G
1.9	High-pressure fluid injection hazard	Clauses 2.8.1, 2.8.2, 2.8.3, 2.8.4, 2.8.5, 2.8.10
1.10	Ejection of parts	NS
1.11	Loss of stability (of machinery and machine parts)	Clauses 2.1, 2.2.2, 2.2.6, 2.2.7, 2.2.9, 2.2.10, 2.2.11, 2.2.22, 5.2.3
1.12	Slip, trip and fall hazards	Clauses 2.5.2, 2.5.4, 2.5.5, 2.5.6, 2.5.7, 2.5.8, 4.2.13, 5.2.9, Appendix O
2	**Electrical hazards caused, for example, by**	
2.1	Electrical contact (direct or indirect)	Clauses 2.7, 4.2.1(q), Section 7, Appendix B, Clause G.2.1(g), Appendix G, Appendices K, L, M, N
2.2	Electrostatic phenomena	NS
2.3	Thermal radiation	NS
2.4	External influences on electrical equipment	Clause 2.7.1
3	**Thermal hazards resulting, for example, in**	
3.1	Burns and scalds by possible contact of persons with flames or explosions and also with radiation from heat sources	Clauses 2.2.19, 2.2.20, 7.8.5
3.2	Health-damaging effects from hot or cold work environment	Clauses 2.2.19, 2.2.20
4	**Hazards generated by noise resulting, for example, in**	
4.1	Hearing loss (deafness), other physiological disorders (e.g. loss of balance, loss of awareness, etc.)	NS
4.2	Interference with speech communication, acoustic signals, etc.	Clause G.2.1(I), Appendix G

Table A.1 *(continued)*

Hazards		Relevant clause in this document
5	**Hazards generated by vibration (resulting in a variety of neurological and vascular disorders)**	
6	**Hazards generated by radiation, especially by**	
6.1	Electrical arcs	Clause G.2.1(g), Appendices G, K, L, M
6.2	Lasers	NS
6.3	Ionizing radiation sources	NS
6.4	Machines using high-frequency electromagnetic fields	Clause 2.7.1
7	**Hazards generated by materials and substances processed, used or exhausted by machinery, for example**	
7.1	Hazards resulting from contact with or inhalation of harmful fluids, gases, mists, dusts and fumes	Clause 2.2.19
7.2	Fire or explosion hazard	Clauses 2.2.20, 2.2.21
7.3	Biological and microbiological (viral or bacterial) hazards	NS
8	**Hazards generated by neglecting ergonomic principles in machine design (mismatch of machinery with human characteristics and abilities) caused, for example, by**	
8.1	Unhealthy postures or excessive efforts	Clauses 2.5.9, 2.5.8, 2.6.1, 2.6.4
8.2	Inadequate consideration of human hand-arm or foot-leg anatomy	NS
8.3	Neglected use of personal protection equipment	NS
8.4	Inadequate area lighting	NS
8.5	Mental overload or underload, stress, etc.	NS
8.6	Human error	Clauses 2.6.1, 2.6.3, 6.2.1
9	**Hazard combinations**	
10	**Hazards caused by failure of energy supply, breakdown of machinery parts, and other functional disorders, for example**	
10.1	Failure of energy supply (of energy or control circuits)	Clauses 2.2.12, 2.6.6, 2.6.7, 2.6.8, 2.6.9, 5.2.4, 6.2.3, 7.8.7
10.2	Unexpected ejection of machine parts or fluids	Clause 7.8.6
10.3	Failure or malfunction of control system	Clauses 2.6, 2.10, 5.2.10, 6.2.3, Appendix H
10.4	Errors of fitting	Clauses 2.8.11, 6.2.1
10.5	Overturn, unexpected loss of machine stability	Clauses 2.1, 2.2.2, 2.2.6, 2.2.7, 2.2.22, 4.2.1(k), 5.2.3
11	**Hazards caused by (temporary) missing or incorrectly positioned safety-related measures or means, for example**	
11.1	All kinds of guards	Clause 2.2.17
11.2	All kinds of safety-related (protection) devices	Clauses 2.10, 6.2.6
11.3	Starting and stopping devices	Clauses 2.2.1, 2.3.5, 2.4.2.7, 2.4.3.7, 2.4.5.2, 2.5.4, 2.6.1, 2.6.2, 2.6.3, 2.6.4, 2.6.5, 2.6.6, 2.6.7, 2.6.8, 2.10, 5.2.4, 5.2.5, 5.2.6, 6.2.5, 6.2.6
11.4	Safety signs and signals	Clauses 2.5.11, 2.6.1, 2.8.10, 4.2, 5.2.3, 5.2.12
11.5	All kinds of information or warning devices	Clauses 2.2.2, 2.5.12, 4.1, 4.2, 5.2.3, G.2.1(c) and G.2.2, Appendix G
11.6	Energy supply disconnecting devices	Clauses 2.7.2, 7.8.6
11.7	Emergency devices	Clauses 2.6.5, 6.2.3, 7.8.6
11.8	Feeding or removal means of work pieces	NS

Table A.1 *(continued)*

Hazards		Relevant clause in this document
11.9	Essential equipment and accessories for safe adjusting or maintaining	Clauses 2.3.5, 2.8.1, G.2.5(a) and G.2.5(i), Appendix G
11.10	Equipment evacuating gases, etc.	Clause 2.2.18
12	**Inadequate lighting of moving or working area**	NS
13	**Hazards due to sudden movement or instability during handling**	Clauses 2.1, 2.2.2, 2.2.3, 2.2.6, 2.2.7, 2.2.8, 2.2.9, 2.2.10, 2.2.12, 2.2.13, 2.5.1, 2.6.1, 2.6.3, 2.6.4, 2.6.5, 2.6.9, 5.2.3, 5.2.4, 5.2.6, 5.2.10
14	**Inadequate or non-ergonomic design of driving/ operating position**	Clause 2.5.1
14.1	Hazards due to dangerous environments (contact with moving parts, exhaust gases, etc.)	Clauses 2.2.19, 2.2.20
14.2	Inadequate visibility from driver's or operator's position	Clauses 2.6.1, 2.6.3, 2.6.4
14.3	Inadequate seat or seating (seat index point)	NA
14.4	Inadequate or un-ergonomic design or positioning of controls	Clauses 2.6.1, 2.6.2, 2.6.3, 5.2.10
14.5	Starting or moving of self-propelled machinery	Clauses 2.2.14, 2.2.15, 2.2.16, 2.2.17, 2.2.18, 2.2.22, 2.6.1, 2.6.3, 5.2.5, 5.2.6, 5.2.10
14.6	Road traffic of self-propelled machinery	Clauses 2.2.12, 2.2.16, 2.2.17, 2.2.18
14.7	Movement of pedestrian-controlled machinery	Clause 2.2.16
15	**Mechanical hazards**	
15.1	Hazards to exposed persons due to uncontrolled movement	Clauses 2.1.6, 2.3.5, 2.6.1, 5.2.10, 6.2.5, 6.2.6
15.2	Hazards due to break-up or ejection of parts	NS
15.3	Hazards due to rolling over (roll over protection — ROP)	NS
15.4	Hazards due to falling objects (falling object protection — FOP)	NS
15.5	Inadequate means of access	Clauses 2.5.8, 2.5.9
15.6	Hazards caused due to towing, coupling, connecting, transmission	NS
15.7	Hazards due to batteries, fire, emissions, etc.	Clauses 2.2.19, 2.2.20, 7.3.1, 7.8.5
16	**Hazards due to lifting operation**	
16.1	Lack of stability	Clauses 2.1, 2.2.2, 2.2.6, 2.2.7, 2.2.9, 2.2.10, 2.2.11, 2.3.1,3.6.2, 3.6.3, 5.2.3, 6.2.5, 7.8.1, 7.8.2
16.2	Derailment of machinery	Clause 2.2.21
16.3	Loss of mechanical strength of machinery and lifting accessories	Clauses 2.1.4, 2.1.6, 2.3.1, 2.3.7, 2.3.5, 4.1.2, 4.1.3, 6.2.6, G.2.1(a) and G.2.2(b), Appendix G
16.4	Uncontrolled movements	Clauses 2.2.3, 2.2.4, 2.2.5, 2.3, 2.4, 2.5.1, 2.6.2, 2.9.2, 5.2.6, 5.2.10, 6.2.6, 7.8.9, 7.8.10
17	**Inadequate view of trajectories of the moving parts**	Clause 2.2.22
18	**Hazards caused by lightning**	NS
19	**Hazards due to loading or overloading**	Clauses 2.3.1, 6.2.2, 7.8.1, 7.8.3
20	**Hazards due to lifting persons**	
20.1	Mechanical strength	Clauses 2.1, 2.3.1, 2.4.2, 2.4.3, 6.2.3
20.2	Loading control	Clauses 2.3.1, 6.2.2, 7.8.1, 7.8.2

Table A.1 *(continued)*

Hazards		Relevant clause in this document
21	**Controls**	
21.1	Movement of work platform	Clauses 2.3, 2.5.1, 2.6.1, 2.6.2, 2.6.3, 2.6.4, 2.6.9, 5.2.10, 6.2.3, 7.8.7, 7.8.9
21.2	Safe travel control	Clauses 2.6.1, 2.6.2, 2.6.3, 2.6.4, 5.2.5, 5.2.10
21.3	Safe speed control	Clauses 2.2.1, 2.2.14, 2.2.16, 2.3.6, 5.2.5
22	**Falling of persons**	
22.1	Personal protective equipment	Clauses 2.5.5, 3.6.2, 4.2.2
22.2	Trapdoors	Clauses 2.5.5, 2.5.10
22.3	Work platform tilt control	Clauses 2.5.2, 5.2.8
23	**Work platform falling or overturning**	
23.1	Falling or overturning	Clauses 2.1.5, 2.2.2, 2.2.6, 2.2.7, 2.2.9, 2.2.10, 2.2.11, 2.2.13, 2.3.1, 2.3.3, 2.5.13, 2.9, 3.6.2, 3.6.3, 5.2.3, 5.2.7, 6.2.5, 7.8.1, 7.8.2
23.2	Acceleration or braking	Clauses 2.2.11, 2.2.15, 2.4.1.6, 5.2.4
24	**Markings**	Clauses 4.2, 5.2.12, 7.9.16, 7.9.17

Appendix B
(informative)

Explanatory notes on the changes for electrically insulated MEWPS

B.1 General

This appendix provides explanatory notes on the changes to MEWP insulation that have been introduced in this edition of the document.

B.2 Insulation rating

A rating system has been introduced according to the condition of the insulation, as it is intended to be used in service. It has been recognized that the majority of MEWPs are used in conditions where the insulation has been exposed to moisture, either from dew or after exposure to rain or washing. Research clearly revealed that the majority of users regularly used MEWPs in a damp or wet condition, near live HV, and no compensating measures were in place to distinguish the possible difference in insulation performance.

This document uses the concept of a “dry”, “wet” and “rain” rating and corresponding test criteria that apply to each rating.

A MEWP which has only been proven to possess insulation in the clean and dry condition should not be considered to be insulated when used in a “wet” condition or in “rain”.

A risk assessment of MEWPs built to this document should be carried out to assess whether the dry rating is appropriate for their continued operation. Insulation has to be regularly cleaned and maintained in an as-tested condition to be certain it retains its rating.

The operator of a MEWP is responsible for the identification of all electrical operating hazards and the management of these to ensure the MEWP is safe to use.

MEWPs used for HV live work are expected to have clean and dry insulation. A “wet” insulation rating is anticipated to become the default insulation requirement for the majority of insulated MEWPs as it should be recognized that most MEWPs operate in “wet” conditions. This document caters for a dry-rated MEWP, which could apply to MEWPs used in certain climatic conditions, or where other preventative measures are taken to ensure dryness.

The test regime specified in this document is designed to verify the integrity of the insulation under conditions in which it may be used.

B.3 Chassis insulation

The chassis insulation system is designed to protect personnel at ground level and the public from electric shock should any portion of the MEWP come into contact with HV mains below the boom insulation.

It is a requirement for all insulated MEWPs to be equipped with a chassis insulation system — either with LV insulation for LV rated MEWPs or an HV insert or combination of covers for HV-rated machines.

The provision of an HV chassis insulation system does not fully protect personnel at ground level under all possible circumstances. Due to practical limitations, the rated voltage of the insert is limited to 33 kV system voltage (rated at 19.1 kV to earth) and only becomes fully effective at some height below 7.5 m above ground level. Such limitations are identified and the reader is guided to the need for additional measures to control risk in such circumstances.

B.4 Total leakage current test

This document specifies an electrical testing regime that includes measurement of total leakage current.

Historically, MEWP insulation has been tested with the boom in a clean and dry condition and a rigorous (1 μA/kV) criteria applied to the measurement of leakage current across the insulation. This test is designed to measure the resistive component of the a.c. current.

The leakage current measured by the surface leakage test represents only one part of the total current that an operator may experience when placed in series with the HV source and earth. The component measured by the classical test is largely the resistive component associated with electrical charges travelling across the boom surfaces, and through the boom and other media bridging the insulation. The other component that proves to be significant and potentially hazardous to the operator is that associated with electric fields.

These capacitive effects are associated with a.c. currents and are a function of the configuration of the MEWP and its presence in the immediate electrical environment.

This document specifies a “total leakage current test” that is intended to measure the total leakage current that an operator may experience in the field and limit this value to a defined level (2.5 mA), irrespective of the rated insulation level of the MEWP. The defined level is derived from AS/NZS IEC 60479.1 and is 25 % of the value associated with Zone 2, which is recognized to usually have no harmful physiological effect on the human body.

It should be recognized that the capacitive current is the dominant quadrature component in the total leakage current measured during tests. This component is not affected to any great extent by the condition of the insulator. The magnitude of capacitive currents is influenced by the size of the components in the electric field and the distance between them and, as such, is influenced by the position of the MEWP. Therefore, the total leakage test is not sensitive to small variations in the resistive current that is directly affected by the condition of the insulator. Users should be aware that for dry-rated MEWPs, a gradual deterioration in the insulator, which may eventually result in insulation failure, might go undetected at some time if total reliance is placed on the total leakage current test. The periodic tests for boom inserts, which are designed to monitor the degradation of the insulation, are specified in this document as either the surface leakage test, a d.c. leakage test, or a total leakage test with a pass criterion equal to 10 μA/kV for MEWPs rated up to 33 kV. These tests are equivalent to the tests specified as periodic tests in ANSI/SAIA A92.2 and IEC 61057.

B.5 Wet-rated MEWPs

It has been recognized for some time that the classical test in a “clean and dry” condition does little to prove the insulation integrity of an insert that is in service and exposed to the elements.

Proper OH&S management would demand that electrical insulation integrity be verified in the condition in which it is expected to be put to use.

The test method devised for wet rating of MEWPs is relatively simple and portable — relying on measurement of insulation resistance and a power frequency withstand test.

Users are cautioned that measurement of insulation resistance alone, particularly on dry inserts, is not a sufficient means of verifying the condition of the insulation. In addition, a hydrophobicity test is included, which is intended to enable routine monitoring of the surface condition of the boom, chassis and other insulating components by visual observation of the formation of water on the insulator surface for both exterior and interior surfaces.

To facilitate wet insulation integrity, the design requirements for inserts in general have been revised so that greater attention will have to be paid to ensuring the resistance of inserts and insulation, in general, against the retention of water.

The philosophy followed in this series of requirements was derived having regard to the requirements specified in IEC 61057.

B.6 Rain-rated MEWPs

There is a requirement by some users to operate MEWPs for storm recovery work in the rain. Such situations may occur during large-scale storms or emergencies. The risk associated with this type of work is that of inadvertent contact with HV. This document specifies procedures to verify insulation capabilities under such conditions.

Not all MEWPs are required to be rain-rated, as generally there is a greater scope to implement procedural methods to control risk and the exposure is limited simply to the demand for this type of work.

B.7 Insulated baskets

Basket insulation is intended to minimize the risk to operators from either transfer of potential, resulting in electric shock or short-circuit, resulting in flash and explosion.

The positioning of a basket is typically near or between HV (either energized or de-energized and earthed) and LV conductors, where a possibility of phase/earth, phase/phase or circuit/circuit transfer of potential or short-circuit exists. (Standard work procedures dictate the use of insulating mats over conductors when working in proximity to live HV, and basket insulation is not intended as a substitute. Rather, it intended to supplement the use of mats and to protect against inadvertent contact.)

The most significant hazard is considered to be from contact with an HV conductor above the basket and an LV conductor below (i.e. circuit/circuit). Consideration needs to also be given to other structures that are earthed; for example catenary wires of optic fibre networks, street light brackets, pole hardware or vegetation.

Where the possibility of horizontal phase-to-phase short-circuit exists on modern baskets, multiple simultaneous breaches need to arise (that is through the basket wall, along internal conductive material or air and back through basket wall). Hence, no specific horizontal test is specified.

It has been recognized that most present day baskets are only effectively LV insulated from inner to outer. This can be improved by installation of an insulating liner as a means of improving the basket wall insulation.

This edition of this Standard has an expectation that baskets have effective insulation from top to bottom. This indicates that the vertical surface insulation level is at least LV rated for general purpose units. However, for units intended to be fitted with an insulating liner for HV live work, it indicates that the basket vertical surface insulation is 33 kV rated.

The resultant basket and liner combination will have an insulation rating both inner to outer and vertical surface approaching Class 4 in HV glove and barrier live work terms.

Following acceptance tests, periodic testing of basket wall insulation (inner to outer) is limited to damaged areas only.

B.8 Defined test procedures

It has been recognized that there were some differences of opinion in test procedures in the previous edition of the Standard, which resulted in unnecessary test anomalies. This was further confused by the slight differences in detail of different designs. This document requires the manufacturer to develop and document a test procedure in accordance with the requirements specified in this document, ensuring they are tailored to suit each specific model.

B.9 Identified hazards

This document identifies certain limitations that exist with the defined insulation systems, which cannot be addressed by design. Identification of these limitations is an essential part of OH&S management and it is intended to assist the user and help them avoid situations where the insulation may not be fully effective. For this purpose, Appendix L lists the various hazards that have been addressed and notes those that are not fully controlled.

Additional guidance relating to safe use of insulated MEWPs (including periodic tests) is provided in Appendix M.

B.10 Application to MEWPs designed to previous editions of this document

The concern that is always raised when there is a significant change in design requirements is the effect of the impact on the existing fleet. It should be recognized that MEWPs designed to previous editions of this document (prior to 2004) only satisfy the requirements of a “dry” insulation rating. There could be a body of opinion that would say that the present day fleet is unsafe. This, however, is not the case. When MEWPs are used properly and with all necessary procedures in place and adhered to, a present day MEWP can work safely. History has shown this. However, certain risks associated with use near powerlines can be reduced by design, which places less onus on the necessity to adhere rigorously to procedural risk management methods.

This document refers to the risk assessment process (more generally known as the hazard identification, risk assessment and risk control process) as a means of identifying hazards and implementing appropriate risk control measures. The purpose of the hazard identification, risk assessment and risk control process is to identify all possible situations associated with MEWPs that could give rise to injury or illness to people. Once a hazard has been identified, and the associated risk to persons assessed with regard to the probability and severity of any harm that could be caused by the hazard, then appropriate risk control measures may be implemented to eliminate or reduce the risk. Each individual MEWP should be subjected to this process, having regard to the type of work required, the environment in which it operates, the characteristics of the MEWP and the network on which it will be utilized. Appendix K outlines what type of insulation systems have to be employed for the work at hand. The most common electrical hazards associated with insulated MEWPs are listed in Appendix L. Risk control measures, which may be satisfied by conformance to this document, are also referenced against each identified hazard.

Hazards that are not fully addressed by the requirements specified in this document are also itemized in Appendix L, and appropriate procedural risk controls should be implemented to address these if they exist.

A flow chart outlining the hazard identification, risk assessment and risk control process is shown in Figure B.10.

Although it is possible that some of the provisions of this document may not be able to be adopted for MEWPs designed and manufactured to previous Standards, it is quite possible that many provisions can. For example, although it may not be possible to fit chassis insulation or fully revise the LV cover insulation to meet the requirements of this document, it is likely that hose assemblies may be modified and the boom treated to achieve a wet insulation rating at least at most voltages frequently encountered in the workplace.

Periodic insulation verification would then be undertaken according to a periodic test schedule drawn up having regard to the type of insulating components installed, that is, by testing those new or revised insulating components to the requirements of this document and testing unaltered components to the requirements of the Standard to which they were originally designed.

The hazard arising from the absence of chassis insulation and an insulated basket may be addressed by procedural measures detailed in Clauses M.2 and M.3.

An example of such a test schedule is shown in Tables B.10.1 and B.10.2.

An alternative to achieving a wet insulation rating in accordance with the requirements of this document may be achieved by a combination of test and pre-operational procedure. For example, a conditional wet insulation rating may be achieved by wetting the boom in accordance with the procedure outlined in Clause M.4.10, operating the MEWP through a complete operating envelope and then wiping down the outside surface.

The MEWP would then be subjected to the test voltage according to the requirements specified in Clause M.4.10. Subject to satisfactory completion of the test, the MEWP could be rated accordingly, depending on the condition that, as part of the pre-operational procedure, the boom is subjected to the procedure that was established and verified during the test.

Operators should be conversant with the insulation rating of the inserts and the conditions under which they apply under varying weather conditions. Appropriate documented administrative controls should be provided in place of a comprehensive engineering solution.

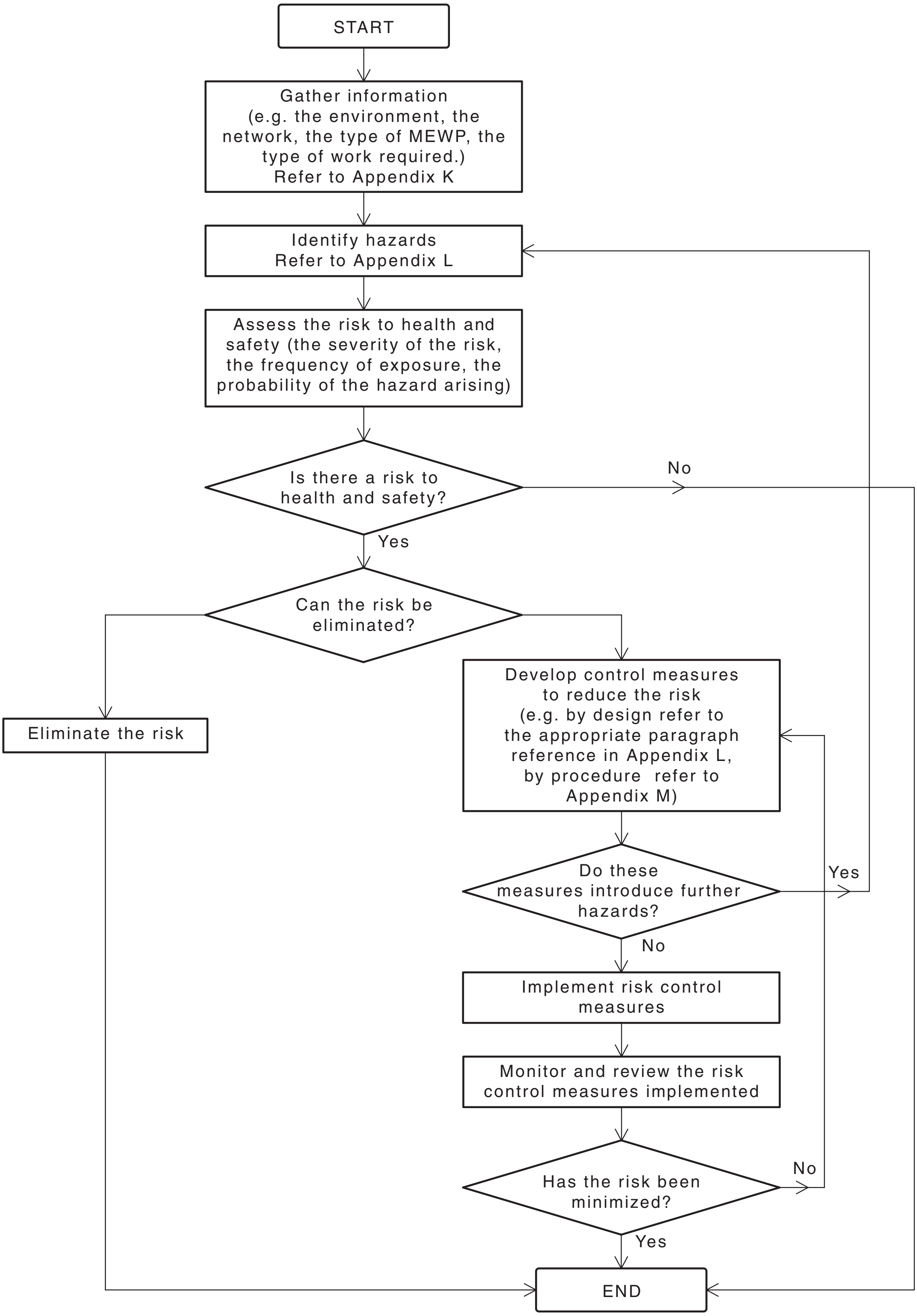


Figure B.10 — Flow chart for hazard identification, risk assessment and risk control process

Table B.10.1 — Schedule of periodic tests (example only) MEWP information

MEWP information	
Model name	"MEWP model XYZ"
MEWP serial number	"XYZ123"
Insulation rating	Dry 66/LV/LV Wet 11/LV/LV Rain 0/0/0

Table B.10.2 — Schedule of periodic tests (example only) relevant tests

Reference Clause	Test	Rating		
		Dry 66 kV	Wet 11 kV	Rain 0 kV
Clause M.4.2	Dry insert insulation resistance (IR)/ withstand boom	✓	✓	—
Clause M.4.2	Dry insert IR/withstand chassis	—	—	—
Clause M.4.3	Dry total leakage current boom	—	✓	—
Clause M.4.3	Dry total leakage current chassis	—	—	—
Clause M.4.4	Surface leakage boom	—	—	—
Clause M.4.5	Low-voltage covering	✓	—	—
Clause M.4.6	Basket vertical withstand	✓	✓	—
Clause M.4.7	Basket puncture	✓	✓	—
Clause M.4.8	HV Insulating basket liner/basket	—	—	—
Clause M.4.10	Wet insert IR/withstand boom	—	✓	—
Clause M.4.10	Wet insert IR/withstand chassis	—	—	—
Clause M.4.11	Wet basket	—	✓	—

Key

✓ Indicates applicability

Appendix C
(informative)

Dynamic factors in stability and structural calculations

C.1 Stability calculations

Different methods of determining stability, used in existing Standards, were considered, for example, the following methods:

(a) Application of a factor to the rated capacity. It was eventually agreed that this was inadequate, particularly for large machines with large structural masses.

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

(c) Residual load (that is, the percentage of the total weight of the MEWP to remain on the ground on the unloaded side) when carrying the rated capacity on the work platform. This was shown to be impractical for machines with variable stabilizer/outrigger widths and with several tipping lines at different distances from the slewing centre.

It was concluded that the method to be used should take into account not only structural masses, rated capacity, wind forces, manual forces, etc., but also their dynamic effects, where applicable, expressed as a percentage acting in the direction of movement. It was also agreed that the calculation method should 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 percentage figure to be used for the dynamic effects, and it was agreed that this needs to be determined experimentally. The method chosen was to straingauge the stabilizers/outriggers, during operation of the extending structure with the rated capacity in the work platform, on the basis that the load on the stabilizers/outriggers determines the stability.

Taking the static stresses as unity, the stress fluctuations, when reversing the controls to obtain the most violent oscillations possible, varied between the minimum of 0.9 and the maximum of 1.2, over a curve similar to a sine wave. It was considered that the dynamic forces producing this result could be represented by a static test calculated using the mean value. The mean value 1.05 was rounded up to 1.10 to give a substantial margin of safety, and various calculations to compare the resulting test loads with their existing test methods were conducted.

Compared with existing test methods (which varied considerably), the new method showed slightly lower test loads for some smaller 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 value of 1.10 (1.0 vertically plus 0.10 angularly) was accepted as giving a more reliable test over the whole range of machine types and sizes than previous methods. The increase from 1.05 to 1.10 was considered to provide an 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.

C.2 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 (refer to BS 2573-2) but responsible entities 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.

Appendix D
(informative)

Stability calculations

D.1 General

This appendix provides an energy method for assessing the stability of a MEWP in dynamic impact situations, as follows:

(a) A MEWP with the raised boom contacting a step during the kerb and depression test (see Clause 3.6.3.2.2), and failing to pass over.

(b) A boom-lift MEWP, with the boom in the lowered level position, dropping into a depression as it comes off the step in a step and depression test (see Clause 3.6.3.2.2).

(c) A MEWP undertaking the braking test on a rated slope (see Clause 3.6.3.2.3).

The following example is for the impact situation noted in Item (a) above (see Figures D.1(A) to D.3.

(i) Kinetic energy (E_{kin}) of MEWP:

$$E_{kin} = \frac{m}{2} \times v^2 = \frac{m}{2} \times 0.7^2$$

$$= m \times 0.245 \text{kgm}^2/\text{s}^2$$

where

m = mass of MEWP, in kilograms

v = speed of MEWP (0.7 m/s)

(ii) Potential energy (E_{pot}) necessary for tipping:

$$E_{pot} = mgx = mg(y - s)$$

$$= mg\left(\sqrt{s^2 + a^2 - s}\right)$$

$$= mg\left(\sqrt{4^2 + 0.7^2 - 4}\right)$$

$$= m \times 0.6 \text{kgm}^2/\text{s}^2$$

where

g = acceleration due to gravity (9.81 m/s^2)

s = vertical distance measured from the tipping axis to the centre of mass of the MEWP and rated load

a = horizontal distance measured from the tipping axis to the centre of mass of the MEWP and rated load

y = $\sqrt{s^2 + a^2 - s}$

x = $y - s$

(iii) Conclusion:

$E_{kin} < E_{pot}$, that is, no tipping will occur

Dimensions in metres

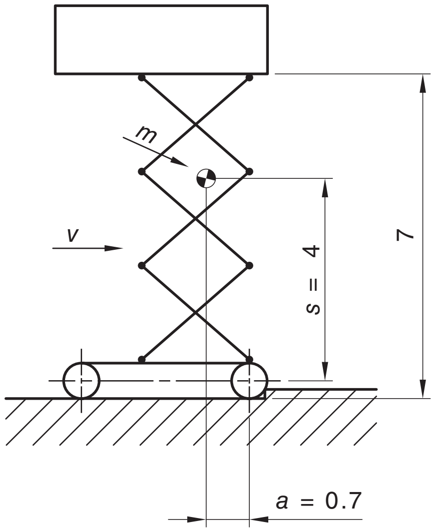


Figure D.1(A) — MEWP in front of obstacle

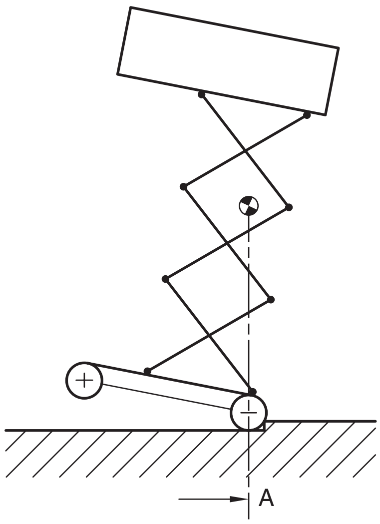


Figure D.1(B) — MEWP at obstacle

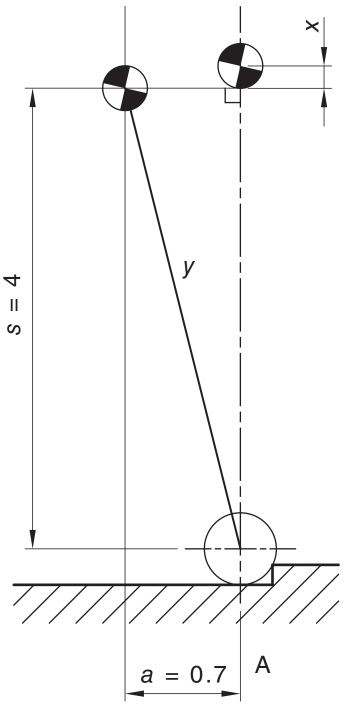
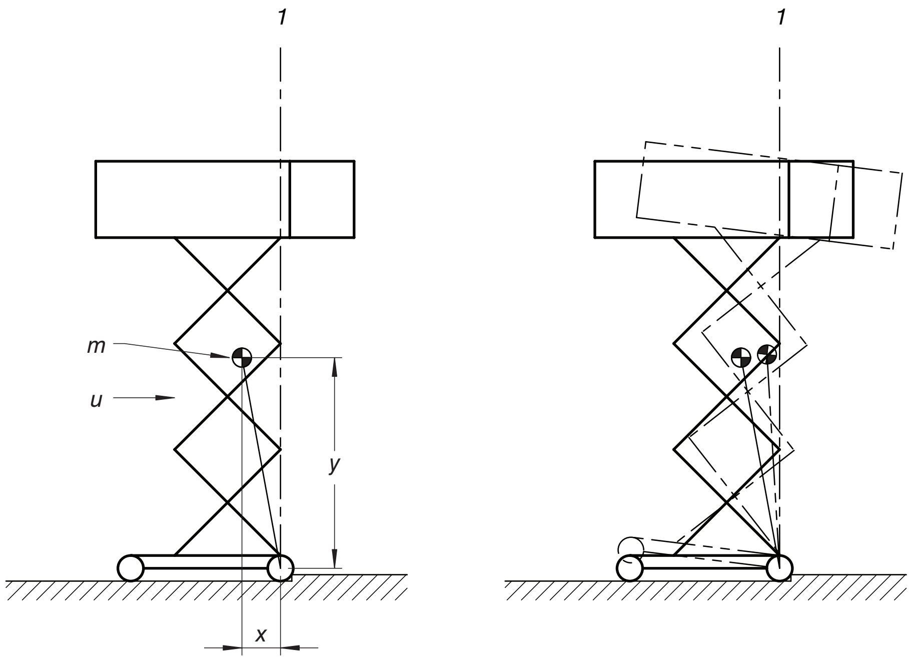


Figure D.1(C) — Potential energy

D.2 Calculation example 1 — z factor, kerb obstacle collision



Key

1 Tipping line

u Initial velocity of MEWP

m MEWP mass

x Horizontal distance of MEWP CoG from axle centre

y Vertical distance of MEWP CoG from axle centre

Figure D.2(A) — MEWP coming into contact with an obstacle

For a given initial velocity u, when the MEWP comes into contact with an obstruction (kerb) the kinetic energy will be converted to potential energy (assume a perfectly rigid structure and that no deformation occurs).

$$KE = \frac{1}{2} m u^2$$

$$PE = mgh$$

$$\frac{1}{2} m u^2 = mgh$$

Rearranging we have

$$h = \frac{u^2}{(2g)} \qquad \text{D.1}$$

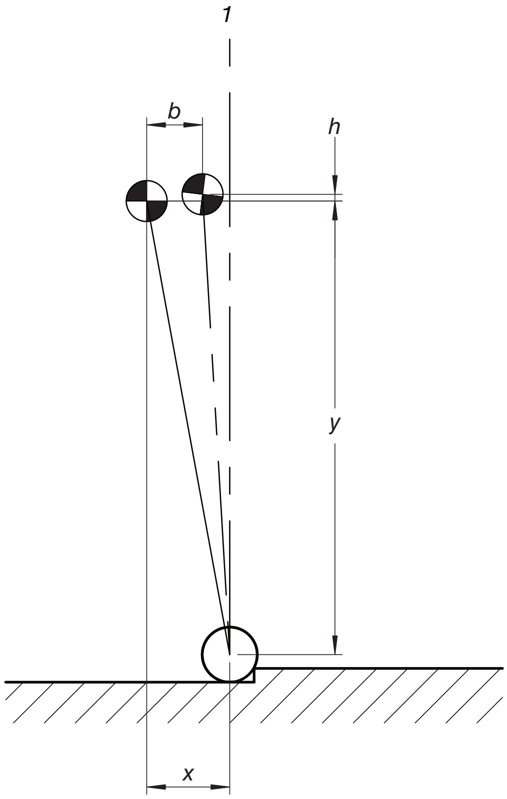
where

m = MEWP mass

u = initial velocity

g = gravitational acceleration (9.81 m/s^2)

h = change in height of the MEWP mass



Key

1 Tipping line

b Horizontal distance the MEWP CoG moves at impact

h Vertical distance the MEWP CoG moves at impact

x Horizontal distance of MEWP CoG from axle centre

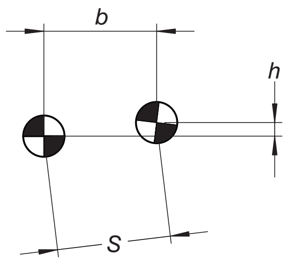
y Vertical distance of MEWP CoG from axle centre

Figure D.2(B) — Movement of mass during deceleration — Survey

From Figure D.2(B) we have the following geometric relationship:

$$b = x - \sqrt{\left\{x^2 + y^2 - (h + y)^2\right\}} \quad \text{D.2}$$

We can now calculate the distance the mass moves during the deceleration when the MEWP runs into the kerb.



Key

b Horizontal distance the MEWP mass moves at impact

h Vertical distance the MEWP mass moves at impact

s The distance the MEWP mass moves at impact

Figure D.2(C) — Movement of mass during deceleration — Details

To calculate the distance the MEWP mass moves at impact, use the following equation:

$$s = \sqrt{\left(h^2 + b^2\right)} \qquad \text{D.3}$$

Now using the equation of motion

$$v^2 = u^2 + 2as$$

where

v = final velocity

u = initial velocity

a = acceleration

s = displacement of the mass

Because the final velocity $v = 0$, and rearranging to make a the subject of the formula, we get:

$$a = \frac{-u^2}{(2 \times s)} \qquad \text{D.4}$$

The deceleration can be given in terms of z as follows: $a = -g \times z$ (see Clause 2.1.4.1.1) (the negative sign denotes that the MEWP is decelerating).

Where g is the gravitational acceleration (9.81 m/s^2).

Rearranging the equation and making the substitutions we have:

$$z = \frac{u^2}{(2 \times g \times s)} \qquad \text{D.5}$$

For example, if the initial velocity is 0.7 m/s and the mass CoG is fixed at x = 0.7 m and y = 4 m, from Equation (D.1) we obtain h:

$$h = \frac{0.7^2}{(2 \times 9.81)}$$

h = 0.024975 m

Now using the result of Equation (D.1) and substituting the values of x and y we obtain b:

$$b = 0.7 - \sqrt{\left\{\left(0.7^2 + 4^2\right) - \left(0.024975 + 4\right)^2\right\}}$$

b = 0.161837 m

And using Equation (D.3) we obtain s:

$$s = \sqrt{\left(h^2 + b^2\right)}$$

s = 0.163789 m

Using these results and Equation (D.5) we obtain z:

$$z = \frac{u^2}{\left(2 \times g \times s\right)}$$

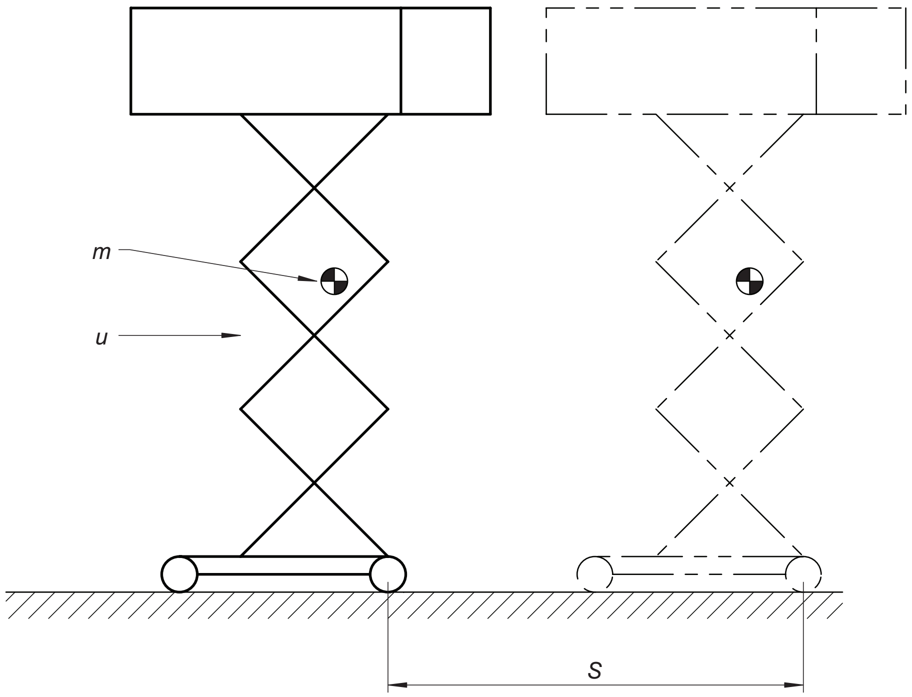
$$z = \frac{0.7^2}{\left(2 \times 9.81 \times 0.163789\right)}$$

z = 0.15248

The angle (to the horizontal) of the acceleration vector is given by:

$$\theta = \tan^{-1}\left(\frac{h}{b}\right) = 8.773°$$

D.3 Calculation example 2 — z factor, braking deceleration



Key

s Stopping distance (metres)

u Initial velocity (m/s)

m MEWP mass (kg)

Figure D.3 — Braking

Deceleration of MEWP under braking is given by: $v^2 = u^2 + 2as$.

Rearranging we obtain:

$$a = \frac{\left(v^2 - u^2\right)}{\left(2 \times s\right)}$$

If the final velocity $v = 0$ we have:

$$a = \frac{-u^2}{\left(2 \times s\right)}$$

where

a = deceleration of the MEWP under braking (m/s²)

v = final velocity of the MEWP (m/s) (in this case $v = 0$)

u = initial velocity of the MEWP for each configuration (m/s)

s = stopping distance (m)

Now the deceleration can be given in terms of z as follows: $a = -g \times z$ (see Clause 2.1.4.1.1) (the negative sign denotes that the MEWP is decelerating).

Where g is the gravitational acceleration (9.81 m/s²).

Rearranging the equation and making the substitutions we have:

$$z = \frac{u^2}{(2 \times g \times s)}$$

For example, if the MEWP is initially travelling at a velocity of 0.7 m/s and the stopping distance is 0.25 m the *z* factor is calculated as follows:

$$z = \frac{0.7^2}{(2 \times 9.81 \times 0.25)}$$

$$z = 0.1$$

Appendix E
(informative)

Use of MEWPs in wind speeds greater than 12.5 m/s (Beaufort scale 6)

Beaufort Scale 6 was adopted after discussing a number of previously existing Standards and the experience of users of MEWPs. A significant response from users was that Beaufort Scale 6 represented a natural limit at which operators became aware of the effects of wind speed and were reluctant to use the machines.

Higher wind speeds come into the category of "special loads and forces" (see Clause 2.1.4.4) and may be dealt with by the design allowing for the higher wind speeds [see Clause 4.2.1(k)].

Appendix F
(normative)

Tipping lines of MEWPs

F.1 General

This appendix designates tipping lines for various lifts of MEWPs.

Figures F.2.1, F.2.2, F.3 and F.4 are illustrative only. In practice, tipping lines are dependent on individual designs.

F.2 MEWPs on wheels (tyres)

F.2.1 MEWPs on wheels (tyres) without suspension or with the suspension locked (see Figure F.2.1)

The tipping line is the line joining the points of contact of the wheels. For axles mounted on twin tyres, the following two cases shall be taken into account:

(a) In cases where the axle is fixed or blocked, the point of contact of the outer wheel.

(b) In the case where the wheel is on a rocking axle, the pivot axis of this rocking axle.

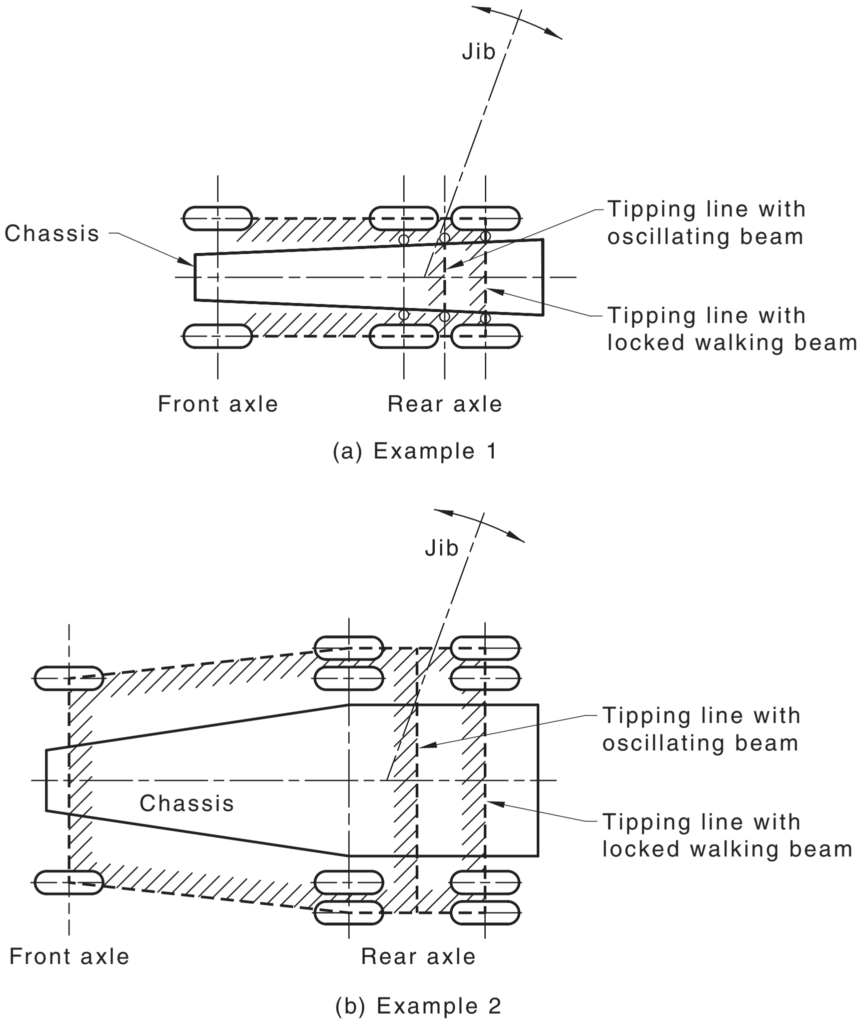


Figure F.2.1 — Tipping line without suspension, or with suspension locked

F.2.2 MEWPs on wheels with the suspension unlocked (see Figure F.2.2)

The tipping line is the line joining the points of application of the suspension.

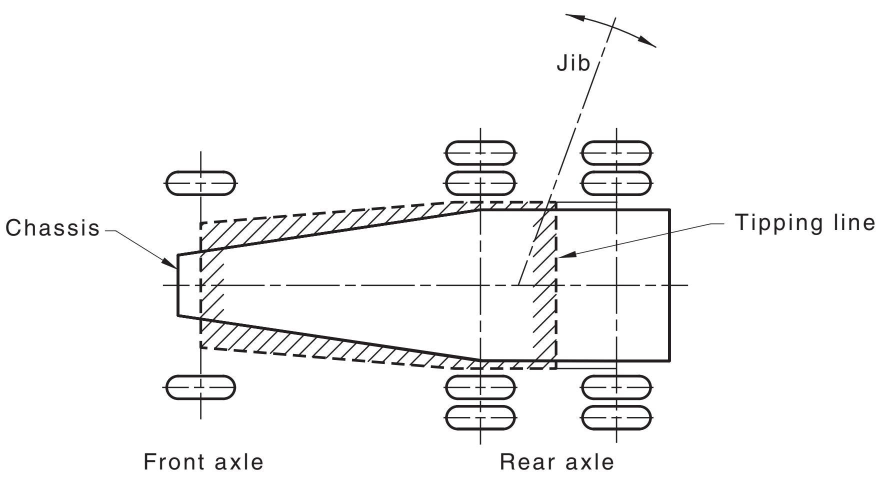


Figure F.2.2 — Tipping line with suspension unlocked

F.3 MEWPs on outriggers (see Figure F.3)

The tipping line is the line joining the centres of the support. If flexible supporting surfaces exist besides the outriggers (such as wheels with pneumatic tyres), then these shall be taken into account.

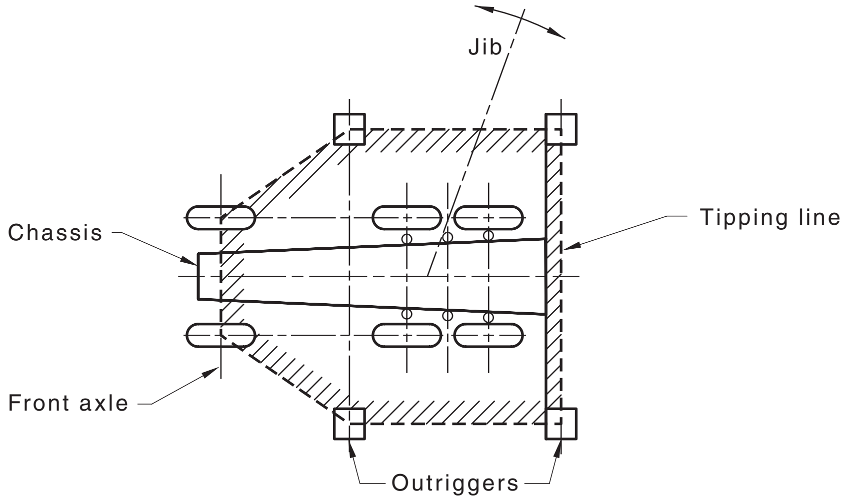
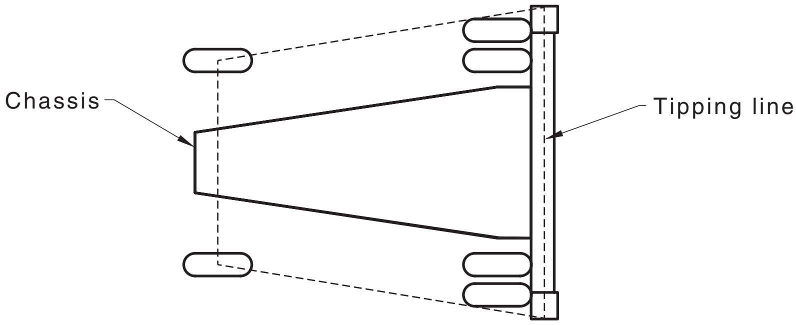


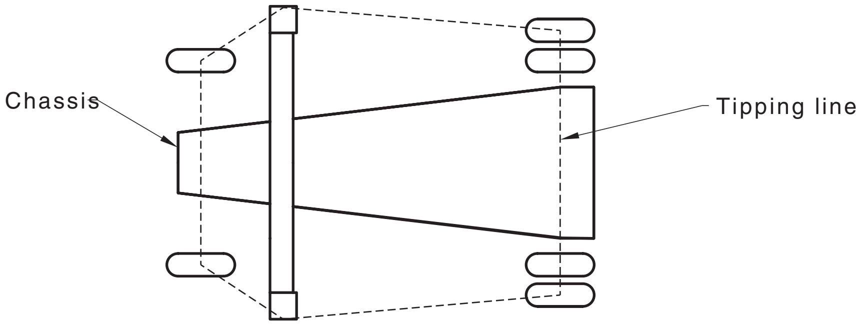
Figure F.3 — Tipping line on outriggers

F.4 MEWPs on outriggers and wheels

The tipping line is the line joining the centres of the support and the line joining the points of contact of the wheels [where the suspension is locked, see Figure F.4(A)] or the points of application of the suspension [where the suspension is unlocked, see Figure F.4(B)].

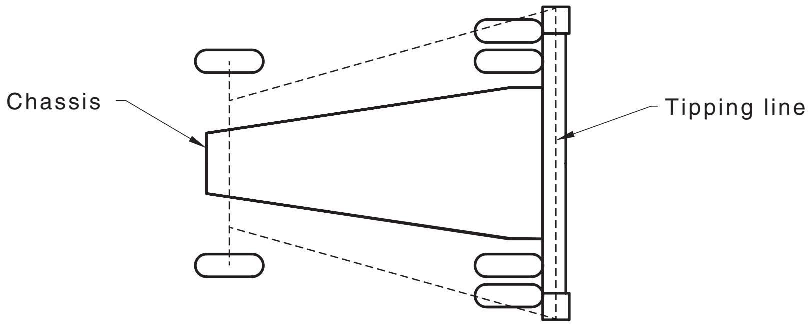


(a) Example 1

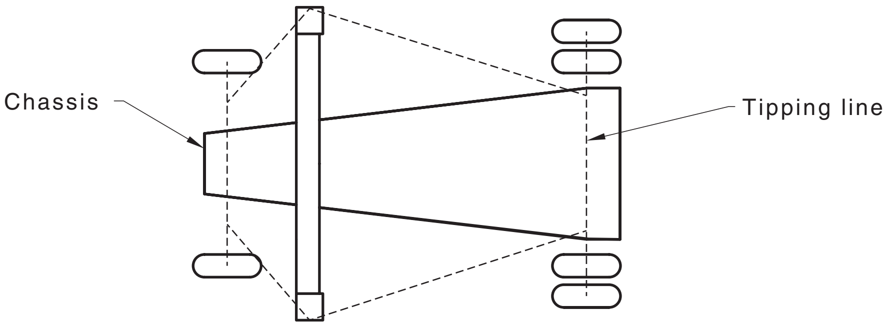


(b) Example 2

Figure F.4(A) — Tipping line with suspension locked — Licensed



(a) Example 1



(b) Example 2

Figure F.4(B) — Tipping line with suspension unlocked

Appendix G
(informative)

Instruction manual

G.1 General

The information in this appendix represents the minimum content that should be included in the instruction manual and considered for each of the relevant topics.

G.2 Operating instructions

G.2.1 Safe use

The operating instructions should give details for safe use, such as the following:

(a) Information on the characteristics and description of the MEWP, as well as on setting up the MEWP and its intended use.

(b) The necessary bearing strength of the ground.

(c) Location, purpose and use of all normal controls, emergency lowering and any emergency stop equipment.

(d) Prohibition of overloading the work platform.

(e) Prohibition of use as a crane.

(f) Adherence to national traffic regulations.

(g) Keeping clear of live electric conductors.

(h) Avoidance of contact with fixed objects (buildings, etc.) or moving objects (vehicles, cranes, etc.).

(i) Prohibition of any increase in reach or working height of the MEWP by use of additional equipment (e.g. ladders).

(j) Prohibition of any addition that would increase the wind loading on the MEWP, e.g. notice boards, banners, etc. (for exceptions, see Clause 2.1.4.4).

(k) Environmental limitations.

(l) Information on vibration.

(m) Noise level.

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

(o) Securing of removable guardrails.

(p) Prohibition or precautions regarding getting on and off the work platform when elevated.

(q) Precautions for travelling with the work platform elevated.

(r) Methods of securing the MEWP against unauthorized use.

(s) Minimum requirements or skills for MEWP operators.

(t) Chassis levelling and levelling limitations.

G.2.2 Transport, handling and storage

The operating instructions should provide transport, handling and storage information, such as the following:

(a) Any special provision for preparing and securing the MEWP for transport between places of use (e.g. free wheel).

(b) The method of loading onto other vehicles or vessels for transport between places of use, including lifting points, mass, centre of gravity, etc., for lifting purposes.

(c) Precautions to be taken before periods of storage indoors or outdoors.

(d) Checks to be made prior to use after periods of storage or exposure to extremes of ambient conditions such as heat, cold, moisture, dust, etc.

G.2.3 Commissioning

The operating instructions should provide commissioning information, such as —

(a) test reports;

(b) 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.); and

(c) for insulated MEWPs, acceptance test procedures.

G.2.4 Periodic examination and tests

The operating instructions should provide recommended periodic examinations or tests, such as the following:

(a) Pre-operational inspections.

(b) Periodic examinations and tests to be carried out according to the operating conditions and frequency of use.

(c) The content of periodic examinations and tests, that is —

  (i) a visual examination of the structure with special attention to corrosion and other damage of loadbearing parts and welds;

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

  (iii) applicable examination and test criterion;

  (iv) a test to prove the effectiveness of brakes or overload devices; and

  (v) functional tests (see Clause 3.6.5).

(d) The advice that the frequency and extent of periodic examinations and tests may also depend on national regulations.

(e) The design life as a number of operating hours or load cycles.

(f) Other items required to be inspected or replaced at the end of the design life.

(g) For insulated MEWPs, periodic insulation test procedures.

NOTE It is normally not necessary to dismantle parts at periodic examinations unless there are doubts in relation to reliability and safety. The removal of covers, the exposure of observation apertures, and bringing the MEWP to the transport position are not considered to be dismantling.

G.2.5 Maintenance

The operating instructions should provide maintenance information for use by trained personnel, such as the following:

(a) Technical information on the MEWP, including electric/hydraulic/pneumatic circuit diagrams.

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

(c) Safety features to be checked at specified intervals, including safety devices, load-holding actuators, overriding emergency devices, and any emergency stop equipment.

(d) Measures to be taken to ensure safety during maintenance.

(e) Checking for any dangerous deterioration (corrosion, cracking, abrasion, etc.).

(f) Criteria for method and frequency of examination and repair or replacement of parts, for example —

 (i) for wire rope drive systems, single wire ropes according to Clause 2.4.2.1.2, or first and second ropes in systems according to Clause 2.4.2.1.3, Items (a), (b) or (c), should be replaced when the limits of wear are detected in any one of those ropes, as indicated in ISO 4309, or as specified by the wire rope manufacturers;

 (ii) for chain drive systems, single chains according to Clause 2.4.3.2.2, or pairs of chains according to Clause 2.4.3.2.3, Items (a) or (b), should be replaced when the limits of wear indicated by the chain manufacturer are detected in any one of these chains; and

 (iii) other components should be included, if applicable (e.g. expected lifetime).

(g) The importance of using only approved replacement parts, particularly for load-supporting and safety-related components.

(h) The necessity of obtaining approval for any alteration that might affect stability, strength or performance.

(i) Parts requiring adjustment, including setting details.

(j) Any necessary tests or checks after maintenance to ensure safe operating conditions.

(k) Recommended procedures on routine cleaning and hydrophobic restoration of all insulation surfaces.

(l) A full maintenance schedule.

Appendix H
(normative)

Additional requirements for control systems using encoded data transmission techniques

H.1 General

This appendix applies to remote controllers used on MEWPs using encoded data transmissions communication. It is inclusive of systems using all media for data transmission, including but not limited to wireless, radio, infrared, laser, fibre optics and communication bus systems.

H.2 System design requirements

The system shall conform to the following requirements:

(a) The control system shall be fitted with a means of isolation.

(b) With any single fault occurring in the receiver or transmitter, it shall be possible to render the MEWP safe by operating the emergency stop or turning the key switch to “off”. The emergency stop system shall be protected against faults to Category 3 in accordance with AS 4024.1501 or ISO 13849-1 or SIL 2 in accordance with AS 62061. As minimum requirements, there shall be two individual decoders in the receiver, and redundant STOP outputs. Failure of either shall be detected and prevent system operation.

(c) Any of the following shall activate the emergency stop:

  (i) No valid signal being received for a period exceeding 550 ms, due to interference or other causes.

  (ii) Key switch to “off” position.

  (iii) Operation of the emergency stop actuator.

  (iv) Battery voltage below operating minimum.

(d) The system shall provide a transmission reliability to a hamming distance of the total number of bits in a frame divided by 20 and at least 4, or other means that ensure an equal level of reliability such that the probability of an erroneous frame getting through is less than 10^{-8}. The design shall provide protection from sources of interference such as arc welding, direct sunlight, electromagnetic fields or other control systems.

(e) Except where the data transmission medium is completely closed (e.g. single drop fibre optic system), each system shall have a unique address code that ensures that all data communication occurs only between the intended transmitter and receiver. The address code shall be protected against corruption. It shall not be changeable by a user, even with the use of tools. Each transmitter shall be fitted with an emergency stop.

(f) Where multiple control stations, cordless or otherwise, exist for the MEWP, they shall be arranged so that only one station is operative at any one time, and so that the overall safety of the MEWP is not adversely affected. An indicator shall identify which controller is active. Each controller shall operate in a transmission range without unwanted interference with each other. The lower control station shall be capable of isolating the other stations. For cordless systems, each station shall be labelled according to its location.

(g) Each control station shall be fitted with an emergency stop. All emergency-stop actuators shall be of the normally closed, positive-break type. Emergency-stop actuators on the MEWP shall remain active when in remote control mode.

(h) Where a battery is the power source for the transmitter or receiver a low battery warning signal shall be provided. The signal may be visible or audible, or both. This signal shall indicate to the operator, at least 10 min prior to the battery output voltage falling below its operating minimum level, that the control system is about to shut down, giving the operator sufficient time to make safe current operations and change over batteries. The low battery shall not cause any unintended transmission to occur.

(i) The control system shall incorporate sufficient logic such that, unless all motion and function enable controls are in the off position on start-up, there shall be no command output. All motion commands on the controller shall require activation of a second separate function enable control.

NOTE The system should not rely on a proportional signal alone to generate a motion command.

(j) All cordless transmitters shall be protected to a minimum of IP65 to AS 60529.

(k) Unless otherwise specified the control system shall remain active even when unused for a period of time.

(l) Where observer remote control is used or remote control is not used in a designated position, a means of allowing the operator to carry the remote shall be provided in the form of a shoulder strap or belt.

(m) The receiver shall withstand the vibration, random wide band test specified in AS 60068.2.64.

H.3 Risk assessment

An assessment about the safety risk of a machine that is remotely controlled shall be made prior to commissioning and acceptance. This assessment shall give an indication of the safety importance of the control function concerned and determine the relative attention that shall be paid to its design specification operability, maintenance and training in use.

NOTE AS 4024.1301 provides guidance on safety of machinery risk assessment.

H.4 Construction

All controllers shall be capable of withstanding a free vertical fall of 1 m onto a rigid steel surface without the inadvertent starting or preventing the stopping of any control function.

H.5 Covers, guards and enclosures

Control stations shall be adequately enclosed, guarded or otherwise protected from damage or inadvertent operation. The control levers on the basket control shall be 50 mm below the level of the rim of the basket or enclosure. Control levers on auxiliary or portable control stations shall be protected by a guardrail that is integral with the enclosure.

H.6 Instructions

The control system shall be supplied with the following information in English:

(a) The manufacturer’s trademark, model information and contact details.

(b) Specifications for the control system. For radio systems, the applicable licence, the recommended operating range, frequency and bandwidth used shall be supplied.

(c) Any precautions and approvals necessary for the fixing, safe use and operation of the remote control.

(d) Instructions for operation.

(e) Maintenance and care instructions.

(f) Power supply requirements, including rechargeable batteries.

(g) Electrical wiring diagrams for installation, transmitter and receiver.

(h) Special environmental requirements (e.g. electromagnetic interference, radio-frequency interference limitations, and temperature and humidity, where appropriate).

(i) Safeguards and procedures to ensure non-interference with adjacent equipment.

Appendix I
(informative)

Commentary on design safety requirements for orchard MEWPs

I.1 Introduction

MEWPs were first introduced to orchards in the late 1960s to lift workers to pick fruit and maintain orchard trees. The risk environment, work functions and priorities of orchards differ from those of general industry. This combination of factors has led to the parallel evolution of specialist orchard MEWPs.

Ladders have historically provided the solution to gaining a height advantage in orchards.

However, ladders expose orchard workers to the risk of fall and strain injury, particularly when working on slopes. MEWPs are inherently safer due to their increased stability. The risk of strain injury is reduced because the heavy picking bag is carried on the MEWP.

Growers report that the increased use of MEWPs in orchards has enabled experienced and reliable orchard workers, and more women, to be retained. This has been advantageous because the large workforce required to work orchards by ladder is increasingly difficult to attract.

Orchard MEWPs covered by this document provide for one person only on the platform. The majority of orchard MEWPs are boom-type on a two-wheel drive axle and castor wheel.

Variants have evolved with additional drive wheels, steer axles, and layouts to improve access and stability. Orchard MEWPs vary in lift height and character across growing areas and climates. Stone fruit and citrus orchards typically employ orchard MEWPs with a lift height of 2.4 m to 4.5 m. Avocado orchards employ MEWPs with a lift height 5.5 m to 8.0 m.

Growers maintain that MEWPs are now essential to the economic well-being of orchards due to their inherent efficiency and improved safety. The continued active involvement by the horticulture community in the development of design Standards and safe work practices will ensure that orchard MEWPs continue to evolve as functional, relatively low-cost machines that are readily maintained in the rural community.

I.2 Essential characters of orchard MEWPs

I.2.1 Controls

Orchard MEWPs are production machines. As an example, operators in one growing district pick over 12 000 avocados on average in a day. The operators need both hands to pick and comb through foliage to access fruit. The operator typically repositions the platform over 4000 times in a shift.

Foot controls have been developed to provide the necessary efficiency so that both hands are free for picking (no function enable control). The function enable hand controls typical of an industrial MEWP are not suited to this operation.

Alternative solutions have evolved to control the risk of unintentional operation of controls, including the following:

(a) The operator stands directly on the foot controls at all times. The controls are therefore shielded from unintentional operation.

(b) The risk of an unauthorized person stepping on to the MEWP and operating the controls accidentally has been eliminated by the requirement that the controls are to be automatically deactivated when the operator steps off the platform and reset by the operator using a separate hand control.

NOTE Deactivating controls includes the option of stopping the engine or otherwise isolating power.

(c) Simple orchard MEWPs are typically controlled by cable-operated spring-return fullflow control valves. These controls are recognized as reliable and not prone to faulty operation.

This appendix covers only foot controls. Where hand controls are employed, the provisions of the main Standard to prevent unintended operation should be employed.

I.2.2 Platform guardrail

The Committee considered raising the minimum guardrail height requirement for MEWPs from 950 mm to 1.1 m to align with recognized MEWP Standards ISO 16368 and EN 280.

While the initiative did not proceed, it should be noted that raising the guardrail height would have a detrimental effect on the orchard operations.

Manufacturers and operators have demonstrated that persons picking from orchard MEWPs need to lower their arms regularly to minimize fatigue. The natural low-fatigue position is with upper arms vertical and forearms parallel to the ground. Raising the guardrail height of orchard MEWPs would put most workers at high risk of striking their elbows on the guardrail when returning to this position. Continuous contact of elbows on the guardrail is known to cause painful bruising that can prevent operators from continuing to work. To prevent this injury, the operator’s elbows need to be clear of the guardrail when the upper arms are returned to the vertical position.

Problems have been reported with orchard MEWPs exported to Europe with the guardrails set at 1.1 m. Operators were unable to pick efficiently and reported fatigue because they were unable to readily lower their upper arms.

Most orchard MEWP operators in Australia and New Zealand clear the guardrail with their elbows when the guardrail is set at a height of 950 mm. However; operators from orchard communities originating from southern Europe report that the guardrail height at 950 mm is too high for their shorter stature. They report that operators are injured by constant impact of their elbows on the top guardrail and have requested that the minimum guardrail height be reduced to 900 mm. The minimum guardrail height for orchard MEWPs has been reduced to 900 mm to provide for this exception.

Falling over the guardrail has not been reported as a cause of injury. The top guardrail maximum internal clearance is limited to 0.65 m^2 and tends to hold the operator in position when moving, reducing the risk of the operator overbalancing and falling.

I.2.3 Operation on slopes

Specially designed orchard MEWPs can operate safely on slopes up to 15 degrees. The operator is not at risk at increased inclination because he or she is confined by the padded top guardrail and automatically leans against the confined guardrail to compensate for the slope. The inclination limit of an orchard MEWP is established by the manufacturer by proving satisfactory performance in the stability and dynamic performance tests.

Orchard MEWPs are required to sound an alarm once the stability limit has been reached and are not required to limit motion. This approach was arrived at because of the risk of destabilizing an orchard MEWP if it was caused to come to a stop while travelling on a steeper slope, and because devices that can detect the inclination limit satisfactorily are not available.

Simple on-off inclination switches have previously been used on orchard MEWPs to initiate the inclination alarm, but they are generally not effective and cause nuisance initiations. The stability of an orchard MEWP is increased as the operator’s platform is lowered. For a simple boom-type MEWP, lowering the platform is the only function available to the operator on the platform to improve stability. However, a simple on-off inclination switch cannot be arranged to reset when the platform has been lowered and the MEWP is again within the inclination limit.

A programmable inclination monitor is required, which recognizes the “inclination limit vs. platform height” envelope for the particular MEWP. The programmable inclination monitor would be arranged to switch when the MEWP chassis has reached the inclination limit for the current platform lift height, and then reset when the platform is lowered to bring the MEWP back within the stability envelope.

Orchard MEWPs are normally more stable fore-aft than lateral and have been known to travel up and down a slope safely and then roll over when the platform is steered across the slope without first lowering the platform to improve stability. This risk will not be totally controlled with the new inclination monitor. It can be shown that the inclination monitor will require a time delay in responding to excess inclination to prevent nuisance operation (up to two cycles at the natural oscillation frequency of the MEWP). If the MEWP were driven up or down the slope and steered quickly across the slope, the MEWP could become unstable before the inclination monitor was able to respond.

I.2.4 Load and moment monitoring

Clause 2.3.1 exempts MEWPs with limited platform dimensions from the requirement for load- and moment-sensing systems. Clause 5.2.7 references equivalent dimensional criteria for orchard MEWPs.

Orchard MEWPs meeting the platform and fruit bag dimension criteria are exempt from the requirement for load- and moment-sensing systems provided the stability test is carried out at 150 % of the rated capacity as described in Clause 2.3.1.

I.2.5 Fall-arrest system

The risk of the operator being ejected due to component failure is controlled by a requirement for the levelling system of orchard MEWPs to be designed to take twice the imposed load and incorporate maintenance-free pins and bearings (see Clause 5.2.8).

Fall-arrest harnesses are generally required on boom-type MEWPs because of catapult effect. The long booms of industrial MEWPs are known to whip the platform if the drive wheels contact an obstacle or fall into a depression, causing the operator to be ejected. However, orchard MEWPs generally employ short, less flexible booms with the platform close to the drive wheels, and the catapult effect is greatly diminished as a result.

AS 2550.10 provides guidance on determining the risk to a person being ejected from the platform. The travel speed, operating height, natural frequency of the MEWP, proximity of structures that may catch on the harness or lanyard, and the slope and unevenness of the ground should be considered. The “kerb and depression” test described in Clause 3.6.3.2.2 is a recognized test, which may be suitable to determine whether a MEWP displays catapult effect. The test may need to be carried out at various platform heights. The standard kerb and depression height of 100 mm may be increased to 150 mm to represent conditions that are more demanding. A test dummy may be required to prevent injury to an operator.

I.2.6 Access gate in the top guardrail

The orchard MEWP Standard has modified the general requirements for MEWPs by prohibiting access gates in the top guardrail. This action has been taken due to a number of incidences being reported where the operator has fallen through an open gate aperture. The gates are reported to have opened by action of tree branches or to have been left open by the operator.

In contrast, the New Zealand orchard MEWP Standard has prohibited gates in the top guardrail for many years, thus avoiding such accidents.

I.2.7 Travel speeds in the elevated position

The travel speed of self-propelled MEWPs in the elevated position is limited to 0.4 m/s, specified in Clause 2.2.14. Orchard MEWPs with lift height 6.5 m and below are permitted an increased travel speed based on height range.

From a dynamic performance perspective, the speed limit is redundant, as all MEWPs are required to pass the full range of braking tests and dynamic stability tests at full speed. The speed limit may have been applied for general MEWPs to reduce the risk of collision when working around industrial sites. Orchard MEWPs are not exposed to the same risk of collision. Orchard MEWPs typically move every few seconds during most work operations and, therefore, ground personnel are not permitted to work in the vicinity. Further, the consequence of colliding with an orchard tree is considerably less than the consequence of colliding with a hard building surface.

I.2.8 Travel speed in the lowered travel position

In some applications, orchard MEWPs are required to travel considerable distances to the work site or to transport fruit back to base. These MEWPs typically need to travel at increased speed with the operator platform around 1.5 m above ground so that the platform is not at risk of impacting the ground. This position is known as the “lowered travel position” and is a defined term.

An additional test requirement has been added at Clause 5.2.5.2 to provide assurance that the operator is not at risk of being catapulted from the platform at the increased speed allowed in the lowered travel position.

I.2.9 Mass of an operator

The mass provision for the operator on an orchard MEWP has been increased from the general provision of 80 kg to 100 kg. The increase was in response to grower concern that orchard MEWPs designed for an 80 kg operator are at risk of being overloaded when heavy build operators are employed.

I.2.10 Travel and lift controls used concurrently

MEWP standard EN 280 requires that MEWPs be designed to prevent travel controls and lift controls being used concurrently.

Orchard MEWP operators typically reposition the platform up to 4000 times in one shift to access and pick fruit. Concurrent operation of lift and travel controls is essential to provide for efficient operation.

Appendix J
(normative)

Electrical test reports

The electrical test results shall be contained in a formal test report. The report shall list the following:

(a) The testing organization and the testing officer.

(b) The testing location and the date of the test.

(c) Clear identification of the MEWP being tested, the vehicle on which it is mounted and this document.

(d) Details of the MEWP configuration during the test and, for an electrical test, of any temporary electrodes used, including photos or sketches of critical test configurations.

(e) A brief description of the test, any test equipment and, for an electrical test, the test circuit.

(f) The test results, which shall include the values of the test measurements and their uncertainties, the formal result of the test (satisfactory or unsatisfactory) and any relevant comments.

(g) Conditions imposed on the operator or owner, which shall be conformed to for the certification to remain valid.

(h) Calibration dates for the test equipment.

NOTE 1 Such conditions will normally be restricted to the replacement or repair of signs etc.

NOTE 2 Examples of insulation inspection and test report pro forma are shown in this appendix. See Figures J(A) to J(D).

INSULATION ACCEPTANCE TESTS

TEST REPORT NUMBER: ....

DETAILS OF TESTING ORGANIZATION:

Name: ....

Address: ....

Telephone: .... Fax: ....

Test Location: .... Test Date: ....

CLIENT DETAILS:

Name: ....

Address: ....

Telephone: .... Fax: ....

MEWP DETAILS:

Make/Model: .... Serial Number: ....

Description:..

Registration Number: .... Asset Number: ....

Liner serial Number: .... MEWP Category: ....

Telescopic: ☐ Articulated: ☐ Fly-boom: ☐

RATING:

Condition	**Upper insert (kV)**	**Chassis insulation (kV)**	**Basket (kV)**	
			Without liner	**With liner**
Dry				
Wet				
Rain				

CONCLUSION:

PASS ☐ FAIL ☐

☐ The above model MEWP complies with the test requirements specified in AS 1418.10

Testing Officer: .... Signature: .... Date: ....

NEXT DUE TEST DATE:

NOTES: (if additional space is required attach separate pages.)

Figure J(A) — Insulation acceptance test report

Ref. Clause	Test		Result	Pass	Fail
7.9.3	Dry insert insulation resistance (IR)/ Withstand	Boom	MΩ kV		
7.9.3	Dry insert IR/Withstand	Chassis	MΩ kV		
7.9.4	Dry total leakage current	Boom	kV mA		
7.9.4	Dry total leakage current	Chassis	kV mA		
7.9.5	Boom insert surface leakage		kV µA		
7.9.6	Low-voltage insulating covering		kV		
7.9.7	Basket vertical withstand		kV		
7.9.8	Basket puncture		kV		
7.9.9	HV insulating basket liner/Basket		kV		
7.9.11	Wet insert IR/Withstand	Boom	MΩ Maximum mA Minimum mA		
7.9.11	Wet insert IR/Withstand	Chassis	MΩ Maximum mA Minimum mA		
7.9.12	Wet basket vertical withstand		kV		
7.9.13	Corrected precipitation/Rain insert IR/Withstand	Boom	MΩ Maximum mA Minimum mA		
7.9.13	Corrected precipitation/Rain insert IR/Withstand	Chassis	MΩ Maximum mA Minimum mA		
7.9.14	Rain vertical withstand basket		kV		
7.9.16 and 7.9.17	Insulation marking verified				

Ambient temperature (°C): ....

Relative humidity (%): ....

Water resistivity (Ωm): ....

Water conductivity (µS/cm): ....

Earth resistance (Ω): ....

Test equipment details: ....

Description: ....

Serial Number: ....

Recalibration due date: ....

Attach boom configuration details and photos (or sketch) of acceptance tests here:

Figure J(B) — Insulation acceptance test report cont

PERIODIC INSULATION TEST REPORT

TEST REPORT NUMBER: ....

DETAILS OF TESTING ORGANIZATION:

Name: ....

Address: ....

Telephone: .... Fax: ....

Test Location: .... Test Date: ....

CLIENT DETAILS:

Name: ....

Address: ....

Telephone: .... Fax: ....

MEWP DETAILS:

Make/Model: .... Serial Number: ....

Description:..

Registration Number: .... Asset Number: ....

Liner serial Number: .... MEWP Category: ....

Telescopic: ☐ Articulated: ☐ Fly-boom: ☐

RATING:

Condition	**Upper insert (kV)**	**Chassis insulation (kV)**	**Basket (kV)**	
			Without liner	**With liner**
Dry				
Wet				
Rain				

CONCLUSION:

PASS ☐ FAIL ☐

☐ The above model MEWP complies with the test requirements specified in AS 1418.10

Testing Officer: .... Signature: .... Date: ....

NEXT DUE TEST DATE:

NOTES: (if additional space is required attach separate pages.)

Figure J(C) — Periodic insulation test report

Ref. Paragraph/ Clause	Test		Result		Pass	Fail
M4.2, App. M	Dry insert IR/Withstand	Boom	MΩ	kV		
M4.2, App. M	Dry insert IR/Withstand	Chassis	MΩ	kV		
M4.3, App. M	Dry leakage current	Chassis	kV	mA		
M4.4.2, App. M	Dry leakage current Category C	Boom	kV	μA		
M4.4.3, App. M	Dry leakage current d.c.	Boom	kV	μA		
M4.4.4, App. M	Surface leakage test	Boom	kV	μA		
M4.5, App. M	Low-voltage covering test			kV		
M4.6, App. M	Basket vertical withstand test			kV		
M4.7, App. M	Basket puncture			kV		
M4.8, App. M	HV insulating basket liner/Basket			kV		
M4.10, App. M	Wet insert IR/Withstand	Boom		MΩ Maximum mA Minimum mA		
M4.10, App. M	Wet insert IR/Withstand	Chassis		MΩ Maximum mA Minimum mA		
M4.11, App. M	Wet basket vertical withstand			kV		
7.9.16 and 7.9.17	Insulation marking verified					

Ambient temperature (°C): ....

Relative humidity (%): ....

Water resistivity (Ωm): ....

Water conductivity (μS/cm): ....

Earth resistance (Ω): ....

Test equipment details: ....

Description: ....

Serial Number: ....

Recalibration due date: ....

Signature of owner or owner's representative: .... Date: ....

In signing this certificate, the owner or his representative acknowledges that the conditions specified above have been explained and will be complied with during the subsequent operating period.

Test by: .... Date of test: .... Locations: ....

Figure J(D) — Periodic insulation test report cont

Appendix K
(normative)

MEWP insert selection

Table K(A) provides a method for the selection of MEWPs with appropriate electrical insulating ratings for various applications. Table K(B) sets out a schedule of acceptance tests.

Table K(A) — MEWP insert selection

Insert design objective	Adverse environmental condition	Activity examples	Risk control			Wet test method
			Identified risk	Workplace instructions	Residual risk	
Suitable for inadvertent HV contact when dry	Inserts are dry after long exposure to dry weather conditions, apparatus housed indoors	HV live working or close approach tree trimming, special work indoors	Inadvertent contact of inserts or trees contacting with HV	Work does not start or resume after rain or exposure to moisture, etc.	Risk managed by insulation system design Reference should be made to operational instructions or procedures, or administrative control	Dry HV
Suitable for inadvertent HV contact when wet[a]	Inserts may be wet following rain	HV live working or close approach tree trimming	Inadvertent contact of wet inserts or trees contacting with HV	Work starts or resumes after rain, etc.	Risk managed by insulation system design Risk managed by insert design Phase-to-phase risk not controlled (wet covers)	Wet HV[b]
Suitable for work on live LV when wet		Storm recovery work (e.g. live LV work or HV switching)	Risk of inadvertent contact with LV and HV	Work starts or resumes after rain (Note 1)	Risk of inadvertent contact with HV not managed by insert design Reference should be made to operational instructions or procedures or administrative control Hot sticks or gloves shall be "wet capable" Phase-to-phase risk not controlled (wet covers)	Wet LV[b]
Suitable for live LV work when raining	Raining	Storm recovery work on live LV	Risk of inadvertent contact with LV or HV	Keep clear of HVLV gloves shall be "wet capable"	Risk of inadvertent contact with HV not managed by insert design Reference should be made to operational instructions or procedures for administrative control Phase to phase risk not controlled (wet covers)	Rain LV
Suitable for inadvertent HV contact during rain (optional)		Storm recovery work (e.g. live LV or HV switching)	Risk of inadvertent contact with HV	Work continues during rain Hot sticks or gloves shall be "wet capable"	Risk managed by insulation system design. Reference should be made to operational instructions or procedures or administrative controls where the rating differs from the maximum system voltage specified by the purchaser[c] Phase-to-phase risk not controlled (wet covers)	Rain HV

Table K(A) *(continued)*

Insert design objective	Adverse environmental condition	Activity examples	Risk control			Wet test method
			Identified risk	Workplace instructions	Residual risk	

a Examples include a wet MEWP, driven through rain or wet roads, following a downpour but do not include moisture accumulation due to “fogging”. However, water droplets do not form into a continuous conducting path along any longitudinal crevices or cavities and the surface condition conforms to WC1 to WC2.

b At test voltages appropriate to the HV or LV design.

c Some MEWP designs present a greater risk of inadvertent contact.

Table K(B) is a summary of acceptable tests.

Table K(B) — Schedule of aceptance tests

Clause Ref.	Test		Class					
			Dry LV	Wet LV	Rain LV	Dry HV	Wet HV	Rain HV
7.9.3	Dry insert insulation (IR)/Withstand	Boom	a b	a b	a b	a	a	a
7.9.3	Dry insert IR/Withstand	Chassis	a b	a b	a b	a	a	a
7.9.4	Dry combined leakage current	Boom	a b	a b	a b	a	a	a
7.9.4	Dry combined leakage current	Chassis	a	a	a	a	a	a
7.9.5	Boom insert surface leakage					a b, c	a b, c	a b, c
7.9.6	Low-voltage covering			a	a	a	a	a
7.9.7	Basket vertical withstand		a b	a b	a b	a	a	a
7.9.8	Basket puncture		a b	a b	a	a	a	a
7.9.9	HV insulating basket liner/Basket					a b	a b	a b
7.9.11	Wet insert IR/withstand	Boom		a b			a	
7.9.11	Wet insert IR/withstand	Chassis		a b			a	
7.9.12	Wet basket vertical withstand						a	
7.9.13	Rain insert IR/withstand	Boom			a b			a
7.9.13	Rain insert IR/withstand	Chassis			a b			a
7.9.14	Rain vertical withstand	Basket			a			a

[a] Mandatory test to verify class.

[b] If applicable.

[c] A surface leakage test according to Clause 7.9.5 or a total leakage Category C test according to Clause 7.9.4 (for Category C vehicles), or a d.c. test according to Clause M.4.4.3, shall be undertaken prior to placing the MEWP into service.

Appendix L
(informative)

List of electrical hazards

The hazards listed in Table L and illustrated in Figure L.1 have been identified by a risk assessment procedure and the corresponding requirements formulated. The table, together with the insert selection procedure in Appendix K, lists residual risks and suggested procedures that should be addressed by the development of work procedures.

Table L — List of electrical hazards associated with insulated MEWPs

No.	Hazard	Specified risk control measures (Clause)		Residual	Recommended residual controls
1	**Primary preventative measures**				
1.1	Excess movement of mains or earthed media				Work procedure/PPE[a]
1.2	Use near voltages greater than insulation rating	7.3 7.9.16, 7.9.17	Insulation rating Insulation marking	Use on networks at higher than rated voltage —	Select MEWP insulation rating appropriate to the network voltage
1.2	Use in adverse environmental conditions	7.1.3 7.1.4 7.9.16 7.9.17	Use Insulation rating Insulation marking Insulation rating labels	Improper use — —	Training and procedures[b] Select MEWP insulation rating appropriate to or the configuration applicable to the anticipated environmental conditions
1.3	Close approach due to excessive deflection	7.8.9 7.8.10	Vertical deflection limits Lateral deflection limits	Breach of clearances Breach of clearances	Work procedure/PPE Work procedure/PPE
1.3	Close approach due to control system failure	7.8.6 2.10	Emergency stop controls Controls Controls and indicators	Failure of E stop Failure of E stop or power on control	Maintenance/Test Maintenance/Test
1.4	Structural failure	7.1.5	Materials and construction	Material deterioration	Maintenance and inspection
1.5	Electrical insulation breakdown	7.1.5 7.9	Materials and construction Insulation testing Test schedule Certification	Material deterioration — — —	Maintenance and inspection
2	**Operator injured due to phase-to-earth fault through MEWP [Figure L1(a)]**				

Table L *(continued)*

No.	Hazard	Specified risk control measures (Clause)		Residual	Recommended residual controls
2.1	Proximity to HV at rated voltage	7.2.1(b), 7.5	Boom insulator Insulation inserts	Use on networks at higher than rated voltage Maintenance	Select MEWP insulation rating appropriate to the network voltage
2.1	Proximity to HV at rated voltage	7.2.1(b)	Boom insulator	Use on networks at higher than rated voltage	Select MEWP insulation rating appropriate to the network voltage
2.2	Dielectric breakdown	Clauses 7.9.3 / M.4.2 Clauses 7.9.4 / M.4.4 7.9.5	Insert withstand test Surface leakage	Contamination or degradation Contamination or degradation	Maintenance Maintenance of insulator surfaces
2.2.1	Formation of vacuum	7.8.8 7.9.3	Vacuum exclusion Insert withstand test	Failure of system —	Periodic tests Periodic tests
2.2	Dielectric breakdown due to surface condition	7.9.10 / M.4.9	Hydrophobicity test	—	Maintenance of insulator surface
2.2.3	Dielectric breakdown due to dampness	7.5 7.9.11 / M.4.10	Insulation inserts Wet test	Contamination or degradation —	Maintenance Maintenance of insulator surfaces
2.2.4	Dielectric breakdown during storm recovery work	7.9.13 / M.4.10	Rain test	—	
2.3	Capacitive effects	7.9.4	Total leakage test	—	—
2.4	LV	7.2.1(a) 7.4 7.6	Cover insulation LV platforms LV cover	Contamination or degradation — Contamination or degradation	Maintenance Maintenance Periodic test
2.5	Dielectric breakdown due to damp condition	7.9.6 7.9.6 7.9.11	LV cover test LV cover test Wet test	— — —	Maintenance Maintenance Maintenance of insulator surfaces
3	**Operator injured due to phase-to-phase or phase-to-earth fault across basket [Figure L1(b)]**				
3.1	Contact with HV > 33 kV	7.9.16	Insulation marking	Uncontrolled	Selection of MEWP configuration to minimize risk of contact Work procedures

Table L *(continued)*

No.	Hazard	Specified risk control measures (Clause)		Residual	Recommended residual controls
3.2	HV < 33 kV	7.3 7.6	Insulated baskets Cover insulation	Exposure above 33 kV —	Work procedure[c] —
3.3	Dielectric breakdown due to surface condition	7.9.7 / M.4.6	Basket vertical surface test	Use of tools that reduce insulation in basket	Work procedure
3.4	Dielectric breakdown wall puncture	7.9.8 / M.4.7 7.9.9 / M.4.8	Basket wall puncture test Basket liner test	— —	— —
3.5	Dielectric breakdown due to dampness	7.9.12 / M.4.11	Wet basket test	—	—
3.6	Dielectric breakdown during storm recovery work	7.9.14	Rain basket test	—	—
3.7	LV	7.2.1 7.6	Basket or platforms Cover insulation	—	—
3.8	Fire in basket	7.3.1 Clauses 7.8.5, 7.8.6	Fire-retardant basket Emergency stop containment of hoses	Not fully controlled —	— Operator training[d]
3.9	Boom collapse as a result of fire	7.5.2 7.8.5	Smooth surfaces Hydraulic hoses location	Not fully controlled —	— —
4	**Crew at ground level injured phase-to-earth fault [Figure L1(c)]**				
4.1	MEWP contact with STV > 33 kV	Clauses 7.9.16, 7.8.4	Insulation marking Earth connection	Uncontrolled Contact with live vehicle	Selection of MEWP configuration to minimize risk of contact[e] Work procedure
4.2	MEWP contact with PDV < 33 kV [Figure L1(e)]	7.2.2 7.8.4 7.9.16	Chassis insulation below 7.5 m Earth connection Insulation marking	Uncontrolled area between 4.5 m and 7.5 m Not fully controlled —	Selection of MEWP configuration to reduce risk of contact[f] Earth vehicle Operator training
4.3	Bridging chassis insulation system [Figure L1(d)]		Dependent on configuration	Not fully controlled	Training Work procedure
4.4	Dielectric breakdown	7.9.3 / M.4.2 7.9.4 / M.4.4 7.9.5	Insert withstand test Surface leakage	Contamination or degradation Contamination or degradation	Maintenance Maintenance of insulator surfaces

Table L *(continued)*

No.	Hazard	Specified risk control measures (Clause)		Residual	Recommended residual controls
4.4.1	Dielectric breakdown due to surface condition	7.9.10 / M.4.9	Hydrophobicity test	—	Maintenance of insulator surfaces
4.4.2	Dielectric breakdown due to dampness	7.5 7.9.11	Insulation inserts Wet test	Contamination or degradation or wet covers Wet cover insulation	Maintenance Maintenance of insulator surfaces
4.4.3	Dielectric breakdown during storm recovery work	7.9.13 / M.4.10	Rain test	—	See Item 1.2
4.4.4	Capacitive effects	7.9.4	Total leakage test	—	—
4.5	LV	7.2.1(a) 7.4 7.6	Cover insulation LV platforms LV covers	Contamination or degradation or wet covers — —	Maintenance Maintenance Maintenance
4.6	Dielectric breakdown	7.9.6 / M.4.5	LV cover test	—	Periodic test
5	**Crew at ground level injured phase-to-phase or local phase-to-earth fault [Figure L1(f)]**				
5.1	HV > 33 kV	7.2.1(b)	Location of boom insulation	Uncontrolled	Work procedure
5.2	HV > 33 kV	7.2.1(b)	Location of boom insulation	Not fully controlled (location of insert and wet covers)	Work procedureg
5.3	LV	7.6	LV cover above 4.5 m	—	—
5.4	Fire	7.8.6	E stops	Not fully controlled	Provide fire extinguisher on vehicle
5.5	Hydraulic line failure	7.8.5 7.8.6	Hydraulic hose location Emergency stops	— —	— —
6	**Public injured phase-to-earth fault**	Control measures as in 4		—	Traffic control and area isolation
7	**Public injured phase-to-phase fault**	Control measures as in 5		—	Traffic control and area isolation
8	**Risk to assets**				
8.1	Phase-to-earth faults resulting in damage to machine	Control measures as in 1 and 3		Damage to MEWP	Inspection and maintenance of MEWP
8.2	Phase-to-phase faults resulting in damage to machine	Control measures as in 2 and 4		Damage to MEWP	Inspection and maintenance of MEWP

Table L *(continued)*

No.	Hazard	Specified risk control measures (Clause)		Residual	Recommended residual controls
8.3	Phase-to-earth faults resulting in damage to system	Control measures as in 1 and 3		Damage to system	Implement necessary inspection and maintenance procedures
8.4	Phase-to-phase faults resulting in damage to system	Control measures as in 2 and 4		Damage to system	Specify inspection procedures necessary after contact with live mains and faults occurs
9	**Exacerbated injuries**				
9.1	MEWP recovery	7.8.7	Lower controls to override emergency stop	—	Communications First aid procedures
9.2	—	7.8.7	Upper controls to be isolated and overridden	—	Communications First aid procedures
9.3	—	2.6.10	Emergency retrieval	—	Communications First aid procedures
9.4	Injury from fault current exiting earth	7.8.4	Location away from access	—	Communications First aid procedures
9.5	Injury when working solo				Reporting procedures Risk assessment

[a] Excessive movement of conductors or earthed media is considered the primary hazard and may occur in conjunction with other listed hazards.

[b] See Appendix K.

[c] 33 kV insulation up to 50 kV for HV Live working baskets.

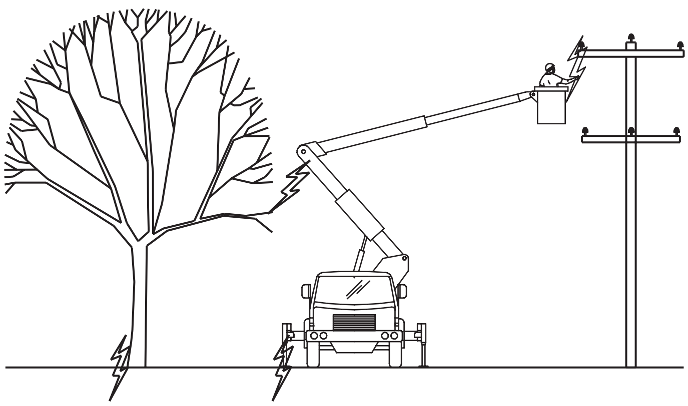
[d] Necessary to effect retrieval.

[e] The majority of distribution voltages are 33 kV or less.

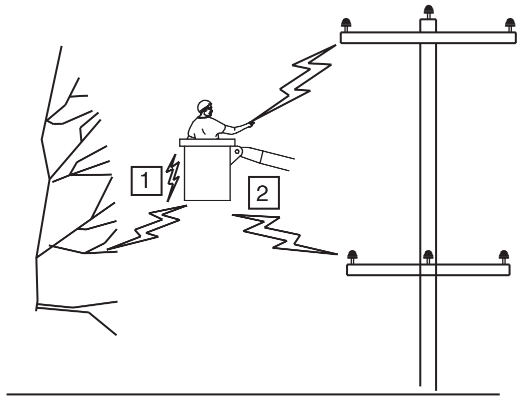
[f] The majority of conductors carrying distribution voltages are 7.5 m above ground level; however, the minimum specified ground clearance is 6.7 m over carriageways, and 5.5 m over land traversable by vehicles.

[g] Wet cover insulation may not necessarily protect against phase/phase or phase/earth faults.

NOTE Faults current may physically excite earth leads or chains, resulting in a striking hazard as well as an electrical hazard.

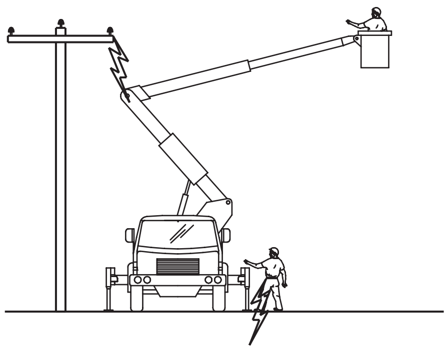


(a) Boom insulation fault



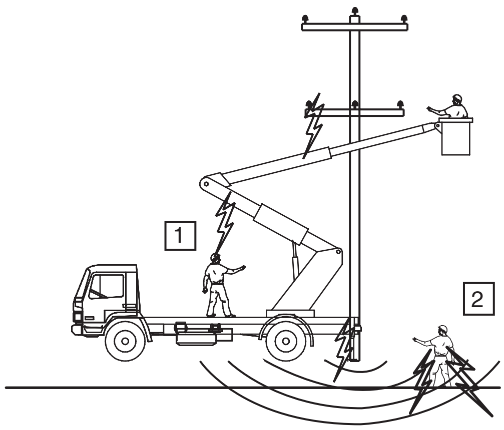
1) External surface leakage/flashover
2) Puncture through basket wall, floor or hole

(b) Basket insulation fault



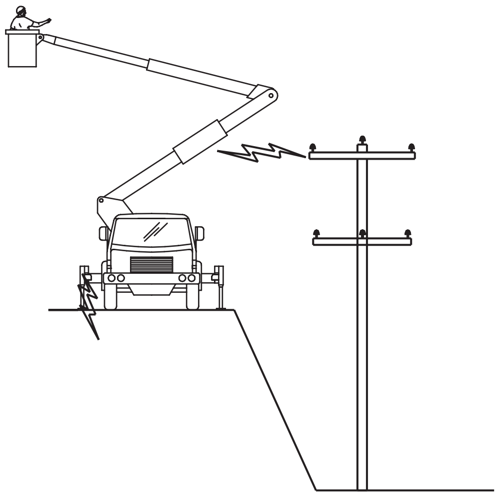
Chassis touch potential due to non-existent and/or inadequate chassis insulator

(c) Chassis insulation fault



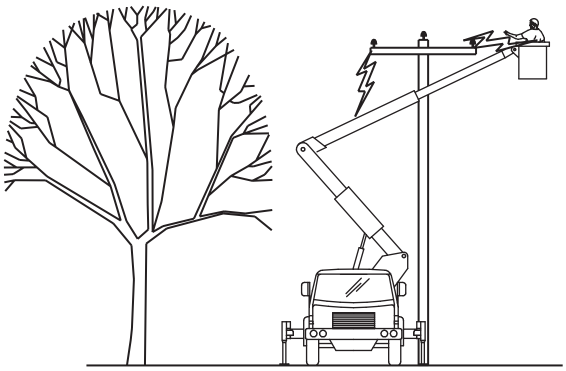
1) Touch above chassis insert
2) Step between earth fault ground gradients

(d) Step and touch potential



Chassis insulation non-existent and/or inadequate

(e) Approach at elevated height



Boom insert / covering non-existent and/or inadequate

(f) Phase to phase fault

Figure L.1 — Schematic representation of some common electrical hazards

Appendix M
(normative)

Operational procedures and periodic testing for electrically insulated MEWPs

M.1 General

M.1.1 Use

Insulated MEWPs designed in accordance with this document are intended for work in which the boom insulation is not considered as primary insulation. However, the glove and barrier live work method does require that the upper boom insulator forms one part of one of the two independent levels of insulation required for this live work process.

A correctly rated MEWP may be used for live working, provided minimum approach distances are maintained. Additional insulation is required to carry out live work, such as insulating gloves or barriers or insulating sticks that are appropriate to the authorized work procedure undertaken.

M.1.2 Work procedures

Where established procedures permit, insulated MEWPs designed, manufactured and tested in accordance with this document are intended to be used as follows:

(a) *Dry weather procedures* — The following applies:

  (i) Work on exposed live low-voltage mains.

  (ii) Close approach tree trimming procedures.

  (iii) High-voltage live work glove and barrier method up to 33 kV.

  (iv) Other established HV live work methods up to 132 kV.

(b) *Wet weather procedures* — The following applies:

  (i) Work on exposed live low-voltage mains.

  (ii) Close approach tree trimming procedures.

  (iii) Some high-voltage switching activities.

  NOTE Wet tests to AS 1931.1 prescribe a rain rate of 150 mm per hour. Owners and operators of MEWPs should be aware of the limitations and ensure risk management procedures prohibit the indiscriminate use of a MEWP during wet conditions outside the scope defined above, e.g. in mist and sleet. Additionally, administrative controls for wet weather work would require personal protective equipment or insulated tools, and the like, to have an appropriate wet weather rating.

MEWPs designed in accordance with this document shall not be used in proximity to electrical networks with a system highest voltage exceeding 145 kVa.c. Reference should be made to IEC 61057 or ANSI/SAIA A92.2 for MEWPs that are designed to be used on higher system voltages.

MEWPs designed in accordance with this document shall not be used for high-voltage live work in rain, mist, fog, snow, sleet or immediately after washing.

MEWP insulation shall be cleaned, and the hydrophobicity maintained, on a regular basis to ensure that the insulation maintains its designed rating.

M.2 Selection of insulated MEWPs for work on or near exposed energized overhead powerlines

M.2.1 General

The application and use of MEWPs for HV live work shall be in accordance with Table M.2.1.

Table M.2.1 — Application and use of MEWPs for HV live work

Category	Bare-hand	Glove and barrier	Stick method
A	✓	a, b	✓
B	a	✓	✓
C	N/A	✓	✓

Key

✓ = Applicable

N/A = Not applicable

a A MEWP manufactured as a Category A may be modified and used as a Category B and a Category B may be modified and used as a Category A in accordance with the manufacturer's instructions. In the event that this is done, particular attention should be paid to the appropriate acceptance test, gradient control devices, capacitive shields, conductive liners and bonding.

b This document does not cover Category A MEWPs.

M.2.2 Insulation rating

Where an elevating work platform is intended to work on or near exposed live conductors, the insulation rating of the MEWP shall be equal to or greater than the voltage of the conductors on which work is intended to be performed. The boom insulation rating should be at least equal to the highest voltage of the conductor present on the network that the operators' basket or booms may access, either by inadvertent contact or work-procedure.

The chassis insulation rating should be equal to or exceed the voltage of the conductors to which any portion of the MEWP, below the boom insulation, may be exposed.

NOTE 1 The maximum practical insulation rating of chassis insulating systems is generally 33 kV. Additional control measures should be implemented when working on or near networks exceeding this value.

NOTE 2 The chassis and boom insulation system will not protect personnel from phase-to-phase or phase-to-ground contacts at the basket end. Work procedures should be designed to include appropriate personal protective equipment.

NOTE 3 HV-rated insulated MEWPs are provided with HV insulation systems, which are effective above 7.5 m from the base level of the MEWP. Where an HV conductor is located at a height less than 7.5 m measured to the MEWP support surface, additional risk control measures may be necessary. Such measures may include the following:

(a) Selection of a MEWP with insulation that is effective at a reduced height.

(b) Selection of a MEWP with a configuration that reduces the likelihood of inadvertent contact.

(c) Siting of the MEWP to minimize the risk of inadvertent contact.

(d) Provision of temporary insulating barriers on lower level conductors.

(e) Isolation of the MEWP from personnel at ground level.

(f) The use of a qualified observer to alert the operators to potentially hazardous situations.

M.2.3 Environmental conditions

Where the MEWP has been or is likely to be exposed to environmental conditions that may impair the insulating properties of the boom, either the insulation rating shall be the wet rating or additional risk control measures shall be implemented. Such measures may include the following:

(a) The use of weatherproof covers for storage and transport over the insulating inserts and boom ends.

(b) Online condition monitoring of the insulation.

(c) Routine insulation resistance testing of the inserts prior to use (see Clause M.5).

(d) Use of proximity alarms.

(e) Siting of the MEWP to minimize risk of inadvertent contact (see Clause M.3).

(f) Selection of a MEWP with a configuration that reduces the likelihood of inadvertent contact.

NOTE 1 It is recognized that most MEWPs are used when the insulation system is wet. Previous editions of this document specified periodic testing in a clean and dry condition and the insulation was rated accordingly. This is no longer considered sufficient, and consideration should be given to the practicality of upgrading the dielectric properties of each insulating component according to the requirements of this document. Only where it is not practical to implement such alterations, additional administrative risk controls should be implemented instead.

NOTE 2 A risk assessment of MEWPs built to this document should be carried out to assess whether the dry rating is appropriate for their continued operation.

NOTE 3 The various classes in Appendix K provide for the continued use of MEWPs currently in operation. The MEWP may be used in a higher category than its nominated rating, provided that suitable additional risk controls are in place.

M.3 Siting

In addition to the requirements specified in AS 2550.10, the following shall be taken into account to minimize the risk of inadvertent contact between any portion of the MEWP and overhead conductors.

(a) Configuration and size of the MEWP for the type of work required.

(b) Location of the MEWP in relation to the public and vehicular traffic.

(c) Possibility of effecting retrieval in the event of MEWP power failure or emergency.

NOTE MEWPs designed in accordance with this document are considered to be insulated to the rated voltage when the vehicle is positioned at ground level and live conductors are positioned overhead. It is possible that the MEWP may be sited other than at ground level, in which case the electrical insulation may be ineffective. In these cases, additional (administrative) risk control measures may be necessary. See Figure L.1(e) for an example of a MEWP sited other than on ground level.

M.4 Periodic testing of insulated MEWPs

M.4.1 General

M.4.1.1 Test regime

Periodic testing shall be performed by competent persons.

NOTE 1 It is recommended that users of MEWPs satisfy themselves that testing organizations or staff engaged to perform periodic testing have suitable qualifications regarding the safe use of potentially lethal HV test equipment and have knowledge of test procedures.

Periodic test procedures shall be developed in accordance with Clause M.4 and provided by the manufacturer in the instruction manual. All tests shall be carried out in accordance with AS 1931.1.

Periodic tests shall be conducted throughout the service life of the MEWP to monitor the integrity of the insulation. Periodic test procedures shall not be altered without conducting a new acceptance test. The periodic test regime shall be developed having regard to the applicable tests for each insulating component and class of MEWP as shown in Table M.4.12(C).

NOTE 2 Testers need to be aware that with tests employing alternating current, varying boom positions or the proximity of earthed or unearthed metal structures or apparatus will have an effect on the voltage stress profile and the value of measured total leakage currents.

NOTE 3 Consideration should be given to the fact that the application of large leakage currents over extended periods may result in the deterioration of the insulation of control circuits and its containment.

M.4.1.2 Test frequency

M.4.1.2.1 Periodic tests

It is the intent of the periodic tests to verify that the insulation system, as maintained by the user, satisfies the insulation requirements specified by this document. As such, the test shall be conducted with the boom as presented for test. No attempt shall be made to clean or dry out the insulation by the tester.

Periodic tests shall be conducted at least at six-monthly intervals. A variation of 21 days is acceptable to provide for orderly test programming. Periodic tests are intended to monitor the adequacy of the particular maintenance regime used and to confirm that no physical damage has occurred to insulated components. Hence, the period between tests will depend on the usage, adequacy of the maintenance regime and the environment in which the equipment has been operating.

If during the life of the MEWP a component of the insulation fails a periodic test, as part of the causal investigation, a documented risk assessment shall be conducted to assess the frequency of the periodic test and maintenance regime.

M.4.1.2.2 Acceptance tests

An acceptance test shall be conducted —

(a) before the MEWP is first placed in service to verify that the insulation design and materials used in construction meet the requirements of this document;

(b) in accordance with Clause M.6; and

(c) on change of ownership, if the original acceptance test report is not available.

M.4.1.3 MEWP general set-up for all tests

The following applies:

(a) All hydraulic lines bridging the insulation shall be filled completely with the hydraulic oil from the MEWP's reservoir.

(b) Where the insulation rating varies according to the configuration of the boom, for example in a dual-rated boom with different boom extensions, the boom shall be tested for each voltage rating at the corresponding minimum extended length, as marked by the manufacturer.

(c) To prevent flashover during the application of the test voltage, the MEWP boom and basket should be positioned so that air clearances between the high-voltage electrode and earth are not less than those specified in AS 2067 for the test voltage applied (e.g. for 145 kV > 1.1 m).

M.4.1.4 Tests of longer duration

Where, for special reasons, it is not possible to periodically test the insulation to the voltage levels specified in Table M.4.12(A), the duration of the test may be increased and the test voltage reduced in accordance with Table M.4.12(B). This provision is applicable only to withstand tests on insulating inserts.

M.4.2 Withstand tests

M.4.2.1 Dry withstand test for insulating inserts

The purpose of the insulating insert withstand test is to verify that the boom and chassis inserts have been adequately maintained, have no physical damage and are able to withstand individually a temporary over-voltage that may be imposed by the system on which it is used.

M.4.2.2 MEWP set-up

The following applies:

(a) The MEWP should be set up as shown in Figure 7.9.4.5.

(b) The vehicle chassis shall be connected to earth.

(c) All metalwork at the platform shall be bonded electrically and connected to the upper test electrode.

(d) The insert not under test shall be short-circuited.

(e) Where the boom and chassis insulation is formed by one continuous insert, an external temporary foil test electrode shall be applied to all portions of the boom insert between a height of 7.5 m from the support surface, when the boom is fully raised, and the upper electrode (boom tip). The foil shall be shaped into the internal cavities of the insulation, using the simulated conductor (as in Clause 7.6). If necessary, the electrode may be applied in successive sections not less than 100 mm wide to reduce capacitive currents.

(f) Where chassis insulation is provided by cover insulation, either in part or in whole, an external temporary foil test electrode shall be applied to all portions of the boom exterior that lie between a height of 7.5 m measured from the support surface, when the boom is fully raised, and the extremity of the cover insulation. The foil shall be shaped into internal cavities of the insulation using the simulated conductor (as in Clause 7.6). If necessary, the electrode may be applied in successive sections not less than 100 mm wide to reduce capacitive currents.

M.4.2.3 Test method

The procedure shall be as follows:

(a) Measure the insulation resistance of the insert under test at a minimum of 2.5 kV. After 1 min, the insulation resistance shall be greater than 1000 MΩ. The test shall not proceed further if these values are not achieved.

(b) Apply a 1 min, dry withstand test voltage, corresponding to the rated working voltage of the component specified in Table M.4.12(A), between the upper test point and the vehicle chassis.

M.4.2.4 Pass criteria

There shall be no puncture or disruptive discharge.

M.4.2.5 Withstand test for LV rated MEWPs without inserts

The purpose of the withstand test is to verify that the low-voltage cover insulation has been adequately maintained, has no physical damage and is able to withstand individually a temporary over-voltage that may be imposed by the system on which it is used.

M.4.2.6 MEWP set-up

The following applies:

(a) The MEWP should be set up as shown in Clause 7.9.4.

(b) The vehicle chassis shall be connected to earth.

(c) All parts of the platform cover insulation shall be wet with a minimum of 10 l of water.

(d) An external temporary foil test electrode shall be applied to all portions of the platform surfaces. The foil shall be shaped into internal cavities of the insulation. If necessary, the electrode may be applied in successive sections not less than 100 mm wide to reduce capacitive currents.

M.4.2.7 Test method

The procedure shall be as follows:

(a) Measure the insulation resistance of the insert under test at a minimum of 2.5 kV. After 1 min, the insulation resistance shall be greater than 1000 MΩ. The test shall not proceed further if these values are not achieved.

(b) Apply a 1 min, 5 kV test voltage between the test electrodes and the vehicle chassis.

M.4.2.8 Pass criteria

There shall be no puncture or disruptive discharge.

M.4.3 Dry total leakage current test for chassis insulation inserts

M.4.3.1 Purpose

The purpose of the dry total leakage current test of chassis insulation inserts is to quantify and record the value of leakage current in the chassis insulation system.

M.4.3.2 MEWP set-up

The following applies:

(a) When under test, the booms shall be positioned according to the applicable test position depicted in Figure 7.9.4.5. The height from the ground level to the top of the basket should be 7.5 m.

(b) When in the test position and connected to the upper electrode, the high-voltage test supply lead should be set at an angle of approximately 45 degrees to horizontal and in line with the MEWP axis.

(c) When required, electrical stress control devices may be temporarily installed to the metalwork immediately adjacent to the insulation being tested. The type and positioning of any temporary stress control device shall be noted in the record of test.

(d) If the location is indoors, the boom and basket should be positioned so that air clearances are not less than those stated in AS 2067.

(e) For repeatability, all portable apparatus not associated with the test shall be located at least 3.0 m from the MEWP.

(f) The MEWP should be positioned to minimize stray capacitance effects.

(g) The stabilizing legs or wheels should be placed on low-voltage insulators. When measured with a low-voltage ohmmeter, the insulation resistance of the chassis to earth shall be least 100 times the impedance of the current-measuring circuit.

(h) All metalwork at the platform shall be electrically bonded and connected to the upper test electrode and the boom insert short-circuited.

(i) The vehicle chassis shall be connected to the current-measuring circuit, and then to earth, through a coaxial cable that has the screen earthed.

(j) Where boom and chassis insulation is formed by one continuous insert, an external temporary foil test electrode shall be applied to all portions of the boom insert between a height of 7.5 m from the support surface, when the boom is fully raised, and the upper electrode (boom tip). The foil shall be shaped into internal cavities of the insulation using the simulated conductor (as in Clause 7.6). The foil electrode shall be connected to the upper test point.

(k) Where chassis insulation is provided by cover insulation, either in part or in whole, a 25 mm wide external temporary foil test electrode shall be applied to the exterior surface at a height of 7.5 m measured from the support surface when the boom is fully raised.

M.4.3.3 Test method

Apply a 1 min test voltage equivalent to the highest system voltage phase-to-earth, and corresponding to the rated working voltage of the component specified in Table M.4.12(A), between the upper test point and earth.

M.4.3.4 Pass criteria

The following requirements apply:

(a) The leakage current shall not increase during the test.

(b) The leakage current shall not exceed 2.5 mA a.c. total or 0.5 µA/kV d.c. of the test voltage.

M.4.4 Dry leakage current tests for boom insulation inserts

M.4.4.1 Purpose

The purpose of the periodic boom insulation insert leakage current test is to quantify and record the leakage currents of the boom insulation when subjected to the specified test voltage. One of the three options for tests specified in Clauses M.4.4.2, M.4.4.3 or M.4.4.4 shall be conducted.

NOTE The total leakage current test (Clause 7.9.4.) is not an acceptable periodic test for monitoring boom insulation condition, as capacitive effects dominate the test result and do not provide an adequate means of monitoring the condition of the insulation.

M.4.4.2 Option 1 — a.c. leakage current test for MEWPs of Category C not fitted with test electrodes in accordance with Clause 7.7.5

M.4.4.2.1 MEWP set-up

The following apply:

(a) Capacitive shields shall not be used.

(b) When under test, the booms should be positioned according to the applicable test position depicted in Figure 7.9.4.5. The height from the ground level to the top of the basket should be 7.5 m.

(c) When in the test position and connected to the upper electrode, the high-voltage test supply lead should be set at an angle of approximately 45 degrees to horizontal and in line with the MEWP axis.

(d) When required, electrical stress control devices may be temporarily installed to the metalwork immediately adjacent to the insulation being tested. The type and positioning of any temporary stress control device shall be noted in the record of test.

NOTE Testers should be aware that these devices might increase the value of the capacitive leakage current.

(e) If the location is indoors, the boom and basket should be positioned so that air clearances are not less than those stated in AS 2067.

(f) The insulation resistance of the chassis to earth shall be at least 100 times the impedance of the current-measuring circuit. A low-voltage ohmmeter may be used.

(g) All metalwork at the basket shall be electrically bonded and connected to the upper test electrode.

(h) The chassis insulation shall be short-circuited.

(i) The vehicle chassis shall be connected to the current-measuring circuit and then to earth, through a coaxial cable that has the screen earthed.

(j) In plan view of the vehicle, the booms shall be aligned parallel to the vehicle longitudinal axis with the basket to the rear.

M.4.4.2.2 Test method

Apply a 1 min dry power frequency test voltage, equivalent to the highest system voltage phase-to-earth and corresponding to the rated working voltage of the component under test as specified in Table M.4.12(A), between the upper test point and earth.

M.4.4.2.3 Pass criteria

The following apply:

(a) The leakage current shall not increase during the test.

(b) The leakage current shall not exceed 10 µA/kV of test voltage.

(c) When previous test results are compared, any indicated degradation should be noted.

M.4.4.3 Option 2 — d.c. leakage current test

NOTE If required, this test may also be conducted during the acceptance test to establish a benchmark resistive leakage current.

M.4.4.3.1 MEWP set-up

The following apply:

(a) When under test, the booms should be positioned according to the applicable test position depicted in Figure 7.9.4.5. The height from the ground level to the top of the basket should be 7.5 m.

(b) When required, electrical stress control devices may be temporarily installed to the metalwork immediately adjacent to the insulation being tested. The type and positioning of any temporary stress control device shall be noted in the record of test.

(c) All metalwork at the basket shall be electrically bonded and connected to the upper test electrode.

(d) The chassis insulation shall be short-circuited.

(e) The vehicle chassis shall be connected to earth.

(f) A current-measuring device shall be connected between the HV test supply source and the upper test electrode. Alternatively, it shall be included in the earth return of the HV test supply.

M.4.4.3.2 Test method

Apply a dry 3 min d.c. test voltage, equivalent to the highest system voltage phase-to-earth and corresponding to the rated working voltage of the component under test as specified in Table M.4.12(A), between the upper test point and earth.

M.4.4.3.3 Pass criteria

The following apply:

(a) The current shall not increase during the test.

(b) The leakage current measured shall be less than 0.5 µA/kV of test voltage.

(c) When previous test results are compared, any indicated degradation should be noted.

M.4.4.4 Option 3 — a.c. surface leakage test for MEWPs fitted with test electrodes in accordance with Clause 7.7.5

M.4.4.4.1 MEWP set-up

The following apply:

(a) It shall be confirmed that the surface leakage monitoring electrode conforms to Clause 7.7.5.

(b) A temporary external surface electrode shall be wrapped around the external surface of the insulator in a similar position to the internal electrode. The temporary electrode shall be bonded to the permanent internal electrode. The external temporary electrode shall be fitted with a capacitive shield that is connected directly to earth. Neither the capacitive shield nor any shield insulation shall make contact with the insulating insert surface above the leakage current monitoring electrode.

NOTE The temporary electrode should be nominally 25 mm in width and in intimate contact with the surface of the insulator.

(c) When under test, the booms should be positioned according to the applicable test position depicted in Figure 7.9.4.5. The height from the ground level to the top of the basket should be 7.5 m.

(d) When in the test position and connected to the upper electrode, the high-voltage test supply lead should be set at an angle of approximately 45 degrees to horizontal and in line with the MEWP axis.

(e) The chassis insulation shall be short-circuited.

(f) The vehicle chassis shall be connected to earth.

(g) The insulation resistance to earth, measured at a minimum of 2.5 kV of the combined surface leakage current monitoring electrodes, shall be 100 times greater than the current-measuring circuit with the capacitive shield in place.

(h) All metalwork at the basket shall be electronically bonded and connected to the upper test electrode.

(i) In plan view of the vehicle, the booms shall be aligned parallel to the longitudinal axis with the basket to the rear.

(j) A current-measuring circuit shall be connected between the surface leakage monitoring electrode (see Clause 7.7.5) and earth, using a screened coaxial cable that has the screen earthed.

M.4.4.4.2 Test method

Apply a dry 1 min power withstand test voltage, corresponding to the rated working voltage of the component under test, as specified in Table M.4.12(A), between the upper test point and earth.

M.4.4.4.3 Pass criteria

The following apply:

(a) The current shall not increase during the test.

(b) The measured leakage current shall be less than 1.0 μA/kV of test voltage.

(c) When previous test results are compared, any indicated degradation should be noted.

M.4.5 Cover insulation test

M.4.5.1 Purpose

The purpose of the cover insulation test is to check the integrity of repaired or damaged boom-insulating covering.

M.4.5.2 Test method

The procedure shall be as follows:

(a) Visually inspect the insulating covering. Identify any damaged, recently repaired or contaminated areas.

(b) Apply the temporary electrode to those areas identified in Item (a) and to an area extending 300 mm around the perimeter that may be contacted by a simulated conductor applied in accordance with Clause 7.6.3.

(c) Bridge all metalwork of the various parts of the booms and basket and connect to earth. The chassis should also be connected to earth.

(d) Apply a 1 min dry withstand test voltage, as specified in Table M.4.12(A), to the temporary electrodes.

M.4.5.3 Pass criteria

There shall be no puncture or disruptive discharge.

M.4.6 Basket vertical withstand test

M.4.6.1 Purpose

The purpose of the basket vertical withstand test is to verify that the insulation rating of the basket, complete with all fittings and attachments installed (except for HV live work liner, which shall be removed for the test), is adequate to minimize the risk of short-circuit or transfer of potential in the vertical plane.

M.4.6.2 Test set-up

The test shall be set up as illustrated in Figure 7.9.7.4.

M.4.6.3 Test method

If radio remote controls are fitted in the basket, they shall be replaced with dummy units wrapped in metallic foil, or similar material, for this test.

NOTE This test may be carried out in multiple sections if required (the test current due to capacitive leakage on the complete temporary electrodes may exceed the maximum current available from the test set).

Baskets capable of being fitted with an HV live work liner shall at minimum have a 33 kV dry vertical surface rated working voltage.

The procedure shall be as follows:

(a) Install a temporary upper (plate or foil) electrode in contact with the entire top horizontal lip of the basket.

(b) Bond the operator’s controls, harness attachment points and power tool outlets, plus any exposed conductive components near the top of the basket, to the temporary upper electrode.

(c) Install a temporary lower (foil) electrode in contact with the external surface of the base of the basket. The electrode shall be shaped into all contours of the external surface of the basket bottom and covers using the simulated conductor described in Clause 7.6. The electrode shall cover the surface lying below a horizontal plane located 50 mm above the level of the internal floor and extend to a vertical plane intersecting the boom pivot pin as shown in Figure 7.9.7.4.

(d) Position the basket to best simulate the most onerous likely working position when elevated to greater than 7.5 m.

(e) Apply a 1 min dry withstand test voltage, at the level specified in Table M.4.12(A), to the upper electrode with the lower electrode connected to earth.

M.4.6.4 Pass criteria

There shall be no puncture or disruptive discharge during the application of the test voltage.

M.4.7 Basket puncture test

M.4.7.1 Purpose

The purpose of the basket puncture test is to verify that the insulation rating of the basket, complete with all fittings and attachments (except for HV live work liner, which shall be removed for the test), is adequate to minimize the risk of short-circuit or transfer of potential through the basket wall.

M.4.7.2 Test set-up

The test shall be set up as illustrated in Figure 7.9.8.3.

M.4.7.3 Test method

The procedure shall be as follows:

(a) Visually inspect the basket to identify any damaged, recently repaired or contaminated areas.

(b) Apply temporary electrodes to those areas identified in Item (a)and to an area extending 300 mm around the perimeter.

(c) Install the temporary inner electrode(s) in close contact with the inner surface of the basket. The temporary outer electrode(s) shall be shaped to contours using the simulated conductor described in Clause 7.6.

NOTE The electrodes(s) may be foil or tap water, or a combination of both.

(d) Apply a 1 min dry withstand test voltage at the level specified in Table M.4.12(A) to the inner electrode with the outer electrode connected to earth.

M.4.7.4 Pass criteria

There shall be no puncture or disruptive discharge during the application of the test voltage.

NOTE Where any metalwork causes excessive audible discharges, the test should be repeated with the metalwork connected to the nearest electrode.

M.4.8 HV live work liner puncture test

M.4.8.1 Purpose

The purpose of the HV live work liner puncture test is to verify that the insulation rating of the liner is adequate to minimize the risk of short-circuit or transfer of potential and conforms to requirements of HV live work Standards.

M.4.8.2 Test method

The procedure shall be as follows:

(a) Install a temporary exterior electrode in close contact with the exterior surface of the liner. The electrode shall be shaped to all contours of the exterior surface.

NOTE 1 The electrode may be foil or tap water, or a combination of both.

(b) Install a temporary inner electrode in close contact with the inner surface of the liner.

The electrode shall be shaped to all contours of the inner surface.

NOTE 2 The electrode may be foil or tap water, or a combination of both.

(c) Vertically extend the electrodes to a position 150 mm from the top horizontal lip of the liner.

(d) Apply a 1 min dry withstand test voltage, at the level specified in Table M.4.12(A), to the inner electrode with the outer electrode connected to earth.

M.4.8.3 Pass criteria

There shall be no puncture or disruptive discharge during the application of the test voltage.

M.4.9 Hydrophobicity test for wet and rain-rated MEWPs (reference only)

M.4.9.1 Purpose

The purpose of the hydrophobicity test is to verify that the insulation inserts and basket surfaces are hydrophobic.

M.4.9.2 Test method

The procedure shall be as follows:

(a) Using a pressurized sprayer from a distance of 250 ± 100 mm or a distance so as not to disturb surface pollution, apply a fine mist of water to the inner surfaces where covers do not prevent moisture ingress, and to the outer surface (over 360 degrees) of the insulation.

(b) Continue the wetting until droplets just begin to drip from the bottom surface. Evaluate the hydrophobic properties within 10 s after spraying is complete.

M.4.9.3 Pass criteria

The classification shall be WC1 to WC2 (see Figure 7.9.10.3).

M.4.10 Wet insert withstand and leakage current test

M.4.10.1 Purpose

The purpose of the wet insert withstand and leakage current test is to verify that the dielectric properties of the MEWP boom insert and chassis insulating system are not unduly impaired after exposure to moisture.

M.4.10.2 Apparatus

The water used for wetting shall have a resistivity greater than 100 Ωm (or conductivity less than 100 μS/cm).

NOTE A 6 m extension hose is recommended to allow the testing officer to move around the MEWP without carrying the heavy knapsack container.

M.4.10.3 MEWP set-up

The following applies:

(a) When under test, the MEWP should be set up as shown in Figure 7.9.4.5, in a position to permit water runoff.

(b) To prevent flashover during the application of the test voltage, the MEWP boom and basket should be positioned so that air clearances between the high-voltage electrode and earth are not less than those specified in AS 2067 for the test voltage applied (e.g. for 145 kV > 1.1 m).

(c) When required, electrical stress control devices may be temporarily installed to the metalwork immediately adjacent to the insulation being tested.

(d) Throughout the tests, the insulation resistance of the chassis to earth shall be maintained at a value of at least 100 times the impedance of the current-measuring circuit when measured with a low-voltage ohmmeter. The insulation resistance shall be measured at 500 V.

NOTE If required, the stabilizers/outriggers and wheels may be placed on low-voltage insulators.

(e) All metalwork at the basket shall be electrically bonded and connected to the upper test electrode.

(f) The vehicle chassis shall be connected to the current-measuring circuit, and then to earth, through a coaxial cable that has the screen earthed.

(g) All hydraulic lines bridging the insulation shall be completely filled with hydraulic oil from the MEWP's reservoir.

(h) Transit covers shall be removed.

(i) The insert not under test shall be short-circuited.

M.4.10.4 Test method

The procedure shall be as follows:

(a) Completely wet all internal and external surfaces of the insert under test with a minimum of 10 l of water to simulate worst likely wet conditions. The spray shall be directed inside each hollow insulator.

(b) Within 3 min of completion of wetting, measure the insulation resistance using a minimum of 5 kV for a period of 1 min. The minimum insulation resistance shall be not less than 2 MΩ/kV of the rated working voltage of the component for the insert under test. If this criterion is not met, the MEWP fails the test and the remainder of the test shall not be carried out.

(c) Apply a wet 1 min withstand test voltage corresponding to the rated working voltage of the component, as specified in Table M.4.12(A), between the upper test point and earth.

M.4.10.5 Pass criteria

The following apply:

(a) The resistance shall be not less than 2 MΩ/kV of the rated working voltage of the component.

(b) There shall be no puncture or disruptive discharge during the test.

(c) The leakage current trend shall not increase during the application of the test voltage.

NOTE 1 Where there is significant documentary evidence to support the proposition that the wet boom insulation test is a more onerous test than the dry test regime as described in Clause M.4.3, owners may consider deleting the dry withstand and leakage current test from their periodic test regime.

NOTE 2 Testers need to be aware that varying boom positions or the proximity of earthed or unearthed metal structures or apparatus will have an effect on the voltage stress profile and the value of measured total leakage currents.

M.4.11 Basket wet vertical withstand test

M.4.11.1 Purpose

The purpose of the basket wet vertical withstand test is to verify that the insulation rating of the basket, complete with all fittings and attachments installed (except for HV live work liner, which shall be removed for the test), is adequate to minimize the risk of short-circuit or transfer of potential in the vertical plane when wet.

M.4.11.2 Test set-up

The test shall be set up as described in Clause 7.9.7.3.

If radio remote controls are fitted in the basket, they shall be replaced with dummy units wrapped in metallic foil, or similar material, for this test.

NOTE This test may be carried out in multiple sections if required (the test current due to capacitive leakage on the complete temporary electrodes may exceed the maximum current available from the test set).

M.4.11.3 Test method

The procedure shall be as follows:

(a) After the satisfactory completion of the dry basket vertical withstand test (see Clause M.4.6), wet the basket using the apparatus described in Clause 7.9.11.2. Wet all internal and external surfaces of the basket completely, to simulate wet conditions.

(b) Within 3 min of wetting, apply a 1 min wet test voltage, at the level specified in Table M.4.12(A), to the upper electrode with the lower electrode connected to earth.

M.4.11.4 Pass criteria

There shall be no puncture or disruptive discharge during the application of the test voltage.

M.4.12 Test report

A test report shall be provided and shall contain the following information about each elevating work platform:

(a) Type or identification.

(b) Name of the manufacturer.

(c) Serial number.

(d) Insulation ratings.

(e) Test results including indication of “pass” or “fail” for each test.

(f) Name and status of the signatory.

(g) Date of test and next due date.

(h) Resistivity of water used.

(i) Atmospheric conditions during tests.

(j) Test equipment details.

(k) Reference to manufacturer’s test procedure.

NOTE The report may be to the test certificate format given in Appendix J.

Table M.4.12(A) — MEWP Insulation — Periodic test

Insulation component	Rated working voltage of component (Nominal system voltage — U)	Dry withstand test voltage[a]		Wet withstand test voltage[a]		Highest system voltage, phase-to-earth $\left(\frac{Um}{\sqrt{3}}\right)$ [c]		Maximum leakage current at highest system voltage, phase-to-earth $\left(\frac{Um}{\sqrt{3}}\right)$					
								Dry boom			Dry chassis		Wet boom and chassis
	kV a.c. (r.m.s.)	kV a.c. (r.m.s.) (1 min)	kV d.c.[b] (3 min)	kV a.c. (r.m.s) (1 min)	kV d.c.[b] (3 min)	kV a.c. (r.m.s.)	kV d.c. equivalent[b]	Option 1 a.c. Cat. C [e]	Option 2 d.c. Cat. B [f]	Option 3 a.c. Cat. B [g]	a.c.	d.c.	
Inserts (and when chassis insulation is achieved by cover)	132	206	291	109	154	84	119	N/A	59.5µA	84 µA	2.5 mA	59.5 µA	Not increasing during test
	66	105	149	54	77	42	59	N/A	29.5 µA	42 µA	2.5 mA	30 µA	
	33	53	75	27	38	21	30	210 µA	15 µA	21 µA	2.5 mA	15 µA	
	22	38	54	18	25	14	20	140 µA	10 µA	14 µA	2.5 mA	10 µA	
	11	21	30	9	13	7	10	70 µA	5 µA	7 µA	2.5 mA	5 µA	
	LV	5	7	N/A[d]	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	
Cover insulation	33	26	37	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
	22	19	27										
	11	11	16										
	LV	5	7										
Basket — Vertical surface	33	38	54	28	40	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
	LV	5	7	5	7								
Basket puncture	HV	38	54	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
	LV	5	7										
HV live work liner	33	38	54	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A

a Periodic withstand test voltages (except for LV tests) are 75 % of the acceptance test voltage levels stated in Table 7.9.14.3.

b The d.c. test voltage is 1.414 times the r.m.s. value of the a.c. test voltage.

c Leakage current is measured at the dry withstand test voltage.

d Insulation resistance at 5 kV d.c. is sufficient to confirm wet rating for LV rated inserts.

e See Clause M.4.4.2 for guidance.

Table M.4.12(A) *(continued)*

Insulation component	Rated working voltage of component (Nominal system voltage — U)	Dry withstand test voltage[a]		Wet withstand test voltage[a]		Highest system voltage, phase-to-earth $\left(\frac{Um}{\sqrt{3}}\right)$[c]		Maximum leakage current at highest system voltage, phase-to-earth $\left(\frac{Um}{\sqrt{3}}\right)$					
								Dry boom			Dry chassis		Wet boom and chassis
	kV a.c. (r.m.s.)	kV a.c. (r.m.s.) (1 min)	kV d.c.[b] (3 min)	kV a.c. (r.m.s) (1 min)	kV d.c.[b] (3 min)	kV a.c. (r.m.s.)	kV d.c. equivalent[b]	Option 1 a.c. Cat. C [e]	Option 2 d.c. Cat. B [f]	Option 3 a.c. Cat. B [g]	a.c.	d.c.	

[f] See Clause M.4.4.3 for guidance.

[g] See Clause M.4.4.4 for guidance.

Table M.4.12(B) — High-voltage tests a.c (reduced periodic test values)

Multiple of test period specified in Clause M.4.1	Percent of test voltage according to Table M.4.12(A)
1	100
2	83
3	75
4	70
NOTE This provision is applicable only to withstand tests on insulating inserts.	

Table M.4.12(C) — Schedule of periodic tests

Clause No.	Test		Class					
			Dry LV	Wet LV	Rain LV	Dry HV	Wet HV	Rain HV
M.4.2	Dry insert IR/Withstand	Boom	a b	a b	a b	a	a	a
M.4.2	Dry insert IR/Withstand	Chassis	ab	ab	ab	a	a	a
M.4.3	Dry total leakage current[c]	Chassis	a b	a b	a b	a	a	a
M.4.4	Dry surface leakage current	Boom	a b	a b	a b	a	a	a
M.4.5	Low-voltage covering		a	a	a	a	a	a
M.4.6	Dry basket vertical withstand		a b	a b	a b	a		
M.4.7	Dry basket puncture		a b	a b	a b	a		
M.4.8	Basket liner					a b	a b	
M.4.10	Wet insert IR/Withstand	Boom		a b	a b		a	a
M.4.10	Wet insert IR/Withstand	Chassis		a b	a b		a	a
M.4.11	Wet basket			a	a		a	a

[a] Mandatory tests to confirm adequacy of maintenance regime.

[b] If applicable to design/rating of unit.

[c] Total leakage current should be reasonably consistent throughout service life of unit.

M.5 Unscheduled checks

M.5.1 General

Unscheduled checks are conducted at more frequent intervals than periodic tests and are designed to verify the integrity of the insulation as required. Unscheduled checks are particularly useful when work procedures require a greater level of certainty in relation to the insulation level of the MEWP. These situations may arise under the following conditions:

(a) The network voltage on which the MEWP is required to work is equal to the insulation rating of the MEWP.

(b) The MEWP has been or could be exposed to environmental conditions that may degrade the insulation (e.g. when the MEWP has been exposed to rain or sea air immediately prior to use, or where the MEWP has travelled over dirt roads).

(c) The MEWP is to be placed in a position where the risk of inadvertent contact with high-voltage conductors is high.

M.5.2 Unscheduled check procedures

The following unscheduled checks may be undertaken:

(a) Visual inspection of the insulator interior and exterior surfaces for cleanliness and moisture resistance.

(b) Visual inspection of all necessary safety decals for legibility and condition.

(c) Verification of the operation of all controls, including emergency stop and rescue controls.

NOTE For critical procedures, consideration may be given to the hydrophobicity test specified in Clause M.4.9 and the insulation resistance test specified in Clause M.4.10, as applicable.

M.6 Alterations, modification and significant repairs of insulation systems

M.6.1 General

Alteration or modification and significant repairs on any insulating component of the MEWP shall not be performed without the approval of the manufacturer or a competent person.

Where an alteration, modification or significant repair is undertaken with such approval, the MEWP shall be subjected to the relevant acceptance test(s) for those component(s) prior to placement into service.

M.6.2 Alterations

Alterations that affect the insulating properties of the MEWP include, but are not limited to, the following:

(a) The drilling of holes in the basket or platform.

(b) The modification of an insulating liner.

(c) The installation or removal of any conducting component on or near the basket or platform.

(d) The installation of antennae or high-set bodies or lockers on the vehicle chassis, which may increase the capacitive effects at lower height of the MEWP basket.

M.6.3 Modifications

Modifications may include, but are not limited to, the following:

(a) The drilling of holes in the basket or platform or booms.

(b) Additions to or removal of any component within the insulating system.

M.6.4 Significant repairs

Significant repairs may include, but are not limited to, the following:

(a) Replacement of components that bridge the insulation insert.

(b) Where damage has occurred to the fibre-reinforced plastic insert so as to expose glass fibres to moisture.

NOTE 1 An acceptance test for hose replacement may not be required where an owner has a documented procedure for controlling hose replacements using only HV-rated hoses approved by the manufacturer and stored in a controlled environment.

NOTE 2 Electrical wiring should not be installed for MEWP control or power tools, as this may render electrical insulation ineffective.

M.7 Maintenance of insulation components

The maintenance of insulation is critically important to maintaining the insulation rating and structural integrity of the MEWP. The maintenance regime shall be designed having regard to the damaging effects of moisture and the possibility of structural degradation on the components. Maintenance of the insulation system shall include the following:

(a) Inspection of the interior and exterior insulator surfaces for signs of damage, which may lead to a reduction in strength or dielectric properties.

(b) Inspection of cover insulation for signs of cracking or corrosion, which may indicate fatigue cracking in the underlying structure.

(c) Routine cleaning of the insulator interior and exterior surfaces of all road grime and dust and other contaminants.

NOTE 1 The presence of metallic smears on the insulator surfaces reduces the creepage distance of the insulation and it is important that such marks are completely removed.

(d) Routine surface conditioning of the insulator surfaces so that the surface remains resistant to moisture.

NOTE 2 For this purpose, the hydrophobicity test specified in Clause M.4.9 provides acceptable criteria.

(e) Periodic repair of the surfaces to remove any surface cracks or damage.

NOTE 3 A competent person should undertake an assessment of the surface condition and the repair method. Where a MEWP has suffered a high impact or overload, consideration should be given to verification of the structural integrity of the insert(s) by a suitable non-destructive test.

(f) Inspection and replacement, as required, of all insulation markers or signs as specified in Clause 7.9.16.

Any suspect items shall be carefully examined and tested by a competent person and a determination made as to whether they constitute a safety hazard. All unsafe items shall be repaired or replaced before use.

M.8 Actions following breach or failure of the insulation under operating conditions

When a MEWP has suffered from a breach or failure of the insulation components, the following procedures should be implemented:

(a) The MEWP should be immediately withdrawn from service and the surrounding area secured from unauthorized access.

(b) If necessary, all pneumatic tyres should be deflated in a safe manner.

NOTE High currents that may have been present during the period of contact may cause combustion of the tyres and explosion for periods up to 24 h.

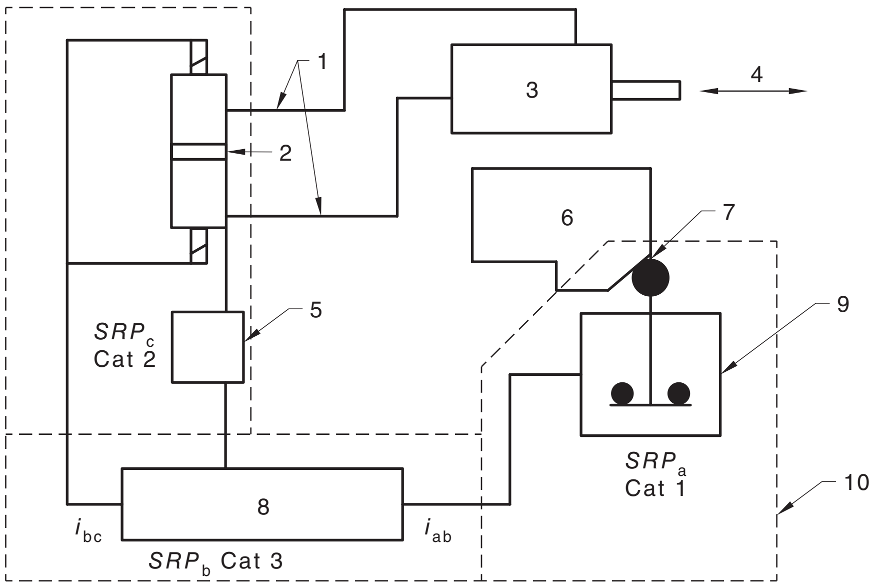
(c) The MEWP should be inspected by a competent person and a structured inspection and maintenance plan implemented to verify the condition of the components that may have experienced arcing damage. Such components are typically rolling bearings (including slew rings and wheel bearings and other bushes or journals that lie in the path of the current).

(d) Where the MEWP has experienced fire or ionization of the surrounding air, the insulator surfaces should be thoroughly cleaned and subject to an acceptance test prior to use. In the case of fire, all hydraulic hoses and electrical wiring lying in the heat path should be inspected and replaced if damaged.

Appendix N
(informative)

Example of the application of control system categories

The validation of the safety functions and categories in Clause 2.10 is given in AS 4024.1502 or ISO 13849-2. As shown in Figure N, a safety function may be achieved by a combination of a number of components of different technologies (e.g. mechanical, hydraulic, pneumatic, electronic) and the selection of the category of each component taking into account the technology used. As an example, a Category 3 safety function may be achieved by an appropriate combination of Category 1 components (see Figure N).



Key:

1 Output signal
2 Fluidic directional valve
3 Fluidic actuators
4 Hazardous movement
5 Checking function
6 Guard
7 Input signal
8 Electronic control logic
9 Position device
10 Scope of AS 4024.1501

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

Figure N — Example — Use of categories

Figure N is a schematic diagram of the safety-related parts that provide one of the functions to control a machine actuator. This is not a functional or working diagram and is included only to demonstrate the principle of combining categories and technologies in this one function.

The control is provided through electronic control logic and a fluidic directional valve checked at suitable intervals. 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 begin at 7 and end at 1 (see Figure N).

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

These combined safety-related parts provide a stop function as a safety function. 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 machine, this stops the hazardous movement of the actuator.

This combination of safety-related parts creates a safety function to demonstrate the categorization requirements. 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 N can be categorized as follows:

(a) *Category 1 for the electro-mechanical position device* — To reduce the probability of faults, this device comprises well-tried components applied using well-tried safety principles (e.g. positive opening operation, over-dimensioning).

(b) *Category 3 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.

(c) *Category 2 for the checked fluidic directional valve* — To achieve the required level of safety performance, this safety-related part uses components that are periodically checked (e.g. monitoring, in order to detect the faults that have not been avoided using well tried safety principles).

NOTE The position, size and layout of the interconnecting means should also 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 should both be considered.

Appendix O
(normative)

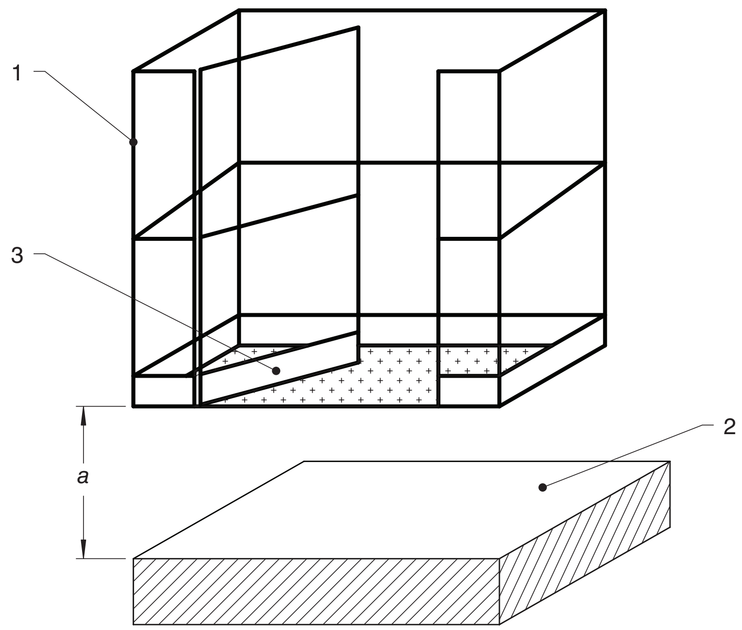
Dimensions of access height, steps and ladders

O.1 Access height

Table O.1 gives the access heights of different MEWPs. Figures O.1(A) and O.1(B) show the parts and dimensions of a work platform with opening gate and toe-guard.

Table O.1 — Access height of MEWPs

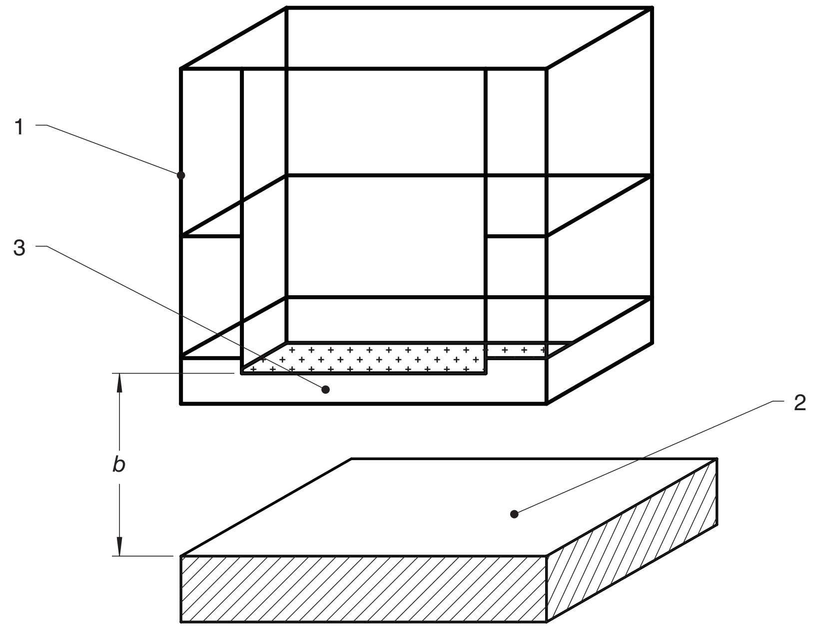
Symbol	Description	Dimension (mm)
a	Height from access level to platform floor if toe-guard at the entrance opens with the gate [see Figure O.1(A)]	500 (600)[a]
b	Height from access level to top of toe-guard if the toe-guard at the entrance is fixed [see Figure O.1(B)]	500 (600)[a]
[a] 500 mm for slab-type MEWPs and may be increased to 600 mm for all other MEWPs.		



Key

1 Work platform
2 Access level
3 Gate
a Access height (if toe-guard opens with gate)

Figure O.1(A) — Work platform with opening gate and toe-guard



Key

1 Work platform

2 Access level

3 Fixed toe-guard at entrance

b Access height (if toe-guard is fixed)

Figure O.1(B) — Work platform with fixed toe-guard at entrance

O.2 Access steps and ladders

Table O.2 gives the possible dimensions of MEWP access systems. Figures O.2(A) to O.2(E) show the parts and dimensions of different work platform access systems.

Table O.2 — Dimensions of MEWPs

Symbol	Description	Dimensions (mm)		
		Min.	Max.	Target
A	Height of first step above ground	-	500 (600)[a]	400
B	Tread spacing (riser height)[b]	-	250[c]	180
	Rung spacing[b]	230	400	300
C	Step width	320	-	400
	Rung width			
	For one foot	160	-	200
	For both feet	320	-	400
D	Step tread depth (stairs)	240	400	300
	Rung depth – circular (D1)	19	60	-
	Rung depth – square or rectangular	6	-	50
	Tread element depth – multiple element step (D3)	3	-	-
	Tread element spacing – multiple element step (D4)	-	50[d]	50[d]
E	Distance from top step or rung of ladder to landing or work platform	230	400	300

Table O.2 *(continued)*

Symbol	Description	Dimensions (mm)		
		Min.	Max.	Target
F	Toe clearance (free space behind front edge of step or centreline of circular step)	150	-	200
G	Vertical distance from landing to work platform	230	400	300
H	Horizontal distance from landing to work platform	-	50	20
J	Width between parallel handrails Ladder Stairway	 - 460	 600 -	 400 700
K	Distance from top step to upper edge of basket	-	500	-

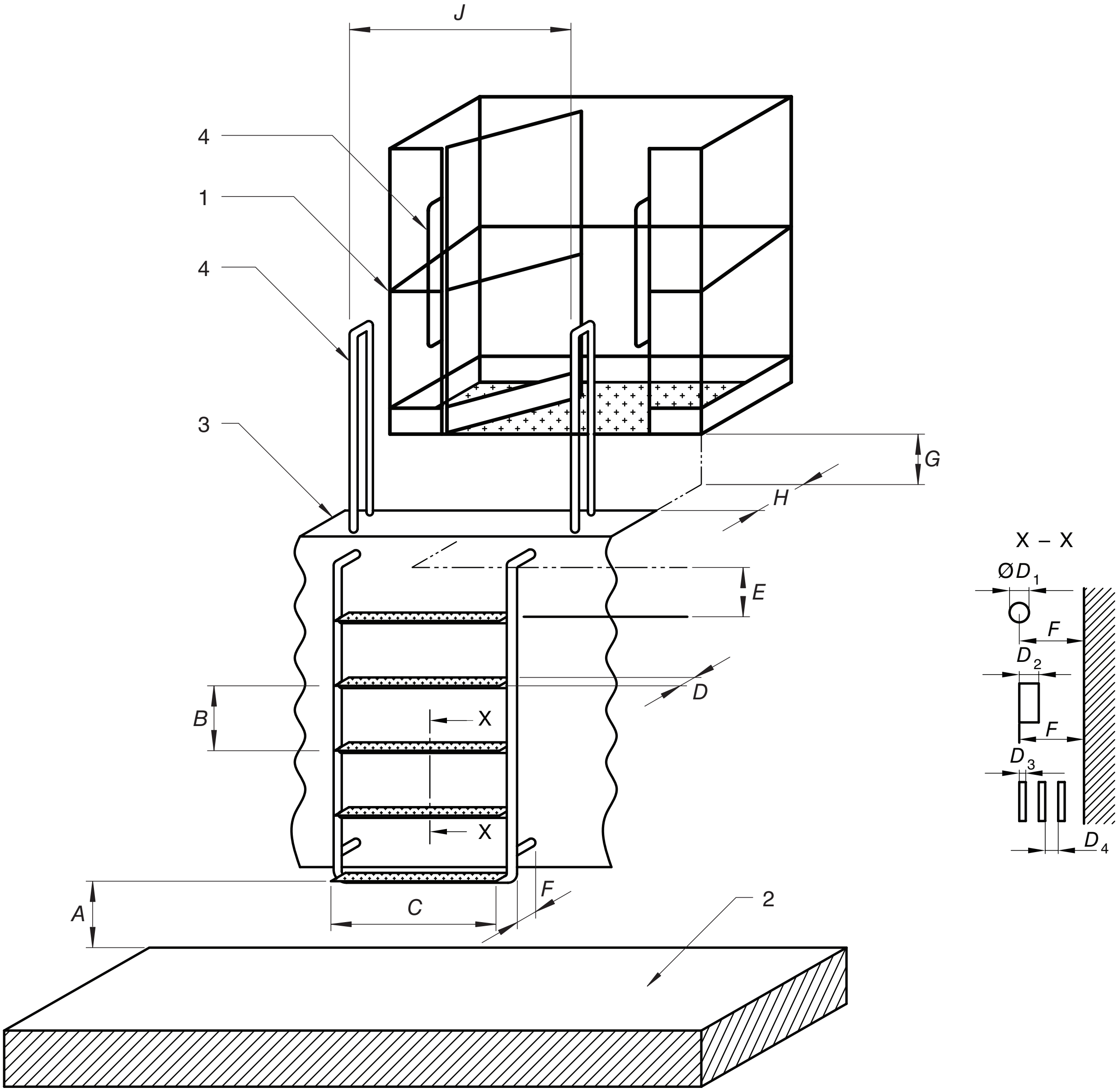
[a] 500 mm for slab-type MEWPs and may be increased to 600 mm for all other MEWPs.

[b] Riser or rung heights shall be uniform.

[c] This may be increased to 400 for fully enclosed baskets.

[d] 40 mm if the foot will be positioned parallel to the tread elements.

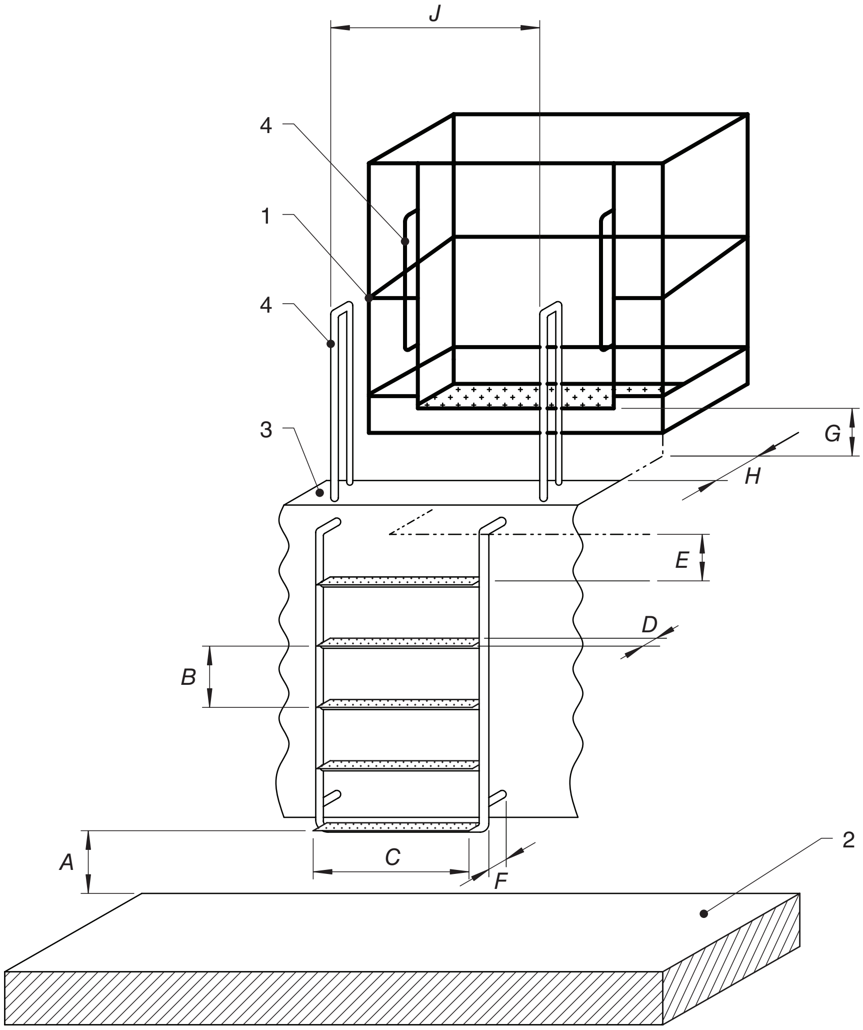
NOTE See Figures O.2(A) to O.2(E).



Key

1	Work platform with opening gate and toe-guard
2	Access level
3	Landing
4	Hand holds
A	Height of first step/rung above the access level
B	Riser height
C	Step width
D	Tread/rung depth
E	Distance from top step/rung of ladder to landing
F	Toe clearance (free space behind steps/rungs)
G	Vertical distance from landing to work platform floor
H	Horizontal distance from landing to front edge of work platform
J	Horizontal spacing of handholds

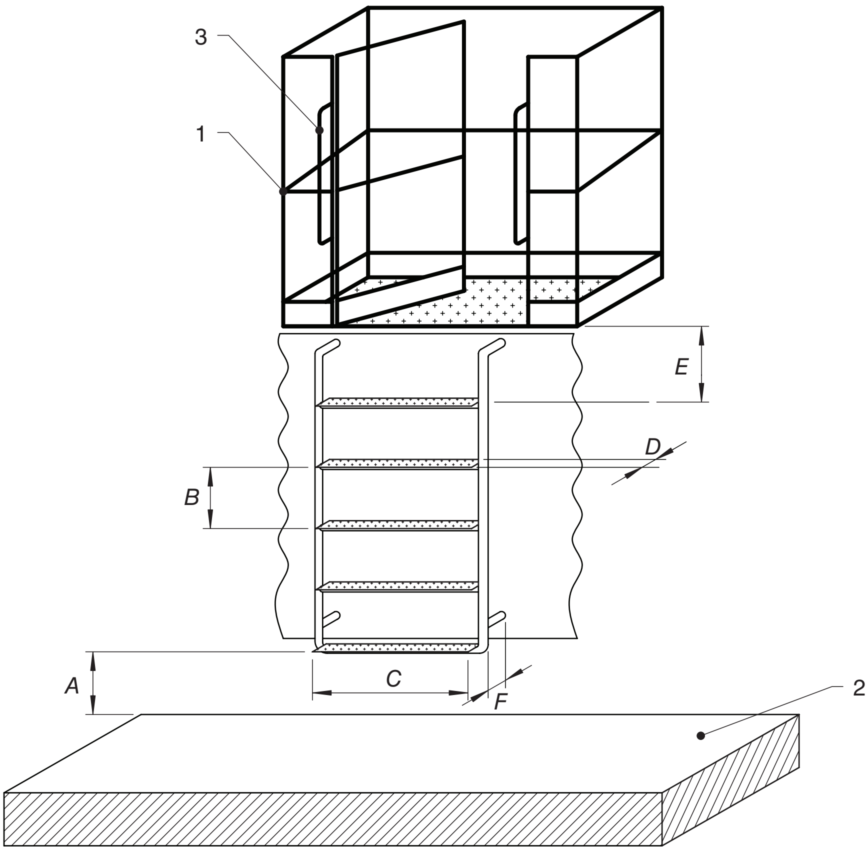
Figure O.2(A) — Work platform with opening gate and toe-guard with landing



Key

1 Work platform with opening gate and toe-guard
2 Access level
3 Landing
4 Hand holds
A Height of first step/rung above the access level
B Riser height
C Step width
D Tread/rung depth
E Distance from top step/rung of ladder to landing
F Toe clearance (free space behind steps/rungs)
G Vertical distance from landing to work platform floor
H Horizontal distance from landing to front edge of work platform
J Horizontal spacing of handholds

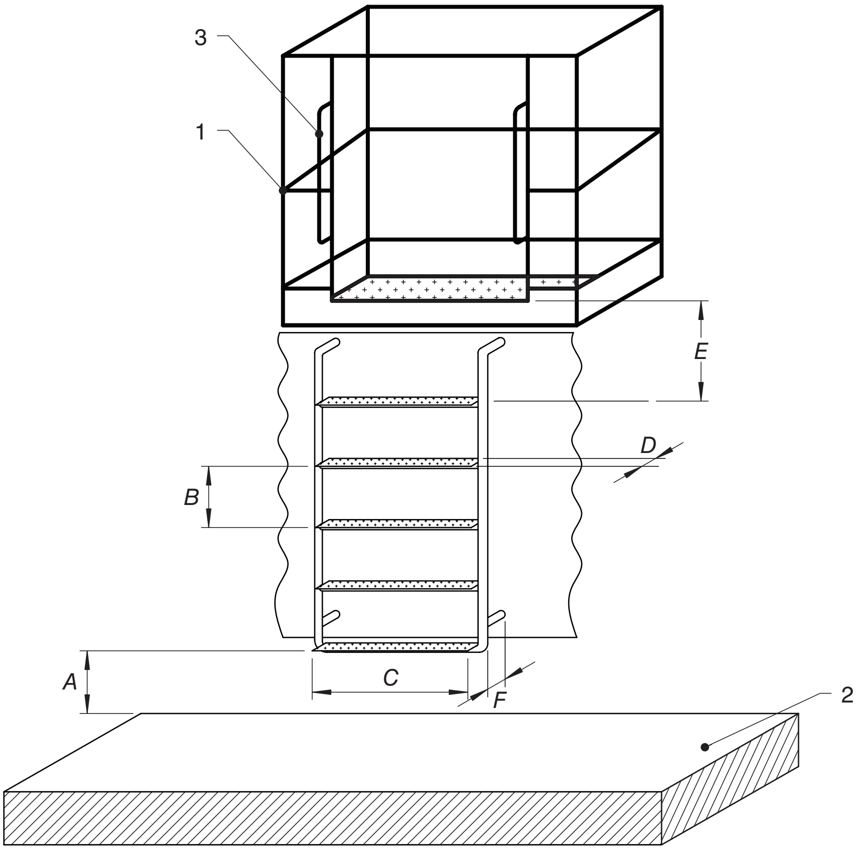
Figure O.2(B) — Work platform with fixed toe-guard at entrance with landing



Key

1 Work platform with opening gate and toe-guard
2 Access level
3 Hand holds
A Height of first step/rung above the access level
B Riser height
C Step width
D Tread/rung depth
E Distance from top step/rung of ladder to work platform floor
F Toe clearance (free space behind steps/rungs)

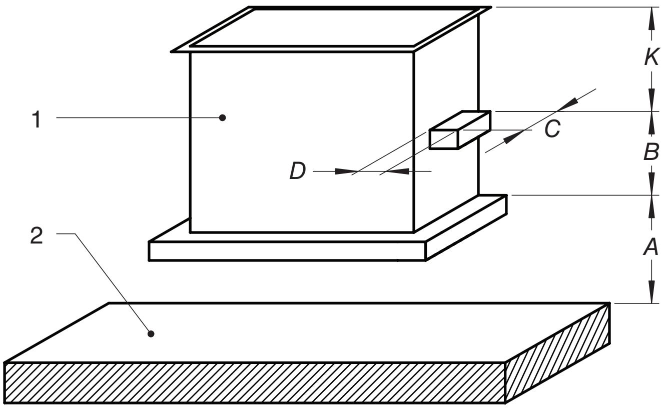
Figure O.2(C) — Work platform with opening gate and toe-guard without landing



Key

1 Work platform with fixed toe-guard at entrance
2 Access level
3 Hand holds
A Height of first step/rung above the access level
B Riser height
C Step width
D Tread/rung depth
E Distance from top step/rung of ladder to work platform floor
F Toe clearance (free space behind steps/rungs)

Figure O.2(D) — Work platform with fixed toe-guard at entrance without landing



Key

1 Fully enclosed work platform
2 Access level
A Height of first step above the access level
B Riser height
C Step width
D Step depth
K Distance from top step to top edge of work platform

Figure O.2(E) — Fully enclosed work platform

Appendix P
(informative)

Wind speed and pressure as a function of elevation

Table P(A) shows the 3-s wind gust speed as a function of mean wind speed. Table P(B) shows the quasistatic impact pressure as a function of mean wind speed.

Table P(A) — 3-s wind gust speed as a function of mean wind speed as per Beaufort Scale and as per elevation

Beaufort Grade	3	4	5[a]	5	6	7[a]	7	8	9	10
v [m/s][b]	5.4	7.9	10.1	10.7	13.8	14.3	17.1	20.7	24.4	28.4
z [m]	*v*(*z*) [m/s]									
10	7.6	11.1	14.1	15.0	19.3	20.0	23.9	29.0	34.2	39.8
20	8.1	11.9	15.2	16.1	20.7	21.5	25.7	31.1	36.6	42.7
30	8.5	12.4	15.8	16.8	21.6	22.4	26.8	32.4	38.2	44.5
40	8.7	12.8	16.3	17.3	22.3	23.1	27.6	33.4	39.4	45.8
50	8.9	13.1	16.7	17.7	22.8	23.6	28.3	34.2	40.3	46.9
60	9.1	13.3	17.0	18.0	23.3	24.1	28.8	34.9	41.1	47.9
70	9.3	13.5	17.3	18.3	23.6	24.5	29.3	35.5	41.8	48.7
80	9.4	13.7	17.6	18.6	24.0	24.8	29.7	36.0	42.4	49.4
90	9.5	13.9	17.8	18.8	24.3	25.1	30.1	36.4	42.9	50.0
100	9.6	14.1	18.0	19.1	24.6	25.4	30.4	36.9	43.4	50.6
110	9.7	14.2	18.2	19.2	24.8	25.7	30.8	37.2	43.9	51.1
120	9.8	14.3	18.3	19.4	25.1	25.9	31.1	37.6	44.3	51.6
130	9.9	14.5	18.5	19.6	25.3	26.2	31.3	37.9	44.7	52.0
140	10.0	14.6	18.7	19.8	25.5	26.4	31.6	38.2	45.1	52.5
150	10.0	14.7	18.8	19.9	25.7	26.6	31.8	38.5	45.4	52.9
160	10.0	14.8	18.9	20.1	25.9	26.8	32.1	38.8	45.7	53.2
170	10.2	14.9	19.1	20.2	26.0	27.0	32.3	39.1	46.0	53.6
180	10.3	15.0	19.2	20.3	26.2	27.1	32.5	39.3	46.3	53.9
190	10.3	15.1	19.3	20.4	26.4	27.3	32.7	39.5	46.6	54.2
200	10.4	15.2	19.4	20.6	26.5	27.4	32.8	39.8	46.9	54.6

Key

v [m/s] = Mean wind speed at 10 m elevation (upper limit of Beaufort grade) over a period of 10 min.

z [m] = Elevation above even ground.

v(*z*) [m/s] = 3-s wind gust speed acting at elevation *z* and decisive for calculations.

q(*z*) [N/mm^2] = quasistatic impact pressure acting at elevation *z* and calculated based on *v*(*z*), see Table P(B).

[a] In-service wind:

1 Light

v = 10.1 [m/s] = > for *z* = 10 [m] = > *q*(*z*) = 125 [N/mm^2]

2 Normal

v = 14.3 [m/s] = > for *z* = 10 [m] = > *q*(*z*) = 250 [N/mm^2]

Table P(A) *(continued)*

Beaufort Grade	3	4	5[a]	5	6	7[a]	7	8	9	10
v [m/s][b]	5.4	7.9	10.1	10.7	13.8	14.3	17.1	20.7	24.4	28.4
z [m]	*v*(*z*) [m/s]									

[b] Upper Beaufort Limit.

Table P(B) — Quasistatic impact pressure as a function of mean wind speed as per the Beaufort Scale and as a function of elevation

Beaufort Grade	3	4	5[a]	5	6	7[a]	7	8	9	10
v [m/s][b]	5.4	7.9	10.1	10.7	13.8	14.3	17.1	20.7	24.4	28.4
z [m]	*q*(*z*) [N/m^2]									
10	35.7	76.5	125.0	140.3	233.3	250.0	358.2	524.9	729.3	988.0
20	41.1	88.0	143.8	161.4	268.5	287.7	412.2	604.1	839.4	1137.1
30	44.7	95.7	156.4	175.5	292.0	312.9	448.3	657.0	912.8	1236.6
40	47.5	101.6	166.1	186.4	310.1	332.3	476.2	697.8	969.6	1313.5
50	49.8	106.5	174.2	195.5	325.1	348.4	499.2	731.5	1016.4	1376.9
60	51.8	110.8	181.0	203.2	338.0	362.2	519.0	760.5	1056.6	1431.4
70	53.5	114.5	187.1	210.0	349.3	374.3	536.4	786.0	1092.1	1479.5
80	55.0	117.8	192.6	216.1	359.5	385.2	552.0	808.9	1123.9	1522.6
90	56.5	120.8	197.5	221.7	368.8	395.1	566.2	829.7	1152.8	1561.8
100	57.8	123.6	202.1	226.8	377.3	404.3	579.3	848.9	1179.5	1597.9
110	59.0	126.2	206.3	231.6	385.2	412.7	591.4	866.7	1204.2	1631.3
120	60.1	128.6	210.3	236.0	392.6	420.6	602.8	883.3	1227.2	1662.6
130	61.2	130.9	214.0	240.2	399.5	428.1	613.4	898.8	1248.9	1691.9
140	62.2	133.1	217.5	244.1	406.0	435.1	623.4	913.6	1269.3	1719.6
150	63.1	135.1	220.8	247.8	412.2	441.7	632.9	927.5	1288.7	1745.9
160	64.0	137.0	224.0	251.4	418.1	448.0	642.0	940.8	1307.1	1770.8
170	64.9	138.9	227.0	254.8	423.7	454.1	650.6	953.4	1324.7	1794.7
180	65.7	140.6	229.9	258.0	429.1	459.8	658.9	965.5	1341.6	1817.5
190	66.5	142.3	232.6	261.1	434.3	465.4	666.8	977.2	1357.7	1839.3
200	67.3	144.0	235.3	264.1	439.3	470.7	674.5	988.3	1373.2	1860.4

Key

v [m/s] = Mean wind speed at 10 m elevation (upper limit of Beaufort grade) over a period of 10 min.

z [m] = Elevation above even ground.

v(*z*) [m/s] = 3-s wind gust speed acting at elevation *z* and decisive for calculations, see Table P(A).

q(*z*) [N/mm^2] = quasi-static impact pressure acting at elevation *z* and calculated based on *v*(*z*).

[a] In-service wind:

1 Light

v = 10.1 [m/s] = > for *z* = 10 [m] = > *q*(*z*) = 125 [N/mm^2]

2 Normal

v = 14.3 [m/s] = > for *z* = 10 [m] = > *q*(*z*) = 250 [N/mm^2]

[b] Upper Beaufort Limit.

Appendix Q
(informative)

Platform deflection calculation

Q.1 General

This appendix provides a calculation method for determining the stability of a single person indoor only MEWP instead of performing the platform deflection test detailed in Clause 3.6.3.1.4. See Figure Q.1 for an illustration of the platform deflection calculation.

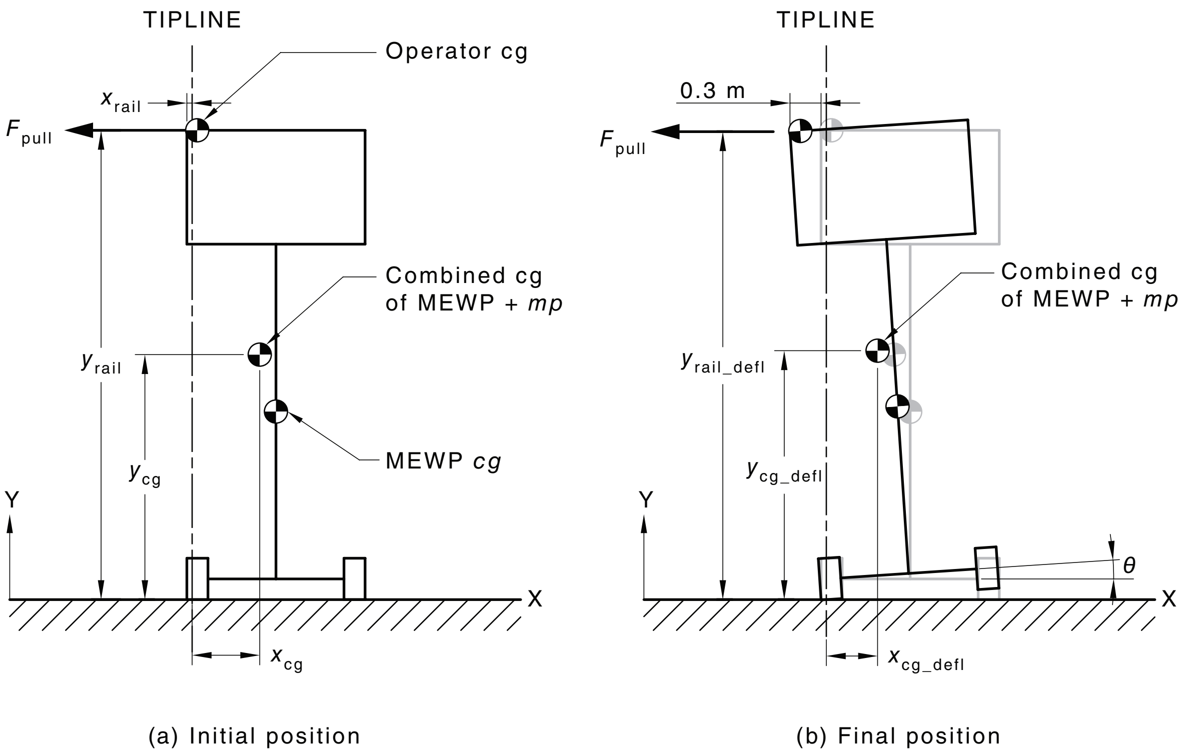


Figure Q.1 — Platform deflection calculation

With the MEWP in the initial position, determine the location of the combined centre of gravity of the MEWP mass and the mass of a single operator (80 kg) located 0.1 m inside the edge of the work platform which is closest to the tipline. The location of the tipline is determined in accordance with Clause 2.1.5.5. The location of the combined centre of gravity is denoted by x_{cg} and y_{cg}.

Next, determine the location of the platform top rail pull location from the tipline. Call this point x_{rail} and y_{rail}.

Let the combined mass of the MEWP and the operator be m_{total}.

Next, calculate the straight-line distance from the ground/tipline intersection to the top rail pull location. Call this d_{rail}.

$$d_{rail} = \sqrt{\left(x_{rail}{}^{2} + y_{rail}{}^{2}\right)}$$

Assume the top rail moves 0.3 m. This is called Δ_{defl}.

$$\Delta_{defl} = 0.3m$$

Next, calculate the angle of tilt of the MEWP to achieve a horizontal movement of 0.3 m at the top handrail. For simplicity, assume that there is no deflection in the MEWP structure or tyres etc. Call this θ.

$$\theta = 90° - a\cos\left(\frac{\Delta_{defl} - x_{rail}}{y_{rail}}\right) - a\tan\left(\frac{-x_{rail}}{y_{rail}}\right)$$

Then calculate the vertical height of the top rail pull location when the MEWP is tilted. This will be identified as y_{rail_defl}.

$$y_{rail\_defl} = \tan\left[a\cos\left(\frac{\Delta_{defl} - x_{rail}}{d_{rail}}\right)\right] \times \left(\Delta_{defl} - x_{rail}\right)$$

Calculate the straight-line distance from the ground/tipline intersection to the centre of gravity location.

$$d_{cg} = \sqrt{\left(x_{cg}{}^{2} + y_{cg}{}^{2}\right)}$$

Now calculate the distances x_{cg_defl} and y_{cg_defl}.

$$x_{cg\_defl} = d_{cg} \times \cos\left[a\tan\left(\frac{y_{cg}}{x_{cg}}\right) + \theta\right]$$

$$y_{cg\_defl} = d_{cg} \times \sin\left[a\tan\left(\frac{y_{cg}}{x_{cg}}\right) + \theta\right]$$

Calculate the force F_{pull} required to sustain a platform horizontal deflection of Δ_{defl}.

The requirement is met if $F_{pull} > 70$ N.

$$F_{pull} = \frac{m_{total} \times g \times x_{cg\_defl}}{y_{rail\_defl}}$$

Q.2 Worked example

Let x_{cg} = 256 mm, y_{cg} = 2047 mm, x_{rail} = 37.5 mm, y_{rail} = 4100 mm and m_{total} = 380 kg.

Calculate the straight-line distance from the ground/tipline intersection to the top rail pull location d_{rail}.

$$d_{rail} = \sqrt{\left(37.5^{2} + 4100^{2}\right)}$$

d_{rail} = 4 100.171 mm

Assume the top rail moves 0.3 m. This is called Δ_{defl}.

$$\Delta_{defl} = 0.3m$$

Next, calculate the angle of tilt of the MEWP to achieve a horizontal movement of 0.3 m at the top handrail. For simplicity, assume that there is no deflection in the MEWP structure or tyres etc. Call this θ.

$$\theta = 90° - a\cos\left(\frac{300-37.5}{4100}\right) - a\tan\left(\frac{-37.5}{4100}\right)$$

θ = 4.195°

Then calculate the vertical height of the top rail pull location when the MEWP is tilted. This will be identified as y_{rail_defl}.

$$y_{rail\_defl} = \tan\left[a\cos\left(\frac{300-37.5}{4100.171}\right)\right] \times (300-37.5)$$

y_{rail_defl} = 4091.76 mm

Calculate the straight-line distance from the ground/tipline intersection to the centre of gravity location.

$$d_{cg} = \sqrt{\left(256^2 + 2047^2\right)}$$

d_{cg} = 2063.301 mm

Next, calculate the distances x_{cg_defl} and y_{cg_defl}.

$$x_{cg\_defl} = 2063.301 \times \cos\left[a\tan\left(\frac{2047}{256}\right) + 4.195°\right]$$

x_{cg_defl} = 105.4727 mm

$$y_{cg\_defl} = 2063.301 \times \sin\left[a\tan\left(\frac{2047}{256}\right) + 4.195°\right]$$

y_{cg_defl} = 2060.604 mm

Calculate the force F_{pull} required to sustain a platform horizontal deflection of Δ_{defl}.

The requirement is met if F_{pull} > 70 N.

$$F_{pull} = \frac{380 \times 9.81 \times 105.4727}{4091.76}$$

F_{pull} = 96 N

Therefore the requirement is met.

Appendix R
(informative)

Stress history parameters

R.1 Introduction

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The stress histories at a selected point of the structure depend on the loads, their directions and positions during the use of the MEWP, as well as on the MEWP configuration. The configuration of the MEWP can be a combination of the different motions of its moving structure, e.g. extension, lowering, slewing.

The total number of working cycles of a MEWP during its useful life may be divided into several typical tasks with the numbers of working cycles corresponding to them. The stress histories may be established from those tasks.

A task may be characterized by a sequence of intended movements, with specific MEWP configurations, and a load spectrum which may be deduced for a task.

R.2 Guidance for selection of S class

The number of load cycles for a MEWP is usually in the range between —

(a) *light intermittent duty* — 4×10^4 cycles (e.g. 10 years, 40 weeks per year, 20 h per week, 5 load cycles per hour); and

(b) *heavy duty* — 10^5 cycles (e.g. 10 years, 50 weeks per year, 40 h per week, 5 load cycles per hour).

Table R.2 gives guidance for the selection of S classes for the load-carrying parts with the most severe stress spectrum. Other parts of the structure may be assigned lower S classes.

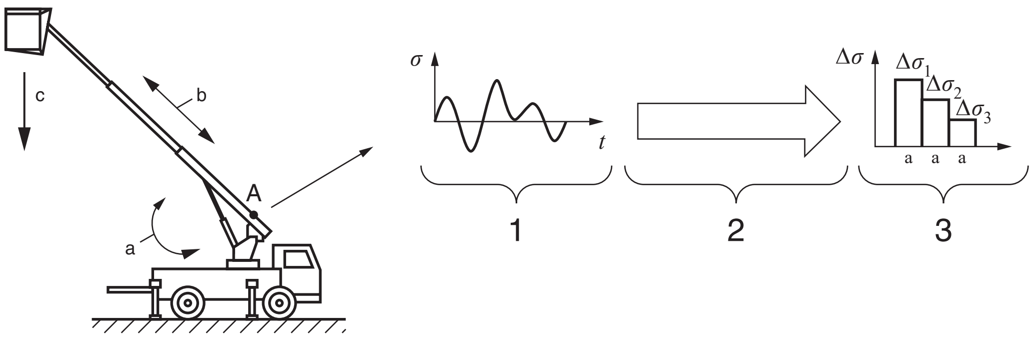
Table R.2 — S classes for different duties

MEWP classification	**Intensity of duty**	
	Number of stress cycles corresponding to 4×10^4 load cycles (light intermittent duty)	**Number of stress cycles corresponding to 10^5 load cycles (heavy duty)**
Load sensing system and position control	S01	S0
Load and moment sensing systems	S01	S0
Moment sensing system with enhanced overload criteria	S0	S1
Position control with enhanced stability and overload criteria	S0	S1
NOTE 1: MEWP classification of Table R.2 in accordance with Table 2.3.1.1.		
NOTE 2: Intensity of duty is defined as the combination of number of stress cycles and stress spectrum.		

R.3 Stress history parameters

R.3.1 General procedure

Ideally, the corresponding series of loadings has to be determined first, i.e. the magnitude, position anddirection of all loads, plus the corresponding configurations of the structure (e.g. extended, lowered/lifted, rotated).Next, the sequence of stress peaks occurring during the performance of each task may be deducted.Figure R.3.1(A) represents an extract of a real stress sequence (history) occurring at point A of the MEWP structure due to two identified movements of the extending structure (extension, lowering) combined with the work platform load.



Key

A Point at which the stress history is being studied

a Slewing motion

b Boom telescope

c Boom lowering

σ Stress magnitude

t Time

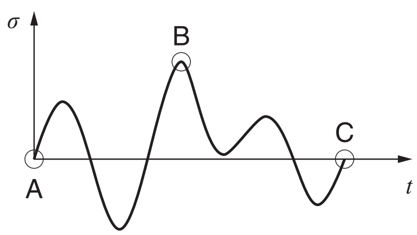
Figure R.3.1 — (A) — Example of stress variations due to movements

Stress cycles may be identified from these resulting sequences or stress histories using one of the established stress cycle counting methods, such as the Rainflow or the Reservoir method. The principle of the Reservoir method is described Figure R.3.1(B).

The complete stress history of a certain point of the structure is obtained by summating the individual stress histories taken from the sequences of movements of all different tasks.

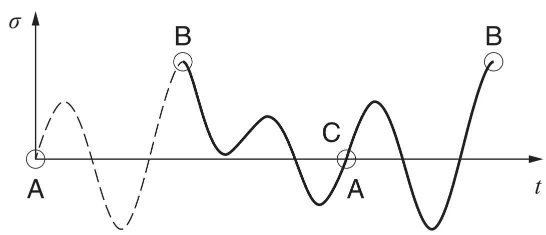
Finally, the stress spectrum factor k can be calculated.

It may also be determined from measurements.



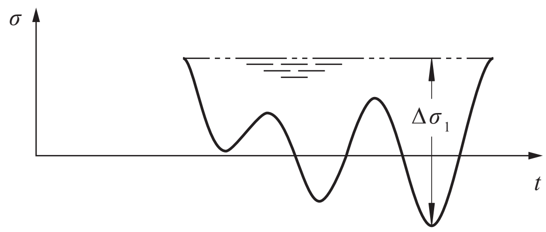
(a) Step 1:

Determine the stress history for the load event. Identify the largest peak B.



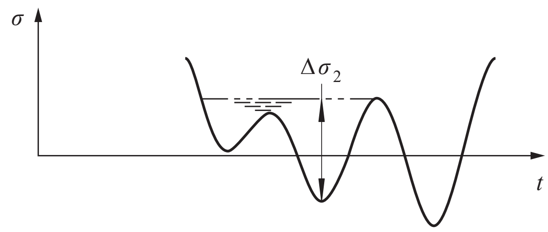
(b) Step 2:

Move the part of the stress history on the left of B to the end of the load event, i.e. link *σ* (A-B) to C.



(c) Step 3:

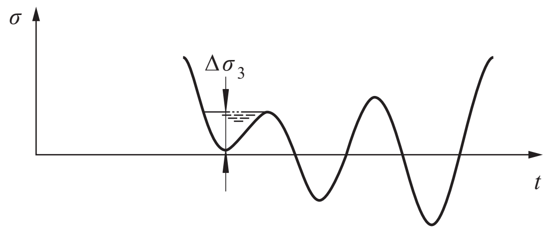
Fill the resulting “reservoir” with “water”. The greatest depth is the major stress cycle, i.e. $\Delta\sigma_1$ occurs once.



(d) Step 4:

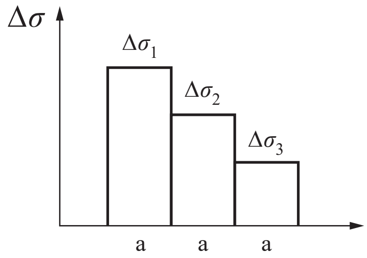
Drain on the greatest depth and find the new maximum depth $\Delta\sigma_2$.

This is the second largest stress cycle.



(e) Step 5 (and onwards):

Repeat step 4 until all the “water” is drained.



(f) Stress-range spectrum:

The results of the cycle counting procedure may be arranged in a stress-range spectrum.

Key

a Cycles

t Time

Figure R.3.1(B) — Reservoir stress cycles counting method

R.3.2 Direct calculation of stress history class

For MEWPs, the stress spectrum factor *k* at a certain point of the structure, and expressed as relative damage per working cycle, may be computed as:

$$k = \frac{1}{N} \cdot \sum_i \left(\frac{\Delta\sigma_i}{\Delta\sigma_{max}} \right)^3 \cdot n_i$$

The corresponding stress history parameter s may be calculated as:

$$s = \frac{N_{tot}}{2 \cdot 10^6} \cdot k$$

where

i = an index, running from 1 to the number of stress range classes used

$\Delta\sigma_i$ = the stress range of class *i*

n_i = the number of stress cycles that fall into class *i*

$\Delta\sigma_{max}$ = the maximum stress range at that point

N the number of work cycles used for elevation of k

N_{tot} the number of work cycles during the life of the MEWP

The stress history parameter s is classified in stress history S classes in accordance with Table R.3.2.

Table R.3.2 — Classes S of stress history parameters

Class	Value of stress history parameter s	Characteristic values of s
S02	$s \leq 0.002$	0.002
S01	$0.002 < s \leq 0.004$	0.004
S0	$0.004 < s \leq 0.008$	0.008
S1	$0.008 < s \leq 0.016$	0.016
S2	$0.016 < s \leq 0.032$	0.032
S3	$0.032 < s \leq 0.063$	0.063
S4	$0.063 < s \leq 0.125$	0.125
S5	$0.125 < s \leq 0.250$	0.250
S6	$0.250 < s \leq 0.500$	0.500
S7	$0.500 < s \leq 1.000$	1.000

Different parts of the MEWP may be assigned different S classes or specific s values.

R.3.3 Simplified method to determine stress history class

For MEWPs having an extending structure, and where the stresses only get negligible contributions from other loadings than the rated load and the weight of the work platform, the value of s may be estimated by:

$$s = \sum_{i} \left[\frac{m_{\mathrm{i}} + w}{m_{\mathrm{rl}} + w} \right]^3 \cdot \frac{n_{\mathrm{i}}}{2 \cdot 10^6} \cdot \sum_{j} \left[\frac{r_{\mathrm{j}}}{r_{\mathrm{max}}} \right]^3 \cdot \frac{k_{\mathrm{j}}}{N}$$

where

m_{rl} = rated load

m_i = load level i

n_i = number of load cycles at level m_i

w = weight of the work platform

r_j = working radius level j

r_{max} = maximum working radius

k_j = number of cycles at radius r_j

N = total number of load cycles

The computed s value will fall into one of the stress history classes given in Table R.3.2.

Appendix S
(normative)

Calculation of service life of wire rope drive systems

S.1 General

This appendix has been reproduced and modified from ISO 16368:2010 with permission from ISO.

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

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.

Wire ropes which do not run on rope drums or over rope pulleys (carrying ropes and tensioning ropes) and sling ropes are not dealt with in this appendix.

S.2 Calculation of service life of wire rope drive systems

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

(a) Mode of operation (drive group).

(b) Wire rope diameter (coefficient *c*).

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

(d) Rope grooves.

The mechanical components shall be graded according to their mode of operation into a "drive group", in accordance with Table S.2, in order to achieve an adequately long service life. The grading is made according to running time categories, which take the average running time of the wire rope drive system into account. As regards the grading into running time categories, the mean running time per day, related to one year, is the determining factor.

Table S.2 — Drive groups according to running time categories

Running time category	Symbol			V006	V012	V025	V05	V1	V2	V3	V4	V5
	Mean running time per day in h, related to one year			≤ 0.125	> 0.125 up to 0.25	> 0.25 up to 0.5	> 0.5 up to 1	> 1 up to 2	> 2 up to 4	> 4 up to 8	> 8 up to 16	> 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

NOTE If the duration of a load 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.

S.3 Calculation of rope diameters (coefficient *c*)

The rope diameter d (in mm) is determined in accordance with the formula below, from the calculated traction force on the rope *S* (in Newtons):

$$d_{\min} = c \cdot \sqrt{S} \qquad \text{S.1}$$

The values of coefficient *c* (in mm/√N) are given in Table S.3 for the various drive groups. These values apply equally to bright and to galvanized wire ropes.

The calculated rope traction force *S* is determined from the static traction force in the wire rope, taking into consideration the acceleration forces and the efficiency of the wire rope drive system (see Clause S.5).

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

Table S.3 — Coefficients *c*

Drive group	*c* in mm/√N for wire ropes which are not non-twisting				
	Nominal strength of individual wires in N/mm²				
	1570	1770	1960	2160[a]	2450[a]
$1E_m$	-	0.0670	0.0630	0.0600	0.0560
$1D_m$	-	0.0710	0.0670	0.0630	0.0600
$1C_m$	-	0.0750	0.0710	0.0670	
$1B_m$	0.0850	0.0800	0.0750	-	
$1A_m$	0.0900	0.0850		-	
2_m	0.0950			-	
3_m	0.106			-	
4_m	0.118			-	
5_m	0.132			-	

[a] Wire ropes of 2160 N/mm² and 2450 N/mm² nominal strength in particular shall be of a design which makes them entirely suitable for the special application concerned here.

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

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 Clause S.3, in accordance with the following formula:

$$D_{\min} = h_1 \cdot h_2 \cdot d_{\min} \qquad \text{S.2}$$

In the above formula, 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 S.4(A). The factor h_2 is dependent on the arrangement of the wire rope drive system and is listed in Table S.4(B).

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 Tables S.4(A) and S.4(B) for the same rope traction force, and without any impairment of the service life, on condition that the groove radius is at least 0.525 times the diameter of the wire rope. Larger rope drum, rope pulley and compensating pulley diameters will increase the service life of the wire rope.

Table S.4(A) — Coefficients h_1

Drive group	Rope drum 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 wire rope drive systems are classified according to the number ω of alternating bending stresses which the most unfavourably stressed portion of the rope has to run through during one load cycle (lifting and lowering of the load). ω is entered as the sum of the following individual values for the elements of the wire rope drive system:

Rope drum $\omega = 1$

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

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

Rope pulley, $\alpha > 5°$ (see Figure S.4(A)) $\omega = 0$

Compensating pulley $\omega = 0$

End attachment of rope $\omega = 0$

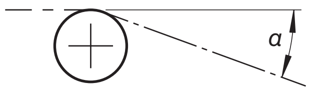


Figure S.4(A) – angle of deflection

Deflection in the opposite direction shall 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 S.4(C)].

Table S.4(B) — Coefficients h_2

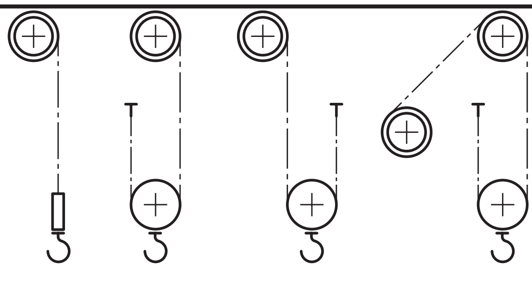
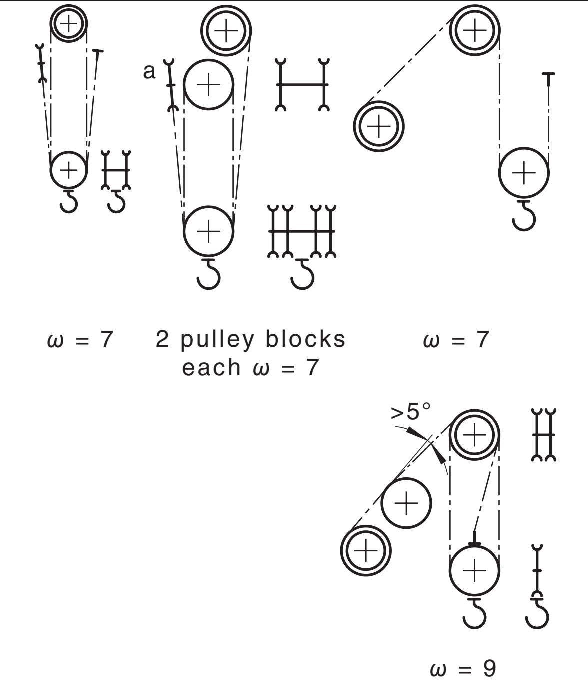
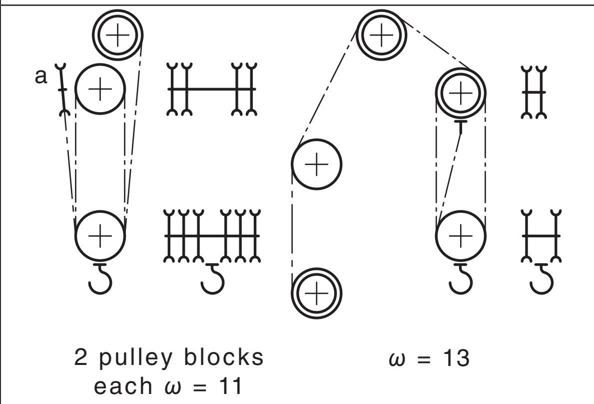
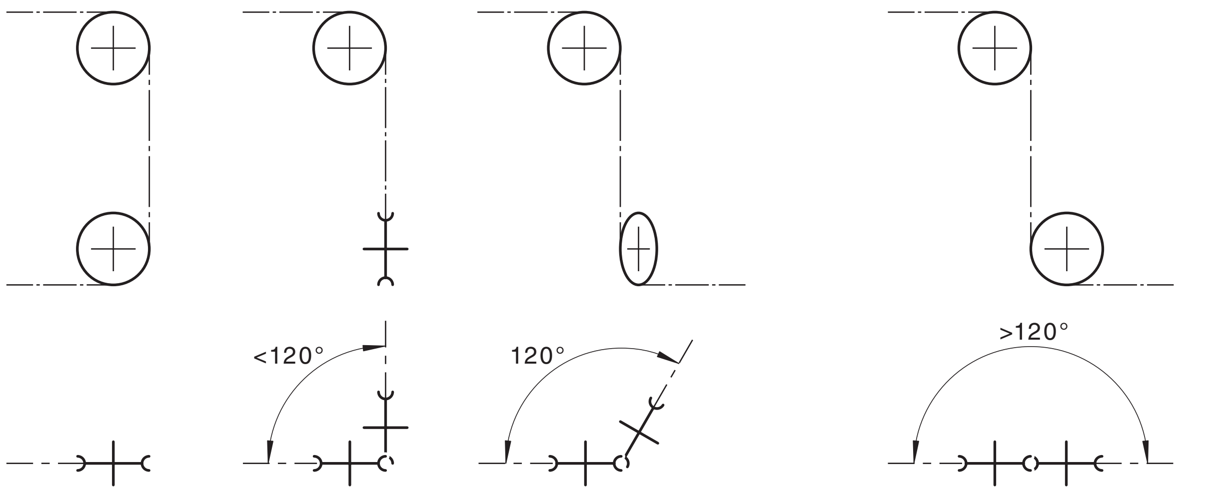
Description	Examples for arrangements of rope drives Examples of application (drums illustrated in double lines)	ω	h_2[b] for: Rope drums, compensating pulleys	h_2[b] for: Rope pulleys
Wire rope runs on rope drum and over no more than: 2 rope pulleys with deflection in the same direction; or 1 rope pulley with deflection in opposite direction.	 ω=1 ω=3 ω=5 ω=5	≤ 5	1	1

Table S.4(B) *(continued)*

Description	Examples for arrangements of rope drives Examples of application (drums illustrated in double lines)	ω	h_2[b] for: Rope drums, compensating pulleys	h_2[b] for: Rope pulleys
Wire rope runs on rope drums and over no more than: 4 rope pulleys with deflection in the same direction; or 2 rope pulleys with deflection in the same direction a 1 rope pulley with deflection in the opposite direction; or 2 rope pulleys with deflection in the opposite direction.		6 up to 9	1	1.12
Wire rope runs on rope drum and over at least: 5 rope pulleys with deflection in the same direction; or 3 rope pulleys with deflection in the same direction plus 1 rope pulley with deflection in the opposite direction; or 1 rope pulley with deflection in the same direction plus 2 rope pulleys with deflection in the opposite direction; or 3 rope pulleys with deflection in the opposite direction.		≥ 10	1	1.25

[a] Compensating pulley.

[b] The correlation of ω 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 ω which occur at the least favourable segment of the rope need to be considered.



a) Deflection in the same direction

b) Deflection in the opposite direction

Figure S.4(C) — Deflection in the same or opposite direction

S.5 Efficiency of wire rope drive systems

The efficiency η_S of a rope drive, for calculation of the rope traction force in accordance with Clause S.3, is determined in accordance with the following formula:

$$\eta_s = (\eta_R)^i \cdot \eta_F = (\eta_R)^i \cdot \frac{1}{n} \cdot \frac{1-(\eta_R)^n}{1-\eta_R} \qquad \text{S.3}$$

where

i = number of fixed rope pulleys between the rope drum and the pulley block or load

n = number of rope plies in one pulley block. One pulley block consists of the sum total of all the rope plies and rope pulleys

η_F = efficiency of the pulley block

$$\eta_F \frac{1}{n} \cdot \frac{1-(\eta_R)^n}{1-\eta_R} \qquad \text{S.4}$$

where

η_R = efficiency of one rope pulley

Figure S.5 shows the possible configurations of pulley blocks.

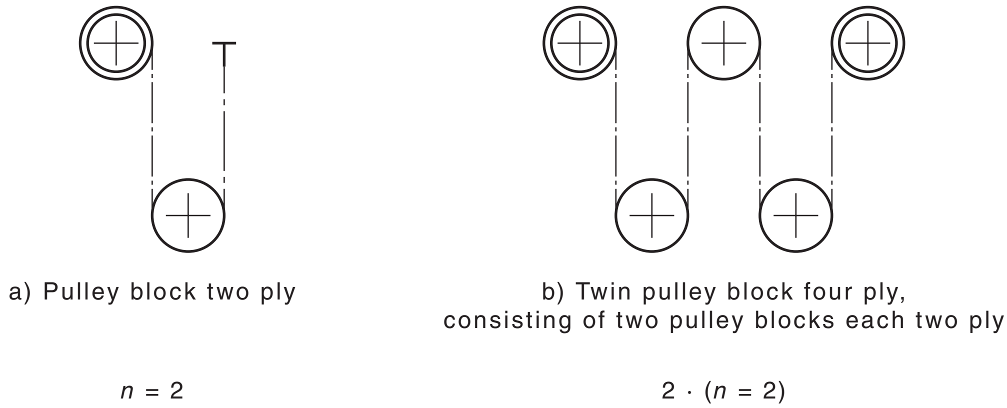


Figure S.5 — Pulley blocks

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, and the type of bearing arrangement of the pulley (plain bearings or anti-friction bearings). In so far as more accurate values have been proved by means of trials, the following shall be assumed for calculations:

(a) *For plain bearings* — $\eta_R = 0.96$

(b) *For anti-friction bearings* — $\eta_R = 0.98$

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

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

Table S.5 — Efficiency of pulley blocks

n	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**13**	**14**
η_F Plain bearings	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
η_F 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

Appendix T
(informative)

Calculation example — Wire rope drive systems

T.1 Method used to determine the coefficients and ratios used for Clause 2.4.2 (wire rope drive systems) using the load cycle figures set out in Clause 2.1.6 and operating speeds set out in Clause 2.3.6

T.1.1 General

This appendix has been reproduced and modified from ISO 16368:2010 with permission from ISO.

This method was preferred to the use of the Group Classification of Mechanisms method in ISO 4301-4:1989, which posed problems of relating the state of loading and load spectrum factors to MEWPs, but gives results in line with the mobile crane standard ISO 16625.

T.1.2 Notes

The following applies:

(a) Assumptions for calculations of wire rope drive systems:

(i) "Light intermittent duty" in accordance with Clause R.2 is interpreted as large machines with large rated loads, often operating with less than the full rated load and used intermittently.

(ii) "Heavy duty" in accordance with Clause R.2 is interpreted as smaller machines with large rated loads regularly carrying the full rated load, and used regularly.

(iii) "Medium term" (see Table S.2) is considered the most severe working case for extending structures, as the load varies during the load 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 load cycle. This does not apply to MEWPs, but would still give the same drive group used in the example.

(b) 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.

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

T.1.3 Appendix S (normative) method summarized

The calculation shown in Appendix S can be summarized as follows:

(a) Use the number of load cycles and operating speeds from this document to derive the "mean running time per day in hours, related to one year" in Table S.2 to determine the drive group.

(b) Calculate the minimum theoretical rope diameter, d_{min}, using the coefficient c, for this drive group from Table T.2(A) in equation T.1:

$$d_{\min} = c \cdot \sqrt{S}$$

where

S = calculated traction force in the rope

This completes the process described in Appendix S for calculating the wire rope diameter. However, the coefficient of utilization may be calculated by dividing the breaking force figures from Table D.5 in ISO 2408:2017, corrected if necessary for different wire strengths, by the calculated traction force in the rope.

(c) Calculate the diameters of drums and pulleys from equation T.2:

$$D_{\min} = h_1 \cdot h_2 \cdot d_{\min}$$

The coefficient h_1 for the drive group is taken from Table T.2(B). The coefficient h_2 is determined by the total number of alternating stresses in the most unfavourably stressed portion of the rope using Table T.2(B).

T.1.4 Calculation example

T.1.4.1 General

The following example illustrates the calculation for wire rope drive systems, but the load figures have been chosen to give an exact 9 mm diameter for the wire rope, so the coefficients in the table are minimal.

T.1.4.2 Mode of operation (drive group)

See Clause T.2 and Table S.2 for guidance on the mode of operation.

The following calculations can be used:

(a) Case 1, light intermittent duty [see Figure T.1.4.2(A)]:

40 000 load cycles over 10 years = $\frac{40000}{365 \cdot 10}$ load cycles per day = 10.96 load cycles per day

T.1

Worst case is considered to be a 25 m boom (r) moving through 180° (360° total) at 0.4 m/s (v) [see Figure T.1.4.2(A)].

The running time for one load cycle is:

$$\frac{\pi \cdot 2r}{v} = \frac{\pi \cdot 2 \cdot 25 \cdot m \cdot s}{0.4 \cdot m} = 393s \qquad \text{T.2}$$

The mean running time per day in hours, relating to one-year results from equations T.1 and T.2, can be calculated as follows:

10.96 · 393 s/day = 1.12 h/day

This corresponds to category V_1 (see Table S.2).

Table S.2 gives $1A_m$ drive group for category V_1, medium duty.

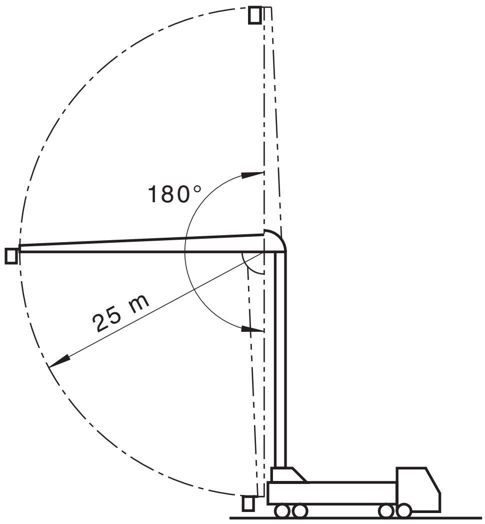


Figure T.1.4.2(A) — Case 1

(b) Case 2, heavy duty [see Figure T.1.4.2(B)]

100 000 load cycles over ten years = 10 000/(365 · 10) load cycles/day = 27.4 load cycles/day (T.3)

Worst case is considered to be a 10 m boom (r) moving through 90° (180°) at 0.4 m/s (*v*) [see Figure T.1.4.2(B)].

The running time for one load cycle is:

$$\frac{\pi \cdot r}{v} = \frac{\pi \cdot 10 \cdot m \cdot s}{0.4 \cdot m} = 78.5s \quad \text{T.4}$$

The mean running time per day in hours, relating to one-year results from equations T.3 and T.4, can be calculated as follows:

78.5 · 27.4 s/day = 0.6 h/day

This corresponds to category V_{05} (see Table S.2).

Table S.2 gives $1A_m$ drive group for category V_{05}, heavy duty.

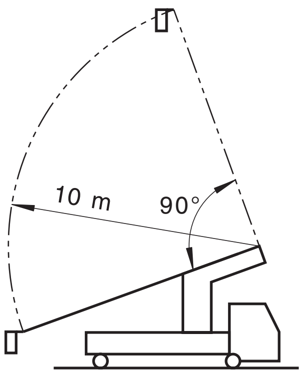


Figure T.1.4.2(B) — Case 2

$1A_m$ drive group is adopted as appropriate for all MEWPs conforming to this document.

T.1.4.3 Calculation of minimum rope diameter

See Clause S.3 for guidance on the calculation of minimum rope diameter.

The minimum rope diameter is:

$$d_{\min} = c \cdot \sqrt{S} \qquad \text{T.5}$$

where

S = calculated traction force in the rope in Newtons

For drives of group $1A_m$, under not non-twisting conditions, Table S.3 gives —:

(a) c = 0,090 for 1 570 N/mm² ropes;

(b) c = 0,085 for 1 770 N/mm² ropes; and

(c) c = 0,085 for 1 960 N/mm² ropes.

For S = 10 000 N and c = 0.09 resp. S = 11 211 N and c = 0,085, equation T.5 leads to a minimum rope diameter of 9 mm.

T.1.4.4 Working coefficients

ISO 2408:2017, Table D.5, gives the following minimum breaking force for 9 mm diameter wire ropes:

(a) F_{01} = 47 300 N (fibre core).

(b) F_{02} = 51 000 N (steel core).

Based on ISO 2408:2017, Table D.5 (tensile grade 1 770 N/mm²), the working coefficients shown in Table T.1.4.4 apply to 9 mm ropes.

Table T.1.4.4 — Working coefficients

Tensile grade R_0 (N/mm²)	Working coefficient		Formula
	Fibre core	Steel core	
1770 (S = 11 211 N)	4.22	4.55	$\frac{F_{01,02}}{S}$
1570 (S = 10 000 N)	4.20	4.52	$\frac{F_{01,02}}{S} \cdot \frac{1570}{1770}$
1960 (S = 11 211 N)	4.67	5.04	$\frac{F_{01,02}}{S} \cdot \frac{1960}{1770}$

T.2 Calculation of the diameters of rope drums, pulleys and static pulleys

Using equation T.4:

$$D_{\min} = h_1 \cdot h_2 \cdot d_{\min}$$

The coefficients h_1 for drive group $1A_m$ are taken from Table T.2(A).

The coefficients h_2 are determined by the total number ω_t of alternating stresses, ω in the least favourable stressed portion of the rope using Table T.2(A). Figure T.2 and Table T.2(B) show that the value h_2 for MEWPs is normally 1.

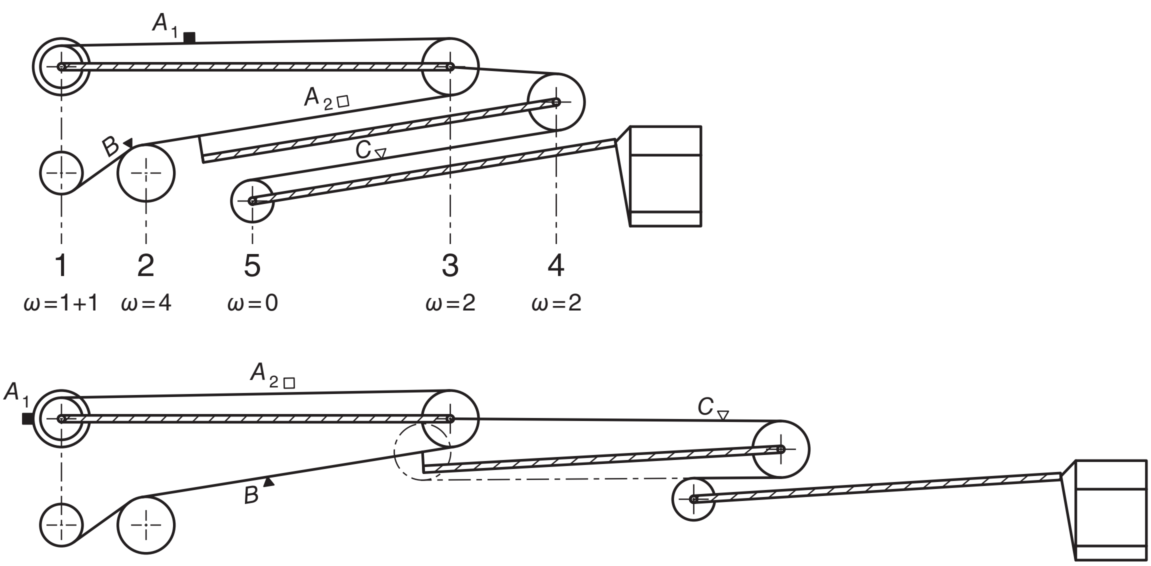
Under these circumstances:

$$D_{min}/d_{min} = h_1 \cdot h_2$$

The following ratio results for MEWPs [see Table T.2(A)]:

Table T.2(A) — Ratio D_{min}/d_{min}

Description	ω_t	h_2	h_1	D_{min}/d_{min}
Rope drum	≤ 5	1	16	16
	6 up to 9	1	16	16
	≥ 10	1	16	16
Pulley deflecting $\alpha > 5°$ in the same direction	≤ 5	1	18	18
	6 up to 9	1.12	18	20.16
	≥ 10	1.25	18	22.5
Pulley deflecting $\alpha > 5°$ in the opposite direction	≤ 5	1	18	18
	6 up to 9	1.12	18	20.16
	≥ 10	1.25	18	22.5
Pulley deflecting $\alpha \le 5°$ in any direction and compensating pulley (e.g. end attachment of rope)	≤ 5	1	14	14
	6 up to 9	1	14	14
	≥ 10	1	14	14



Key

1 Double rope drum

2 Rope pulley (deflection in the opposite direction)

3 Rope pulley (deflection in the same direction)

4 Rope pulley (deflection in the same direction)

5 End attachment of rope

Figure T.2 — Extending structure retracted/extended; determination of the number of alternative bending stresses ω in individual wire ropes for determination of pulley and drum diameters

Table T.2(B) — Example values for omega and h_2

Rope	Number of alternating bending stress ω	h_2
A_1	1	1
A_2	2	1
B	1 + 4 = 5	1
C	2	1

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STANDARDS Australia

GPO Box 476 Sydney NSW 2001
Phone (02) 9237 6000
Email mail@standards.org.au
www.standards.org.au

STANDARDS NEW ZEALAND
TE MANA TAUTIKANGA O AOTEAROA

PO Box 1473 Wellington 6140
Freephone 0800 782 632
Phone (04) 498 5990
Email enquiries@standards.govt.nz
www.standards.govt.nz

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