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ISO 17096

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Cranes — Safety — Load lifting attachments

Appareils de levage à charge suspendue — Sécurité — Accessoires de préhension

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Foreword

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

Attention is drawn to the possibility that some of the elements of this document may be the subject of patent rights. ISO shall not be held responsible for identifying any or all such patent rights. Details of any patent rights identified during the development of the document will be in the Introduction and/or on the ISO list of patent declarations received (see www.iso.org/patents).

Any trade name used in this document is information given for the convenience of users and does not constitute an endorsement.

For an explanation on the meaning of ISO specific terms and expressions related to conformity assessment, as well as information about ISO's adherence to the WTO principles in the Technical Barriers to Trade (TBT) see the following URL: Foreword - Supplementary information

The committee responsible for this document is ISO/TC 96, *Cranes*, Subcommittee SC 9, *Bridge and gantry cranes*.

Introduction

This International Standard covers a wide range of non-fixed load lifting attachments which have never previously been standardized by ISO. The lack of previous standards as a starting point, together with the wide scope of the equipment covered and the wide variety of current practices, among the established manufacturers made this International Standard particularly difficult to draft and to get agreement on. Nevertheless, considerable progress has been made up to the point where the parties involved are now sufficiently in agreement to enable the first draft of this International Standard to be prepared. The ISO technical subcommittee SC 9 which is responsible for the preparation of this International Standard is of the view that while further development may be required, this International Standard, in its present form, contains much useful information to guide the manufacturers and it represents an important step forward. Experience of applying this International Standard will doubtless reveal some matters which, with the benefit of hindsight, have not been adequately dealt with and will need to be reconsidered in the next edition. In particular, readers are advised to exercise a degree of caution about the rigour of some of the verification clauses.

Cranes — Safety — Load lifting attachments

1 Scope

This International Standard specifies safety requirements for the following non-fixed load lifting attachments for cranes, hoists, and manually controlled load manipulating devices as defined in Clause 3:

— plate clamps;

— vacuum lifters;

— self priming,

— non-self-priming (pump, venturi, turbine);

— electric lifting magnets (battery-fed and main-fed);

— permanent lifting magnets;

— electro-permanent lifting magnets;

— lifting beams/spreader beams;

— C-hooks;

— lifting forks;

— clamps.

This International Standard does not specify the additional requirements for the following:

a) load lifting attachments in direct contact with foodstuffs or pharmaceuticals requiring a high level of cleanliness for hygiene reasons;

b) hazards resulting from handling hazardous materials (e.g. explosives, hot molten masses, radiating materials);

c) hazards caused by operation in an explosive atmosphere;

d) hazards caused by noise;

e) electrical hazards;

f) hazards due to hydraulic and pneumatic components.

This International Standard does not cover attachments intended to lift people.

This International Standard does not cover slings, ladles, expanding mandrels, buckets, grabs or grab buckets, and container spreaders.

2 Normative references

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

ISO 4306-1, *Cranes — Vocabulary — Part 1: General*

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

ISO 4778, *Chain slings of welded construction — Grades M (4), S (6) and T (8)*

ISO 7531, *Wire rope slings for general purposes — Characteristics and specifications*

ISO 7593, *Chain slings assembled by methods other than welding — Grade T (8)*

ISO 7731, *Ergonomics — Danger signals for public and work areas — Auditory danger signals*

ISO 8686, *Cranes — Design principles for loads and load combinations*

ISO 11428, *Ergonomics — Visual danger signals — General requirements, design and testing*

ISO 11429, *Ergonomics — System of auditory and visual danger and information signals*

ISO 12100:2010, *Safety of machinery — General principles for design — Part 1: Risk assessment and risk reduction*

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

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

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

EN 1492-1, *Textile slings — Safety — Part 1: Flat woven webbing slings made of man-made fibres for general purpose use*

EN 1492-2, *Textile slings — Safety — Part 2: Roundslings made of man-made fibres for general purpose use*

EN 1492-4, *Textile slings — Safety — Part 4: Lifting slings for general service made from natural and man-made fibre ropes*

3 Terms and definitions

For the purposes of this document, the terms and definitions given in ISO 4306-1, ISO 12100, and the following apply.

3.1
adhesion force
force required to remove the load from a *vacuum lifter* (3.21) at the upper limit of specified pressure range

3.2
C-hook
equipment in the form of a “C” used for lifting hollow loads

EXAMPLE Coils and pipes among others.

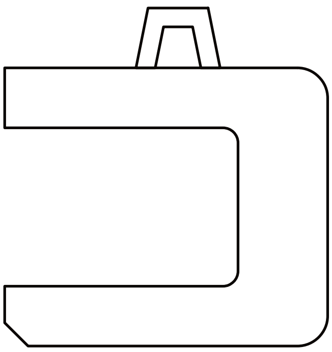


Figure 1 — Example of a C-hook

3.3
design factor
arithmetic ratio between the minimum failure load of the lifting attachment and its *working load limit (WLL)* (3.22)

3.4
clamp
equipment used to handle loads by clamping on a specific part of the load

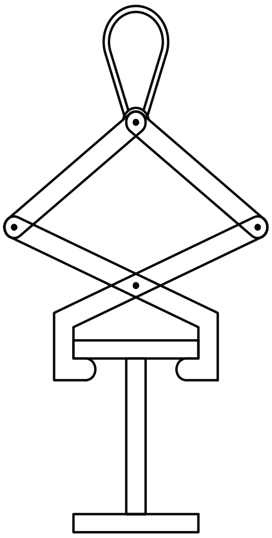


Figure 2 — Example of a clamp

3.5
exclusion area
area from which persons are excluded for the purpose of safety whilst lifting operations are in progress

3.6
exposure area
area where personnel may be exposed to hazards arising from a lifting operation

3.7
individual verification
verification carried out on every item produced

3.8
lifting beam
equipment consisting of one or several members equipped with various attachment points in order to distribute the force as required by the characteristics of the handled loads

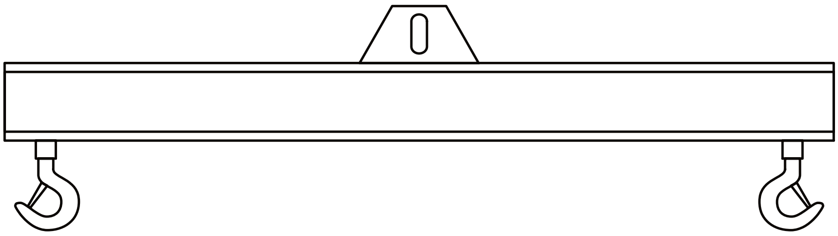


Figure 3 — Example of a lifting beam

3.9
lifting forks
equipment consisting of two or more arms connected to an upright with an upper arm used to lift palletized or similar loads

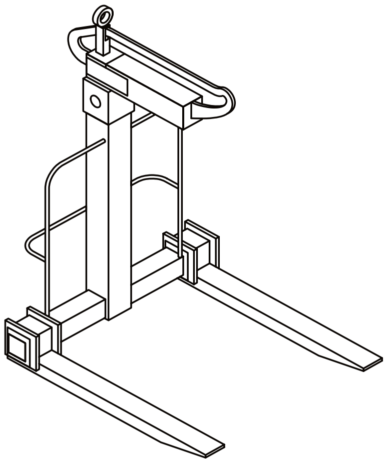


Figure 4 — Example of lifting forks

3.10 lifting magnet

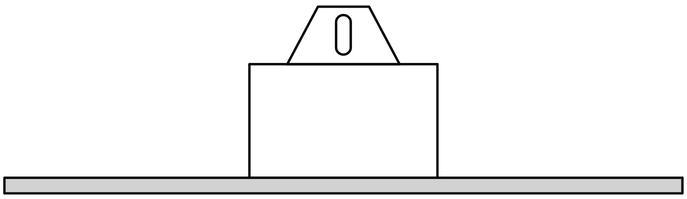


Figure 5 — Example of a lifting magnet

3.10.1
electric lifting magnet
equipment with a magnetic field generated by an electric current creating sufficient force for gripping, holding, and handling loads with ferro-magnetic properties

3.10.2
permanent lifting magnet
equipment with a permanent magnetic field which creates sufficient force for gripping, holding, and handling loads with ferro-magnetic properties

Note 1 to entry: The magnetic field or load holding is controlled by mechanical means.

3.10.3
electro-permanent lifting magnet
equipment with a permanent magnetic field which creates sufficient force for gripping, holding, and handling loads with ferro-magnetic properties

Note 1 to entry: The magnetic field is controlled by an electric current which is not required to sustain the magnetic field.

3.11
minimum working load
minimum load that the *non-fixed load lifting attachment* (3.13) is designed to lift under the conditions specified by the manufacturer

3.12
no-go area
area from which persons are excluded during normal operation

3.13
non-fixed load lifting attachment
lifting attachment which can be fitted directly or indirectly to the hook or any other coupling device of a crane, hoist, or manually controlled manipulating device by the user without affecting the integrity of the crane, hoist, or manually controlled manipulating device

3.14
plate clamps
non-powered gripping device designed for lifting and turning plates or sections

Note 1 to entry: The gripping action or clamping force is achieved with a mechanical leverage or cam action enabling the cam to *clamp* (3.4) the section on to a pad.

Note 2 to entry: Vertical plate clamps are used to lift plates or sections in a vertical plane or from the horizontal to the vertical plane.

Note 3 to entry: Horizontal plate clamps are used to lift plates in a horizontal plane.

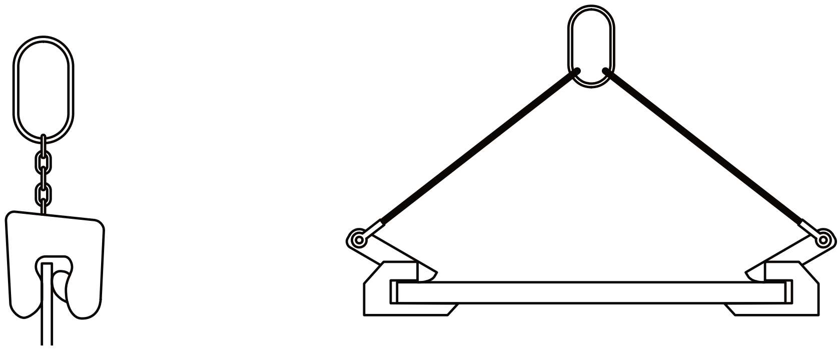


Figure 6 — Example of plate clamps

3.15
positive holding device
device making a direct mechanical connection to hold the load and which does not rely solely on friction, suction, or magnetic adhesion to hold the load

3.16
secondary positive holding device
device to hold loads if the primary holding means fails and which does not rely on friction, suction, or magnetic adhesion to the load

3.17
tear-off force
force applied at a right angle to the plane of the magnet poles which is required to detach the load from the switched-on magnet

3.18
tongs
equipment for lifting loads by clamping forces, positive locking, or by frictional connection and positive locking which act between gripping elements such as tongs arms or jaws, pressure plates, or centres

3.19
two-action control
control which, in order to be operative, requires the performance of two separate actions with one or two hands, such as the following:

a) operation of two separate hold-to-run controls;

b) sequential operation of two movements of a control device;

c) previous unlocking of the control with self-locking in the neutral position

3.20
type verification
verification carried out on one or more samples representative of a particular design and size of product before it is first placed on the market

Note 1 to entry: Although the term “type verification” is normally associated with series produced equipment, for the purpose of this International Standard, it also applies to single unit produced attachment.

3.21
vacuum lifter
suction pad
equipment which includes one or more suction pads operating by vacuum

3.21.1
self-priming vacuum lifter
vacuum lifter (3.21) using the load to create the vacuum

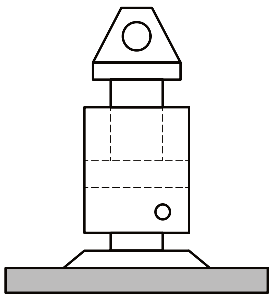


Figure 7 — Example of a self-priming vacuum lifter

3.21.2
non-self-priming vacuum lifter
vacuum lifter (3.21) using an external source of energy

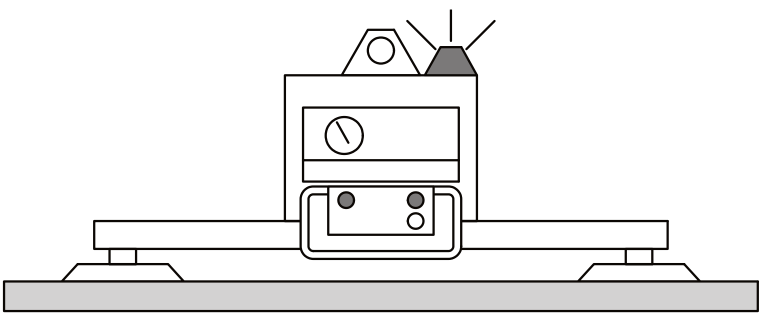


Figure 8 — Example of a non-self-priming vacuum lifter

3.22
working load limit
WLL
maximum load the load lifting attachment is designed to lift under the conditions specified by the manufacturer

4 Safety requirements and/or measures

4.1 General requirements

The attachment shall comply with the safety requirements and/or measures of this subclause. In addition, the attachment shall be designed according to the principles of ISO 12100 for relevant hazards which are not dealt with by this International Standard.

4.1.1 Mechanical load bearing parts

4.1.1.1 Requirements for static strength

The mechanical load bearing parts shall have a mechanical strength to fulfil the following requirements:

a) the attachment shall be designed to withstand a static load of three times the WLL without releasing the load even if permanent deformation occurs;

b) the attachment shall be designed to withstand a static load of twice the working load limit without permanent deformation.

Attachments shall be designed to function properly if tilted to an angle of at least 6°. Attachments designed to tilt shall be designed to function properly if tilted to an angle of at least 6° greater than the maximum working angle.

4.1.1.2 Requirements for fatigue strength

The proof of fatigue strength shall be based on the group classification for the load lifting attachment in accordance with ISO 8686. The class shall be marked in the lifting device or in the accompanying documentation together with the WLL.

The stress ranges used in the fatigue assessment shall be based on the following maximum loadings:

a) vertical force is the gravity force related to the WLL plus the own weight of the lifting device multiplied with a dynamic coefficient typical for the application of the lifting device in question. This dynamic coefficient shall be specified in the documentation by the manufacturer;

b) horizontal force is a typical horizontal force that may be applied to the lifting device or the lifted load simultaneously with the dynamic effect in vertical direction.

The minimum stresses for the stress ranges shall be taken as zero unless the lifting device's own weight is more than 20 % of the WLL and the weight of the lifting device is not placed on the lifted load or ground during normal work cycles.

The calculation of the limit fatigue strengths of structural details shall be in accordance with the appropriate part of ISO 8686 and ISO 20332.

4.1.2 Controls

The electrical controls of the attachment shall be in accordance with IEC 60204-32.

4.1.3 Handles

An attachment that is intended to be guided manually shall be equipped with handle(s) arranged so that finger injuries are avoided. Handles are not required where features exist to provide natural handholds.

4.1.4 Requirements for slings which are integrated

Slings which are an integrated part of the attachment shall be in accordance with ISO 4778, ISO 7531, EN 1492-1, EN 1492-2, and EN 1492-4 as appropriate.

4.1.5 Stability during storage

When not required for use, it shall be possible to set down the attachment so that it is stable during storage. To be regarded as stable, it shall not tip over when tilted to an angle of 10° in any direction. This can be achieved either by the shape of the attachment or by means of additional equipment such as a stand.

4.2 Specific requirements for each category of attachment

4.2.1 Plate clamps

4.2.1.1 Under the conditions specified by the manufacturer, it shall not be possible to unintentionally release the load, in particular, by the following influences:

a) contact of the plate clamp particularly the locking mechanisms with an obstacle;

b) mass of the crane hook, bottom block, or other connections bearing down on the device;

c) intended tipping and/or turning.

4.2.1.2 Plate clamps intended to transport vertically suspended plate shall incorporate a device to prevent the load from unintentional detachment when it is set down.

4.2.1.3 The design factor to prevent the load from slipping shall be at least two.

4.2.1.4 The minimum working load of the plate clamp shall be equal to or less than 5 % of the WLL.

4.2.1.5 Plate clamps shall comply with the requirements specified in 4.2.1.3 using the following tolerances:

a) for a minimum thickness less than or equal to 50 mm, 10 % of the minimum thickness;

b) for a minimum thickness between 50 mm and 100 mm, 5 mm;

c) for a minimum thickness more than 100 mm, 5 % of the minimum thickness.

4.2.1.6 Where the lifting attachment is designed to use more than one clamp, the WLL of each clamp shall take account of the share of the load which can foreseeably be imposed on it (including any inequality of share due to the rigidity of the load).

4.2.1.7 The method of connecting to the crane or intermediate equipment shall ensure that the forces are transmitted through the plate clamp in the correct alignment. Where this is not possible by design, the marking and/or operating instructions shall clearly indicate how it should be connected.

4.2.2 Vacuum lifters

4.2.2.1 Vacuum lifters shall be dimensioned to hold at least a load corresponding to twice the WLL at the end of the working range and the beginning of the fall range respectively at all intended angles of tilt. The maximum angles of tilt shall be increased in accordance with 4.1.1.2.

NOTE The pressure range with which it is possible to work is termed the working range. The fall range adjoins the working range. In some vacuum lifting systems, in particular self-priming vacuum lifters, the pressure decrease arising depends upon the mass of the load.

4.2.2.2 Non-self-priming vacuum lifters shall be equipped with a pressure measuring device showing the working range and the fall range of the vacuum.

4.2.2.3 Self-priming vacuum lifters shall be equipped with an indicator showing to the operator that the end of the working range is reached.

4.2.2.4 The measuring device or the indicator respectively shall be fully visible for the slinger or, where there is no slinger, for the operator of the crane in their normal working position.

4.2.2.5 Means shall be provided to prevent the risks due to vacuum losses. This shall be as follows.

a) *In the case of vacuum lifters with a vacuum pump*: A reserve vacuum with a non-return valve between the reserve vacuum and the pump located as close as possible to the reserve vacuum.

b) *In the case of vacuum lifters with venturi-system*: A pressure-reserve-tank or vacuum-reserve-tank with a non-return valve between the reserve vacuum and the venturi system located as close as possible to the reserve vacuum.

c) *In the case of turbine vacuum lifters*: A supporting battery or an additional flywheel-mass.

d) *In the case of self-priming vacuum lifters*: A reserve-stroke at least equal to 5 % of the total stroke of the piston.

NOTE Vacuum losses can occur, for example, due to leaks or in the case of non-self-priming vacuum lifters, due to a power failure.

4.2.2.6 There shall be a device to warn automatically that the fall range is reached when vacuum losses cannot be compensated. The warning signal shall be optical or acoustic depending upon the circumstances of use for the vacuum lifter and in accordance with ISO 11428, ISO 11429, and ISO 7731. The warning device shall work even when there is a power failure of the vacuum lifter.

NOTE The warning device is not the pressure measuring device of 4.2.2.2 or the indicator of 4.2.2.3.

4.2.2.7 In case of power failure, the vacuum lifter shall be able to hold the load for 5 min. This is not necessary in exclusion areas and this is not necessary for turbine vacuum lifters if all the following conditions are met.

a) The operator maintains control of the load through steering handles which ensures that the operator is outside the fall zone in case of the load falling.

b) In addition to 4.2.2.6, a warning device shall be activated as soon as the power fails.

c) The manufacturer shall instruct that lifting of the geometric centre of the suction pads above 1,8 m is prohibited by appropriate marking and instructions for use.

4.2.2.8 For vacuum lifters intended to be used in an exposure area, a secondary positive holding device is required or there shall be two vacuum reserves each fitted with non-return valves. Each vacuum reserve shall be connected to a separate set of vacuum pads. Each set of vacuum pads shall fulfil the requirement of 4.2.2.1.

4.2.2.9 The releasing of the load shall be actuated by a two-action control. This is not necessary where the release of the load is not possible until the load has been put down or in exclusion areas.

4.2.2.10 Controls for tilting or turning movements shall be hold-to-run type.

4.2.2.11 The shape of the suction pad shall be matched to that of the intended load(s). Where more than one suction pad is used in conjunction with a lifting beam, the layout and working load limit of the suction pads shall be matched to that of the intended load(s). The share of the load which can foreseeably be imposed on each suction pad shall not exceed its WLL taking account of the rigidity of both the load and the vacuum lifter.

4.2.3 Lifting magnets

4.2.3.1 General

4.2.3.1.1 The releasing of the load shall be actuated by a two-action control. This is not necessary where the release of the load is not possible until the load has been put down or in exclusion areas.

4.2.3.1.2 The shape of the magnet shall be suitable for the intended load(s). Where more than one magnet is used in conjunction with a lifting beam, the layout and WLL of the magnets shall be suitable for the intended load(s). The share of the load which can foreseeably be imposed on each magnet shall not exceed its WLL taking account of the rigidity of both the load and the lifting beam.

4.2.3.2 Battery-fed electric lifting magnets

4.2.3.2.1 Battery-fed electric lifting magnets shall provide a tear-off force corresponding to at least twice the WLL under the conditions specified by the manufacturer.

4.2.3.2.2 An automatic warning device shall be provided which monitors the power supply and provides a warning at least 10 min before the supply reaches the level where the load will be released. The warning device shall be optical or acoustic.

4.2.3.2.3 A safety device shall be provided which, after the low power warning device has been activated and the magnet has been switched off, prevents the magnet from being switched on again until the battery is recharged to the minimum level at which the low power warning device is not activated.

4.2.3.2.4 An indicator shall be provided to show that the magnet is energized (ON/OFF).

NOTE The indicator does not necessarily indicate that there is sufficient magnetic field.

4.2.3.3 Mains-fed electric lifting magnets

4.2.3.3.1 Mains-fed electric lifting magnets shall provide a tear-off force corresponding to at least two times the WLL under the conditions specified by the manufacturer.

4.2.3.3.2 An automatic warning device shall be provided to warn when the main power supply fails. The warning device may be optical or acoustic. This is not necessary in exclusion areas.

4.2.3.3.3 A stand-by battery shall be provided to automatically supply power when the main supply fails. It shall be capable of providing the current needed to hold the working load limit for at least 10 min. This is not necessary in exclusion areas.

4.2.3.3.4 Requirements of 4.2.3.3.2 and 4.2.3.3.3 are not necessary where all of the following requirements are met.

a) The manufacturer instructs that lifting the pole geometric centre above 1,8 m is prohibited by appropriate marking and instructions for use.

b) The load mass is less than 20 kg.

4.2.3.3.5 In cases where it is difficult to leave the fall zone (e.g. in an exposure area or in ships during loading and unloading), a redundancy of the flexible cables of the DC supply lines between the control cabinet and the attachment (e.g. spreader beam or single magnet) and of the power control unit of the magnet system shall be provided. Alternatively, a secondary positive holding device shall be provided.

4.2.3.3.6 Magnets for lifting loads such as plates, sheets, or bars from the top of a stack, shall have controls to reduce the power supply so as to facilitate the shedding of excess load. After the excess load has been shed, the controls shall permit restoration of full power.

4.2.3.3.7 The magnet system shall have an indicator to show when the magnet(s) are energized. For magnets with variable power control, the indicator shall distinguish between full and partial magnetization.

NOTE The indicator does not necessarily indicate that there is sufficient magnetic field.

4.2.3.4 Permanent lifting magnets

Permanent lifting magnets shall comply with the following requirements:

a) they shall provide a tear-off force of at least three times the WLL under the conditions specified by the manufacturer;

b) the control shall clearly indicate whether the magnet is ON or OFF;

c) the control for operating the magnet shall be in accordance with ISO 13854 with regard to the place for the operator's hands.

4.2.3.5 Electro-permanent lifting magnets

4.2.3.5.1 Electro-permanent lifting magnets shall provide a tear-off force of at least three times the WLL under the conditions specified by the manufacturer.

4.2.3.5.2 The magnets shall have an indicator to show when the magnet(s) are energized. For magnets with variable power control, the indicator shall distinguish between full and partial magnetization.

4.2.4 C-hooks

4.2.4.1 The unloaded C-hook shall hang with the lower arm within 5° of horizontal to facilitate access to the load.

4.2.4.2 One of the following means shall be provided to prevent the load from sliding on the lower arm or the load or part of the load from falling.

a) The C-hook tilted backwards with an angle greater or equal to 5° of horizontal in the loaded position.

b) For C-hook intended for handling single steel sheet coils, the lower arm shall be horizontal or titled backward in the loaded position.

c) A chain, strap, or bar to close the C-hook opening.

d) A clamping system to secure the load.

e) An end-stop on the lower arm.

4.2.5 Lifting forks

4.2.5.1 The unloaded lifting fork shall hang with the fork arms within 5° of horizontal to facilitate access to the load.

4.2.5.2 Within the intended load range and position of the load centre of gravity, the fork arms shall be tilted backwards with an angle greater or equal to 5° of horizontal to prevent the load from sliding from the fork arms.

4.2.5.3 Lifting forks for loose material (e.g. bricks and tiles) to be used in an exposure area shall have a secondary positive holding device (e.g. net, cage).

The secondary positive holding device shall prevent the release of the complete load or any loose parts of the load.

For handling loose materials (e.g. bricks and tiles), the secondary positive holding device (e.g. nets or cages) shall not have side and bottom openings that a sphere of 50 mm can pass through.

It is recommended that the secondary positive holding device is automatically activated.

4.2.5.4 Lifting forks fitted with a secondary positive holding device required in 4.2.5.3 shall be capable of holding a uniformly distributed load equal to 50 % of the WLL in all four horizontal directions.

4.2.5.5 Lifting forks for unit load (e.g. plastic wrapped palletised load) to be used in an exposure area shall have a retaining device (e.g. chain, strap, or bar) to prevent the unit load sliding off the forks.

4.2.5.6 Lifting forks with a retaining device as required in 4.2.5.5 shall be capable of holding a uniformly distributed load equal to 50 % of the WLL.

4.2.6 Lifting beams

4.2.6.1 Attaching the lifting beam to the crane

4.2.6.1.1 Any connection made by moving or removing a lifting beam component shall be such that it can be secured before lifting so as to prevent any accidental uncoupling of this connection.

4.2.6.1.2 Means shall be provided to prevent any unintended movement and damage to the suspended parts of the lifting beam parts during storage, coupling, or uncoupling from the crane.

4.2.6.2 Securing the load to the lifting beam

4.2.6.2.1 Lifting beams with load securing parts moving along the beam shall have means to prevent them from falling off.

4.2.6.2.2 Load securing parts moving along the beam shall have means to retain them in position when they hold the load.

4.2.6.2.3 Where the means to retain the load securing parts is positioned manually, the state of the means shall be visible for the slinger.

4.2.6.3 Structure

4.2.6.3.1 Where the lifting beam is intended to tilt, the manufacturer shall indicate the maximum permissible angle of tilt from the horizontal. Where the lifting beam is intended for horizontal use, the design shall tolerate a tilt of up to 6° from the horizontal.

4.2.6.3.2 Moving parts of the structure shall have devices to hold them in position when loaded. These devices shall be effective up to 6° from the maximum tilting angle permitted for the lifting beam. Where these devices operate on a friction basis, the design factor shall be at least two.

4.2.6.3.3 Where free movement presents a hazard, lifting beams fitted with a rotation or tilting mechanism shall be equipped with a device to stop movement and to immobilize the load in its intended position.

4.2.6.3.4 When the spacing between moving parts of the beam is controlled by a power source, protection devices shall be provided to avoid crushing and shearing hazards as specified in ISO 13854.

4.2.7 Clamps

4.2.7.1 The holding force of clamps holding by friction to prevent the load from slipping shall be at least two times the WLL.

4.2.7.2 In the case of clamps holding by friction, where the range of thickness does not start at zero, a safety range in which the holding force does not fall below the value given in 4.2.7.1 is required below the smallest specified thickness to be able to compensate for the manufacturing tolerances, elastic deformation, etc.

The following minimum safety ranges are required:

a) for a minimum thickness less than or equal to 50 mm, 10 % of the minimum thickness;

b) for a minimum thickness between 50 mm and 100 mm, 5 mm of the minimum thickness;

c) for a minimum thickness more than 100 mm, 5 % of the minimum thickness.

Due to the wide variety of applications for clamps, it is impossible to specify a safety range which is suitable for all. The above ranges should therefore be treated with caution and increased as appropriate to the application.

4.2.7.3 In the case of clamps holding by friction, the clamping mechanism shall be designed to ensure that the clamping force will be maintained in case of deformation of the load (e.g. surface crushing and elastic and plastic deformation).

NOTE This can be achieved by, for example, a scissor mechanism activated by gravity or by a pressure compensation device (e.g. springs, hydraulic accumulators) etc.

Clamps holding the load hydraulically or pneumatically shall be fitted with a device to compensate for any pressure drop below working pressure.

Where it is not possible to maintain the requirements of 4.2.7.1, an acoustic or optical warning signal shall be automatically activated.

4.2.7.4 For clamps which are not self-closing, the releasing of the load shall be actuated by a two-action control.

This is not necessary where the release of the load is not possible until the load has been put down or in exclusion areas.

4.2.7.5 Clamps to be used in an exposure area shall have a positive holding device or a secondary positive holding device (e.g. slings, net, cage).

The positive holding device or secondary positive holding device shall prevent the release of the complete load or any loose parts of the load.

For handling loose materials (e.g. bricks and tiles), the positive holding device or secondary positive holding device (e.g. nets or cages) shall not have side and bottom openings that a sphere of 50 mm can pass through.

It is recommended that the secondary positive holding device is automatically activated.

4.2.7.6 For handling loose materials (e.g. bricks and tiles) the positive holding device or secondary positive holding device (e.g. nets or cages) shall be capable of holding a uniformly distributed load equal to 50 % of the WLL in all four horizontal directions and 200 % of the WLL in the vertical direction.

4.2.7.7 The requirements of 4.2.7.5 and 4.2.7.6 shall not apply where the clamp is intended to be used only to lift the lowest part of the clamp to a height less than 1,8 m and is either

— for moving single bricks or building components with a weight less than 50 kg, or

— for unloading lorries to the ground.

5 Verification of the safety requirements and/or measures

5.1 General

Conformity to each safety requirement and/or measure (given in Clause 4 and Clause 6) shall be verified by the methods specified in Table 1 and detailed in Annex A to Annex G.

For single unit designed and produced products, type verification and individual verification shall be done. For series produced, product type verification shall be done on one or more representative product of the series and the individual verification shall be done on each product produced.

Table 1 — Methods to be used to verify conformity with the safety requirements and/or measures

Equipment	Requirement		Verification	Method
	Descriptor	**Clause number**	**Type verification**	**Individual verification**
Plate clamps	Mechanical load bearing parts	4.1.1.1	A.2	A.3
	Tilting limit	4.1.1.2	A.2	
	Controls	4.1.2	A.4	
	Handles	4.1.3	A.4	
	Lifting slings	4.1.4	A.4	
	Stability in storage	4.1.5	A.4	
	Preventing unintentional release	4.2.1.1	B.1	
	Preventing unintentional release when setting down	4.2.1.2	B.1	
	Friction coefficient	4.2.1.3	B.2 + B.3	
	Tolerances on rage of thickness	4.2.1.4	B.4	
	Minimum working load	4.2.1.4	B.5	
	Foreseeable share of the load	4.2.1.6	A.4	
	Connection of the crane	4.2.1.7	A.4	
	Information for use	6.1	A.4	A.4
	Marking	6.2	A.4	A.4

Table 1 *(continued)*

Equipment	Requirement		Verification	Method
	Descriptor	Clause number	Type verification	Individual verification
Vacuum lifters	Mechanical load bearing parts	4.1.1.1	A.1 or A.2	A.1 or A.3
	Tilting limit	4.1.1.2	C.10 or A.2	C.9
	Controls	4.1.2	A.4	
	Handles	4.1.3	A.4	
	Lifting slings	4.1.4	A.4	
	Stability in storage	4.1.5	A.4	
	Adhesion force	4.2.2.1	A.4	
	Pressure measuring device	4.2.2.2	C.10 or A.2	
	Leakage indicator	4.2.2.3		C.1
	Visibility of measuring device or indictor	4.2.2.4	C.3	C.2
	Means to prevent risk of vacuum losses	4.2.2.5		
	Warning device	4.2.2.6		C.4 and C.6
	Holding time	4.2.2.7		C.5 and C.8
	Exposure area	4.2.2.8	A.4	C.4
	Two-action control	4.2.2.9	C.7	
	Controls for tilting or turning	4.2.2.10	A.4	
	Design appropriate for the load	4.2.2.11	A.4	
	Information for use	6.1	A.4	A.4
	Marking	6.2	A.4	A.4
Battery-fed lifting magnets	Mechanical load bearing parts	4.1.1.1	A.1 or A.2	A.1 or A.3
	Tilting limit	4.1.1.2	A.2	
	Controls	4.1.2	A.4	
	Handles	4.1.3	A.4	
	Lifting slings	4.1.4	A.4	
	Stability in storage	4.1.5	A.4	
	Two-action controls	4.2.3.1.1	D.2	
	Design appropriate for the load	4.2.3.1.2	D.7	
	Tear-off forces	4.2.3.2.1	D.1	
	Warning devices	4.2.3.2.2	D.3 or D.4	D.3 and D.4
	Safety device preventing switched on	4.2.3.2.3	A.4	A.4
	Magnetisation indicator	4.2.3.2.4	D.5	D.5
	Information for use	6.1	A.4	A.4
	Marking	6.2	A.4	A.4

Table 1 *(continued)*

Equipment	Requirement		Verification	Method
	Descriptor	Clause number	Type verification	Individual verification
Mains-fed lifting magnets	Mechanical load bearing parts	4.1.1.1	A.1 or A.2	A.1 or A.3
	Tilting limit	4.1.1.2	A.2	
	Controls	4.1.2	A.4	
	Handles	4.1.3	A.4	
	Lifting slings	4.1.4	A.4	
	Stability in storage	4.1.5	A.4	
	Two-action controls	4.2.3.1.1	D.2	
	Design appropriate for the load	4.2.3.1.2	D.7	
	Tear-off forces	4.2.3.3.1	D.1	
	Warning devices	4.2.3.3.2	D.3 and D.4	D.3 and D.4
	Discharge time batteries	4.2.3.3.3	D.4	D.4
	Exception	4.2.3.3.4	A.4	A.4
	Redundancy or back-up devices	4.2.3.3.5	D.6	D.6
	Shedding	4.2.3.3.6	D.2	
	Magnetisation indicator	4.2.3.3.7	D.5	D.5
	Information for use	6.1	A.4	A.4
	Marking	6.2	A.4	A.4
Permanent lifting magnets	Mechanical load bearing parts	4.1.1.1	A.1 or A.2	A.1 or A.3
	Tilting limit	4.1.1.2	A.2	
	Controls	4.1.2	A.4	
	Handles	4.1.3	A.4	
	Lifting slings	4.1.4	A.4	
	Stability in storage	4.1.5	A.4	
	Two-action controls	4.2.3.1.1	A.4	
	Design appropriate for the load	4.2.3.1.2	D.7	
	Tear-off forces	4.2.3 a)	D.1	
	Position of the controls	4.2.3.4 b)	A.4	A.4
	Safety distance	4.2.3.4 c)	A.4	A.4
	Information for use	6.1	A.4	A.4
	Marking	6.2	A.4	A.4

Table 1 *(continued)*

Equipment	Requirement		Verification	Method
	Descriptor	Clause number	Type verification	Individual verification
Electro-permanent lifting magnets	Mechanical load bearing parts	4.1.1.1	A.1 or A.2	A.1 or A.3
	Tilting limit	4.1.1.2	A.2	
	Controls	4.1.2	A.4	
	Handles	4.1.3	A.4	
	Lifting slings	4.1.4	A.4	
	Stability in storage	4.1.5	A.4	
	Two-action controls	4.2.3.1.1	D.2	
	Design appropriate for the load	4.2.3.1.2	D.7	
	Tear-off forces	4.2.3.5.1	D.1	
	Magnetisation indicator	4.2.3.5.2	D.5	D.5
	Information for use	6.1	A.4	A.4
	Marking	6.2	A.4	A.4
C-Hooks	Mechanical load bearing parts	4.1.1.1	A.1 or A.2	A.1 or A.3
	Tilting limit	4.1.1.2	A.2	
	Controls	4.1.2	A.4	
	Handles	4.1.3	A.4	
	Lifting slings	4.1.4	A.4	
	Stability in storage	4.1.5	A.4	
	Unloaded position	4.2.4.1	A.4	A.4
	Preventing load slipping or falling	4.2.4.2	A.4	A.4
	Information for use	6.1	A.4	A.4
	Marking	6.2	A.4	A.4
Lifting forks	Mechanical load bearing parts	4.1.1.1	A.1 or A.2	A.1 or A.3
	Tilting limit	4.1.1.2	A.2	
	Controls	4.1.2	A.4	
	Handles	4.1.3	A.4	
	Lifting slings	4.1.4	A.4	
	Stability in storage	4.1.5	A.4	
	Unloaded position	4.2.5.1	A.4	A.4
	Preventing load slipping or falling	4.2.5.2	A.4	A.4
	Exposure area	4.2.5.3	A.4	A.4
	Strength of secondary holding device	4.2.5.4	F.1	
	Retaining device for unit load	4.2.5.5	A.4	
	Strength of the retaining device	4.2.5.6	A.1 or A.2	
	Information for use	6.1	A.4	A.4
	Marking	6.2	A.4	A.4

Table 1 *(continued)*

Equipment	Requirement		Verification	Method
	Descriptor	Clause number	Type verification	Individual verification
Lifting beams	Mechanical load bearing parts	4.1.1.1	A.1 or A.2	A.1 or A.3
	Tilting limit	4.1.1.2	E.1 or E.2	
	Controls	4.1.2	A.4	
	Handles	4.1.3	A.4	
	Lifting slings	4.1.4	A.4	
	Stability in storage	4.1.5	A.4	
	Connecting to the crane	4.2.6.1.1	A.4	
	Damage to suspended parts	4.2.6.1.2	A.4	
	Securing the load to the lifting beams	4.2.6.2	A.4	
	Tilting limit	4.2.6.3.1	E.1 or E.2	
	Securing moving parts of the structure	4.2.6.3.2	E.1 or E.2	
	Securing tilting and rotation mechanisms	4.2.6.3.3	A.4	
	Spacing between moving parts	4.2.6.3.4	A.4	
	Information for use	6.1	A.4	A.4
	Marking	6.2	A.4	A.4
Clamps	Mechanical load bearing parts	4.1.1.1	A.1 or A.2	A.1 or A.3
	Tilting limit	4.1.1.2	A.1 or A.2	
	Controls	4.1.2	A.4	
	Handles	4.1.3	A.4	
	Lifting slings	4.1.4	A.4	
	Stability in storage	4.1.5	A.4	
	Safety coefficient	4.2.7.1	G.1 + G.2	
	Range thickness	4.2.7.2	G.3	
	Deformation of the load	4.2.7.3	A.4	A.4
	Two-action control	4.2.7.4	A.4	A.4
	Holding devices	4.2.7.5	A.4	A.4
	Strength of secondary holding devices	4.2.7.6	A.1 or A.2	
	Exception	4.2.7.7	A.4	
	Information for use	6.1	A.4	A.4
	Marking	6.2	A.4	A.4

5.2 Proof of fatigue strength by testing

The test arrangement shall produce stress variation that corresponds to the maximum and minimum vertical load events as described in 4.1.1.2. This includes that all clamping forces are released between each work cycle.

The design number of working cycles of the lifting device shall not be taken greater than one third of the average life of at least three tested devices. Where not more than seven devices are tested, the design number of working cycles shall not be greater than one half of the minimum life found in the tests.

5.3 Minimum classification

The minimum group classification of the lifting device is LCD1. The devices designed to this group need no proof of fatigue strength where they

— meet the requirements for the static strength according to 4.1.1.1,

— are made from steel with yield stress not more than 500 MPa, and

— do not include details with lower fatigue strength than class 50 according to ISO 20332.

6 Information for use

6.1 Instruction handbook

6.1.1 General information

To allow the purchasers to select, install, use, and maintain suitable removable lifting equipment during its normal lifetime, the manufacturer shall at least provide the following information and guidance in an instruction handbook specific to the equipment supplied (see ISO 12100:2010, 6.4.5):

a) brief description;

b) WLL;

c) intended use;

d) characteristics of the load including the performance and the number of parts that can be handled at one time;

e) determination of the operating range;

f) instructions for operation and use;

g) fitting, securing, coupling/uncoupling, and adjustment of the equipment on the crane;

h) handling and storage of equipment;

i) stability (where applicable);

j) the range of temperature within which the attachment can be operated;

k) restriction for operation in special atmospheres (e.g. high humidity, explosive, saline, acid, alkaline);

Chains slings in accordance with ISO 4778 and ISO 7593 are not recommended for use in pickling baths due to the danger of hydrogen embrittlement.

l) restriction for handling dangerous goods (e.g. molten masses, radioactive materials);

m) where appropriate, prohibition of handling above persons;

n) specific training of operators, where necessary;

o) dynamic coefficient for apparatus.

6.1.2 Specific information

In addition to the above general information, the manufacturer shall provide specific information on the following.

6.1.2.1 Plate clamps

a) Vertical lifting for one part at a time.

b) Turning plates over when on the ground.

c) Operation of the safety locking device.

d) Surface condition (grease, paint, or coating) of the part to be handled.

e) Clamping ranges to be observed.

f) Minimum working load.

g) Surface hardness of parts to be handled.

h) Measures to prevent unintentional release of the load due to the mass of the crane hook, bottom block, or connections acting on the clamp (e.g. short length of chain).

6.1.2.2 Vacuum lifters

a) Checking of the vacuum level.

b) Measures to be taken as soon as the warnings are actuated.

c) Checking of the condition of the vacuum connections and hoses.

d) Checking of the condition of the suction pads.

e) Holding time in case of power failure.

f) Intended ambient maximum noise level up to which warning devices are effective.

6.1.2.3 Battery- and mains-fed lifting magnets

a) Safety measures to be taken as soon as the warnings are activated.

b) Checking of the condition of cables.

c) Guidance for the maintenance and checking of the state of charge and capacity of battery.

d) Holding time in case of power failure (where applicable).

e) Intended ambient maximum noise level up to which warning devices are effective.

6.1.2.4 C-hooks and lifting forks

a) Checking the suitability of the load.

b) Required load range and position of the load's centre of gravity to prevent the load from sliding.

c) When using lifting forks in exposure areas, a check that the secondary positive holding device is in its place.

6.1.2.5 Lifting beams

a) The lifting beam's manufacturer shall provide information in the instruction handbook about the methods of attaching the load to enable the user to ensure that the combined lifting beam and load will be stable when lifted.

   The information shall identify the centre of rotation of the lifting beam to the crane, the centre of rotation of the suspension points to the load, and the vertical distance between them. This is illustrated schematically in Figure 9 in one plane only together with similar illustrations for the centre of rotation of the suspension points to the load and the vertical distance to the centre of gravity.

NOTE An object with a narrow base and a high centre of gravity will need less force to topple it than one with a wide base and a low centre of gravity. As the height of the centre of gravity increases relative to the width of the base, a point will be reached where the object will fall over, unless it is supported by external means. At this point, the object is regarded as being unstable and the greater the support required, the more unstable it is. A similar situation exists with a suspended load. Forces which try to topple the load will inevitably be present (e.g. wind, acceleration, braking). It is important, therefore, when slinging a load to ensure that it is sufficiently stable to resist these toppling forces. A load will be inherently stable when the lifting sling is attached above the centre of gravity and properly disposed around it.

In Figure 9, lifting beam 1 has a positive stability height, and lifting beam 2 has a negative stability height. Load 1 has a positive stability height and load 2 has a negative stability height. For stability of the combined lifting beam and load, the total stability height shall be positive. Although illustrated in one plane only, this shall apply to each horizontal axis of rotation. The result of each combination is as follows:

Lifting beam 1 + Load 1: will always be stable;

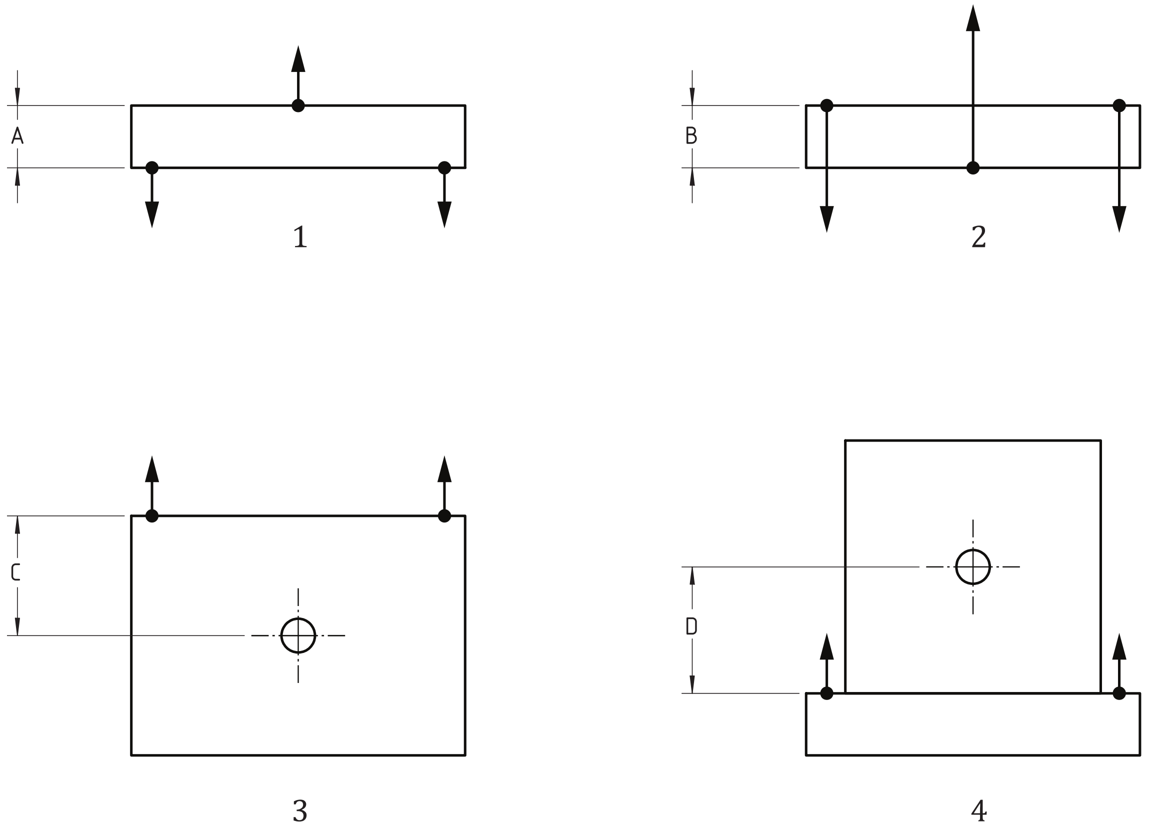
Lifting beam 1 + Load 2: will be stable if A > D*;

Lifting beam 2 + Load 1: will be stable if C > B;

Lifting beam 2 + Load 2: will always be unstable.

The load shall be supported in more than one vertical plane to be stable in both horizontal axes.

b) Maximum tilting angle permitted for the lifting beams.



Key

1 lifting beam 1

2 lifting beam 2

3 load 1

4 load 2

⌖ denotes centre of gravity

• denotes centre of rotation

Figure 9 — Centres of rotation (pivot points) of a load and lifting beam

6.1.2.6 Clamps

a) Surface condition (grease, paint, or coating) of the part to be handled.

b) Clamping ranges to be observed.

c) Surface hardness of parts to be handled.

d) Measures to prevent unintentional release of the load due to the weight of the crane hook, bottom block, or connections acting on the clamp (e.g. short length of chain).

6.1.3 Guidance for maintenance

The manufacturer shall provide sufficient information to ensure the proper maintenance of the attachment to include the following:

a) instructions for periodic maintenance;

b) instructions for repair;

c) precautions to be taken during repairs;

d) use of original spare parts;

e) maintenance records, where necessary;

f) list of parts requiring particular operation and checking;

g) use of special lubricants.

6.1.4 Verifications and inspections

The manufacturer shall indicate the inspections and verifications that are necessary for the following:

a) before commissioning;

b) after repair or recoupling;

c) during the equipment service life.

The manufacturer shall also include the following:

a) list of the parts which require special operation and checking;

b) defects to look for.

6.2 Marking

6.2.1 General

The WLL of the attachment, hazard warnings and safety instructions shall be legibly marked.

The WLL of the lifting device shall be marked on the main structure where it is visible. Where the lifting device is made up of several lifters, each detachable from the group, these lifters shall also be marked with their individual loads.

6.2.2 Minimum marking

All removable equipment shall bear in a clearly visible place a durable identification with the following information:

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

b) designation of the machinery;

c) serial number;

d) mass of the unloaded attachment when it exceeds 5 % of the WLL of the equipment or 50 kg, whichever is the less;

e) WLL in tonnes or kg; when the attachment is used in several configurations, the resulting WLL's shall also be indicated;

f) number of lifting cycles.

6.2.3 Additional marking

6.2.3.1 In addition to the data in 6.2.2, the following shall be stated, where applicable:

a) on attachment which holds the load using clamping forces, the permissible gripping range;

b) on plate clamps and self-priming vacuum lifters, the minimum load;

c) on equipment connected mechanically to the load, indication on the connectors fitted on the load (e.g. connectors integrated in prefabricated concrete parts);

d) on C-hook and lifting forks, the limits of the intended position of the load centre of gravity;

e) on lifting forks where a minimum load is required to tilt the fork in accordance with 4.2.5.2, the minimum load.

6.2.3.2 For turbine vacuum lifters with a holding time in case of power failure of less than 5 min, the following shall be marked:

"WARNING — Load must not be lifted above 1,8 m"

6.2.3.3 6.2.1 e) does not apply for load lifting magnets provided the lifting capacity can be taken from documents at the place of use.

In the case of magnets, the lifting capacity depends, amongst other things, upon the material of the load, its thickness and surface, and the air gap between the load and the magnet. It is therefore recommended to state the maximum permissible loading as a function of the various parameters. However, it shall be recognized that the lifting capacity does not depend solely upon the magnetic forces, but also can be limited by the lifting capacity of the suspension.

Annex A
(normative)

General verification methods

A.1 Verification of mechanical strength without static tests

Verification of mechanical strength without static test shall be carried out using the requirements of the relevant part of ISO 8686 and ISO 20332.

A.2 Verification of mechanical strength on the type by a static test

A.2.1 Conditions

The test shall be conducted by applying a static force, F3, in a manner which replicates the conditions in which the attachment is intended to be used.

A.2.2 Procedure

The attachment shall be loaded through its suspension and load attachment points so that the lines of force through these points are the same as they will be in service. The test force, F3 ± 2 %, shall be applied without shock for a minimum period of 1 min.

Where the intended use of the attachment permits or requires it to tilt or move in any way such that the lines of force through the suspension or attachment points will vary, the test shall be repeated at several positions throughout the range of movement. These positions shall be selected to simulate the worst operational conditions and take account of the tilting tolerance required by 4.1.1.2.

After the force has been removed, the attachment shall be examined for deformation, cracks, and other defects.

A.2.3 Acceptance criteria

An attachment representative of the type shall withstand the static force, F3 = 3 × working load limit. The attachment shall withstand the force even if permanent deformation occurs.

A.3 Verification of mechanical strength on each individual attachment by a static test

A.3.1 Conditions

The test shall be conducted by applying a static force, F2, in a manner which replicates the conditions in which the attachment is intended to be used.

A.3.2 Procedure

The attachment shall be loaded through its suspension and load attachment points so that the lines of force through these points are the same as they will be in service. The test force, F2 ± 2 %, shall be applied without shock for a minimum period of 1 min.

Where the intended use of the attachment permits or requires it to tilt or move in any way such that the lines of force through the suspension or attachment points will vary, the test shall be repeated at several positions throughout the range of movement. These positions shall be selected to simulate the worst operational conditions.

After the force has been removed, the attachment shall be examined for deformation, cracks, and other defects.

A.3.3 Acceptance criteria

Each individual attachments of a series shall withstand a static force, F2, equivalent to 2 × working load limit without permanent deformation and after removal of the force, there shall be no visible defects.

A.4 Verification by inspection

A.4.1 Procedure

The equipment shall be inspected and the feature checked to see whether it is present and/or functions in the manner required. In assessing compliance with the requirements, the manufacturer's instructions shall be taken into account.

The markings on each sling and the certificates provided with each sling shall be inspected for conformance with the following:

— ISO 4778;

— ISO 7593;

— ISO 4309;

— EN 1492-1;

— EN 1492-2.

A.4.2 Acceptance criteria

The equipment shall meet the appropriate requirements according to Clause 4 and Clause 6.

Annex B
(normative)

Verification methods for plate clamps

B.1 No detachment when the load is brought down and in case of impact

B.1.1 Conditions

The equipment shall be suspended from a crane. The test load mass shall be at least equal to the working load limit.

B.1.2 Procedure

NOTE The tester can be at risk when disconnecting and reconnecting the locking mechanism because if the plate clamp does not hold the load, it can fall against him.

The load shall be attached to the equipment and the locking mechanisms brought into the closed position. The load shall be lifted and put down onto the ground during a maximum duration of 5 s. The load shall be lifted again without any operator's intervention on the equipment.

The procedure shall then replicate the impact of the equipment against an obstacle. Where the equipment is fitted with a locking mechanism, the impact shall occur against this device.

With the load lifted from the ground, the locking mechanisms shall be moved to the open position and the plate clamp shall hold the load. The locking mechanisms shall be returned to the lock position and the load shall be put down on the ground and the connection between the crane hook and the equipment be allowed to go slack. This shall be done under the conditions specified in the instructions handbook (e.g. length of chain) which prevent the weight of the crane hook acting on the equipment in a way which releases the load.

B.1.3 Acceptance criteria

The load shall not detach from the equipment at any time during the simulation.

B.2 Determination of the friction coefficient

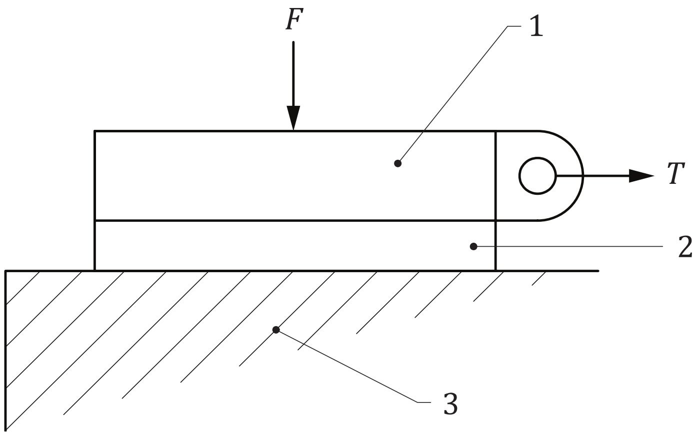
B.2.1 Conditions

The test apparatus shall include the following:

a) the load or a material sample corresponding to the load under the maximum conditions specified in the instruction manual (e.g. material hardness);

b) a support covered with the clamp material which is in contact with the load;

c) the shape of the coating shall be reproduced (e.g. teeth of the clamp jaws).



Key

1 support

2 clamp coating

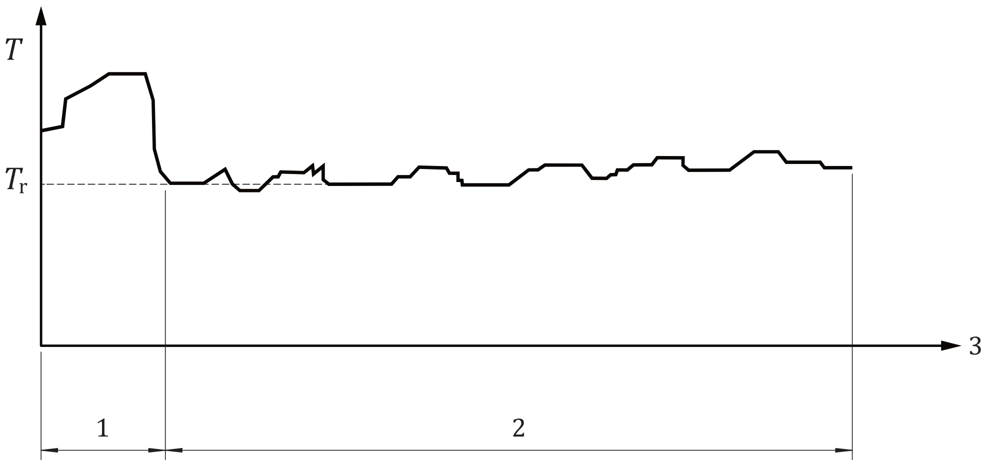
3 load sample

Figure B.1 — Test apparatus and forces applied

The actual environmental conditions which are of importance for friction (e.g. presence of oil or moisture) shall be reproduced.

B.2.2 Procedure

A vertical force, *F*, shall be applied on the support producing a pressure between 2 and 3 corresponding to the minimum contact pressure between the clamp and the load when the load is lifted. A horizontal tensile force, *T*, shall be applied between 1 + 2 and 3, until the part 1 + 2, starts moving (see Figure B.1). The variation of this tensile force represents a curve usually corresponding to the diagram in Figure B.2.



Key

1 transitory state

2 steady-state (motion)

3 displacement

Figure B.2 — Characteristics of tensile force, *T*

B.2.3 Acceptance criteria

The friction coefficient, μ, used for the calculations is the ratio of T_r (average horizontal tensile force in steady-state) to the vertical force, F.

A minimum of three tests is required and the friction coefficient shall be taken as the smallest of the measurements.

B.3 No slipping of the load — Clamping by friction or penetration

B.3.1 Procedure

The maximum obtainable force to hold a load is called holding force. It is determined by Formula (B.1).

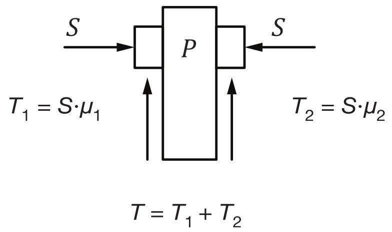
$$T = S\left(\mu_1 + \mu_2\right) \tag{B.1}$$

where

- S is the clamping force of the clamp;
- μ_1 is the friction coefficient between load and one clamping part;
- μ_2 is the friction coefficient between load and the other clamping part.

See Figure B.3.

The holding force is determined by calculation. The calculation shall be done for the most unfavourable gripping range.



Key

P work piece

Figure B.3 — Clamping forces

B.3.2 Acceptance criteria

The holding force, T, holding the load shall be two times the load to be held.

This requirement shall be verified throughout the lifting operation regardless of whether the clamping force, S, is due to self-actuation (in proportion to the load weight) or to a mechanical actuator.

B.4 Range of thickness of clamps

B.4.1 Conditions

The clamp shall be tested using a sheet sample with a thickness equal to the lower limit of the range of thicknesses less the safety range.

EXAMPLE Clamp with a range of thicknesses of 30 mm to 60 mm, test with a 30 mm sheet – 10 %, i.e. a thickness of 27 mm.

B.4.2 Procedure

The sheet sample shall be lifted vertically.

B.4.3 Acceptance criteria

The clamp shall not release the sheet sample.

B.5 Minimum working load

B.5.1 Conditions

The clamp shall be tested using a sheet sample weighing not more than 5 % of the clamp’s WLL and with a thickness equal to the lower limit of the range.

EXAMPLE Clamp with a range of thicknesses of 30 mm to 60 mm, test with a 30 mm sheet – 10 %, i.e. a thickness of 27 mm.

B.5.2 Procedure

The sheet sample shall be lifted vertically.

B.5.3 Acceptance criteria

The clamp shall not release the sheet sample.

Annex C
(normative)

Verification methods for vacuum filters

C.1 Verification of pressure measuring device

C.1.1 Conditions

The test is to verify the correct functioning of the pressure measuring device. The arrangement shall be such as to limit risk in the event of vacuum drop.

C.1.2 Procedure

A condition for which the device is required shall be simulated by reducing the maximum vacuum level in the vacuum system.

C.1.3 Acceptance criteria

The pressure measuring device indicates the vacuum level reduction. The working range and the fall range are clearly shown.

C.2 Verification of leakage indicator

C.2.1 Conditions

The test is to verify the correct functioning of the leakage indicator. The arrangement shall be such as to avoid risk in the event of vacuum drop.

C.2.2 Procedure

A condition for which the device is required shall be simulated by creating leakage under the suction pads. The size of the leakage shall correspond with the agreed minimum hanging time of the load to be specified in the instruction handbook.

C.2.3 Acceptance criteria

When the fault or condition is simulated, the device shall comply with 4.2.2.3.

C.3 Verification of visibility of measuring device or indicator

C.3.1 Conditions

The test is to verify the visibility of the measuring device or the indicator.

C.3.2 Procedure

Check if the measuring device or the indicator can be seen from the normal position of the vacuum lifter operator or the crane operator. When the position of the crane operator is relevant to the operation of the vacuum lifter and is unknown, the instruction handbook shall indicate the correct position of the lifting equipment with respect to the crane operator.

C.3.3 Acceptance criteria

The measuring device or the indicator can be seen properly.

C.4 Verification of devices to compensate for vacuum losses

C.4.1 Conditions

The test applies to self-priming and non-self-priming vacuum lifters.

The test is to verify that the devices for compensation for vacuum losses function correctly. The arrangement shall be such as to avoid risk when the load is dropped.

C.4.2 Procedure

The vacuum lifter shall be loaded with the WLL per suction pad which shall be indicated in the instruction handbook. The material and other conditions (e.g. dirt) shall be comparable with the load which will be manipulated in practice. With the power switched off, the hanging time shall be measured or extrapolated.

C.4.3 Acceptance criteria

The hanging time shall be at least equal to the hanging time specified in the instruction handbook. The time shall be long enough for all persons to leave the fall area and comply with 4.2.2.5 and 4.2.2.7.

C.5 Verification of warning device

C.5.1 Conditions

The test is to verify the correct functioning of the warning device indicating that the limit of the safe working range of the vacuum system has been reached.

C.5.2 Procedure

The vacuum lifting device shall be sucked onto a load and a small non-compensated leakage shall be made in the vacuum system. When the safe working range of the vacuum system has been reached, an automatically acting warning device shall come into action.

C.5.3 Acceptance criteria

The moment the warning device comes into action shall correspond with the limit of the working range of the vacuum.

The warning device is optical and/or acoustical and easily seen/heard by the operator.

C.6 Verification of the non-return valve

C.6.1 Conditions

The test is to verify the correct functioning of the non-return valve and its position.

C.6.2 Procedure

The vacuum pump shall be energized for sufficient time to generate vacuum in the vacuum system with the load. When the vacuum pump is stopped, the vacuum level shall be checked visually for any noticeable decrease.

C.6.3 Acceptance criteria

The valve shall comply with the requirement specified in 4.2.2.5. Where there is no noticeable decrease in the vacuum level, this indicates an air-tight vacuum system including the non-return valve.

C.7 Verification of controls

C.7.1 Conditions

A test load shall be sucked by the vacuum lifter. The arrangement shall be such as to avoid risk in event of control malfunction.

C.7.2 Procedure

One representative sample of each design and size shall be inspected and operated. The controls shall be inspected and operated in all combinations foreseen by the manufacturer. In addition, a power failure shall be simulated to check if it alters the condition of the vacuum system.

C.7.3 Acceptance criteria

The vacuum lifting system shall comply with 4.2.2.9.

C.8 Verification of energy source failure warning system

C.8.1 Conditions

The test is to verify that the automatically warning device functions correctly. The test is to be conducted in the unloaded condition.

C.8.2 Procedure

A failure in the energy source shall be simulated.

C.8.3 Acceptance criteria

When the failure is simulated, the device shall comply with 4.2.2.6.

C.9 Verification of the position of the load

C.9.1 Conditions

A test load is used that is equal to the WLL and representative of the intended loads.

C.9.2 Procedure

The test load shall be lifted and placed at the maximum intended tilting angle plus 6°, but not more than 90°.

The vacuum level shall be at the end of the working range and the beginning of the fall range.

C.9.3 Acceptance criteria

The test load shall not slip.

C.10 Verification of adhesion force by calculation

C.10.1 Procedure

The friction coefficient between the suction pads and the material to be handled shall be determined in accordance with C.11 and the components of the adhesion force at the end of the working range shall be calculated.

$F_a \perp = PS$

$F_a // = \mu PS$

P: The vacuum level in Pa

$S = \Sigma$ Si: Total interior surface of the suctions pads in m^2

μ: Friction coefficient

C.10.2 Acceptance criteria

Both effective components of the adhesion force shall be greater or equal to two times the corresponding effective component of the working load limit.

$F_a \perp = PS \geq 2\ WLLg\cos\alpha$

$F_a // = \mu PS \geq 2\ WLLg\sin\alpha$

g: Gravity acceleration in m/s^2

WLL: Working load limit in kg

See Figure C.1.

The calculation shall be carried out for the maximum intended tilting angle plus 6°, except for vacuum lifter designed for a vertical position of the vacuum pads.

The above calculations determine the components of the adhesion force. To fully verify the requirement, the moments arising from the position of the centre of gravity of the load and the geometry of the vacuum lifter shall also be taken into account.

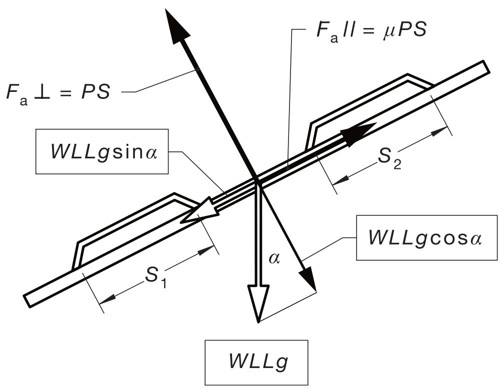


Figure C.1 — Adhesion force and effective component of the working load limit weight

C.11 Determination of the friction coefficient

C.11.1 Conditions

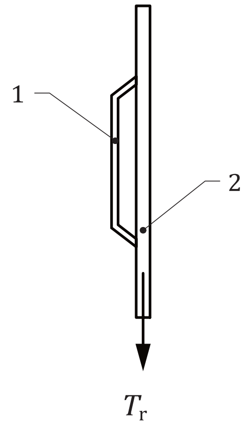
The test apparatus shall include the following:

a) the load or a material sample corresponding to the load under the maximum conditions specified in the instruction manual;

b) the suction pad connected to a system able to create a vacuum level corresponding to the end of the working range;

c) a load cell to record the variation of the tensile force necessary to move the load.

See Figure C.2.



Key

1 suction pad with a vacuum level equal to the end of the working range

2 load material sample

T_r vertical tensile force

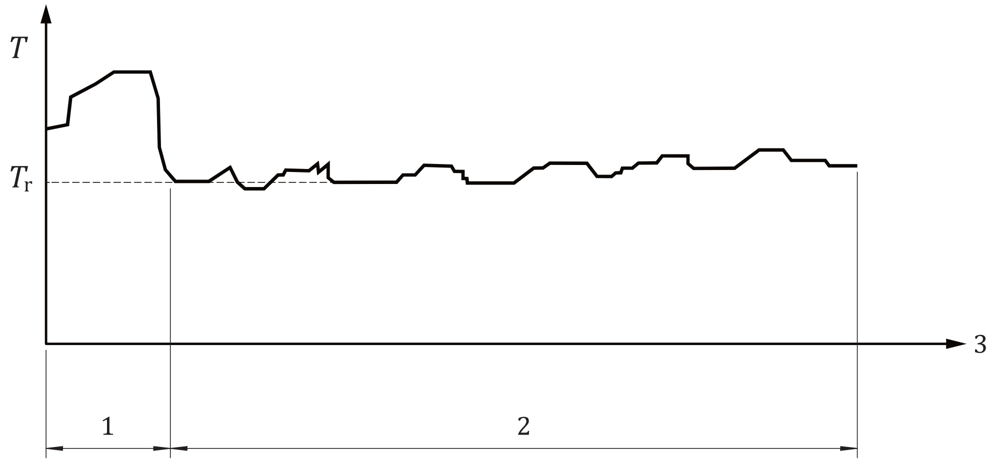
Figure C.2 — Test apparatus and forces applied

The actual environmental conditions which are of importance for friction (e.g. presence of oil or moisture) shall be reproduced.

C.11.2 Procedure

A pressure level equal to the end of the working range shall be applied to the suction pad.

A vertical displacement shall be applied on the load to move it. The tensile force necessary to move the load shall be measured. The curve obtain is usually corresponding to the diagram in Figure C.3.



Key

1 transitory state

2 steady-state (motion)

3 displacement

Figure C.3 — Characteristics of tensile force, T

C.11.3 Acceptance criteria

The friction coefficient, μ, used for the calculation is the ratio of T_r (average horizontal tensile force in steady-state) plus the weight of the material sample to the adhesion force, PS.

$$\mu = \left(T_r + \mathrm{m\,g}\right)/\,\mathrm{PS} \qquad \text{(C.1)}$$

where

m mass of material sample in kg;

g gravity acceleration in m/s^2.

A minimum of three tests is required and the friction coefficient shall be taken as the smallest of the measurements.

Annex D
(normative)

Verification methods for lifting magnets

D.1 Verification of tear-off force

D.1.1 Verification by pull test

D.1.1.1 Conditions (referring to Figure D.1)

a) Test piece length

 1) $l_2 \geq l_1 \times 1{,}2$ for rectangular magnets

 2) $d_2 \geq d_1 \times 1{,}1$ for round magnets

b) Test piece width

 1) $w_2 \geq w_1 \times 1{,}2$ for rectangular magnets

 2) $d_2 \geq d_1 \times 1{,}1$ for round magnets

c) Test piece thickness, $t_{min,}$ at least equal to the following:

 1) half of the middle pole diameter for round magnets;

 2) the width of the middle pole for three polar magnets;

 3) two times the width of the pole for bipolar magnets.

d) Test piece shape: Flatness smaller than 0,1 mm/500 mm

e) Test piece material: Low carbon steel (such as S 235)

f) One out of the following gaps shall be chosen for the verification of the tear-off force:

 1) for round magnets: No gap, 1/300 or 1/100 of the outer diameter;

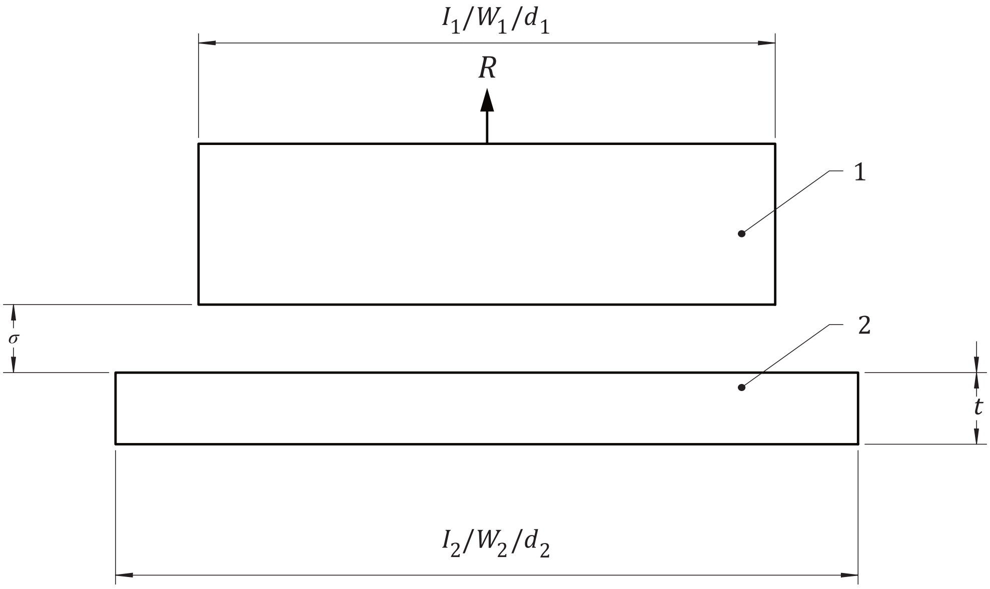
 2) for rectangular magnets: No gap, 1/300 or 1/100 of width over the poles.

The chosen gap shall correspond to the specified use of the magnet in the instructions for use.

g) Magnet supply current shall be as rated

h) Ambient temperature range: +10 °C to 40 °C

As an alternative, at the manufacturer’s discretion, special purpose magnets may be tested in conditions which simulate the intended purpose.



Key

d_1 diameter over poles of round magnets
d_2 diameter of the test piece
I_1 length over poles of rectangular or bipolar magnets
W_1 width over poles of rectangular or bipolar magnets
I_2 length of the test piece
W_2 width of the test piece
t thickness of the test piece
R tear-off force
σ air gap
2 test piece

Figure D.1 — Test set up for verification of lifting magnets

D.1.1.2 Procedure

The magnet shall be placed on the test piece so that all the poles are covered and then fully energized at the minimum allowable voltage. The test force, F ± 2 %, shall be applied without shock through the attachment point of the magnet and at right angles to the plane between the magnet and the test piece.

D.1.1.3 Acceptance criteria

The test force, F, reaches the tear-off force specified in 4.2.3.2.1, 4.2.3.3.1, 4.2.3.4 a), or 4.2.3.5.1 as appropriate.

D.1.2 Verification by flux measurement and calculation

D.1.2.1 Conditions

The same conditions apply as specified in D.1.1 except that there shall always be no gap. The magnet shall be placed directly upon the work piece. As an alternative, at the manufacturer's discretion, special purpose magnets may be tested in conditions which simulate the intended purpose.

D.1.2.2 Procedure

The flux shall be measured at the surface of contact between magnet and work piece around the middle pole for round and three polar magnets and around one pole of bipolar magnets. The force shall be calculated from this measured flux.

D.1.2.3 Acceptance criteria

The calculated force, *F*, reaches the tear-off force specified in 4.2.3.2.1, 4.2.3.3.1, 4.2.3.4 a), or 4.2.3.5.1 as appropriate.

D.2 Verification of controls

D.2.1 Conditions

A nominal load or test piece shall be provided against which the magnet can be operated. The arrangement shall be such as to avoid risk in the event of a control malfunction.

D.2.2 Procedure

One representative sample of each design and size of controls shall be inspected and operated in all functions foreseen by the manufacturer.

D.2.3 Acceptance criteria

The magnet complies with 4.2.3.1.1 and 4.2.3.3.6 as appropriate.

D.3 Verification of back-up and warning devices

D.3.1 Conditions

The test to verify that the back-up and warning devices function correctly shall be carried out on either the control circuits and warning devices only or on the complete magnet.

D.3.2 Procedure

The fault or condition for which the device is required shall be simulated by reducing or cutting the power supply as appropriate to the requirement.

D.3.3 Acceptance criteria

When the fault or condition is simulated, the device shall comply with 4.2.3.2.2, 4.2.3.2.3, 4.2.3.3.2, and 4.2.3.3.3 as appropriate.

D.4 Verification of the discharge time of batteries

D.4.1 Conditions

The tests to verify the discharge time of batteries shall be carried out using batteries which meet the magnet manufacturer’s minimum specification in terms of capacity and state of charge.

The magnet shall be tested against the test piece specified in procedure D.1. As an alternative, at the manufacturer’s discretion, special purpose magnets may be tested against a test piece which simulates the intended purpose.

D.4.2 Procedure

The magnet shall be placed on the test piece so that all the poles are covered and then fully energized. The test force, *F*, equal to the working load, ±2 %, shall be applied without shock through the attachment point of the magnet and at right angles to the plane between the magnet and the test piece. The fault or condition for which the requirement applies shall then be simulated.

One sample of each design and size of magnet shall be tested.

D.4.3 Acceptance criteria

The magnets sustain the test force, *F*, for the minimum time specified in 4.2.3.2.2 or 4.2.3.3.3 as appropriate.

D.5 Verification of indicating devices

D.5.1 Conditions

The test to verify the indicating devices shall be carried out by applying the rated voltage to the magnet(s).

D.5.2 Procedure

The indicating device shall be tested simultaneously with procedures D.2 to D.4.

D.5.3 Acceptance criteria

The indicating device shall indicate magnetization. For variable power control, the indicator shall distinguish between full and partial magnetization in accordance with 4.2.3.2.4, 4.2.3.3.7, and 4.2.3.4 b) as appropriate.

D.6 Verification of alternative mechanical back-up devices

D.6.1 Conditions

The magnet or magnets and any associated lifting beam shall be tested with a representative sample load equal to the maximum capacity of the magnet(s) under conditions where failure of the power supply and back-up device can be simulated without risk.

D.6.2 Procedure

The magnet(s) shall be placed on the load and fully energized. The load shall be lifted a sufficient height to permit the mechanical back-up device to be put in place. After the back-up device is in place, the magnet shall be switched off.

D.6.3 Acceptance criteria

After release by the magnet(s), the load is retained by the back-up device as specified in 4.2.3.3.5.

D.7 Verification that the magnet is matched to the intended load(s)

D.7.1 Procedure

For special purpose magnets where details of the intended load(s) are known to the manufacturer, the design of the magnet or magnets and any associated lifting beam shall be reviewed to ensure it meets the requirements in 4.2.3.1.2.

D.7.2 Acceptance criteria

The design review confirms that the magnet satisfies 4.2.3.1.2.

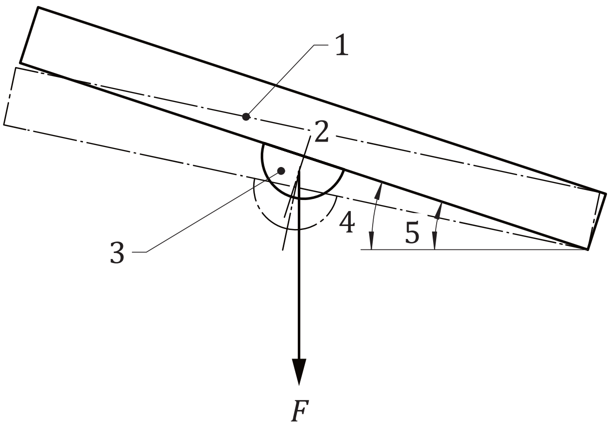
Annex E
(normative)

Verification methods for lifting beams

E.1 Verification of locking or holding devices by testing

E.1.1 Conditions

The test shall be conducted either by lifting a live test load or by means of a static force applied by a test rig.



Key

1 lifting beam at different working angles

2 lifting beam at different working angles

3 moving part

4 maximum working angle of the lifting beam plus 6°

5 maximum working angle of the lifting beam

F test force

Figure E.1 — Angles associated with verification of lifting beams

E.1.2 Procedure

The moving part shall be locked in position by means of its locking device and subjected to a force, *F*, without shock for a minimum period of 1 min and equal to 2× the static force that it is required to sustain in service at an angle of 6° in excess of that specified by the manufacturer (see Figure E.1). The test shall be repeated in both directions about each horizontal axis and both horizontal axes in combination for each available locking position. Where the moving part does not have predetermined positions, but locks by friction, the test shall be carried out at the two extremes of travel and at one intermediate point.

After the force has been removed, the moving part and its locking device shall be examined for deformation, cracks, and other defects.

E.1.3 Acceptance criteria

The moving part and its locking device sustains the test force, *F*, without slippage, deformation, or failure and after release of the load, there are no visible defects and the moving part and its looking device operate freely.

E.2 Verification of the locking or holding by calculation

The mechanical parts shall be calculated in accordance with A.1 for the maximum intended tilting angle plus 6° except for lifting beams designed for a vertical position.

Where the moving parts of the structure are held in position by devices operating on a friction basis (e.g. resulting from brake torque), the calculation shall demonstrate that the friction force is at least twice the force due to the self-weight of the parts plus WLL for the maximum intended tilting angle plus 6° (except for lifting beams designed for a vertical position).

Annex F
(normative)

Verification methods for lifting forks

F.1 Verification of mechanical strength of the secondary positive holding device for lifting forks in horizontal direction

F.1.1 Conditions

The test shall be conducted by applying a uniformly distributed static force equal 1/2 WLL on the 90° tilted lifting forks.

F.1.2 Procedure

The empty attachment shall be tilted and fixed in a manner such that the secondary positive holding device is not in contact with anything other than the lifting forks or the test load and has enough space to deform. A force equal to half the WLL shall be applied to the lower part of the secondary positive holding device. The test shall be carried out for at least the two most unfavourable directions.

F.1.3 Acceptance criteria

The secondary positive holding device shall withstand the force even if permanent deformation occurs.

Annex G
(normative)

Verification methods for clamps

G.1 Determination of the friction coefficient

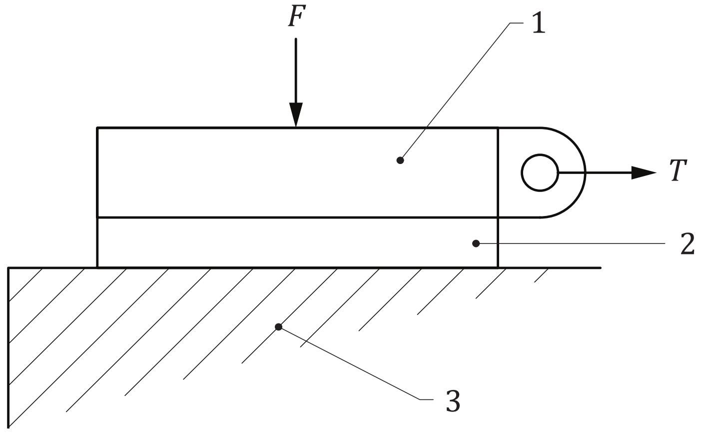
G.1.1 Conditions

The test apparatus shall include the following:

a) the load or a material sample corresponding to the load under the maximum conditions specified in the instruction manual (e.g. material hardness);

b) a support covered with the clamp material which is in contact with the load;

c) the shape of the coating shall be reproduced (e.g. teeth of the clamp jaws).



Key

1 support

2 clamp coating

3 load sample

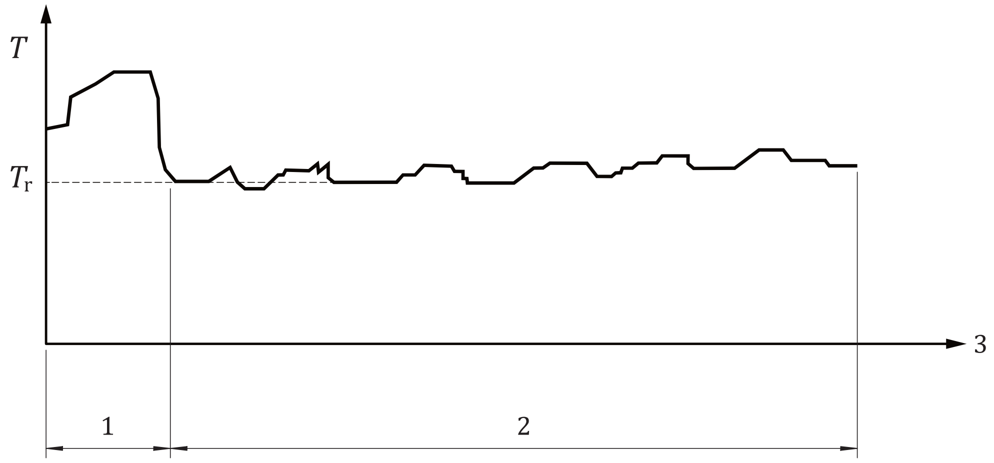
Figure G.1 — Test apparatus and forces applied

The actual environmental conditions which are of importance for friction (e.g. presence of oil or moisture) shall be reproduced.

G.1.2 Procedure

A vertical force, *F*, shall be applied on the support producing a pressure between 2 and 3 corresponding to the minimum contact pressure between the clamp and the load when the load is lifted (see Figure G.1).

A horizontal tensile force, *T*, shall be applied between 1 + 2 and 3, until the part 1 + 2 starts moving. The variation of this tensile force represents a curve usually corresponding to the diagram in Figure G.2.



Key

1 transitory state

2 steady-state (motion)

3 displacement

Figure G.2 — Characteristics of tensile force, T

G.1.3 Acceptance criteria

The friction coefficient, μ, used for the calculations is the ratio of T_r (average horizontal tensile force in steady-state) to the vertical force, F. A minimum of three tests is required and the friction coefficient shall be taken as the smallest of the measurements.

G.2 No slipping of the load — Clamping by friction or penetration

G.2.1 Conditions

The maximum obtainable force to hold a load is called holding force. It is determined by Formula (G.1).

$$T = S\left(\mu_1 + \mu_2\right) \qquad \text{(G.1)}$$

where

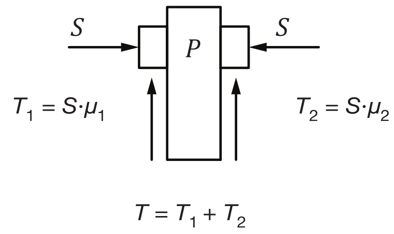
S is the clamping force of the clamp or the tongs;

μ_1 is the friction coefficient between load and one clamping part;

μ_2 is the friction coefficient between load and the other clamping part.

See Figure G.3.

The holding force is determined by calculation. The calculation shall be done for the most unfavourable gripping range



Key

P work piece

Figure G.3 — Clamping forces

G.2.2 Acceptance criteria

The holding force, *T*, holding the load shall be two times the load to be held.

This requirement shall be verified throughout the lifting operation regardless of whether the clamping force, *S*, is due to self-actuation (in proportion to the load weight) or to a mechanical actuator.

G.3 Verification of mechanical strength of the secondary positive holding device for clamps in horizontal direction

G.3.1 Conditions

The test shall be conducted by applying a uniformly distributed static force equal 1/2 WLL on the 90° tilted attachment.

G.3.2 Procedure

The empty attachment shall be tilted and fixed in a manner such that the secondary positive holding device is not in contact with anything other than the clamp or the test load and has enough space to deform. A force equal to half the WLL shall be applied to the lower part of the secondary positive holding device. The test shall be carried out for at least the two most unfavourable directions.

G.3.3 Acceptance criteria

The secondary positive holding device shall withstand the force even if permanent deformation occurs.

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