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## **prEN ISO 8100-2 ed2 final draft with track changes**

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Please find attached the final versions of the EN ISO standards as prepared by WG1. These are the versions as submitted to ISO.



**CEN/TC 10/WG 1 "Lifts and service lifts"**  
WG Secretariat: **AFNOR**  
Convenor: **Hermann René Mr**



**prEN ISO 8100-2 ed2 final draft with track changes 2023-09-07**

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General / Other		2023-09-19	<b>INFO</b>

**ISO/PRF 8100-2:2023(E)**

**Second edition**

ISO TC 178/WG 04

Date: 2023-09-07

**Lifts for the transport of persons and goods — Part 2: Design rules, calculations, examinations and tests of lift components**

**WD/CD/DIS/FDIS stage**

**Warning for WDs and CDs**

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Recipients of this draft are invited to submit, with their comments, notification of any relevant patent rights of which they are aware and to provide supporting documentation.

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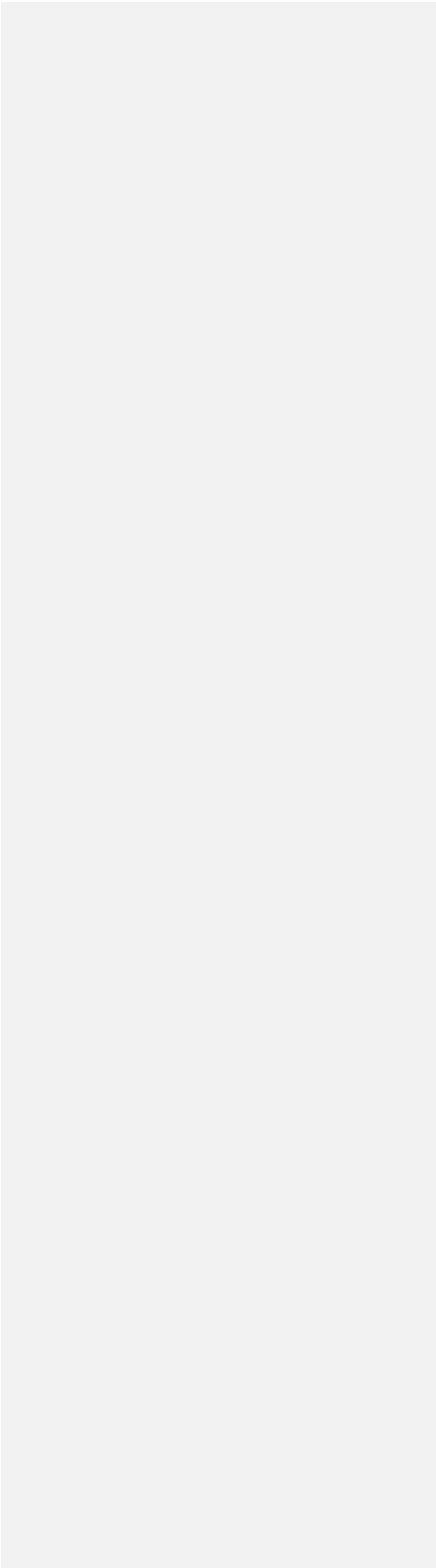
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## European Foreword

This document (prEN ISO 8100-2:2023) has been prepared by Technical Committee CEN/TC 10 “Lifts, escalators and moving walks”, the secretariat of which is held by AFNOR.

This document is currently submitted to the CEN Enquiry.

This document will supersede EN 81-20:2020.

~~This document is part of the EN 81 series of standards. The structure of the EN 81 series is described in CEN/TR 81-10:2008.~~

~~The content of this standard provides the design rules, calculations, examinations and tests for lifts component, the requirements of which are specified in other EN 81 series of standards. Therefore this standard can only be used in conjunction with the standards for specific lift types, e.g. ISO 8100-1:2025 for passenger and goods passenger lifts.~~

~~This is the second edition of the standard. The need for replacement was based on the following points:~~

~~— incorporation of proposals resulting from interpretation requests<sup>1)</sup>~~

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

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

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

<sup>1)</sup> ~~Within CEN/TC 10 an interpretation committee has been established to answer questions about the spirit in which the experts have drafted the various clauses of this standard. All such interpretations are published within CEN TS 81-11 until incorporated by amendment into the standards concerned.~~

**Commented [AD1]:** How to solve this?

**Commented [SD2]:** Updated WG1 comments N2046

**Commented [IJ3]:** Add reasons for new version of Part 50 i.e. new part 20, update of referenced documents, correction of editorial mistakes, general update in technology.

**Commented [SD4]:** Combined Comments N2056 (deleted footnote at bottom of page)

**Commented [IJ5]:** We still need to find a way to describe the interpretations process.

## Foreword

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

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](http://www.iso.org/directives)).

ISO draws attention to the possibility that the implementation of this document may involve the use of (a) patent(s). ISO takes no position concerning the evidence, validity or applicability of any claimed patent rights in respect thereof. As of the date of publication of this document, ISO *[had/had not]* received notice of (a) patent(s) which may be required to implement this document. However, implementers are cautioned that this may not represent the latest information, which may be obtained from the patent database available at [www.iso.org/patents](http://www.iso.org/patents). ISO shall not be held responsible for identifying any or all such patent rights.

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

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

This document was prepared by Technical Committee ISO/TC 178, *Lifts, escalators, passenger conveyors*.

This second edition cancels and replaces the first edition (ISO 8100-2:2019), which has been technically revised.

The main changes are as follows:

- editorial revision of the document structure according to the ISO/IEC Directives, part 2;
- mechanical tests and temperature tests of safety circuits and SIL-rated circuits are updated;
- errors in the formulae for traction calculation are corrected;
- verification methods for suspension and compensation means other than steel wire ropes are added;
- discard criteria for suspension means and power transmission contact are added;
- Requirements for SIL-rated circuits (previously called PESSRAL) have been revised.

For relationship with this document and ISO 8100-20, see informative Annex G, which is an integral part of this document.

A list of all parts in the ISO 8100 series can be found on the ISO website.

Any feedback or questions on this document should be directed to the user's national standards body. A complete listing of these bodies can be found at [www.iso.org/members.html](http://www.iso.org/members.html).

## Introduction

~~The content of this document was already published in EN 81-50:2014. This document contains only editorial changes and update of references.~~

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

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

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

~~— health and safety bodies (regulators, accident prevention organizations, market surveillance etc.);~~

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

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

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

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

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

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

Commented [AD7]: CEN/ISO default text

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

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

The object of this document is to define safety rules related to lifts with a view to safeguarding persons and objects against the risk of accidents associated with the use, maintenance and emergency operations of lifts.

Reference is made to the respective introductions of the standards (e.g. ISO 8100-1:2023) calling for the use of this document with regard to persons and objects to be safeguarded, assumptions, principles, etc.



## Lifts for the transport of persons and goods — Part 2: Design rules, calculations, examinations and tests of lift components

### 1 Scope

This document specifies for passenger lifts and goods passenger lifts:

- the verification of door locking devices;
- the verification of safety gears;
- the verification of overspeed governors;
- the verification of buffers;
- the verification of safety circuits and SIL-rated circuits;
- the verification of ascending car overspeed protection means;
- the verification of unintended car movement protection means;
- the verification of rupture valves and one-way restrictors;
- the verification of suspension and compensation means;
- the discard criteria for suspension means and power transmission contact;
- the calculation of guide rails;
- the calculation of rams, cylinders, rigid pipes and fittings;
- the evaluation of the traction;
- the evaluation of the safety factor on suspension means;
- the pendulum shock tests;
- fault exclusion for electric and electronic components;
- the design rules for SIL-rated circuits.

~~the design rules, calculations, examinations and tests of lift components which are referred to by other standards used for the design of passenger lifts, goods passenger lifts, goods only lifts, and other similar types of lifting appliances.~~

This document is not applicable to passenger lifts, goods passenger lifts or lift components, which are installed or manufactured before the date of its publication.

### 2 Normative references

The following documents are referred to in the text in such a way that some or all of their content constitutes requirements of this document. For dated references, only the edition cited applies. For undated references, the latest edition of the referenced document (including any amendments) applies.

ISO 3108:2017, *Steel wire ropes — Test method — Determination of measured breaking force*

Commented [AD8]: New scope as required by EU-C3, TFHAS\_86\_v5

## ISO / PRF 8100-2:2023(E)

ISO 4344:2022, *Steel wire ropes for lifts — Minimum requirements*

ISO 8100-1:2023, *Lifts for the transport of persons and goods — Part 1: Safety rules for the construction and installation of passenger and goods passenger lifts*

~~ISO/TS 8100-3:2019, Lifts for the transport of persons and goods — Part 3: Requirements from other Standards (ASME A17.1/CSA B44 and JIS A 4307-1/JIS A 4307-2) not included in ISO 8100-1 or ISO 8100-2~~

ISO 8100-33:2022, *Lifts for the transport of persons and goods — Part 33: T-type guide rails for lift cars and counterweights*

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

Commented [AD9]: TFHAS\_86\_v5

ISO 29584:2015, *Glass in building — Pendulum impact testing and classification of safety glass*

IEC 60068-2-6:2007, *Environmental testing — Part 2-6: Tests — Test Fc: Vibration (sinusoidal)*

IEC 60068-2-14:2009, *Environmental testing — Part 2-14: Tests — Test N: Change of temperature*

IEC 60068-2-27:2008, *Environmental testing — Part 2-27: Tests — Test Ea and guidance: Shock*

IEC 60112:2020, *Method for the determination of the proof and the comparative tracking indices of solid insulating materials*

IEC 60664-1:2020, *Insulation coordination for equipment within low-voltage supply systems — Part 1: Principles, requirements and tests*

IEC 60893-3-1:2012, *Insulating materials — Industrial rigid laminated sheets based on thermosetting resins for electrical purposes — Part 3-1: Specifications for individual materials - Types of industrial rigid laminated sheets*

IEC 60947-4-1:2018, *Low-voltage switchgear and control gear — Part 4-1: Contactors and motor-starters — Electromechanical contactors and motor-starters*

IEC 60947-5-1:2016, *Low-voltage switchgear and control gear — Part 5-1: Control circuit devices and switching elements — Electromechanical control circuit devices*

IEC 61508-2:2010, *Functional safety of electrical/electronic/ programmable electronic safety-related systems — Part 2: Requirements for electrical/electronic/programmable electronic safety-related systems*

IEC 61508-3:2010, *Functional safety of electrical/electronic/programmable electronic safety-related systems — Part 3: Software requirements*

IEC 61558-1:2017, *Safety of power transformers, power supplies, reactors and similar products — Part 1: General requirements and tests*

IEC 61709:2017, *Electric components - Reliability - Reference conditions for failure rates and stress models for conversion*

EN 10025-2:2019, *Hot rolled products of structural steels — Part 2: Technical delivery conditions for non-alloy structural steels (all parts), ~~Hot rolled products of non-alloy structural steels — Technical delivery conditions~~*

EN 12385-1:2002+A1:2008, *Steel wire ropes – Safety — Part 1: General requirements*

EN 12385-5:2021, *Steel wire ropes - Safety — Part 5: Stranded ropes for lifts*

EN 13411-6:2004+A1:2008, *Terminations for steel wire ropes — Part 6: Safety. Asymmetric wedge socket*

EN 13411-7:2021, *Terminations for steel wire ropes — Part 7: Safety. Symmetric wedge socket*

### 3 Terms and definitions

For the purposes of this document, ~~the terms and definitions given in ISO 8100-1:2023~~ the following terms and definitions apply.

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

- ISO Online browsing platform: available at <https://www.iso.org/obp>
- IEC Electropedia: available at <http://www.electropedia.org/>

**3.1**  
**approved body**  
organization or manufacturer, operating an approved full quality assurance system to undertake testing of safety components (3.2)

**Commented [SD10]:** Do we need to change this as Approved body is now UK term for Notified Body

**Commented [AD11]:** TFHAS\_86\_v5

**3.2**  
**safety component**  
component provided to fulfil a safety function when in use

**Commented [AD12]:** TFHAS\_86\_v5

**3.3**  
**type examination certificate**  
document issued by an *approved body* (3.1) carrying out a type-examination in which it certifies that the product example under consideration complies with the provisions applicable to it

**Commented [AD13]:** TFHAS\_86\_v5

### 4 List of significant hazards

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

**Table 1 — List of significant hazards**

No.	Hazards as listed in ISO 12100:2010, Annex B	Relevant clauses
1	<b>Mechanical hazards due to:</b>	-
	Acceleration, deceleration (kinetic energy)	5.3; 5.4; 5.5; 5.7; 5.8; 5.9
	Approach of a moving element to a fixed part	5.2
	Elastic elements	5.10; 5.11; 5.12; 5.13
	Falling objects	5.3; 5.4; 5.5; 5.9
	Gravity (stored energy)	5.3; 5.4; 5.5; 5.9
	Height from the ground	5.3; 5.4; 5.5; 5.9
	High pressure	5.13

**Commented [ID14]:** This table to be updated or deleted.

No.	Hazards as listed in ISO 12100:2010, Annex B	Relevant clauses
	Moving elements	5.2; 5.3; 5.4; 5.5; 5.6; 5.7; 5.8; 5.9; 5.10; 5.11; 5.12; 5.13; 5.14; 5.15; 5.16
	Rotating elements	5.4; 5.11; 5.12
	Stability	5.10; 5.11; 5.12; 5.13; 5.14
	Strength	5.10; 5.11; 5.12; 5.13; 5.14
2	<b>Electrical hazards</b>	-
	Arc	5.2; 5.4; 5.6; 5.7; 5.8; 5.17; 5.18
	Electrostatic phenomena	5.2; 5.4; 5.6; 5.7; 5.8; 5.17; 5.18; 5.15; 5.16
	Live parts	5.2; 5.4; 5.6; 5.7; 5.8; 5.17; 5.18; 5.15; 5.16
	Not enough distance to live parts under high voltage	5.2; 5.4; 5.6; 5.7; 5.8; 5.17; 5.18; 5.15; 5.16
	Overload	5.2; 5.4; 5.6; 5.7; 5.8; 5.17; 5.18; 5.15; 5.16
	Parts which have become live under faulty conditions	5.2; 5.4; 5.6; 5.7; 5.8; 5.17; 5.18; 5.15; 5.16
	Short-circuit	5.2; 5.4; 5.6; 5.7; 5.8; 5.17; 5.18; 5.15; 5.16
6	<b>Hazards generated by radiation</b>	-
	Low frequency electromagnetic radiation	5.6; 5.17; 5.18; 5.15; 5.16
	Radio frequency electromagnetic radiation	5.6; 5.17; 5.18; 5.15; 5.16
9	<b>Hazards associated with the environment in which the machine is used</b>	5.2; 5.3; 5.4; 5.5; 5.6; 5.7; 5.8; 5.9; 5.10; 5.11; 5.12; 5.13; 5.14; 5.15; 5.16; 5.17; 5.18

**Commented [KA15]:** Electrical requirements are in 5.17 and 5.18 due to renumbering.  
5.2 editorial to 5.2 (comma to dot)

#### 4 5 Design rules, calculations, examinations verifications and tests

##### 4.1 5.1 General provisions for type examinations of safety components

###### 5.1.1 Object and extent of the tests

The safety component/device is submitted to a test procedure to verify that insofar as construction and operation are concerned, it conforms to the requirements imposed by this document. It shall be checked, in particular, that the mechanical, electrical and electronic components of the device are properly rated and that, in the course of time, the device does not lose its effectiveness, particularly through wear or aging. If the safety component is needed to satisfy particular requirements (waterproof, dust proof or explosion proof construction), supplementary examinations and/or tests under appropriate criteria shall be made.

###### 5.1.2 General provisions

**5.1.2.1** For the purposes of this document, it is assumed that the laboratory undertakes both the testing and the certification as an approved body. An approved body may be that of a manufacturer operating an approved full quality assurance system. In certain cases, the test laboratory and the body approved for the issue of type examination certificates may be separate. In these cases, the administrative procedures can differ from those described in this document.

**5.1.2.2** The application for type examination shall be made by the manufacturer of the component, or their authorized representative, and shall be addressed to an approved test laboratory.

~~5.1.2.3 The dispatch of samples for examination shall be made by agreement between the laboratory and the applicant.~~

~~5.1.2.4 The applicant may attend the tests.~~

~~5.1.2.5 If the laboratory entrusted with the complete examination of one of the components requiring the supply of a type examination certificate has no appropriate means available for certain tests or examinations, it may, under its responsibility, have these made by other laboratories with the agreement of the applicant.~~

Passenger and goods passenger lifts shall comply with the safety requirements and/or protective measures of the following clauses. In addition, the passenger and goods passenger lifts shall be designed according to the principles of ISO 12100:2010 for hazards relevant but not significant that are not dealt with by this document (e.g. sharp edges).

~~5.1.2.6 Unless specified otherwise, the precision of the instruments shall allow measurements to be made within the following accuracy:~~

- a)  $\pm 1$  % for masses, forces, distances, speeds;
- b)  $\pm 2$  % for accelerations, retardations;
- c)  $\pm 5$  % for voltages, currents;
- d)  $\pm 5$  °C for temperatures;
- e) recording equipment shall be capable of detecting signals, which vary in time of 0,01 s;
- f)  $\pm 2,5$  % for flow rate;
- g)  $\pm 1$  % for pressure,  $P$ , below 200 kPa;
- h)  $\pm 5$  % for pressure,  $P$ , above 200 kPa.

Commented [AD16]: Default text

Commented [AD17]: TFHAS\_86\_v5

## 4.2 5.2 — Type examination Verification of landing and car door locking devices

### 4.2.1 ~~5.2.1~~ — General provisions

#### 4.2.1.1 ~~5.2.1.1~~ — Field of application

~~These procedures are applicable to locking devices for landing and car doors. It is understood that each component taking part in the locking of doors and in the checking of the locking forms part of the locking device.~~

#### 4.2.1.2 ~~5.2.1.2~~ — Documents to be submitted

##### 4.2.1.2.1 ~~5.2.1.2.1~~ Schematic arrangement drawing with description of operation

~~This drawing shall clearly show all the details relating to the operation and the safety of the locking device, including:~~

- ~~a) the operation of the device in normal service, showing the effective engagement of the locking elements and the point at which the electrical safety device operates;~~
- ~~b) the operation of the device for mechanical checking of the locking position if this device exists;~~
- ~~c) the control and operation of the emergency unlocking device;~~
- ~~d) the type (A.C. and/or D.C.), rated voltage and rated current.~~

##### 4.2.1.2.2 ~~5.2.1.2.2~~ Assembly drawing with key

~~This drawing shall show all parts important to the operation of the locking device, in particular those required to conform to the requirements of this document. A key shall indicate the list of the principal parts, the type of materials used, and the characteristics of the fixing elements.~~

#### 4.2.1.3 ~~5.2.1.3~~ — Test samples

~~One door locking device shall be submitted to the laboratory.~~

~~If the test is carried out on a prototype, it shall be repeated later on a production model.~~

~~If the test of the locking device is only possible when the device is mounted in the corresponding door, the device shall be mounted on a complete door in working order. However, the door dimensions may be reduced by comparison with a production model, on the condition that it does not falsify the test results.~~

Commented [AD18]: TFHAS\_86\_v5

## 4.2.24.2.1 5.2.2 — Examination Verifications and tests

### 4.2.2.14.2.1.15.2.2.1 — Examination Verification of operation

~~This examination aims to verify that:~~

~~— the mechanical and electrical components of the locking device are operating correctly with respect to safety, and in conformity with:~~

- ~~— the requirements of this document;~~
- ~~— the standard calling for this locking device; and~~
- ~~— the device is in conformity with the particulars provided in the application.~~

In particular, it shall be verified that:

- a) there is at least 7 mm engagement of the locking elements before the electric safety device operates;
- b) it is not possible to operate the lift from positions normally accessible to persons with a door open or unlocked, after one single action not forming part of the normal operation.

~~4.2.2.24.2.1.2.5~~ **Mechanical tests**

~~4.2.2.24.2.1.2.1~~ **5.2.2.2.1** — General

~~These tests have the purpose of verifying the strength of the mechanical locking components and the electrical components.~~

~~The sample of the locking device in its normal operating position is controlled by the devices normally used to operate it.~~

~~The sample shall be lubricated in accordance with the requirements of the manufacturer of the locking device.~~

When there are several possible means of control and positions of operation, the endurance test shall be made in the arrangement which is regarded as the most unfavourable stressed condition from the point of view of the forces on the components.

The number of complete cycles of operation and the travel of the locking components shall be registered by mechanical or electrical counters.

~~4.2.2.24.2.1.2.2~~ **5.2.2.2.2** — Endurance test

The locking device shall be submitted to 1 000 000 (±1 %) complete cycles; one cycle comprises one forward and return movement over the full travel possible in both directions.

The driving of the device shall be smooth, without shocks, and at a rate of 60 (±10 %) cycles per minute.

During the endurance test, the electrical contact of the lock shall close a resistive circuit under the rated voltage and at a current value double that of the rated current.

If the locking device is provided with a mechanical checking device for the locking pin or the position of the locking element, this device shall be submitted to an endurance test of 100 000 (±1 %) cycles.

The driving of the device shall be smooth, without shocks, and at a rate of 60 (±10 %) cycles per minute.

~~4.2.2.24.2.1.2.3~~ **5.2.2.2.3** — Static test

~~For locking devices intended for hinged doors, a~~ The test shall be made consisting of the application over a total period of 300 s of a static force, increasing gradually progressively to a the value laid down in the standard calling for the use of this standard (e.g. ISO 8100-1:2023, 5.3.9.1.74.3.9.1.6) between 30 s to 60 s. of 3 000 N. ~~The force shall be applied for a period of 300 s.~~

~~This force shall be applied in the opening direction of the door and in a position corresponding as far as possible to that which can be applied when a user attempts to open the door. The force applied shall be 1 000 N in the case of a locking device intended for sliding doors.~~

Commented [AD19]: TFHAS\_86\_v5

Commented [AD20]: TFHAS\_86\_v5

Commented [SD21]: As WG1 comments N2046 & N1954

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Commented [IJ23]: This text still under review by WG1  
To apply the value at the point of locking the force applied to the point at which a user interacts with the door may be unreasonable.

Commented [AD24]: As WG1 comments N2046 & N1954 Annex IX  
N2222 comment AD-073

~~4.2.2.2.4.4.2.1.2.4~~ ~~5.2.2.2.4~~ — Dynamic test

The locking device, in the locked position, shall be submitted to a shock test in the opening direction of the door.

The shock shall correspond to the impact of a rigid mass of 4 kg falling in free fall from a height of 0,50 m.

~~4.2.2.34.2.1.35.2.2.3~~ — Criteria for the mechanical tests

After the endurance test (~~5.2.2.2.24.2.1.2.2~~), the static test (~~5.2.2.2.34.2.1.2.3~~) and the dynamic test (~~5.2.2.2.44.2.1.2.4~~), there shall not be any wear, deformation or breakage, which could adversely affect safety.

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~~4.2.2.44.2.1.45.2.2.4~~ — Electrical test

~~4.2.2.4.14.2.1.4.1~~ ~~5.2.2.4.1~~ — Endurance test of contacts

This test is included in the endurance test laid down in ~~5.2.2.2.24.2.1.2.2~~.

~~4.2.2.4.24.2.1.4.2~~ ~~5.2.2.4.2~~ — Test of ability to break circuit

~~5.2.2.4.2.14.2.1.4.2.1~~ **General**

Commented [SD26]: Combined comments N2056

This test shall be carried out after the endurance test. It shall check that the ability to break a live circuit is sufficient. This test shall be made in accordance with the procedure in IEC 60947-4-1 and IEC 60947-5-1. The values of current and rated voltage serving as a basis for the tests shall be those indicated by the manufacturer of specified for the device.

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If nothing is specified, the rated values shall be as follows:

- a) alternating current: 230 V, 2 A;
- b) direct current: 200 V, 2 A.

~~Unless indicated otherwise,~~ The capacity to break circuit shall be examined for both A.C. and D.C. conditions.

The tests shall be carried out with the locking device in ~~the all~~ working positions. ~~If several positions are possible, the test shall be made in the most unfavourable position.~~

The sample tested shall be provided with covers and electric wiring as used in normal service.

~~4.2.1.4.2.25.2.2.4.2.2~~ A.C. locking devices shall open and close an electric circuit under a voltage equal to 110 % of the rated voltage 50 times, at normal speed and at intervals of 5 s to 10 s. The contact shall remain closed for at least 0,5 s.

The circuit shall comprise a choke and a resistance in series. Its power factor shall be  $0,7 \pm 0,05$  and the test current shall be 11 times the rated current indicated by the manufacturer of the device.

~~4.2.1.4.2.35.2.2.4.2.3~~ D.C. locking devices shall open and close an electric circuit under a voltage equal to 110 % of the rated voltage 20 times, at normal speed and at intervals of 5 s to 10 s. The contact shall remain closed for at least 0,5 s.

The circuit shall comprise a choke and a resistance in series having values such that the current reaches 95 % of the steady-state value of the test current in 300 ms.

The test current shall be 110 % of the rated current indicated by the manufacturer of the device.

~~4.2.1.4.2.4.5.2.2.4.2.4~~ The tests are considered satisfactory if no tracking or arcing is produced and if no deterioration occurs which can ~~adversely~~ affect safety.

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~~4.2.2.4.3.4.2.1.4.3~~ **5.2.2.4.3 — Test for resistance to leakage currents**

This test shall be made in accordance with the procedure in IEC 60112:2020. The electrodes shall be connected to a source providing an A.C. voltage which is sinusoidal at 175 V, 50 Hz.

~~4.2.2.4.4.2.1.4.4~~ **5.2.2.4.4 — Examination-Verification of clearances and creepage distances**

The clearances in air and creepage distances shall be in accordance with the requirements laid down in the standards calling for the use of this document (e.g. ISO 8100-1:2023, ~~5.11.2.2.4.4.11.2.2.4~~).

Commented [SD29]: As WG1 comments N2046

~~4.2.2.4.5.4.2.1.4.5~~ **5.2.2.4.5 — Examination-Verification of the requirements appropriate to safety contacts and their accessibility**

This ~~examination-verification~~ shall be made taking account of the mounting position and the layout of the locking device, as appropriate.

~~4.2.3.4.2.2~~ **5.2.3 — Test particular to certain types of locking devices**

~~4.2.3.14.2.2.15.2.3.1~~ **Locking device for horizontally or vertically sliding doors with several panels**

~~According to the requirements laid down in the standards calling for the use of this document, the devices providing direct mechanical linkage between panels (e.g. ISO 8100-1:20192025, 5.3.14.1) or indirect mechanical linkage (e.g. ISO 8100-1:20192025, 5.3.14.2) are considered forming part of the locking device shall be included in the tests mentioned in 4.2.1.~~

Commented [SD30]: As WG1 comments N2046

~~These devices shall be submitted to the tests mentioned in 5.2.2. The number of cycles per minute in such endurance tests shall be suited to the dimensions of the construction between 45 – 60.~~

~~NOTE ISO 8100-1:2023, 5.3.14.14.3.14.1 and ISO 8100-1:2023, 5.3.14.24.3.14.2 specify direct and indirect mechanical linkage.~~

~~4.2.3.24.2.2.25.2.3.2~~ **Flap type locking device for hinged door**

~~If this device is provided with an electric safety device required to check the possible deformation of the flap, and if, after the static test envisaged in 5.2.2.2.3, there are any doubts on the strength of the device, the load shall be increased progressively until the safety device begins to open. No component of the locking device or of the door shall be damaged or permanently deformed by the load applied.~~

~~If, after the static test, the dimensions and construction leave no doubt as to its strength, it is not necessary to proceed to the endurance test on the flap.~~

~~The conditions of ISO 8100-1:2023, 5.3.9.1.144.3.9.1.12 b) to f) shall be verified.~~

~~The locking force limiter according to ISO 8100-1:2023, 5.3.9.1.144.3.9.1.12 f) shall be tested on an operationally constructed door by pushing open the door panels with a steadily increasing force until the locking force limiter releases the flap. The force is applied according to ISO 8100-1:2023, 5.3.9.1.144.3.9.1.12 f). The flap shall not release before the force exceeds the force according to ISO 8100-1:2023, 5.3.9.1.144.3.9.1.12 f).~~

Commented [SD31]: Add ISO 8100-1 dates

~~The test shall be carried out on a door with the largest width.~~

In the case of elements to limit the load on the flap that are triggered via a predetermined breaking point, the locked door shall be force-opened at least three times, each time with renewed trigger elements. In the case of non-destructive release elements, a limited endurance test with at least 50 force openings is required.

There shall be no permanent deformation or breakage on the locking device after the test.

#### 4.2.44.2.3 5.2.4 Type examination certificate Verification report

The certificate report shall indicate the following:

~~e) information according to Annex A;~~

a) type and application of locking device;

b) type (A.C. and/or D.C.) and values of the rated voltage and rated current;

c) in the case of flap type door locking devices: the necessary force to actuate the electric safety device for checking the elastic deformation of the flap in the case of flap type door locking devices: the necessary force to actuate the locking force limiter.

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Commented [SD35]: N2046 & N1988

### 4.3 ~~5.3~~ — ~~Type examination~~ Verification of safety gear

#### 4.3.1 ~~5.3.1~~ — General provisions

The ~~following information shall be provided~~ applicant shall state the range of use provided, i.e.:

- ~~minimum and maximum masses;~~
- ~~maximum rated speed and maximum tripping speed;~~
- ~~Detailed information shall be provided on the materials used,~~ the type of guide rails and their surface condition (drawn, milled, ground) ~~and materials used.~~

~~The following documents shall be attached to the application:~~

- a) ~~detailed and assembly drawings showing the construction, operation, materials used, dimensions and tolerances of the construction components;~~
- b) ~~in the case of progressive safety gear, also a load diagram relating to elastic parts.~~

#### 4.3.2 ~~5.3.2~~ — Instantaneous safety gear

##### 4.3.2.1 ~~5.3.2.1~~ — Test samples

Two gripping assemblies with wedges or clamps and two lengths of guide rail shall be ~~submitted to the laboratory provided.~~

The arrangement and the fixing details for the samples shall be determined ~~by the laboratory~~ in accordance with the equipment that it uses.

If the same gripping assemblies can be used with different types of guide rails, a new test shall not be required if the thickness of the guide rails, the width of the grip needed for the safety gear, and the surface state (drawn, milled, ground) are the same.

##### 4.3.2.2 ~~5.3.2.2~~ — Test

###### 4.3.2.2.1 ~~5.3.2.2.1~~ Method of test

The test shall be made using a press or similar device, which moves ~~without abrupt speed change~~ ~~continuously~~ continuously. Measurements shall be made of:

- a) the distance travelled as a function of the force;
- b) the deformation of the safety gear block as a function of the force or as a function of the distance travelled.

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#### 4.3.2.2.2 ~~5.3.2.2.2~~ Test procedure

The guide rail shall be moved through the safety gear.

Reference marks shall be traced onto the blocks in order to be able to measure their deformation.

The distance travelled shall be recorded as a function of the force.

After the test:

- a) the hardness of the block and the gripping element shall be compared with the original values quoted by the ~~applicant~~ documents. Other analyses may be carried out in special cases;
- b) if there is no fracture, deformations and other changes shall be examined (for example, cracks, deformations or wear of the gripping elements, appearance of the rubbed surfaces);
- c) if necessary, photographs shall be taken of the block, the gripping elements and the guide rail for evidence of deformations or fractures.

#### 4.3.2.2.3 ~~5.3.2.2.3~~ Documents

~~5.3.2.2.3.1~~ 4.3.2.2.3.1 Two charts shall be drawn up as follows:

- a) the first one shall show the distance travelled as a function of the force;
- b) the other shall show the deformation of the block. It shall be done in such a way that it can be related to the first chart.

~~5.3.2.2.3.2~~ 4.3.2.2.3.2 The capacity of the safety gears shall be established by integration of the area of the distance-force chart.

The area of the chart to be taken into consideration shall be:

- a) the total area, if there is no permanent deformation;
- b) if permanent deformation or rupture has occurred, either:
  - 1) the area up to the value at which the elastic limit has been reached; or
  - 2) the area up to the value corresponding to the maximum force.

#### 4.3.2.3 ~~5.3.2.3~~ Determination of the permissible mass

##### 4.3.2.3.1 ~~5.3.2.3.1~~ Energy absorbed by the safety gear

~~A distance of free fall, calculated with reference to the maximum tripping speed of the overspeed governor fixed in the requirements laid down in the standards calling for the use of this document (e.g. ISO 8100-1:2019, 2025, 5.6.2.2.1.2.1), shall be adopted.~~

The distance of free fall in metres,  $h$ , shall be taken as Formula (1):

$$h = \left( \frac{v_1^2}{2 \cdot g_n} \right) + 0,1 + 0,03 \quad (1)$$

where

Commented [SD39]: As WG1 comments N2046

Commented [SD40]: Combined comments N2056

- $g_n$  is the standard acceleration of free fall in metres per square second;
- $v_1$  is the maximum tripping speed of ~~overspeed governor~~ the safety gear expressed in metres per second;
- 0,1 corresponds to the distance travelled during the response time, in metres;
- 0,03 corresponds to the travel during take-up of clearance between the gripping elements and the guide rails, in metres.

The total energy the safety gear is capable of absorbing is calculated with Formulae (2) and (3):

$$2 \cdot K = (P + Q)_1 \cdot g_n \cdot h \quad (2)$$

$$\text{from which: } (P + Q)_1 = \frac{2 \cdot K}{g_n \cdot h} \quad (3)$$

Commented [GE41]: ISO INT #1

where

- $K$  is the energy absorbed by one safety gear block, in joules (calculated in accordance with the chart);
- $P$  are the masses of the empty car and components supported by the car, i.e. part of the travelling cable, compensating compensation means ropes/chains (if any), etc., in kilograms;
- $Q$  is the rated load, in kilograms;
- $(P + Q)_1$  is the permissible mass, in kilograms.

Commented [IJ42]: See N17xx

#### 4.3.2.3.2 ~~5.3.2.3.2~~ Permissible mass

- a) If the elastic limit has not been exceeded, the permissible mass in kilograms,  $(P + Q)_1$ , is calculated with Formula (4):

$$(P + Q)_1 = \frac{2 \cdot K}{2 \cdot g_n \cdot h} \quad (4)$$

where

- $K$  is calculated by the integration of the area defined in 5.3.2.2.3.2.4.3.2.2.3.2 a);
- 2 is taken as the dividing safety coefficient.

- b) If the elastic limit has been exceeded, Formulae (5) and (6) shall be used and the higher permissible mass may be selected.

$$(P + Q)_1 = \frac{2 \cdot K_1}{2 \cdot g_n \cdot h} \quad (5)$$

where

- $K_1$  is calculated by the integration of the area defined in 5.3.2.2.3.2.4.3.2.2.3.2 b) 1);
- 2 is taken as the dividing safety coefficient.

$$(P + Q)_1 = \frac{2 \cdot K_2}{3,5 \cdot g_n \cdot h} \quad (6)$$

where

- $K_2$  is calculated by the integration of the area defined in 5.3.2.2.3.2.4.3.2.2.3.2 b) 2);

3,5 is taken as the dividing safety coefficient.

#### 4.3.3 ~~5.3.3~~ — Progressive safety gear

##### 4.3.3.1 ~~5.3.3.1~~ — Statement and test sample

~~The applicant shall state for what mass in kilograms, and tripping speed in metres per second, of the overspeed governor the test will be carried out. If the safety gear needs to be certified for various masses, the applicant shall specify them and indicate, in addition, whether the adjustment is by stages or continuous.~~

~~The applicant should choose the suspended mass in kilograms by dividing the anticipated braking force in newtons by 16, to aim at an average retardation of 0,6 g<sub>n</sub>.~~

~~A complete safety gear assembly, as agreed with the laboratory, together with the number of brake shoes necessary for all the tests, shall be placed at the disposal of the laboratory. The number of sets of brake shoes necessary for all the tests shall be attached. For the type of guide rail used, the length specified by the laboratory shall also be supplied.~~

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##### 4.3.3.2 ~~4.3.3.15.3.3.2~~ — Test

##### 4.3.3.2.1 ~~4.3.3.1.1~~ 5.3.3.2.1 — Method of test

~~5.3.3.2.1.1~~ ~~4.3.3.1.1.1~~ The test shall be carried out in free fall. Direct or indirect measurements shall be made of:

- a) the total height of the fall;
- b) the braking distance on the guide rails;
- c) the sliding distance of the overspeed governor rope, or that of the device used in its place;
- d) the total travel of the elements forming the spring.

Measurements a) and b) shall be recorded as a function of the time.

~~5.3.3.2.1.2~~ ~~4.3.3.1.1.2~~ The following shall be determined:

- a) the average braking force;
- b) the greatest instantaneous braking force;
- c) the smallest instantaneous braking force.

##### 4.3.3.2.2 ~~4.3.3.1.2~~ 5.3.3.2.2 — Test procedure

##### 4.3.3.2.2.1 ~~4.3.3.1.2.1~~ 5.3.3.2.2.1 — Safety gear certified for a single mass

~~The laboratory shall carry out four tests with the mass (P + Q)<sub>1</sub> shall be carried out.~~ Between each test, the friction parts shall be allowed to return to their normal temperature.

~~If d~~ During the tests, ~~the friction parts are replaced~~ several identical sets of friction parts may be used.

However, ~~one each~~ set of parts shall be capable of:

- a) three tests, if the rated speed does not exceed 4 m/s;
- b) two tests, if the rated speed exceeds 4 m/s.

The height of free fall shall be calculated to correspond to the maximum tripping speed of the overspeed governor for which the safety gear can be used.

The engagements of the safety gear shall be achieved by a means allowing the tripping speed to be fixed precisely.

~~For example, a rope may be used, the slack of which should be carefully calculated, fixed to a sleeve which can slide with friction over a fixed smooth rope. The friction effort should be the same as the effort applied to the operating rope by the governor attached to this safety gear.~~

#### ~~4.3.3.2.2.24.3.3.1.2.2~~ ~~5.3.3.2.2.2~~ Safety gear certified for different masses

Adjustment in stages or continuous adjustment.

Two series of tests according to ~~5.3.3.2.2.14.3.3.1.2.1~~ shall be carried out for:

- a) the maximum; and
- b) the minimum values applied for.

The applicant shall supply a formula, or a chart, shall be provided showing the variation of the braking force as a function of a given parameter.

~~The laboratory shall verify by suitable means (in the absence of anything better, by a third series of tests for intermediary points) the validity of the supplied formula or chart shall be verified by additional tests.~~

#### ~~4.3.3.2.34.3.3.1.3~~ ~~5.3.3.2.3~~ Determination of the braking force of the safety gear

##### ~~4.3.3.2.3.14.3.3.1.3.1~~ ~~5.3.3.2.3.1~~ Safety gear certified for a single mass

The braking force that the safety gear is capable of for the given adjustment and the type of guide rail, is taken as equal to the average of the average braking forces determined during the tests. Each test shall be made on an unused section of guide rail.

A check shall be made that the average values determined during the tests lie within a range of  $\pm 25\%$  in relation to the value of the braking force defined above.

NOTE Tests have shown that the coefficient of friction can be considerably reduced if several successive tests are carried out on the same area of a machined guide rail. This is attributed to a modification in the surface condition during successive safety gear operations. ~~It is accepted that, on an installation, an inadvertent operation of the safety gear would have every chance of occurring at an unused section of guide rail. It is necessary to consider that if, by chance, this were not the case, the braking force would have a lower value until an unused portion of guide rail surface was reached. Hence, greater sliding than normal. This is a further reason for not permitting any adjustment causing too small a retardation at the beginning.~~

#### ~~4.3.3.2.3.24.3.3.1.3.2~~ ~~5.3.3.2.3.2~~ Safety gear certified verified for different masses

Adjustment in stages or continuous adjustment.

The braking force that the safety gear is capable of, shall be calculated as laid down in ~~5.3.3.2.3.14.3.3.1.3.1~~ for the maximum and minimum values applied for.

Commented [SD45]: Combined comments N2056

Commented [SD46]: As WG1 comments N2046 all text after NOTE moved under the NOTE A. Dorsch: deleted by TFHAS\_86\_v5

**4.3.3.2.4.4.3.3.1.4 5.3.3.2.4 — Checking after the tests**

After the tests, it shall be checked that:

- a) the hardness of the block and the gripping elements are compared with the original values submitted by the applicant documents;
- b) the deformations and modifications (for example, cracks, deformations or wear of the gripping elements, appearance of the rubbing surfaces) are checked;
- c) if necessary, the safety gear assembly, the gripping elements and the guide rails are photographed in order to reveal deformations or fractures.

**4.3.3.3.4.3.3.2.5.3.3.3 — Calculation of the permissible mass**

**4.3.3.3.14.3.3.2.1 5.3.3.3.1 — Safety gear certified-verified for a single mass**

The permissible mass shall be calculated using Formula (7):

$$(P + Q)_1 = \frac{F_B}{16} \quad (7)$$

where

- $F_B$  is the braking force in newtons, determined in accordance with 5.3.3.2.3.4.3.3.1.3;
- $P$  is the masses of the empty car and components supported by the car, i.e. part of the travelling cable, compensation means, compensating ropes/chains (if any), etc., in kilograms;
- $Q$  is the rated load, in kilograms;
- $(P + Q)_1$  is the permissible mass, in kilograms.

Commented [I47]: See N17xx

If the calculated permissible mass is larger than the tested mass, the tested mass may be taken as permissible mass, provided that the average retardation of each test did not exceed  $1,0 g_n$ .

**4.3.3.3.2.4.3.3.2.2 5.3.3.3.2 — Safety gear certified for different masses**

**4.3.3.3.2.14.3.3.2.2.1 5.3.3.3.2.1 — Adjustment in stages**

The permissible mass shall be calculated for each adjustment as laid down in 5.3.3.3.14.3.3.2.1.

**4.3.3.3.2.2.4.3.3.2.2.2 5.3.3.3.2.2 — Continuous adjustment**

The permissible mass shall be calculated as laid down in 5.3.3.3.14.3.3.2.1 for the maximum and minimum values applied for, and in accordance with the formula supplied for the intermediate adjustments.

**4.3.3.4 5.3.3.4 — Possible modification to the adjustments**

If, during the tests, the values found differ by more than 20 % from those expected by the applicant, other tests may be made with their agreement, after modification of the adjustments, if necessary.

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4.3.4 ~~5.3.4~~ **Additional verifications** ~~Comments~~

a) ~~a)~~ Applicable mass

The applicable mass used for a lift shall not exceed the permissible mass for instantaneous safety gear.

In the case of progressive safety gear, the mass stated may differ from the applicable mass stated in ~~5.3.3.3.3.2~~ by  $\pm 7,5\%$ . ~~It is accepted, in these conditions, that the requirements laid down in the standards calling for the use of this document (e.g. ISO 8100-1:2019, 2025, 5.6.2.1) are met on the installation, notwithstanding the usual tolerances on the thickness of the guide rails, the surface conditions, etc.~~

Commented [SD49]: Update date

~~b) b)~~ To evaluate the validity of welded parts, reference shall be made to standards on this subject.

~~c) b)~~ e) A check shall be made that the possible travel stroke of the gripping elements is sufficient under the most unfavourable conditions (covers the accumulation of manufacturing design tolerances).

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~~d) The friction parts shall be suitably retained so that it can be certain that they will be in place at the moment of operation.~~

~~e) In the case of a progressive type safety gear, it shall be checked that the travel of the components forming the spring is sufficient.~~

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4.3.5 ~~5.3.5~~ **Type examination certificate** ~~Verification report~~

The ~~certificate report~~ shall indicate ~~the following~~:

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~~d) a)~~ the information according to Annex A;

a) the type and the application of the safety gear;

b) the limits of the permissible masses [see 5.3.4.4.3.4 a)];

c) the maximum tripping speed of the ~~overspeed governors~~ safety gear;

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d) the type of guide rail;

e) the permissible thickness of the guide rail blade;

f) the minimum width of the gripping areas;

and, for progressive safety gear only:

g) the surface condition of the guide rails (drawn, milled, ground);

h) the state of lubrication of the guide rails. If they are lubricated, the category and specification of the lubricant.

#### 4.4 ~~5.4~~ — Type examination ~~Verification~~ of overspeed governors

##### 4.4.1 ~~5.4.1~~ — General provisions

The applicant shall indicate the following to the laboratory shall be provided:

- a) the type (or the types) of safety gear which will be operated by the governor;
- b) the maximum and minimum rated speeds of lifts specified for which the governor may be used;
- c) the anticipated value of the tensile force produced in the rope by the overspeed governor when tripped;
- d) detailed and assembly drawings showing the construction, operation, materials used, dimensions and tolerances of the construction components shall be attached to the application.

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##### 4.4.2 ~~5.4.2~~ — Check on the characteristics of the overspeed governor

###### 4.4.2.1 ~~5.4.2.1~~ — Test samples

The following shall be submitted to the laboratory provided:

- a) one overspeed governor;
- b) one rope of the type used for the overspeed governor, and the normal condition in which it should be installed. The length to be supplied is fixed by the laboratory;
- c) a tensioning pulley assembly of the type used for the overspeed governor.

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###### 4.4.2.2 ~~5.4.2.2~~ — Test

###### 4.4.2.2.1 ~~5.4.2.2.1~~ Method of test

The following shall be checked:

- a) the speed of tripping is within the specified range stated by the applicant;
- b) the operation of the electric safety device initiating the stopping of the lift machine before the car speed, either up or down, reaches the tripping speed of the governor called for in the standards calling for the use of this document [e.g. ISO 8100-1:2023, 5.6.2.2.1.6 4.6.2.2.1.6 a)] causing the machine to stop, if this device is mounted on the overspeed governor;
- c) if after release of the safety gear the overspeed governor does not automatically reset itself, the operation of the electric safety device preventing the starting of the lift while the overspeed governor is not in the reset position [e.g. ISO 8100-1:2023, 5.6.2.2.1.6 4.6.2.2.1.6 b)] the operation of the electric safety device called for in the standards calling for the use of this document e.g. ISO 8100-1:2025, 5.6.2.2.1.6 b)] preventing all movement of the lift when the overspeed governor is tripped;
- d) the tensile force produced in the rope by the overspeed governor when tripped.

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###### 4.4.2.2.2 ~~5.4.2.2.2~~ Test procedure

At least twenty tests shall be made in the speed range for tripping, corresponding to the range of rated speeds of the lift, indicated in 5.4.1 4.4.1 b).

~~Six tests shall be made for the minimum and six tests shall be made for the maximum values of the range. The majority of tests should be made at the extreme values of the range.~~

The acceleration to reach the tripping speed of the overspeed governor ~~shall not exceed 0,1 m/s<sup>2</sup> should be as low as possible, in order to eliminate the effects of inertia.~~

In addition to twenty tests, a minimum of two tests shall be made, starting from standstill with an acceleration between 0,9  $g_n$  and 1,0  $g_n$  in order to simulate a free fall situation and prove no deterioration of the governor has been caused.

Commented [SD56]: Combined comments N2056

**4.4.2.2.3 ~~5.4.2.2.3~~ Interpretation Assessment of the test results**

In the course of twenty tests, the tripping speeds shall lie within the ~~specification~~limits laid down for overspeed governors in the standards calling for the use of this document.

NOTE — If the limits laid down are exceeded, an adjustment can be made by the manufacturer of the component and 20 new tests carried out.

In the course of the twenty tests, the operation of the devices for which the test is required in ~~5.4.2.2.1~~ 4.4.2.2.1 b) and c) shall occur as specified within the limits laid down in the standards calling for the use of this document [e.g. ISO 8100-1:2023, ~~5.6.2.2.1.64.6.2.2.1.6~~ a) and ~~5.6.2.2.1.64.6.2.2.1.6~~ b)].

The tensile force in the rope produced by the overspeed governor when tripped shall be at least 300 N or any higher value specified by the applicant.

~~Unless otherwise requested by the manufacturer of the device and specified in the test report, the arc of engagement should be 180°.~~

In the case of a device which operates by gripping the rope, ~~there shall be it should be checked that there is~~ no permanent deformation of the rope.

Commented [SD57]: Combined comments N2056

**4.4.3 ~~5.4.3~~ — Type examination certificate Verification report**

The ~~certificate-report~~ shall indicate ~~the following~~:

Commented [AD58]: Same text everywhere

~~e)~~ the information according to Annex A;

~~f)e)~~ the type and application of overspeed governor;

- a) the maximum and minimum rated speeds of the lift for which the overspeed governor may be used;
- b) the diameter of the rope to be used and its construction;
- c) in the case of an overspeed governor with traction pulley, the minimum tensioning force;
- d) the tensile force in the rope which can be produced by the overspeed governor when tripped.

#### 4.5 ~~5.5~~ **Verification of buffers**

##### 4.5.1 ~~5.5.1~~ **General provisions**

The applicant shall state the range of use provided, i.e. maximum impact speed, minimum and maximum masses. The following shall be attached to the application provided:

- a) ~~maximum impact speed, minimum and maximum masses;~~
- b) ~~a)~~ detailed and assembly drawings showing the construction, operation, materials used, dimensions and tolerances of the construction components;

In the case of hydraulic buffers, the graduation (openings for the passage of the liquid), in particular, shall be shown as a function of the stroke of the buffer;

- ~~a)c) b)~~ specifications for the liquid used;
- ~~b)d) e)~~ information regarding environmental conditions for use (temperature, humidity, pollution, etc.) and of life cycle (aging, rejection criteria).

##### 4.5.2 ~~5.5.2~~ **Samples to be submitted subject to test**

The following shall be submitted to the laboratory provided:

- a) one buffer;
- b) liquid, in the case of hydraulic buffers, ~~the necessary liquid sent separately.~~

##### 4.5.3 ~~5.5.3~~ **Test**

###### 4.5.3.1 ~~5.5.3.1~~ **Energy dissipation buffers**

###### 4.5.3.1.1 ~~5.5.3.1.1~~ **Test procedure**

The buffer shall be tested with the aid of weights, corresponding to the minimum and maximum masses, falling in free fall to reach the maximum speed called for at the moment of impact.

The speed shall be recorded at least from the moment of impact of the weights. The acceleration and the retardation shall be determined as a function of time throughout the movement of the weights.

###### 4.5.3.1.2 ~~5.5.3.1.2~~ **Equipment to be used**

###### 4.5.3.1.2.1 ~~5.5.3.1.2.1~~ **Weights falling in free fall**

The weights shall correspond, with the tolerances of ~~5.1.2.64.1~~, to the maximum and minimum masses. They shall be guided vertically ~~ensuring acceleration in free fall condition of at least 0,9 g<sub>n</sub> with the minimum friction possible.~~

###### 4.5.3.1.2.2 ~~5.5.3.1.2.2~~ **Recording equipment**

The recording equipment shall be able to detect signals with the tolerances of ~~5.1.2.64.1~~. The measuring chain, including the recording device for the recording of measured values as a function of time, shall be designed with a system frequency of at least 1 000 Hz.

Commented [AD59]: TFHAS\_86\_v5

Commented [AD60]: TFHAS\_86\_v5

**4.5.3.1.2.3 ~~5.5.3.1.2.3~~ — Measurement of speed**

The speed shall be recorded at least from the moment of impact of the weights on the buffer or throughout the travel of the weights, with the tolerances of [5.1.2.64.1](#).

**4.5.3.1.2.4 ~~5.5.3.1.2.4~~ — Measurement of the retardation**

If there is a device for measuring retardation (see [5.5.3.1.14.5.3.1.1](#)), it shall be placed as close as possible to the axis of the buffer, and shall be capable of measurement with the tolerances of [5.1.2.64.1](#).

**4.5.3.1.2.5 ~~5.5.3.1.2.5~~ — Measurement of time**

Time pulses of duration of 0,01 s shall be recorded and measured with the tolerances of [5.1.2.64.1](#).

**4.5.3.1.3 ~~5.5.3.1.3~~ — Ambient temperature**

The ambient temperature shall be between +15 °C and +25 °C.

The temperature of the liquid shall be measured with the tolerances of [5.1.2.64.1](#).

**4.5.3.1.4 ~~5.5.3.1.4~~ — Mounting of the buffer**

The buffer shall be placed and fixed in [accordance with its installation instructions](#) ~~the same manner as in normal service~~.

Commented [AD61]: TFHAS\_86\_v5

**4.5.3.1.5 ~~5.5.3.1.5~~ — Filling of the buffer**

The buffer shall be filled up [in accordance with its to the mark indicated, following the instructions of the component manufacturer](#).

Commented [AD62]: TFHAS\_86\_v5

**4.5.3.1.6 ~~5.5.3.1.6~~ — Checks****4.5.3.1.6.1 ~~5.5.3.1.6.1~~ — Checking of retardation**

The height of free fall of the weights shall be chosen in such a way that the speed at the moment of impact corresponds to the maximum impact speed stipulated in the application.

The retardation shall conform to the requirements of the standard calling for this device (e.g. ISO 8100-1:2023, [5.8.2.2.34.8.2.2.2](#)).

The creeping at the end of the buffer stroke for calculation of the average retardation shall be ignored where the retardation is below 0,5 m/s<sup>2</sup>.

A first test shall be made with maximum mass, with a check on the retardation.

A second test shall be made with minimum mass, with a check on the retardation.

**4.5.3.1.6.2 ~~5.5.3.1.6.2~~ — Checking of the return of the buffer to the normal position**

After each test, the buffer shall be held in the completely compressed position for 5 min. The buffer shall then be freed to permit return to its normal extended position.

When the buffer is of a type with spring or gravity return, the position of complete return shall be reached in a maximum period of 120 s.

Before proceeding to another retardation test, there shall be a delay of 30 min to allow the liquid to return to the tank and for air bubbles to escape.

**4.5.3.1.6.3** ~~5.5.3.1.6.3~~ — **Checking of the liquid losses**

The level of liquid shall be checked after having made the two retardation tests required in ~~5.5.3.1.6.1~~~~4.5.3.1.6.1~~. After an interval of 30 min, the level of liquid shall again be sufficient to ensure normal operation of the buffer.

**4.5.3.1.6.4** ~~5.5.3.1.6.4~~ — **Checking of the condition of the buffer after tests**

After the two retardation tests required in ~~5.5.3.1.6.1~~~~4.5.3.1.6.1~~, no part of the buffer shall show any permanent deformation, or be damaged, so that its condition shall guarantee normal operation.

~~4.5.3.1.7~~ ~~5.5.3.1.7~~ **Procedure in the case of tests failing the requirements**

~~When the test results are not satisfactory with the minimum and maximum masses appearing in the application, the laboratory may, in agreement with the applicant, establish the acceptable limits.~~

Commented [AD63]: TFHAS\_86\_v5

**4.5.3.2** ~~5.5.3.2~~ — **Energy accumulation buffers with non-linear characteristics**

**4.5.3.2.1** ~~5.5.3.2.1~~ **Test procedure**

The buffer shall be tested with the aid of masses falling in free fall from a height to reach the maximum speed called for at the moment of impact, but not less than 0,8 m/s.

The falling distance, speed, acceleration and retardation shall be recorded from the moment of release of the weight to complete standstill.

The masses shall correspond to the maximum and minimum masses called for. ~~They shall be guided vertically ensuring acceleration in free fall condition of with a minimum of friction possible, so that at least 0,9  $g_n$  is reached at the moment of impact.~~

Commented [AD64]: TFHAS\_86\_v5

**4.5.3.2.2** ~~5.5.3.2.2~~ **Equipment to be used**

The equipment shall correspond to ~~5.5.3.1.2~~~~4.5.3.1.2~~.

**4.5.3.2.3** ~~5.5.3.2.3~~ **Ambient temperature**

The ambient temperature shall be between +15 °C and +25 °C.

**4.5.3.2.4** ~~5.5.3.2.4~~ **Mounting of the buffer**

The buffer shall be placed and fixed in the same manner as in normal service.

**4.5.3.2.5** ~~5.5.3.2.5~~ **Number of tests**

Three tests shall be made with the maximum mass and the minimum mass called for.

The time delay between two consecutive tests shall be between 5 min and 30 min.

In the three tests with maximum mass, the reference value of the buffer force at a stroke given by ~~the applicant's instructions~~, equal to 50 % of the real height of the buffer, shall not vary by more than 5 %. In the tests with minimum mass, this shall be observed in analogy.

Commented [AD65]: TFHAS\_86\_V5, EU-C3: to exclude applicant

Within 30 min before the test, the buffer shall be once loaded, either statically or dynamically, in order to prevent further settlement and deviations during the test.

4.5.3.2.6 ~~5.5.3.2.6~~ Checks

4.5.3.2.6.1 ~~5.5.3.2.6.1~~ Checking of retardation

The retardation “a” (e.g. ISO 8100-1:2019, 5.8.2.1.2.1), shall conform to the following requirements:

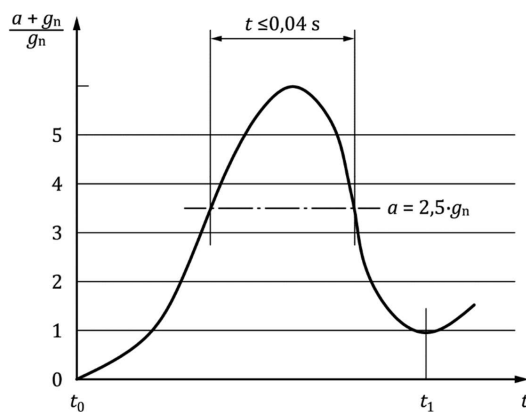
- a) The retardation will be evaluated taking into account the time between the first two absolute minima of the retardation (see Figure 1). The retardation shall not exceed the maximum as required by the standard calling for this device. [e.g. ISO 8100-1:2023, ~~5.8.2.1.2.1~~ 4.8.2.1.2.1 a)];
- b) Peaks ~~duration~~ of retardation above a value specified by the standard calling for this device shall not exceed the maximum duration of these peaks as required by the standard calling for this device [e.g. ISO 8100-1:2023, ~~5.8.2.1.2.1~~ 4.8.2.1.2.1 b)];
- c) The maximum peak retardation shall not exceed the maximum as required ~~in by~~ the standard calling for this device [e.g. ISO 8100-1:2023, ~~5.8.2.1.2.1~~ 4.8.2.1.2.1 e)];
- d) The return speed shall not exceed the maximum as required ~~in by~~ the standard calling for this device. [e.g. ISO 8100-1:2023, ~~5.8.2.1.2.1~~ 4.8.2.1.2.1 c)].

Commented [SD66]: Update date

Commented [SD67]: As WG1 comments N2046

Commented [SD68]: As WG1 comments N2046

Commented [SD69]: As WG1 comments N2046



Key

- a retardation in metres per square second
- $g_n$  standard acceleration of free fall in metres per square second
- $t$  time in seconds
- $t_0$  moment of hitting the buffer (first absolute minimum)
- $t_1$  second absolute minimum

Figure 1 — Retardation graph — Example using ISO 8100-1 requirements

4.5.3.2.6.2 ~~5.5.3.2.6.2~~ Checking of the condition of the buffer after tests

After the tests with the maximum mass, no parts of the buffer shall show any permanent deformation or be damaged, so that its condition shall guarantee normal operation.

4.5.3.2.7 ~~5.5.3.2.7~~ Procedure in the case of tests failing the requirements

~~When the test results are not satisfactory with the minimum and maximum masses appearing in the application, the laboratory may, in agreement with the applicant, establish the acceptable limits.~~

Commented [AD70]: TFHAS\_86\_v5

4.5.4 ~~5.5.4~~ Type examination certificate Verification report

The certificate report shall indicate the following:

- ~~a) the information according to Annex A;~~
- a) the type and application of buffer;
- b) the dimensions of the buffer;
- c) the maximum impact speed;
- d) the maximum mass;
- e) the minimum mass;
- f) the kind of fixation;
- g) the specification of the liquid in the case of hydraulic buffers;
- h) the environmental conditions for use of buffer according to instructions of the manufacturer (temperature, humidity, pollution, etc.).

Commented [AD71]: Same text everywhere

Commented [AD72]: TFHAS\_86\_v5

**4.6** ~~5.6~~ **— Type examination** Verification of safety circuits and SIL-rated circuits containing electronic components and/or programmable electronic systems (PESSRAL)

Commented [IJ73]: AH06 proposal

**4.6.1** ~~5.6.1~~ **— General provisions**

**4.6.1.1** ~~5.6.1.1~~ **— General**

~~For safety circuits containing electronic components, laboratory tests are necessary because practical checks on site, by inspectors, are impossible.~~

Commented [AD74]: TFHAS\_86\_v5

In the following, mention is made to printed circuit board. If a safety circuit is not assembled in such a manner, then the equivalent assembly shall be assumed.

**4.6.1.2** ~~5.6.1.2~~ **— Safety circuits containing electronic components** Documentation

The ~~following shall be provided~~ applicant shall indicate to the laboratory:

- a) identification on the board;
- b) environmental working conditions;
- c) list of components used;
- d) layout of the printed circuit board;
- e) layout of the hybrids and marks of the tracks used in safety circuits;
- f) function description;
- g) electrical wiring diagram, including input and output definitions of the board;
- h) method of failure analysis employed and documented results.

**4.6.1.3** ~~5.6.1.3~~ **— Documentation for SIL-rated circuits** Safety circuits based on programmable electronic systems

Commented [IJ75]: AH06 proposal

In addition to ~~5.6.1.2~~ 4.6.1.2, the following documentation shall be provided:

- a) documents and descriptions relating to the measures ~~listed in~~ referenced in Annex B ~~5.18~~ 4.18;
- b) general description of the software used (e.g. programming rules, language, compiler, modules);
- c) function description, including software architecture and hardware/software interaction;
- d) description of blocks, modules, data, variables and interfaces;
- e) software listings.

Commented [KA76]: 5.16 changed to 5.18 due to paragraph re-numbering.

**4.6.2** ~~5.6.2~~ **— Test s** Samples subject to test

The following shall be ~~submitted to the laboratory~~ provided:

- a) one printed circuit board;
- b) one bare printed circuit board (without components).

4.6.3 ~~5.6.3~~ — Tests

4.6.3.1 ~~5.6.3.1~~ — Mechanical tests

4.6.3.1.1 ~~5.6.3.1.1~~ General

During the tests, the ~~tested object (printed circuit)equipment~~ shall be kept under operation. During and after the tests, no unsafe operation and condition shall appear within the ~~safety-related~~ circuit.

~~After the test the safety-related~~ circuit shall operate ~~when needed~~ as ~~intended~~.

4.6.3.1.2 ~~5.6.3.1.2~~ Vibration and shocks

~~Transmitter elements~~Equipment of safety circuits shall ~~withstand the requirements of~~ be tested ~~according to~~:

a) IEC 60068-2-6:2007, Vibration test:

1) ~~Table C.2~~Endurance by sweeping: 20 sweep cycles in each axis;

2) ~~at~~ amplitude 0,35 mm;

3) ~~and in the~~ frequency range 10 Hz–55 Hz; ~~and~~

b) IEC 60068-2-27:2008, Non-repetitive shocks ~~Table 1~~Acceleration and duration of pulse: the combination of:

1) peak acceleration ~~294-300~~ m/s<sup>2</sup> or 30 g<sub>n</sub>;

2) ~~corresponding~~ duration of pulse 11 ms; ~~and~~

3) pulse shape: half sine;

4) number of shocks per each axis and direction: 3;

5) three axis and two directions; ~~corresponding velocity change 2,1 m/s~~ half sine.

c) ~~IEC 60068-2-27:2008~~ Repetitive shocks:

1) peak acceleration: 100 m/s<sup>2</sup> or 10 g<sub>n</sub>;

2) duration of pulse: 16 ms;

3) pulse shape: half sine;

4) number of shocks per each axis and direction: 1000 ± 10;

5) repetition rate: 2/s;

6) three axis and two directions;

NOTE Where shock absorbers ~~for transmitter elements~~ are fitted, they are ~~considered~~ as part of the ~~transmitter element~~equipment.

After tests, clearances and creepage distances shall not become smaller than the minimum accepted.

**Commented [KA77]:** IEC 61508 is using term safety-related.

**Commented [KA78]:** IEC 61508 is using term safety-related

**Commented [KA79]:** Change term "when needed" to "as intended" as text is used also in EMC standard EN 12016

**Commented [KA80]:** Change text "withstand the requirements of" to text "be tested according to". This change is already in AH6 22.2.2019 report but unfortunately not highlighted.

**Commented [KA81]:** Formatting changed to similar than b) and c) below. No technical changes.

**Commented [KA82]:** Name of the test clarified. Shock tests are Non-repetitive and Repetitive shocks.

**Commented [KA83]:** Word "corresponding" deleted. Use same format as in c) below.

**Commented [KA84]:** Word "and" deleted from end of the line

**Commented [KA85]:** Use same format as in c) below

**Commented [KA86]:** Use same format as in c) below

**Commented [KA87]:** EN 60068-2-27:2009 changed to IEC 60068-2-27:2008

**Commented [IJ88]:** AH06 proposal

**Commented [KA89]:** Delete text "for transmitter elements". This change is already in AH6 22.2.2019 report but unfortunately not highlighted.

~~1.1.1.1.1 Bumping (IEC 60068-2-27)~~

~~4.6.3.1.2.1 1.1.1.1.1 General~~

~~Bumping tests shall simulate the cases when printed circuits fail, introducing the risk of rupture of components and unsafe situations.~~

~~Tests are divided into partial shockings and continuous shockings.~~

~~The tests object shall satisfy the following minimum requirements:~~

~~4.6.3.1.2.2 1.1.1.1.1.1 Partial shocking~~

- ~~a) Shocking shapes: half-sinus;~~
- ~~b) Amplitude of acceleration: 15 g;~~
- ~~c) Duration of shock: 11 ms.~~

~~4.6.3.1.2.3 1.1.1.1.1.1 Continuous shocking~~

- ~~a) Amplitude of acceleration: 10 g;~~
- ~~b) Duration of shock: 16 ms;~~
- ~~c) 1) Number of shocks:  $1\,000 \pm 10$ ;~~
  - ~~2) Shock frequency: 2/s.~~

**4.6.3.2 5.6.3.2 Temperature tests (IEC 60068-2-14)**

~~Equipment shall be tested according to IEC 60068-2-14:2009 Test Nb with following severity parameters:~~

- ~~— lower temperature  $T_A$ : 0 °C;~~
- ~~— higher temperature  $T_B$ : + 65 °C;~~
- ~~— temperature change rate at least: 1 +/-0,2 °C /min;~~
- ~~— exposure time to each of the two temperatures: 4h;~~
- ~~— number of cycles: 2~~

~~Operating ambient limits: 0 °C, +65 °C (the ambient temperature is of the safety device).~~

Test conditions:

**Commented [KA90]:** Replace text EN 60068-2-14:2009 with text IEC 60068-2-14:2009 Test Nb

**Commented [IJ91]:** AH06 proposal

**Commented [KA92]:** delete text "at least" because it is in contradiction with IEC 60068-2-14 test requirements. At least means that temperature can be changed in few seconds from 0 to 65 and then back to 0. IEC 60068-2-14 requires test to be performed within 20% tolerance of specified value. In this case specified rate is 1C/min and range is 0,8 - 1,2 C / min.

~~— the lower and higher temperatures are to be understood as the ambient temperature of the equipment; the ambient temperature is of the safety device;~~

**Commented [KA93]:** AH6 opinion is that this is better expression

- the printed circuit board shall be in operational position;
- the printed circuit board shall be supplied with rated operational voltage;

~~— the safety device shall operate during and after the test, the safety device shall operate correctly when demanded. Demand rate minimum once in 10 min;~~

— if the printed circuit board includes components other than safety circuits, they also shall operate during the test (their failure is not considered); ~~tests shall be carried out for minimum and maximum temperature (0 °C, +65 °C). Tests shall last a minimum of four hours;~~

— if the ~~printed circuit board~~ equipment is designed to operate within wider temperature limits, it shall be tested for these values.

**Commented [KA94]:** It is better to have last French line as own individual requirement because higher and lower temperatures are not "conditions" but they are "parameters".  
Printed circuit board changed to Equipment.

#### 4.6.3.3 ~~5.6.3.3~~ Failure analysis of electric safety circuits

The failure analysis ~~document~~ is required by the relevant standard calling for the use of this document shall be validated. (e.g. ISO 8100-1:2023, ~~5.11.2.34.11.2.3~~).

**Commented [SD95]:** As WG1 comments N2046

#### 4.6.3.4 ~~5.6.3.4~~ Functional and safety test of ~~SIL-rated circuit~~ PESSRAL

In addition to the verification of the measures ~~selected according to 5.18.18 defined in Tables B.1 to B.6~~, the following shall be validated:

**Commented [KA96]:** change text "defined in Tables B.1 to B.6" to text **selected according to 5.18** as 5.18 further guides to IEC 61508 or tables B.1 to B.18

- Software design and coding: Inspect all code statements using methods such as formal design reviews, FAGAN, test cases etc.;
- Software and hardware inspection: Verify ~~selected measures all measures of Tables B.1 and B.2 and the measures chosen, for example, from Table B.7~~ by using, ~~for example~~, fault insertion testing (~~based on IEC 61508-2 and IEC 61508-7~~).

c) ~~Verification of both PFD<sub>avg</sub> and PFH calculations.~~

#### 4.6.4 ~~5.6.4~~ Type examination certificate ~~Verification report~~

The ~~certificate report~~ shall indicate:

- ~~the information according to Annex A;~~
- the type and application of the circuitry;
- ~~the the design for pollution degree according to IEC 60664-1 conditions for safe use;~~
- the operating voltages.
- ~~the distances between the safety circuits and the rest of the control circuits on the board.~~

~~NOTE — Other tests like humidity test, climatic shock test, etc., are not subject for tests because of the normal environmental situation where lifts are operating.~~

**4.7 5.7 — Type examination Verification of ascending car overspeed protection means**

**4.7.1 5.7.1 — General provisions**

~~5.7.1.14.7.1.1 This specification does not apply to speed monitoring elements which are overspeed governors, subject to verifications according to 5.4.4. This specification applies to:~~

- ~~— ascending car overspeed protection means which are not using overspeed governors, or~~
- ~~— programmable electronic systems which are subject to verifications according to 5.4 and 5.6.~~

~~Test results of safety gears which have been verified according to 5.3 may be taken into account for verification of permissible application range.~~

~~5.7.1.24.7.1.2 The following information shall be applicant shall state the range of use provided:~~

- a) minimum and maximum masses, or torque;
- b) minimum (if applicable) and maximum rated speed;
- c) use in installations with compensation means.

~~5.7.1.34.7.1.3 The following documents shall be attached to the applications provided:~~

- a) detailed and assembly drawings showing the construction, operation, materials used, dimensions and tolerances of the construction components;
- b) ~~if necessary, also~~ a load diagram relating to elastic parts;
- c) detailed information on the materials used, the type of part on which the ascending car overspeed protection means acts, and its surface condition (drawn, milled, ground, etc.).

**4.7.2 5.7.2 — Statement and test sample**

~~5.7.2.14.7.2.1 The applicant shall state be stated for what mass (in kilograms) and tripping speed (in meters per second) the test will be carried out. If the device needs to be certified shall be verified for various masses, it shall be stated and indicated the applicant shall specify them and indicate, in addition, whether the adjustment for various masses is by stages or continuous.~~

~~5.7.2.24.7.2.2 As defined between the applicant and the laboratory for the test, either:~~

- ~~— a complete assembly consisting of both elements, braking device and speed monitoring device; or~~
- ~~— only that device which was not subject to verifications according to 5.34.3, or 5.44.4 and 5.6;~~

~~shall be provided by the applicant.~~

~~The number of sets of gripping elements necessary for all the tests shall be attached. The type of part on which the device acts, shall also be supplied with the dimensions agreed with the laboratory provided.~~

**4.7.3 5.7.3 — Test**

**4.7.3.1 5.7.3.1 — Test method**

~~The test method shall be defined between the applicant and the test laboratory, depending on the device and its function to achieve a realistic function of the system. Measurements shall be made of:~~

Commented [SD97]: As WG1 comments N2046

Commented [SD98]: Combined comments N2056

Commented [AD99]: TFHAS\_86\_v5

Commented [SD100]: Combiend comments N2056

Commented [AD101]: TFHAS\_86\_v5

Commented [AD102]: TFHAS\_86\_v5

ISO / PRF 8100-2:2023(E)

- a) the acceleration and speed;
- b) the braking distance;
- c) the retardation.

Measurements shall be recorded as a function of the time.

4.7.3.2 ~~5.7.3.2~~ — Test procedure

4.7.3.2.1 ~~5.7.3.2.1~~ General

At least ~~ten~~ twenty tests shall be made with the speed monitoring element in the speed range for tripping, corresponding to the range of rated speeds of the lift indicated in ~~5.7.1.24.7.1.2~~.

The acceleration of the mass to reach the tripping speed shall not exceed 0,1 m/s<sup>2</sup> ~~should be as low as possible, in order to eliminate the effects of inertia~~.

Commented [AD103]: TFHAS\_86\_v5, in analogy to the change in 5.7.3.2.1

4.7.3.2.2 ~~5.7.3.2.2~~ Device certified-verified for a single mass

The laboratory shall carry out ~~four~~ tests shall be carried out with the system mass representing an empty car.

Between each test, the friction parts shall be allowed to return to their normal temperature.

~~During the tests, several identical sets of friction parts may be used.~~

~~If during the test the friction parts are replaced~~ However, one each set of parts shall be capable of:

- a) three tests, if the rated speed does not exceed 4 m/s;
- b) two tests, if the rated speed exceeds 4 m/s.

The test shall be made at the maximum tripping speed for which the device ~~may be used~~ is specified.

Commented [AD104]: TFHAS\_86\_v5

4.7.3.2.3 ~~5.7.3.2.3~~ Device certified-verified for different masses

Adjustment in stages or continuous adjustment.

A series of tests shall be carried out for the maximum value ~~applied~~ specified, and a series for the minimum value. ~~The applicant shall supply a~~ formula, or a chart shall be provided, showing the variation of the braking force as a function of a given parameter.

The validity of the supplied formula or chart shall be verified by additional tests ~~laboratory shall verify by suitable means (in the absence of anything better, by a third series of tests for intermediary points) the validity of the supplied formula.~~

Commented [AD105]: TFHAS\_86\_v5

4.7.3.2.4 ~~5.7.3.2.4~~ Overspeed monitoring device

4.7.3.2.4.1 ~~5.7.3.2.4.1~~ — Test procedure

At least ~~ten~~ twenty tests shall be made in the speed range for tripping without applying the braking device.

The majority ~~Twelve~~ of those tests shall be made at the extreme values of the range.

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~~4.7.3.2.4.2~~ ~~5.7.3.2.4.2~~ ~~Assessment~~ **Interpretation of the test results**

In the course of twenty tests, the tripping speeds shall lie within the limits called for in the standards calling for the use of this document (e.g. ISO 8100-1:2025, 5.6.6.1) specification.

Commented [SD107]: Combined comments N2056

Commented [AD108]: TFHAS\_86\_v5

**4.7.3.2.5 Test procedure for self-monitoring**

Ten tests shall be made to verify the operation of the device. All tests shall be positive to verify correct operation.

~~4.7.3.3~~ ~~5.7.3.3~~ **Checking after the tests**

After the test:

- a) the hardness of the gripping element shall be compared with the original values quoted by the applicant documents;
- b) if there is no fracture, deformations and other changes shall be examined (for example, cracks, deformations or wear of the gripping elements, appearance of the rubbing surfaces);
- c) if necessary, photographs shall be taken of the gripping elements and the parts on which the device acts for evidence of deformations or fractures;
- d) it shall be checked that the retardation with the minimum mass has not exceeded 1,0  $g_n$ .

~~4.7.4~~ ~~5.7.4~~ **Possible modification to the adjustments**

If, during the tests, the values found differ by more than 20 % from those expected by the applicant, other tests may be made with his agreement, after modification of the adjustments if necessary.

~~4.7.5~~ ~~4.7.4~~ ~~5.7.5~~ **Test report**

In order to achieve reproducibility, the type examination/verification shall be recorded in all details, such as:

- the method of test defined between applicant and laboratory;
- the description of the testing arrangement;
- the location of the device to be tested in the testing arrangement;
- the number of tests carried out;
- the record of measured values;
- the report of observations during the test;
- the evaluation of the test results to show compliance with the requirements.

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~~4.7.64.7.5~~ 5.7.6 ~~Type examination certificate~~ Verification report

The ~~certificate report~~ shall indicate:

- ~~e) a) the information according to Annex A;~~
- a) the type and application of overspeed protection means;
- b) the limits of the permissible masses;
- c) the tripping speed range of the overspeed monitoring device;
- d) the type of parts on which the braking elements act.

Commented [AD110]: TFHAS\_86\_v5

## 4.8 ~~5.8~~ — ~~Type examination~~ Verification of unintended car movement protection means

### 4.8.1 ~~5.8.1~~ — General provisions

The unintended car movement protection means shall be ~~type tested~~ verified as a complete system. Alternatively, the subsystems for detection, activation and stopping ~~may shall be submitted to an~~ verified individually ~~type examination~~. The ~~type examination~~ verification of subsystems shall define interface conditions and the relevant parameters of each subsystem if integrated in a complete system.

The ~~applicant shall state the following~~ key parameters for use of the system or subsystem that form part of the ~~type examination~~ verification shall be stated:

- minimum and maximum masses;
- minimum and maximum force or torque or fluid pressure, if applicable;
- individual response times of detector, control circuit and stopping element(s);
- highest speed anticipated before deceleration occurs (see NOTE 1);
- distance from the floor at which the detector device will be installed;
- test speed(s) (see NOTE 2);
- limits of temperature and humidity of the design ~~and any other relevant information agreed between the applicant and test laboratory.~~

NOTE 1 As an example and indication, for traction lifts, where the natural acceleration is  $1,5 \text{ m/s}^2$  and without any torque contribution from the motor, the maximum speed attainable would be in the magnitude of  $2 \text{ m/s}$ . This is based on the speed attained at start of deceleration e.g. being the result of a "natural" acceleration of  $1,5 \text{ m/s}^2$  through the response times of the unintended car movement protection device, control circuit and stopping elements, assuming that the movement detector operates when the car reaches the limit of the unlocking zone.

In case of electric failure, it can be assumed that, for traction lifts due to internal control means, the acceleration which can be achieved is not greater than  $2,5 \text{ m/s}^2$ .

NOTE 2 Test speed(s): a speed ~~stated by the manufacturer, used by the test laboratory~~ to establish a distance moved by the lift (verification distance) so that the unintended movement system is verified for correct operation during ~~examinations verifications~~ and tests before putting into service at site. This can be the inspection speed or any other speed determined by the manufacturer and agreed by the laboratory.

The distance the car is permitted to move during unintended movement is defined in the requirements laid down in the standards calling for the use of this document (e.g. ISO 8100-1:2023, ~~5.6.7.54.6.7.5~~).

The following documents shall be ~~attached to the application~~ provided:

- a) Detailed and assembly drawings showing the construction, operation, dimensions and tolerances of the components;
- b) ~~If necessary, also~~ a load diagram relating to elastic parts;
- c) Detailed information of the materials used, the type of part on which the means acts, and its surface condition, if relevant (drawn, milled, ground, etc.).

### 4.8.2 ~~5.8.2~~ — Statement and test sample

~~5.8.2.14.8.2.1~~ ~~The intended duty of the means shall be stated~~ The applicant shall state for what duty the means is intended.

Commented [AD111]: TFHAS\_86\_v5

~~5.8.2.24.8.2.2~~ Test samples shall be ~~supplied as agreed between the applicant and the laboratory consisting of, as appropriate, aprovided as~~ complete assembly of unintended car movement detection device, control circuit (actuator), stopping elements and any monitoring device(s) if applicable.

The number of sets of gripping elements necessary for all the tests shall be attached.

The type of part on which the device acts, shall also be ~~supplied with the dimensions specified by the laboratory provided.~~

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#### 4.8.3 ~~5.8.3~~ — Test

##### 4.8.3.1 ~~5.8.3.1~~ — Test method

The test method shall be defined ~~between the applicant and the test laboratory, depending on the device and its function, to achieve a realistic operation of the system.~~

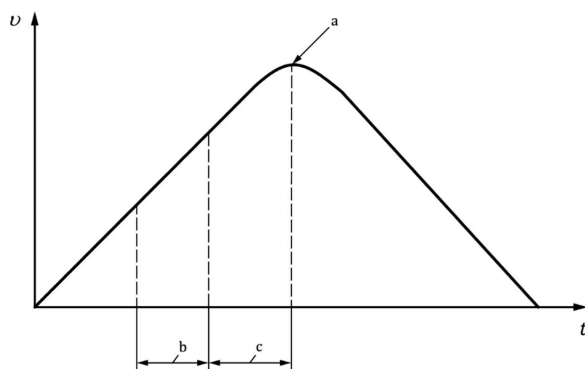
Commented [AD113]: TFHAS\_86\_v5

Measurements shall be made of:

- the stopping distance;
- the average retardation;
- the response time of the detection, actuation, stopping element and control circuits (see Figure 2);
- the total distance travelled (sum of acceleration and stopping distances).

The test shall also include:

- the operation of the unintended car movement detection device; and
- any automatic monitoring system, if applicable.



#### Key

- $v$  speed in meters per second
- $t$  time in seconds
- $a$  Point at which stopping elements start to cause a reduction in speed.
- $b$  Response time of unintended car movement detection and any control circuits.
- $c$  Response time of actuation circuits and stopping elements.

Figure 2 — Response times

**4.8.3.2 5.8.3.2 — Test procedure****4.8.3.2.1 5.8.3.2.1 General**

Twenty tests shall be made on the stopping element with:

- no result outside the specification;
- each result within  $\pm 20\%$  of the average value.

~~Average value shall be stated on the certificate.~~

Commented [AD114]: Mentioned in 5.8.5 / 5.8.6

**4.8.3.2.2 5.8.3.2.2 Device ~~certified-verified~~ for a single mass or torque or fluid pressure**

~~The laboratory following tests shall be carry-carried out:~~

- 10 tests with the system mass or torque or fluid pressure representing an empty car in the upward direction; and
- 10 tests with the system mass or torque or fluid pressure representing a car carrying the rated load in the downward direction.

~~Between each test, the friction parts shall be allowed to return to their normal temperature.~~

~~If during the test the friction parts are replaced, each set shall be capable of minimum five tests. During the tests, several identical sets of friction parts may be used. However, one set of parts shall be capable of 5 tests minimum.~~

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**4.8.3.2.3 5.8.3.2.3 Device ~~certified-verified~~ for different masses or torques or fluid pressures**

~~A series of tests shall be carried out for the maximum value ~~applied-specified~~ for and a series for the minimum value.~~

~~The applicant shall supply a formula or a chart ~~shall be provided~~, showing the ~~calculated~~ variation of the braking force or torque or fluid pressure as a function of a given adjustment. The results is expressed in distance travelled.~~

~~The laboratory shall verify the validity of the ~~supplied~~ formula or chart ~~shall be verified~~.~~

Commented [AD116]: TFHAS\_86\_v5

**4.8.3.2.4 5.8.3.2.4 Test procedure for unintended movement detection means**

Ten tests shall be made to verify the operation of the device. All tests shall be positive to verify correct operation.

**4.8.3.2.5 5.8.3.2.5 Test procedure for self-monitoring**

Ten tests shall be made to verify the operation of the device. All tests shall be positive to verify correct operation.

In addition, the capability of the self-monitoring to detect loss of redundancy of the stopping element before a critical situation occurs, shall be verified.

**4.8.3.3** ~~5.8.3.3~~ — Checks after the test

After the test:

- a) the mechanical characteristics of the stopping element(s) shall be compared with the original values quoted by the **applicant documents**. Other analyses may be carried out in special cases;
- b) it shall be checked that there are no fractures, deformations or any other changes (e.g. cracks, deformations or wear of the gripping elements, appearance of the rubbing surfaces);
- c) if necessary, photographs shall be taken of the gripping elements and the parts on which the device acts for evidence of deformations or fractures.

~~4.8.4~~ ~~5.8.4~~ — Possible modification to the adjustments

~~If, during the tests, the values found differ by more than 20 % from those expected by the applicant, another series of tests may be made with his agreement, after modification of the adjustments, if necessary.~~

Commented [AD117]: TFHAS\_86\_v5

~~4.8.5~~~~4.8.4~~ ~~5.8.5~~ — Test report

In order to achieve reproducibility, the **type examination verification** shall be recorded in all details, such as:

- the method of test ~~defined between applicant and laboratory~~;
- the description of the testing arrangement;
- the location of the device to be used when installed in the testing arrangement;
- the number of tests carried out;
- the record of all measured values;
- the report of observations during the test;
- the evaluation of the test results to show compliance with the requirements.

~~4.8.6~~~~4.8.5~~ ~~5.8.6~~ — **Type examination certificate** **Verification report**

The ~~certificate report~~ shall indicate:

- ~~d)~~ a) ~~the information according to Annex A~~;
- a) ~~b)~~ the type and application of the unintended car movement protection system/subsystem;
- b) ~~e)~~ the limits of the key parameters ~~(as agreed between the laboratory and the manufacturer)~~;
- c) ~~d)~~ the test speed with relevant parameters for final inspection use;
- d) ~~e)~~ the type of parts on which the stopping elements act;
- e) ~~f)~~ the combination of “detecting” device and “stopping” element of the means in the case of complete systems;
- f) ~~g)~~ the interface conditions in case of subsystems.

Commented [AD118]: TFHAS\_86\_v5

**4.9 5.9 — Type examination Verification of rupture valve/one-way restrictor**

In the following, the term “rupture valve” means “rupture valve/one-way restrictor with mechanical moving parts”.

**Commented [SD119]:** As WG1 comment N2046 moved to 5.9.1.1 General

**4.9.1 5.9.1 — General provisions**

**4.9.1.1 5.9.1.1 — General**

In the following, the term “rupture valve” means “rupture valve/one-way restrictor with mechanical moving parts”.

**Commented [SD120]:** As WG1 Comments N2046 - Moved sentence here from 5.9

The applicant following information shall state be provided:

- a) the range of:
  - 1) flow;
  - 2) pressure;
  - 3) viscosity;
  - 4) ambient temperature; and
- b) the method of mounting;

~~of the rupture valve to be type examined verified.~~

c) ~~Details detailed~~ and assembly drawings showing the construction, operation, adjustment, materials, dimensions and tolerances of the rupture valve and the construction components ~~shall be attached to the applications specified.~~

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**Commented [AD122]:** Editorial alignment in line with the changes for other components

**4.9.1.2 5.9.1.2 — Samples subject to be submitted test**

The following shall be submitted to the laboratory provided:

- a) one rupture valve;
- b) a list of liquids which may be used together with the rupture valve, or a sufficient amount of special liquid to be used;

~~c) if necessary, adaptation means to the test facilities of the laboratory.~~

**Commented [AD123]:** TFHAS\_86\_v5

**4.9.1.3 5.9.1.3 — Test**

**4.9.1.3.1 5.9.1.3.1 Test installation**

The rupture valve, mounted in its intended method, shall be tested in a hydraulic system, where:

- a) the required testing pressure is dependent on the mass;
- b) the flow is controlled by adjustable valves;
- c) the pressure before<sup>2</sup> and behind the rupture valve can be recorded;

NOTE "Before the rupture valve" means between the cylinder and the rupture valve.

Commented [AD124]: Moved from footnote 2

- d) means to change the ambient temperature of the rupture valve and the viscosity of the hydraulic liquid are provided.

The system shall allow recording of the flow over time. To determine the values of flow, the measurement of another figure, i.e. the speed of the ram from which the flow can be derived is permitted.

**4.9.1.3.2 5.9.1.3.2 Measuring instruments**

The measuring instruments shall have accuracy according to [5.1.2.64.1](#).

**4.9.1.4 5.9.1.4 — Test procedure**

**4.9.1.4.1 5.9.1.4.1 General**

The test shall:

- a) simulate a total piping failure occurring at a moment when the speed of the car is zero;
- b) evaluate the resistance of the rupture valve against pressure.

**4.9.1.4.2 5.9.1.4.2 Simulation of a total piping failure**

[5.9.1.4.2.14.9.1.4.2.1](#) Simulating a total piping failure, the flow shall be initiated from a static situation by opening a valve, on condition that the static pressure before the rupture valve decreases to less than 10 %.

The tolerances of the closing valve shall be taken into account within the stated range of:

- a) flow;
- b) viscosity;
- c) pressure;
- d) ambient temperature.

This ~~can~~ shall be achieved by 2 test series with:

<sup>2</sup>—"Before the rupture valve" means between the cylinder and the rupture valve.

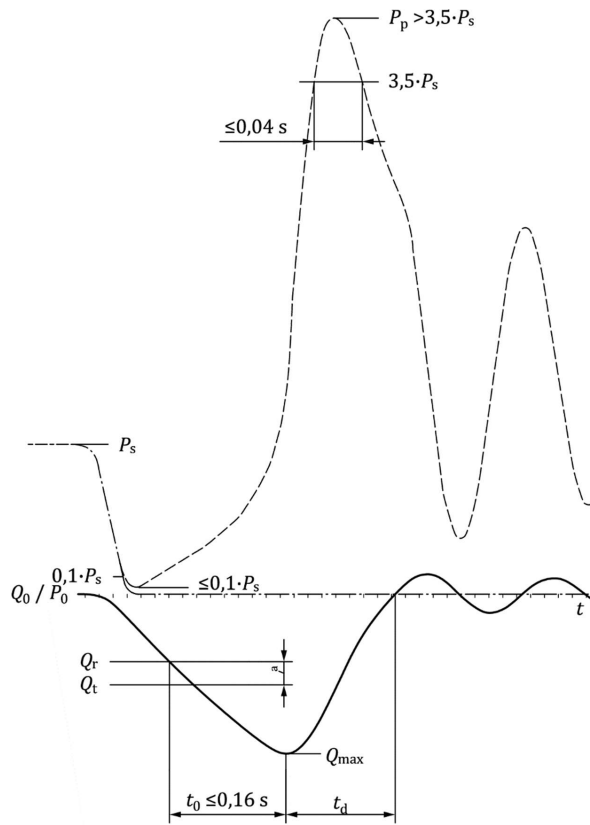
- maximum pressure, maximum ambient temperature, minimum adjustable flow and minimum viscosity;
- minimum pressure, minimum ambient temperature, maximum adjustable flow and maximum viscosity.

In each test series, at least 10 tests shall be carried out to evaluate the tolerances of operation of the rupture valve in these conditions.

5.9.1.4.2.24.9.1.4.2.2 During the tests, the relation between:

- flow and time;
  - pressure before the rupture valve and time;
  - pressure behind the rupture valve and time,
- shall be recorded.

The typical characteristics of these curves are shown in Figure 3.



**Key**

- $P_0$  pressure before test
- $P_p$  pressure peak
- $P_s$  pressure static
- $Q_0$  flow before test
- $Q_{max}$  maximum flow
- $Q_r$  flow at rated speed detection point
- $Q_t$  flow at tripping point
- $t$  time
- $t_0$  time between detection point and maximum flow before closing
- $t_d$  time between maximum closing flow and zero flow before any rebound
- · - · - pressure after rupture valve
- - - hydraulic fluid flow
- - - pressure before rupture valve
- a The rupture valve shall be tripped before the speed is equal to rated speed +0,3 m/s.

**Figure 3 — Hydraulic fluid flow through, pressure before and behind the rupture valve**

**4.9.1.4.3 ~~5.9.1.4.3~~ Resistance against pressure**

Showing the resistance of the rupture valve against pressure, it shall be submitted to a pressure test with 5 times the maximum pressure over 2 min.

**4.9.1.5 ~~5.9.1.5~~ — Interpretation Assessment of the tests****4.9.1.5.1 ~~5.9.1.5.1~~ Closing operation**

The rupture valve fulfils the requirements of this document if the curves recorded according to ~~5.9.1.4.24.9.1.4.2~~ show that:

- a) the time,  $t_0$ , between the rated flow (100 % flow) and the maximum flow,  $Q_{max}$ , does not exceed 0,16 s;
- b) the time,  $t_d$ , for the decrease of the flow is as Formula (8):

$$\frac{|Q_{max}|}{6 \cdot A \cdot 9,81} \leq t_d \leq \frac{|Q_{max}|}{6 \cdot A \cdot 1,96} \quad (8)$$

where

- $A$  is the area of jack, where pressure is acting in square centimetres;
- $Q_{max}$  is the maximum flow of the hydraulic fluid in litre per minute;
- $t_d$  is the braking time in seconds;

- c) a pressure of more than  $3,5 \cdot P_s$ , where  $P_s$  is the static pressure, shall not last longer than 0,04 s;
- d) the rupture valve shall be tripped before the speed is equal to the rated speed + 0,30 m/s.

**4.9.1.5.2 ~~5.9.1.5.2~~ Pressure resistance**

The rupture valve fulfils the requirements of the standard if, after the pressure test according to ~~5.9.1.4.34.9.1.4.3~~, it shows no permanent damage.

**4.9.1.5.3 ~~5.9.1.5.3~~ Readjustment**

~~If the limits of flow decrease or pressure peaks are exceeded, the manufacturer may modify the adjustment of the rupture valve. After that, another series of tests shall be carried out.~~

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4.9.1.6 ~~5.9.1.6~~ — Type examination certificate/Verification report

The certificate/report shall indicate:

- ~~e) a)~~ the information according to Annex A;
- a) ~~b)~~ the type and application of the rupture valve;
- b) ~~e)~~ the range of:
  - 1) flow of the rupture valve;
  - 2) pressure of the rupture valve;
  - 3) viscosity of hydraulic fluids to be used;
  - 4) ambient temperature of the rupture valve.

The certificate/report shall be accompanied with a graph, according to Figure 3, showing the relationship between the maximum flow of hydraulic fluid and pressure from which  $Q_{\max}$  (see Figure 3) and  $t_d$  can be obtained the adjustment of the device.

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Commented [SD127]: Combined comments N2056

**4.10 ~~5.10~~—Guide rails calculation****4.10.1 ~~5.10.1~~—Range of calculation**

Guide rails shall be dimensioned taking into account the following stresses:

- bending stress;
- combined bending;
- buckling stress;
- compression stress/tension stress;
- combined bending and compression/tension stress;
- combined bending and buckling;
- flange bending stress.

In addition, deflections shall be analysed.

~~Parameters used in these calculations can be found described in the standards calling for the use of this standard, e.g. ISO 8100-1:2023, clause 5.74.7.~~

NOTE An example for a calculation based on the following method is given in Annex ~~C~~.B.

**4.10.2 ~~5.10.2~~—Bending**

~~5.10.2.1~~ ~~4.10.2.1~~ Calculating the bending stresses in the different axis of the guide rail (see Figure 4), it can be assumed that:

- the guide rail is a continuous beam<sup>3</sup> with flexible fixing points at distances of the length,  $l$ ;
- the resultant of forces causing bending stresses act in the middle between adjacent fixing points;
- ~~the brackets supporting the guides are rigid and limit horizontal displacement of the guide;~~
- bending moments act on the neutral axis of the profile of the guide rail.

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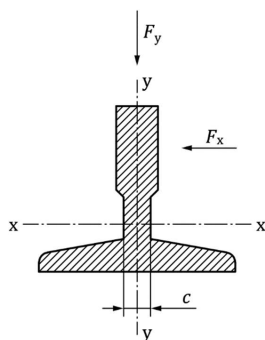
Commented [SD129]: Deleted as footnote was also deleted N2056

Commented [IJ130]: See N1555

Commented [IJ131]: See N1555

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<sup>3</sup> ~~This is due to the safety gear not being considered to actuate at the very top and bottom of the guide line.~~



**Key**

- $c$  width of the connecting part of the foot to the blade
- $F_x$  force exerted to the flat of the guide blade
- $F_y$  force exerted to the end of the guide blade
- $x$  neutral axis in the x-x plane
- $y$  neutral axis in the y-y plane

**Figure 4 — Axis of the guide rail**

Evaluating the bending stress,  $\sigma_m$ , from horizontal forces acting at right angles to the axis of the profile, Formulae (9) and (10) shall be used:

$$\sigma_m = \frac{M_m}{W} \quad (9)$$

$$\text{with } M_m = \frac{3 \cdot F_h \cdot l}{16} \quad (10)$$

where

- $F_h$  is the horizontal force applied to the guide rail by the guide shoes in the different load cases in newtons;
- $l$  is the maximum distance between guide brackets in millimetres;
- $M_m$  is the bending moment in newtons millimetres;
- $\sigma_m$  is the bending stress in newtons per square millimetre;
- $W$  is the cross-sectional area modulus in cubic millimetres.

**5.10.2.34.10.2.2** Bending stresses in different axes shall be combined taking into account the guide rail profile.

If, for  $W_x$  and  $W_y$ , the usual values of tables given in [ISO 8100-33:2022] using the usual values of tables (respectively  $W_{x,\min}$  and  $W_{y,\min}$ ) are used and does not exceed the permissible stresses are not exceeded, no further proof is necessary. Otherwise, it shall be analysed at which outer edge of the guide rail profile the tensile stresses have their maximum.

**5.10.2.34.10.2.3** If more than two guide rails lines are used, an equal distribution of the forces between the guide rails may be assumed, provided that their profiles are identical.

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**5.10.2.44.10.2.4** If more than one safety gear is used, acting on different guide rails, it may be assumed that the whole braking force is equally distributed between the safety gears.

**5.10.2.54.10.2.5** In the case of vertical multiplex safety gears acting on the same guide rail, it shall be assumed, that the braking force of a guide rail is acting on one point.

**4.10.3 5.10.3 —Buckling**

Determining the buckling stresses the omega method shall be used with Formula (11):

$$\sigma_k = \frac{(F_v + k_3 \cdot F_{aux}) \cdot \omega}{A} \quad \sigma_k = \frac{(F_v + k_3 \cdot M_{aux}) \cdot \omega}{A} \quad (11)$$

Commented [AD138]: This is a force and not a mass

where

- A is the cross-sectional area of a guide rail in square millimetres;
- $M_{aux}$  is the force in a guide rail due to auxiliary equipment in newtons;
- $F_v$  is the vertical force on a guide rail of the car, counterweight or balancing weight in newtons;
- $k_3$  is the impact factor;
- $\sigma_k$  is the buckling stress in newtons per square millimetre;
- $\omega$  is the omega value.

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The omega values can be evaluated by using Formulae (12) and (13):

$$\lambda = l_k / i \quad (12)$$

$$l_k = l \quad (13)$$

where

- $\lambda$  is the slenderness;
- $i$  is the minimum radius of gyration in millimetres;
- $l$  is the maximum distance between guide brackets in millimetres;
- $l_k$  is the buckling length in millimetres.

For steel with tensile strength,  $R_m = 370 \text{ N/mm}^2$ :

Value of $\lambda$	Value of $\omega$
$20 \leq \lambda \leq 60$	$\omega = 0,000\ 129\ 20 \cdot \lambda^{1,89} + 1$
$60 < \lambda \leq 85$	$\omega = 0,000\ 046\ 27 \cdot \lambda^{2,14} + 1$
$85 < \lambda \leq 115$	$\omega = 0,000\ 017\ 11 \cdot \lambda^{2,35} + 1,04$
$115 < \lambda \leq 250$	$\omega = 0,000\ 168\ 87 \cdot \lambda^{2,00}$

For steel with tensile strength,  $R_m = 520 \text{ N/mm}^2$ :

Value of $\lambda$	Value of $\omega$
$20 \leq \lambda \leq 50$	$\omega = 0,000\ 082\ 40 \cdot \lambda^{2,06} + 1,021$
$50 < \lambda \leq 70$	$\omega = 0,000\ 018\ 95 \cdot \lambda^{2,41} + 1,05$
$70 < \lambda \leq 89$	$\omega = 0,000\ 024\ 47 \cdot \lambda^{2,36} + 1,03$
$89 < \lambda \leq 250$	$\omega = 0,000\ 253\ 30 \cdot \lambda^{2,00}$

The determination of omega values ( $\omega_R$ ) of steel with tensile strength,  $R_m$ , between 370 N/mm<sup>2</sup> and 520 N/mm<sup>2</sup> shall be carried out by using Formula (14):

$$\omega_R = \left[ \frac{\omega_{520} - \omega_{370}}{520 - 370} \cdot (R_m - 370) \right] + \omega_{370} \quad (14)$$

#### 4.10.4 5.10.4 Combination of bending and compression/tension or buckling stresses

The combined bending and compression/tension or buckling stresses shall be evaluated using Formulae (15) to (17):

Bending stresses:

$$\sigma = \sigma_m = \sigma_x + \sigma_y \leq \sigma_{perm} \quad (15)$$

Bending and compression/tension:

$$\sigma = \sigma_m + \frac{F_v + k_3 \cdot F_{aux}}{A} \leq \sigma_{perm} \quad \sigma = \sigma_m + \frac{F_v + k_3 \cdot M_{aux}}{A} \leq \sigma_{perm} \quad (16)$$

Commented [AD140]: This is a force and not a mass

Bending and buckling:

$$\sigma = \sigma_k + 0,9 \cdot \sigma_m \leq \sigma_{perm} \quad (17)$$

where

$A$  is the cross-sectional area of a guide rail in square millimetres;

$M_{aux}$  is the force in a guide rail due to auxiliary equipment in newtons;

Commented [AD141]: This is a force and not a mass

$F_v$  is the vertical force on a guide rail of the car, counterweight or balancing weight in newtons;

$k_3$  is the impact factor;

$\sigma$  is the combined stress in newtons per square millimetre;

$\sigma_k$  is the buckling stress in newtons per square millimetre

$\sigma_m$  is the bending stress in newtons per square millimetre;

$\sigma_{perm}$  is the permissible stress in newtons per square millimetre, see the standards calling for the use of this document (e.g. ISO 8100-1:2019, 5.7.4.5);

$\sigma_x$  is the bending stress in-related to the xX-axis in newtons per square millimetre;

Commented [SD142]: As WG1 comments N2046

$\sigma_y$  is the bending stress in-related to the yY-axis in newtons per square millimetre.

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#### 4.10.5 ~~5.10.5~~ Flange bending

Flange bending shall be taken into consideration. For T-shaped guide rails, Formulae (18) and (19) shall be used:

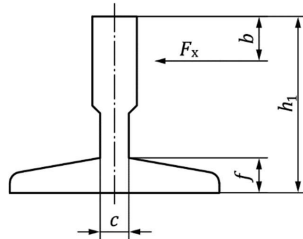
$$\sigma_F = \frac{1,85 \cdot F_x}{c^2} \leq \sigma_{perm} \quad \text{for roller guide shoes} \quad (18)$$

$$\sigma_F = \frac{F_x \cdot (h_1 - b - f) \cdot 6}{c^2 \cdot [l + 2 \cdot (h_1 - f)]} \leq \sigma_{perm} \quad \text{for sliding guide shoes} \quad (19)$$

where

- $b$  is half the width of the guide shoe lining in millimetres;
- $c$  is the width of the connecting part of the foot to the blade in millimetres;
- $f$  is the foot depth of guide rail at its connection with the blade in millimetres;
- $F_x$  is the force exerted by a guide shoe to the flange in newtons;
- $h_1$  is the guide rail height in millimetres;
- $l$  is the length of the guide shoe lining in millimetres;
- $\sigma_F$  is the local flange bending stress in newtons per square millimetre;
- $\sigma_{perm}$  is the permissible stress in newtons per square millimetre.

NOTE Dimensions are shown in Figure 5.



#### Key

- $b$  half the width of the guide shoe lining
- $c$  width of the connecting part of the foot to the blade
- $f$  foot depth of guide rail at its connection with the blade
- $F_x$  force exerted by a guide shoe to the flange
- $h_1$  guide rail height

Figure 5 — Dimensions for flange bending calculation

4.10.6 ~~5.10.6~~ Deflections

The deflections shall be calculated by using Formulae (20) and (21):

$$\delta_x = 0,7 \frac{F_x \cdot l^3}{48 \cdot E \cdot I_y} + \delta_{str-x} \leq \delta_{perm} \quad \delta_y = 0,7 \frac{F_y \cdot l^3}{48 \cdot E \cdot I_x} \quad (20)$$

$$\delta_y = 0,7 \frac{F_y \cdot l^3}{48 \cdot E \cdot I_x} + \delta_{str-y} \leq \delta_{perm} \quad \delta_x = 1,0 \frac{F_x \cdot l^3}{48 \cdot E \cdot I_y} \quad (21)$$

where

- $\delta_{perm}$  is the maximum permissible deflection in millimetres;
- $\delta_x$  is the deflection in the X-axis in millimetres;
- $\delta_y$  is the deflection in the Y-axis in millimetres;
- $\delta_{str-x}$  is the deflection of the building structure fixings (brackets, separation beams) in the ~~x~~X-axis in millimetres;
- $\delta_{str-y}$  is the deflection of the building structure fixings (brackets, separation beams) in the ~~y~~Y-axis in millimetres;
- $E$  is the modulus of elasticity in newtons per square millimetre;
- $F_x$  is the supporting force in the X-axis in newtons;
- $F_y$  is the supporting force in the Y-axis in newtons;
- $I_x$  is the second moment of area ~~in-related to~~ the X-axis in fourth power millimetres;
- $I_y$  is the second moment of area ~~in-related to~~ the Y-axis in fourth power millimetres;
- $l$  is the maximum distance between guide brackets in millimetres.

- Commented [SD144]: Changed 'str' & 'perm' to subscript
- Commented [SD145]: Changed 'str' & 'perm' to subscript and swapped the order of the formula as WG1 comments N2046 and N2043
- Commented [IJ146]: This is a different formula to EN 81-50 but I cant see why.
- Commented [GE147]: ISO INT # 3  
In addition  $\delta_{str-y} \leq \delta_{perm}$  and  $\delta_{str-x} \leq \delta_{perm}$  were added to align with EN 81-20:2014
- Commented [IJ148]: These are missing  $\leq \sigma_{perm}$
- Commented [SD149]: As WG1 comments N2046
- Commented [SD150]: As WG1 comments N2046
- Commented [SD151]: As WG1 comments N2046
- Commented [SD152]: As WG1 comments N2046

## 4.11 ~~5.11~~ Evaluation of traction

### 4.11.1 ~~5.11.1~~ General

Traction shall be ensured at all times taking into account:

- normal travel;
- loading the car at floor level; and
- retardation due to an emergency stop.

~~If the lift machine torque is sufficiently high to raise the car, considerations shall be given to allow slip to occur if the car or the counterweight is stalled in the well for any reason.~~

The following dimensioning procedure applies for the evaluation of traction in the traditional applications which include steel wire ropes and steel/cast iron sheaves.

NOTE The results are, as shown by experience, safe due to built-in safety margins. Therefore, the following elements need not to be taken into consideration in detail: Rope construction, type and amount of lubrication, material of sheaves and ropes and manufacturing tolerances.

### 4.11.2 ~~5.11.2~~ Traction calculation

#### 4.11.2.1 ~~5.11.2.1~~ General

For car loading and emergency braking conditions, Formula (22) shall be applied. For car/counterweight stalled conditions (car/counterweight resting on the buffers and the machine rotating in the “down/up” direction) where protection against raising of the car or counterweight is provided by limiting of traction, Formula (23) shall be applied.

$$\frac{T_1}{T_2} \leq e^{f\alpha} \quad (22)$$

$$\frac{T_1}{T_2} \geq e^{f\alpha} \quad (23)$$

where

- $\alpha$  is the angle of wrap of the ~~suspension means~~ropes on the traction sheave;
- $f$  is the friction factor;
- $T_1, T_2$  are the forces in the portion of the ropes situated at either side of the traction sheave.

#### 4.11.2.2 ~~5.11.2.2~~ Evaluation of $T_1$ and $T_2$

##### 4.11.2.2.1 ~~5.11.2.2.1~~ Car loading condition

The static ratio,  $T_1 / T_2$ , shall be evaluated for the worst case depending on the position of the car in the well with 125 % of the rated load.

~~Where handling devices which are not included in the rated load are used to load/unload the car, the weight of such devices shall be added to the rated load for the purpose of this calculation.~~

Commented [SD153]: Combind comments N2056

Commented [SD154]: As WG1 comments N2046

Commented [AD155]: This is not valid anymore with the modifications in ISO 8100-1.

**4.11.2.2.2 ~~5.11.2.2.2~~—Emergency braking condition**

The dynamic ratio,  $T_1 / T_2$ , shall be evaluated for the worst case depending on the position of the car in the well and the load conditions (empty, or with rated load).

Each moving element shall be considered with its proper rate of retardation, taking into account the reeving ratio of the installation.

In no case shall the rate of retardation to consider be less than:

- 0,5 m/s<sup>2</sup> in normal cases;
- the minimum retardation to slow down the car and counterweight to a value not exceeding that for which the buffers are designed, in the case of reduced buffer stroke.

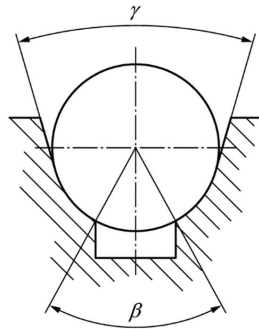
**4.11.2.2.3 ~~5.11.2.2.3~~—Car/counterweight stalled condition**

The static ratio,  $T_1 / T_2$ , shall be evaluated for the empty car at the highest and lowest position.

#### 4.11.2.3 ~~5.11.2.3~~ Evaluation of the friction factor

##### 4.11.2.3.1 ~~5.11.2.3.1~~ Grooving considerations

~~5.11.2.3.1.14.11.2.3.1.1~~ Semi-circular and semi-circular undercut grooves (see Figure 6)



#### Key

$\beta$  undercut angle

$\gamma$  groove angle

Figure 6 — Semi-circular groove, undercut

Formula (24) shall be used:

$$f = \mu \cdot \frac{4 \left( \cos \frac{\gamma}{2} - \sin \frac{\beta}{2} \right)}{\pi - \beta - \gamma - \sin \beta + \sin \gamma} \quad (24)$$

where

$\beta$  is the value of the undercut angle;

$\gamma$  is the value of the groove angle;

$\mu$  is the friction coefficient;

$f$  is the friction factor.

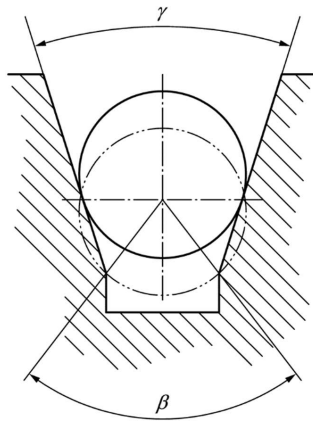
The maximum value of the undercut angle,  $\beta$ , shall not exceed 105° (1,83 rad).

The value of the groove angle,  $\gamma$ , shall ~~be given by the manufacturer according to the grooving design. It should~~ never be less than 25° (0,44 rad).

**Commented [AD156]:** Will be removed by HaS consultancy, obligation to an economic operator

5.11.2.3.1.24.11.2.3.1.2 V-grooves (see Figure 7)

Where the groove has not been submitted to an additional hardening process, in order to limit the deterioration of traction due to wear, an undercut is necessary.



**Key**  
 $\beta$  undercut angle  
 $\gamma$  groove angle

**Figure 7 — V-groove**

Formulae (25) to (27) apply:

— in the case of car loading and emergency braking:

$$f = \mu \cdot \frac{4 \left( 1 - \sin \frac{\beta}{2} \right)}{\pi - \beta - \sin \beta} \text{ for non-hardened grooves} \quad (25)$$

$$f = \mu \cdot \frac{1}{\sin \frac{\gamma}{2}} \text{ for hardened grooves} \quad (26)$$

— in the case of counterweight stalled conditions:

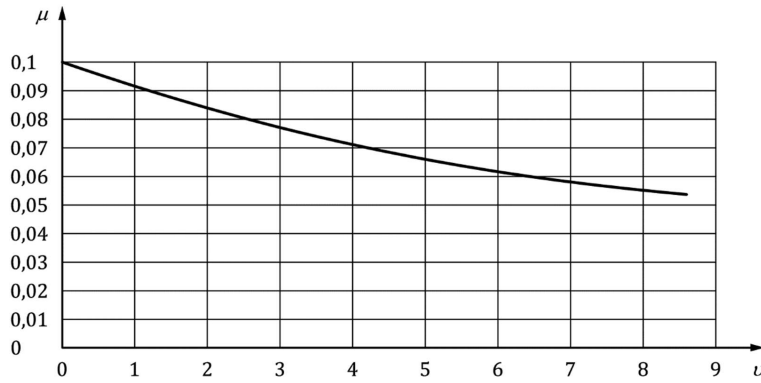
$$f = \mu \cdot \frac{1}{\sin \frac{\gamma}{2}} \text{ for hardened and non-hardened grooves} \quad (27)$$

where

- $\beta$  is the value of the undercut angle;
- $\gamma$  is the value of the groove angle;
- $\mu$  is the friction coefficient;
- $f$  is the friction factor.

The maximum value of the undercut angle,  $\beta$ , shall not exceed  $105^\circ$  (1,83 rad). Angle  $\gamma$  shall never be less than  $35^\circ$  for lifts.

4.11.2.3.2 ~~5.11.2.3.2~~ Friction coefficient consideration (see Figure 8)



Key

$\mu$  friction coefficient

$v$  rope speed at rated speed of the car in meters per second

Commented [SD157]: Combined comments N0256

Figure 8 — Minimum friction coefficient

The following values apply:

- $\mu = 0,1$  for loading conditions;
- $\mu = 0,2$  for counterweight stalled conditions;
- Formula (28) for emergency braking conditions:

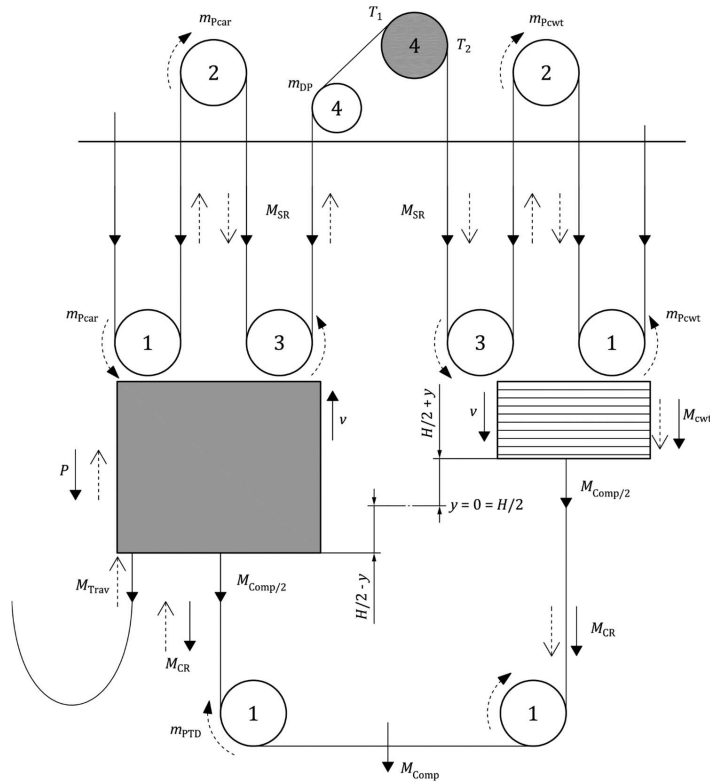
$$\mu = \frac{0,1}{1 + \frac{v}{10}} \quad (28)$$

where

$\mu$  is the friction coefficient;

$v$  is the rope speed at rated speed of the car.

4.11.3 5.11.3 — Formulae for a general case (see Figure 9)



- Key**
- $H$  travel height in metres
  - $m_{PCar}$  reduced mass (related to the car) of pulleys on car side in kilograms
  - $m_{DP}$  reduced mass (related to the car/counterweight) of deflection pulleys on car and/or counterweight side in kilograms
  - $m_{PCwt}$  reduced mass (related to the counterweight) of pulleys on counterweight side in kilograms
  - $m_{PTD}$  reduced mass (related to car/counterweight) of one pulley on tensioning device
  - $M_{CR}$  actual mass of compensation ropes/chains in kilograms
  - $M_{Comp}$  mass of tension device including mass of pulleys in kg
  - $M_{cwt}$  mass of counterweight including mass of pulleys in kg
  - $M_{SR}$  actual mass of suspension ropes in kilograms
  - $M_{Trav}$  actual mass of travelling cable in kilograms
  - $P$  masses of the empty car in kilograms
  - $v$  rotation-speed of the car/counterweight pulley (rope speed) in m/s
  - $Y$  level  $0,5 H \rightarrow y = 0$  in metres;
  - $T_1, T_2$  force exerted on rope in newtons
  - 1, 2, 3, 4 speed factor of pulleys (example:  $2 = 2 \cdot v_{car}$ )

Figure 9 — General case

Commented [SD158]: Combined comments N2056 & N2158

Formulae (29) to (32) apply.

a) For machinery located above:

Commented [AD159]: Combined comments N2046, N2056, N2158

$$T_1 = \left[ \frac{P + Q + M_{CRcar} + M_{Trav}}{r} \cdot (g_n \pm a) \right] + \left[ \frac{M_{Comp}}{2 \cdot r} \cdot g_n \right] + \left[ M_{SRcar} \left( g_n \pm a \cdot \frac{r^2 + 2}{3} \right) \right]$$

$$\pm \left[ \frac{i_{PTD} \cdot m_{PTD}}{2 \cdot r} \cdot a \right] \pm \left[ \frac{m_{DP} \cdot a \cdot r}{r} \right]^I \pm \left[ \sum_{i=1}^{n_p} \frac{m_{Pcar,i} \cdot \left( \frac{v_{P,i}}{v} \right)^2 \cdot i_{Pcar} \cdot a}{r} \right]^{III} \mp \left[ \frac{FR_{car}}{r} \right]$$

(29)

$$T_2 = \left[ \frac{M_{cwt} + M_{CRcwt}}{r} \cdot (g_n \mp a) \right] + \left[ \frac{M_{Comp}}{2 \cdot r} \cdot g_n \right] + \left[ M_{SRcwt} \left( g_n \mp a \cdot \frac{r^2 + 2}{3} \right) \right]$$

$$\mp \left[ \frac{i_{PTD} \cdot m_{PTD}}{2 \cdot r} \cdot a \right] \mp \left[ \frac{m_{DP} \cdot a \cdot r}{r} \right]^II \mp \left[ \sum_{i=1}^{n_p} \frac{m_{Pcwt,i} \cdot \left( \frac{v_{P,i}}{v} \right)^2 \cdot i_{Pcwt} \cdot a}{r} \right]^{III}$$

$$\pm \left[ \frac{FR_{cwt}}{r} \right]$$

(30)

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b) For machinery located below:

$$T_1 = \left[ \frac{P + Q + M_{CRcar} + M_{Trav}}{r} \cdot (g_n \pm a) \right] + \left[ \frac{M_{Comp}}{2 \cdot r} \cdot g_n \right] + [M_{SR1car} \cdot (-g_n \pm a \cdot r)]$$

$$+ \left[ M_{SR2c} \cdot \left( g_n \pm a \cdot \frac{r^2 + 2}{3} \right) \right] \pm \left[ \frac{i_{PTD} \cdot m_{PTD}}{2 \cdot r} \cdot a \right] \pm \left[ \frac{m_{DP} \cdot a \cdot r}{r} \right]^I$$

$$\pm \left[ \sum_{i=1}^{r-1} m_{pcar_i} \cdot \left( \frac{v_{pi}}{v} \right)^2 \cdot i_{pcar} \cdot a \right]^{III} \mp \left[ \frac{FR_{car}}{r} \right]$$

(31)

$$T_2 = \left[ \frac{M_{cwt} + M_{CRcwt}}{r} \cdot (g_n \mp a) \right] + \left[ \frac{M_{Comp}}{2 \cdot r} \cdot g_n \right] + [M_{SR1cwt} \cdot (-g_n \mp a \cdot r)]$$

$$+ \left[ M_{SR2cwt} \cdot \left( g_n \mp a \cdot \frac{r^2 + 2}{3} \right) \right] \mp \left[ \frac{i_{PTD} \cdot m_{PTD}}{2 \cdot r} \cdot a \right] \mp \left[ \frac{m_{DP} \cdot a \cdot r}{r} \right]^II$$

$$\mp \left[ \sum_{i=1}^{r-1} m_{pcwt_i} \cdot \left( \frac{v_{pi}}{v} \right)^2 \cdot i_{pcwt} \cdot a \right]^{III} \pm \left[ \frac{FR_{cwt}}{r} \right]$$

(32)

NOTE 1 Formulae (29) to (32) can be also used for the empty car by deleting  $Q$ . In this case,  $T_1$  becomes  $T_2$ , and  $T_2$  becomes  $T_1$ .

In the above formulae, the symbols  $\pm$  and  $\mp$  shall be used in such a way that:

- the upper operation is applicable in case the car **with its rated load** is retarding in the downward direction, and
- the lower operation in case the **empty** car is retarding in the upward direction.

For cases with car loading and stalled condition,  $a = 0$ .

For the car loading case,  $Q$  shall be replaced by  $1,25 Q$  **plus the weight of handling devices where used in case of goods passenger lifts**.

The friction forces,  $FR_{car}$  and  $FR_{cwt}$ , **should shall** be deleted in all conditions if a minimum friction force cannot be ensured.

NOTE 2 For calculation example, see Annex D.

Conditions:

- $I$  is for any deflection pulley on car side;
- $II$  is for any deflection pulley on counterweight side;
- $III$  is only for reeving  $> 1$ ;

**Commented [AD160]:** Errors corrected EN81-50 --- ISO8100-2  
DS2022-02-05:  
As WG1 comments N2046 - MSR1car "a" car needs to be multiplied with "r"  
DS: 2022-09-23:  
Combined comments N2056 & N2158

**Commented [AD161]:** N2222

**Commented [AD162]:** N2222

**Commented [AD163]:** N2172

**Commented [AD164]:** IR3

**Commented [SD165]:** Are these still valid due to the changes to the equations

Where:

- $a$  is the braking retardation (positive value) of the car in metres per square second;
- $FR_{car}$  is the frictional force in the well (efficiency of bearings car side and friction on guide rails, etc.) in newtons;
- $FR_{cwt}$  is the frictional force in the well (efficiency of bearings counterweight side and friction on guide rails, etc.) in newtons;
- $g_n$  is the standard acceleration of free fall in metres per square second;
- $H$  is the travel height in metres;
- ~~$i_{Pcar}$  is the number of pulleys on car side with same rotation speed  $v_{pulley}$  (without deflection pulleys);~~
- ~~$i_{Pcwt}$  is the number of pulleys on counterweight side with same rotation speed  $v_{pulley}$  (without deflection pulleys);~~
- $i_{PTD}$  is the number of pulleys for tensioning device;
- $J_{Pcar}$  is the moment of inertia of one pulleys on the car side in kilograms square metre;
- $J_{Pcwt}$  is the moment of inertia of one pulleys on the counterweight side in kilograms square metre;
- $J_{DP}$  is the moment of inertia of deflection pulleys on car and/or counterweight side in kilograms square metre;
- $J_{PTD}$  is the moment of inertia of one pulley on tensioning device in kilograms square metre;
- $m_{DP}$  is the reduced mass (related to the car/counterweight) of deflection pulleys on car and/or counterweight side, having the same rope speed than the traction sheave,  $J_{DP} - (v_{pulley}/v)^2 / R^2$  in kilograms;
- $m_{Pcar,1}$  is the reduced mass (related to the car) of one pulleys on the car side  $J_{Pcar} - (v_{pulley}/v)^2 / R^2$  in kilograms;
- $m_{Pcwt,1}$  is the reduced mass (related to the counterweight) of one pulleys on the counterweight side  $J_{Pcwt} - (v_{pulley}/v)^2 / R^2$  in kilograms;
- $m_{PTD}$  is the reduced mass (related to car/counterweight) of one pulley on tensioning device  $J_{PTD} / R^2$  in kilograms;
- $M_{Comp}$  is the mass of tension device including mass of pulleys in kilograms;
- $M_{CR}$  is the actual mass of compensation ropes/chains  $[(0,5 \cdot H \pm y) \cdot n_c \cdot \text{rope weight per unit length}]$ , in kilograms;
- $M_{CRcar}$  is the mass  $M_{CR}$  on the car side;
- $M_{CRcwt}$  is the mass  $M_{CR}$  on the counterweight side;
- $M_{cwt}$  is the mass of counterweight including mass of pulleys in kilograms;
- $M_{SR}$  is the actual mass of suspension ropes  $[(0,5 \cdot H \pm y) \cdot n_s \cdot \text{rope weight per unit length}]$ , in kilograms;
- $M_{SRcar}$  is the mass  $M_{SR}$  on car side.
- ~~$M_{SR1car}$  is the mass  $M_{SR}$  of the rope leading from the machine to the pulley(s) in the headroom in the case of machine below.~~
- ~~$M_{SR2car}$  is the mass  $M_{SR}$  of the rope leading from the pulley(s) in the headroom to the car in the case of machine below, ( $M_{SR2car} = 0$  if car at upmost landing)~~
- ~~In the case of machine below, the rope leading from the machine to the pulley(s) in the headroom is  $M_{SR1car}$  and the rope leading from the pulley(s) in the headroom to the car is  $M_{SR2car}$  ( $M_{SR2car} = 0$  if car at upmost landing);~~
- $M_{SRcwt}$  is the mass  $M_{SR}$  on counterweight side.
- ~~$M_{SR1cwt}$  is the mass  $M_{SR}$  of the rope leading from the machine to the pulley(s) in the headroom~~
- ~~$M_{SR2cwt}$  is the mass  $M_{SR}$  of the rope leading from pulley(s) in the headroom to the counterweight, ( $M_{SR2cwt} = 0$  if counterweight at upmost landing)~~

Commented [AD166]: Replaced by  $n_p$

Commented [AD167]: N2222

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In the case of machine below, the rope leading from the machine to the pulley(s) in the headroom is  $M_{SR1cwt}$  and rope leading from pulley(s) in the headroom to the counterweight is  $M_{SR2cwt}$  ( $M_{SR2cwt} = 0$  if counterweight at upmost landing);

$M_{Trav}$  is the actual mass of travelling cable  $[(0,25H \pm 0,5y) \cdot n_t \cdot \text{travelling cable weight per unit length}]$ , in kilograms;

$n_c$  is the number of compensating ropes/chains;

$n_p$  is the number of pulleys on the car/counterweight side

$n_s$  is the number of suspension ropes;

$n_t$  is the number of travelling cables;

$P$  is the masses of the empty car in kilograms;

$Q$  is the rated load in kilograms;

$r$  is the reeving factor;

$R$  is the radius of related pulleys in metres;

$T_1, T_2$  is the force exerted on rope in newtons;

$v$  speed of the car/counterweight in m/s

$v_{Ppulley,i}$  is the rotation speed of the one pulley (rope speed) in metres per second;

$y$  is on the level  $0,5 \cdot H \rightarrow y = 0$ , in metres;

$\rightarrow$  is the static force;

$\rightarrow$  is the dynamic force;

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**4.12 5.12—Evaluation of safety factor ~~on~~ of steel wire ropes with steel/cast iron traction sheaves**

**4.12.1 5.12.1—General**

~~With reference to the requirements laid down in the standards calling for the use of this document (e.g. ISO 8100-1:2025, 5.5.2.2),~~ This clause describes the method of evaluation of the safety factor “S<sub>r</sub>” for the suspension ropes. This evaluation method shall only be used for:

Commented [AD174]: TFHAS\_86\_v5

- steel or cast iron traction sheaves;
- steel wire ropes according to EN 12385-5:2021 or ISO 4344:2022.

NOTE This method is based on sufficient life time of the steel wire ropes assuming a regular maintenance and inspection.

**4.12.2 5.12.2—Equivalent number,  $N_{equiv}$ , of pulleys**

**4.12.2.1 5.12.2.1—General**

The number of bends and the degree of severity of each bend cause deterioration of the rope. This is influenced by the type of grooves (U- or V-groove) and whether the bend is reversed or not.

The degree of severity of each bend can be equated to a number of simple bends.

A simple bend is defined by the rope travelling over a semi-circular groove, where the radius of the groove is not more than 0,53 of the nominal rope diameter.

The number of simple bends corresponds to an equivalent number of pulleys,  $N_{equiv}$ , which can be derived from Formula (33):

$$N_{equiv} = N_{equiv(t)} + N_{equiv(p)} \tag{33}$$

where

- $N_{equiv(t)}$  is the equivalent number of traction sheaves;
- $N_{equiv(p)}$  is the equivalent number of deflection pulleys.

**4.12.2.2 5.12.2.2—Evaluation of  $N_{equiv(t)}$**

Values of  $N_{equiv(t)}$  ~~can shall~~ be taken from Table 21.

Commented [AD175]: IR3

**Table 21 — Evaluation of equivalent number of traction sheaves  $N_{equiv(t)}$**

<b>V-grooves</b>	V-angle ( $\gamma$ )	35°	36°	38°	40°	42°	45°	50°
	$N_{equiv(t)}$	18,5	16	12	10	8	6,5	5
<b>U-Undercut grooves</b>	U-angle ( $\beta$ )	75°	80°	85°	90°	95°	100°	105°
	$N_{equiv(t)}$	2,5	3,0	3,8	5,0	6,7	10,0	15,2

For U-grooves without undercut,  $N_{equiv(t)} = 1$ .

Values for angles not in ~~the table~~Table 1 may be determined by linear interpolation.

4.12.2.3 ~~5.12.2.3~~ — Evaluation of  $N_{equiv(p)}$

A bend is only considered to be a reverse bend if the distance from the rope contacts on two consecutive pulleys, which have a fixed distance between their axles, is less than 200 times the rope diameter, and the bending planes are rotated through more than 120° [see Formulae (34) and (35)].

$$N_{equiv(p)} = K_p \cdot (N_{ps} + 4 \cdot N_{pr}) \tag{34}$$

where

$N_{ps}$  is the number of pulleys with simple bends;

$N_{pr}$  is the number of pulleys with reversed bends;

$K_p$  is the factor of ratio between sheave and pulley diameters.

$$K_p = \left( \frac{D_t}{D_p} \right)^4$$

with (35)

where

$D_t$  is the diameter of the traction sheave;

$D_p$  is the average diameter of all pulleys, traction sheave excluded.

NOTE Examples for evaluation of equivalent number of pulleys are given in Annex ED.

4.12.3 ~~5.12.3~~ — Safety factor

For a given design of rope drive, the minimum value of safety factor can be selected from Figure 10 taking into account the correct ratio of  $D_t/d_r$  and the calculated  $N_{equiv}$  for the worst-case section of ropes.

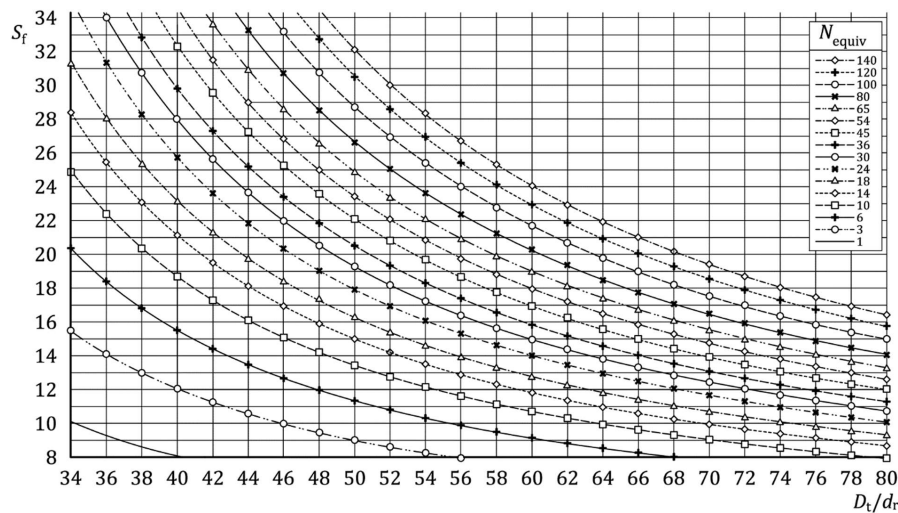


Figure 10 — Evaluation of minimum safety factor

The curves of the Figure 10 are based on Formula (36):

$$S_f = 10^{\left( \frac{2,6834 \cdot \log \left( \frac{695,85 \cdot 10^6 \cdot N_{equiv}}{\left( \frac{D_t}{d_r} \right)^{8,567}} \right)}{\log \left( 77,09 \left( \frac{D_t}{d_r} \right)^{-2,894} \right)} \right)} \quad (36)$$

where

- $D_t$  is the diameter of traction sheave;
- $d_r$  is the diameter of the ropes;
- $N_{equiv}$  is the equivalent number of pulleys;
- $S_f$  is the safety factor.

**4.13 ~~5.13~~—Specific verification methods for suspension and compensation means**

**4.13.1 ~~5.13.1~~—Material and Construction verification**

Compliance with material and construction requirements of the standard calling for the use of this standard (e.g. ~~ISO 8100-1:2023, 5.5.1.24.5.1.2~~) shall be verified through a visual verification of the documents supplied with the suspension means.

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The diameter of wires, strands and ropes shall be measured as follows:

Diameter measurements shall be taken on a straight section in compliance with EN 12385-1:2021-6.3.1.

The minimum accuracy of the measurement instrument shall be 0,02 mm for diameters above 2 mm, 0,01 mm for diameters below 2 mm, and 0,001 mm for diameters below 0,5 mm.

The measurement surface of instruments used for ropes and strands shall cover at least two strands or wires in axial direction.

**4.13.2 ~~5.13.2~~—Verification of elastomeric coated traction sheave**

Wear resistance of the traction sheave coating shall be proven with a wear test.

Therefore, the traction sheave shall rotate against the fixed steel wire rope ~~of the type specified to be used in the lift application~~. The test shall be performed with the following parameters:

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- wrapping angle of 180°;
- traction sheave shall have same design (groove geometry, material, bending diameter) as in the intended application;
- ~~maximum load as specified for the application considering the limits in ISO 8100-1:2023, 5.5.2.24.5.2.2; the minimum safety factor according to the standard calling for the use of this standard (e.g. EN 81-20, 5.5.2.2) that is considered in the application.~~
- rotation speed during slipping test shall be limited such way that contact temperature stays below +40°C.

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The test slip distance shall be calculated according to the below formula and shall not be less than 15 000m.

$$Test\ slip\ distance\ [m] = \frac{Number\ of\ trips \cdot Rope\ length\ [m] \cdot Round\ trip\ slip\ distance\ [m]}{Run\ distance\ [m]}$$

Where,

Test slip distance = Total slip distance for the wear test

Number of trips = At least application level minimum 600 000

Rope Length [m] = Reeving factor \* Travel height [m] = r \* H [m]

Round trip slip distance [m] = Measured slip distance at a round trip

Run distance [m] = r \* car travelled distance during slip distance measurement [m]

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The round-trip slip distance is determined on a mass test bench with two weights corresponding to the maximum T2/T1 or T1/T2 ratio and the masses of the intended application. The applied traction sheave shall have the same design (groove geometry, material, bending diameter) as in the intended application. Make a pen marker over the ropes and traction sheave. After ~~re~~running of full round trip (full trip down and full trip up to the same position) measure the slip distance of the suspension means on the traction sheave.

Acceptable wear depth is 50 % of the coating thickness and the coating shall be firmly in its place in the groove.

**4.13.3 5.13.3 Terminations of ~~suspension and compensation~~ elastomeric coated suspension means**

The strength of the terminations in combination with the elastomeric coated suspension means shall be proven by tests according to EN 13411-6:2004+A1:2008, 5 and 6 or EN 13411-7:2021, 5 and 6 with the following deviations:

- a) ~~tensile efficiency test with deviations to EN 13411-6:2004+A1:2008, 5.3.4 and 6.2.5, or EN 13411-7:2021, 5.4.2 and 6.2.2~~
- b) ~~during testing, the suspension means shall break and shall not slip out of the socket;~~
- c) ~~if terminations are tested in pairs the distance between the two terminals shall be at least 600mm for elastomeric coated ropes, 500mm for elastomeric coated belts and elastomeric coated timing belts.~~
- d) ~~termination and wedge security test (EN 13411-6)~~
- e) ~~pull force of 20 % **MBF** shall be applied. After 1-hour settlement the force shall be reduced to zero and again reapplied to 20 % **MBF** in a second load cycle;~~
- f) ~~acceptance criteria: The test is passed, if the suspension means dead end does not move during the load cycles.~~
- g) ~~fatigue behaviour of the socket body and pin (EN 13411-6)~~
- h) ~~minimum rope force 15 % of **MBF**, maximum 30 % of **MBF**, 75000 cycles with max. 5 Hz frequency;~~
- i) ~~acceptance criterion: no fatigue cracks, no local permanent deformation.~~

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**Commented [SD182]:** Combined comments N2056 & N2205

**Commented [SD183]:** Combined comments N2056 & N2205

**Commented [SD184]:** Aligned with ISO8100-1 MBF WG1 comments N2046

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**4.13.4 5.13.4—Minimum breaking force**

The minimum breaking force for elastomeric coated each type and size of alternative suspension and compensation means for steel ropes less than 6mm shall be determined according to ISO 3108:2017 with the following deviations:

- a) the minimum free test length, excluding any rope terminations, shall be
- b) 600 mm for elastomeric coated ropes;
- c) 500 mm for elastomeric coated belts and elastomeric coated timing belts;
- d) after 80 % of the MBF has been applied, the force shall be increased at a rate of not more than 0,5 % of the MBF per second;
- e) the test may be terminated without breaking the suspension means elastomeric coated rope when the minimum breaking load MBF is achieved or exceeded;
- f) the test may be discounted where the suspension member fractures within a distance from the base of the grip or termination;
- g) 6 x nominal diameter for steel wire ropes;
- h) 6 x nominal diameter of the load bearing member for elastomeric coated suspension means;

and when the minimum breaking load has not been reached.

**4.13.5 5.13.5—Fatigue lifetime testing**

The maximum number of simple bends ( $N_{SB}$ ) and reverse bends ( $N_{RB}$ ) for suspension means shall be proven by means of bend-over-sheave fatigue testing.

Tests shall be performed with sheaves of the same design as the traction sheave and pulleys in the final application. If different designs for traction sheaves and pulleys are applied the most aggressive characteristics shall be used to evaluate  $N_{SB}$  and  $N_{RB}$ .

Definition of most aggressive characteristics of sheaves/pulleys:

- smallest diameter;
- hardest groove material;
- groove shape.

From the bending fatigue test the number of simple bends  $N_{SB}$  and the number of reverse bends  $N_{RB}$  reaching the residual breaking load requirements of the standard calling for use of this standard (e.g. ISO 8100-1:2023, 5.5.2.24.5.2.2) shall be derived.

Bending fatigue test shall fulfil the following requirements:

- minimum bending length 30 times the load bearing member diameter and at least 100 mm;
- minimum wrapping angle of the suspension means over the test sheave 40°;
- minimum safety factor according to the standard calling for use of this standard (e.g. ISO 8100-1:2023, 5.5.2.24.5.2.2) that is considered in the application.

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The number of simple bends  $n_{SB}$  and reverse bends  $n_{RB}$  experienced by the most stressed suspension/compensation means section during one full trip (lowest landing to top landing) of the lift shall be evaluated considering the roping of the lift.

#### 4.13.6 ~~5.13.6~~ Friction Factor (f)

##### 4.13.6.1 ~~5.13.6.1~~ Steel wire ropes with elastomeric coated traction sheave

Friction factors in ~~5.11.2.34.11.2.3~~ are for steel ropes.

##### 4.13.6.2 ~~5.13.6.2~~ Elastomeric coated ropes and belts

The friction factor  $f$  shall be evaluated for the traction conditions:

- a) Static friction factor  $f_{sta}$  for car loading condition (5.11.2.1.) at relative speed  $v = 0$  m/s between the suspension means and the traction sheave;
- b) Dynamic friction factor  $f_{dyn}$  for emergency braking condition (5.11.2.2.) at the maximum relative speed between suspension means and traction sheave.

To demonstrate the application power transmission max. T1/T2 or T2/T1, a minimum of 5 tests per traction condition shall be done under specified conditions representing a range of elevators use.

The testing setup shall be consistent with the intended configuration and includes ~~belt suspension means,~~ traction sheave and wrap angle. It shall be performed.

- with a single suspension means in combination with the same traction sheave design as used in the final application;
- under the wrap angle employed in the final application;
- with the lowest and highest tensile load of the final application for each of the traction conditions a) and b) described above in ~~5.11.2~~;
- covering all ranges of ambient conditions listed in ISO 8100-1:2023, ~~5.54.5~~ and if not listed, as specified for the final application range;
- before and after a run-in period and take into account the lowest friction factor of static and dynamic traction conditions;
- using new suspension means and used representative samples of alternative suspension means, ensure that any significant change of friction factor during normal use is accounted for. The evaluation shall be done with consideration to a minimum and maximum safety factor specified for the application range of the alternative suspension means.

Contaminants such as oil, water and cleaners shall be taken into consideration by the installer for operational conditions.

For elastomeric coated suspension means, the friction factor  $f$  shall be determined for the specific combination of suspension member and traction sheave.

- car loading:

the static friction factor  $f_{sta}$  for loading shall be assessed in a static test setup (relative speed  $v = 0$  m/s between the alternative suspension means and the traction sheave).

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— emergency stop:

the dynamic friction factor  $f_{dyn}$  for emergency braking condition shall be assessed with the maximum elastomeric coated belt/rope speed at rated car speed. It can be performed on a test bench or a lift system test.

#### 4.13.6.3 ~~5.13.6.3~~ Elastomeric coated timing belt design

— car loading and emergency stop:

due to teeth-sprocket contact, there shall not occur slip when performing tests under conditions specified in 5.11.2.2.14.11.2.2.1 and 5.11.2.2.24.11.2.2.2;

— stalled car conditions:

due to teeth-sprocket contact, there shall not occur slip when performing tests under conditions specified in 5.11.2.2.34.11.2.2.3.

#### 4.13.7 ~~5.13.8.7~~ Additional mechanical tests for coated suspension means

Each combination of suspension member and traction sheave design shall pass the tests for slip and emergency stop for the maximum speed and maximum load condition.

##### 4.13.7.1 ~~5.13.8.7.1~~ Slip test for traction belts and ropes

One or more suspension member(s) shall be loaded in tension over the intended driving machine sheave, to the maximum load to be qualified. The suspension member(s) shall be secured such that it/they cannot move. The driving machine sheave shall be running at a speed corresponding to the maximum inspection speed of the lift to which the suspension means will be applied.

The test shall run for 4 minutes, no suspension member shall break.

##### 4.13.7.2 ~~5.13.8.7.2~~ Emergency-Stop Test

The suspension means shall be loaded in tension over the intended traction sheave to the maximum load(s). The suspension means shall run at the maximum speed. The driving sheave shall perform an emergency stop.

The test shall be repeated for a total of 20 emergency stops, and the test arranged such, that suspension means stop and possible slippage occurs over the same portion of the suspension means in each test.

The test set-up shall ensure, that the stop and possible the duration of the slip corresponds to that, attained in the intended application. The suspension means shall not experience damage such, that the suspension means require replacement due to the discard criteria provided.

#### 4.13.8 ~~5.13.9.8~~ Examination certificateVerification report

After verification of suspension and compensation means covered by 5.13.4.13, the examination certificateverification report shall contain the following information:

**Commented [SD192]:** Update Numbering as WG1 comments N2046

**Commented [SD193]:** Update Numbering as WG1 comments N2046

**Commented [SD194]:** Update Numbering as WG1 comments N2046

**Commented [SD195]:** Combined Comments N2056 & N2205

**Table 32 — Type examination certificate Verification report information**

	<u>Steel wire ropes with steel/cast iron sheaves</u>	<u>Ropes with elastomeric coated traction sheaves</u>	<u>Elastomeric coated traction belts</u>	<u>Elastomeric coated ropes</u>	<u>Elastomeric coated timing belts</u>
<u>Information according to Annex A</u>	X	X	X	X	X
<u>Any details about the identification of the installed components** with the supplied certificate</u>	X	X	X	X	X
<u>Construction (including surface treatment) of suspension means</u>	<u>Rope construction</u>	<u>Permitted rope construction or trade name</u>	<u>Construction &amp; number of the load bearing part(s)</u>	<u>Construction of the load bearing part(s)</u>	<u>Construction &amp; number of the load bearing part(s)</u>
<u>Material, treatment, geometry of the contact surface of the traction sheave, sprocket or pulleys to the suspension means</u>	<u>Applicable groove type(s)</u>	<u>Applicable groove type(s)</u>	<u>Roughness and shape (crowning, groove geometry)</u>	<u>Roughness and permitted groove type(s) (groove tolerances)</u>	<u>Roughness and shape including teeth profile and teeth pitch [mm]</u>
<u>Unit mass [kg/m]</u>	X	n.a.	X	X	X
<u>Maximum permitted twist [°/m]</u>	n.a.	n.a.	X	n.a.	X
<u>Maximum permitted fleet angle of the suspension means [°]</u>	X	n.a.	X	X	X
<u>Nominal tensile grade [N/mm<sup>2</sup>]</u>	X	n.a.	n.a.	n.a.	n.a.
<u>Nominal dimension of the suspension member [mm]</u>	<u>Diameter</u>	n.a.	<u>Width, thickness</u>	<u>Outer diameter and load bearing member diameter</u>	<u>Width, thickness</u>
<u>Minimum permitted diameter of the traction sheave or sprocket [mm]</u>	X	X	X	X	X
<u>Minimum permitted diameter of the pulley [mm]</u>	X	X	X	X	X
<u>Minimum breaking load [kN]</u>	X	n.a.	X	X	X
<u>Methods for fatigue lifetime testing and monitoring</u>	X	X	X	X	X
<u>Minimum applicable suspension means safety factor</u>	X	X	X	X	X

	<a href="#">Steel wire ropes with steel/cast iron sheaves</a>	<a href="#">Ropes with elastomeric coated traction sheaves</a>	<a href="#">Elastomeric coated traction belts</a>	<a href="#">Elastomeric coated ropes</a>	<a href="#">Elastomeric coated timing belts</a>
<a href="#">Maximum number of simple bends (NSB) and reverse bends (NRB) according to 5.13.54.13.5</a>	if required	X	X	X	X
<a href="#">Friction factor f</a>	n.a.	<i>f<sub>STA</sub></i> and <i>f<sub>DYN</sub></i> according to <a href="#">5.13.6.14.13.6.1</a>	<i>f<sub>STA</sub></i> and <i>f<sub>DYN</sub></i> according to <a href="#">5.13.6.24.13.6.2</a>	<i>f<sub>STA</sub></i> and <i>f<sub>DYN</sub></i> according to <a href="#">5.13.6.24.13.6.2</a>	n.a.
<a href="#">Environmental limitations and forbidden contaminants</a>	X	X	X	X	X
<a href="#">Maximum speed of the suspension means at normal operation [m/s]</a>	X	X	X	X	X
<a href="#">Suspension means speed at maximum inspection speed according to 5.13.97.1 4.13.7.1 [m/s]</a>	n.a.	X	X	X	n.a.
<a href="#">Maintenance and discard information according to 5.144.14</a>	X	X	X	X	X
<a href="#">Information about any required warnings on the installation, if any</a>	X	X	X	X	X
<a href="#">Information about the required end terminations and their application</a>	X	n.a.	X	X	X
n.a. not applicable					
** <a href="#">Suspension means, compensation means, pulleys, traction sheaves, end connections, sprockets.</a>					

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**4.14 – 5.14 Discard Criteria for suspension means and power transmission contact**

**4.14.1 5.14.1 General**

Discarding criteria shall be specified in the instructions considering ISO 8100-1:2023, Table 12 and the following clauses.

**4.14.2 5.14.12 Steel wire ropes**

**4.14.2.1 5.14.12.1 Steel wire ropes in combination with steel/cast iron traction sheaves**

For steel wire ropes the discard criteria according to ISO 4344:2022 Annex G is applicable.

For steel wire ropes with diameter  $d < 6$  mm additional checks and discard limits with bending fatigue counter shall apply.

**4.14.2.2 5.14.12.2.1 Coated traction sheave in combination with 4-8mm steel wire ropes**

Beside the discard condition indicated by the diameter reduction check with special gauge and visual inspection according to ISO 4344:2022, Annex EG, additional visual discarding criteria shall apply for the traction sheave:

- coating thickness has reached discard criteria;
- wear or damages of coating exposing the traction sheave metallic part; and
- delamination of coating.

**4.14.3 5.14.23 Elastomeric coated steel suspension and compensation means**

Beside the discard condition indicated by the discard monitoring means visual discarding criteria shall be considered and defined based on the specific design needs of the suspension means if required.

The free length of the suspension means including the portion at the termination shall be visually inspected.

**4.14.3.1 5.14.23.1 Elastomeric coated steel traction belts**

The following visual discarding criteria shall be considered:

- worn coating, or cracks in the coating exposing the load bearing member;
- worn or damaged belt profile affecting guidance or traction capability;
- broken wires or cords protruding the elastomeric coating;
- corrosion from the load bearing member protruding through the coating material;
- piercing of the coating by foreign objects.

Addition visual discard criteria shall be defined based on the specific design needs of the suspension means if required.

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**4.14.3.2** ~~5.14.23.2~~ **Elastomeric coated steel wire ropes**

The following visual discarding criteria shall be considered.

- broken wires or a single strand protruding the elastomeric coating;
- the coating is worn, deformed or damaged or has lost its bonding to the steel wire rope;
- corrosion coming from the load bearing member protruding through the coating material;
- steel wire rope with a kink or corkscrew.

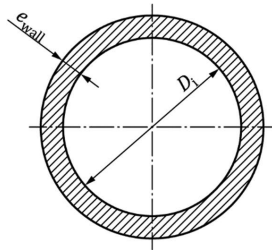
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**4.14.3.3** ~~5.14.23.3~~ **Elastomeric coated steel timing belts**

Following visual discarding criteria shall be considered:

- requirements according to 5.14.3.14.3.1; and
- damaged or missing tooth.

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**4.13.4.15 5.15**—Calculations of rams, cylinders, rigid pipes and fittings**4.13.14.15.1 5.15.1**—Calculation against over pressure**4.13.1.14.15.1.15.15.1.1** Calculation of wall thickness of rams, cylinders, rigid pipes and fittings (see Figure 11)**Key**

$e_{\text{wall}}$  wall thickness of the cylinder/ram/rigid pipe in mm

$D_i$  inside diameter of the cylinder/ram/rigid pipe in mm

**Figure 11 — Wall thickness calculation**

Calculate wall thickness,  $e_{\text{wall}}$ , with Formula (37):

$$e_{\text{wall}} \geq \frac{2,3 \cdot 1,7 \cdot p \cdot D_i}{R_{p0,2}} + e_0 \quad (37)$$

where

$D_i$  is the inside diameter of the cylinder in mm;

$e_0 = 1,0$  mm for wall and base of cylinders and rigid pipes between the cylinder and the rupture valve, if any;

$e_0 = 0,5$  mm for rams and other rigid pipes;

$p$  is the full load pressure in megapascals;

$R_{p0,2}$  is the yield strength of the material proof stress (non-proportional elongation) in newtons per square millimetre;

2,3 is the factor for friction losses (1,15) and pressure peaks (2);

1,7 is the safety factor referred to the proof stress.

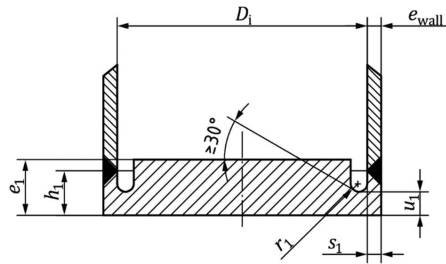
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**4.13.1.24.15.1.25.13.1.2** Calculation of the base thickness of cylinders (examples)**4.13.1.2.14.15.1.2.1 5.15.1.2.1**—General

The bases of cylinders shall be designed according to 4.15.1.2.2, 4.15.1.2.3 or 4.15.1.2.4. The examples shown do not exclude other possible constructions.

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4.13.1.2.24.15.1.2.2 5.15.1.2.2 Flat bases with relieving groove (see Figure 12)



<b>Key</b>			
$e_1$	thickness of the flat base in mm	$u_1$	thickness of the base at the bottom of the relieving groove in mm
$h_1$	height outer base wall in mm	$r_1$	radius of the relieving groove in mm
$D_i$	inside diameter of the cylinder in mm	$s_1$	thickness of the base wall in mm
$e_{wall}$	wall thickness of the cylinder in mm		

Figure 12 — Flat bases with relieving groove

Conditions for the stress relief of the welding seam, see Formulae (38) to (43):

$$r_1 \geq 0,2 \cdot e_1 \quad (38)$$

$$\text{and } r_1 \geq 5 \text{ mm} \quad (39)$$

$$u_1 \leq 1,5 \cdot s_1 \quad (40)$$

$$h_1 \geq u_1 + r_1 \quad (41)$$

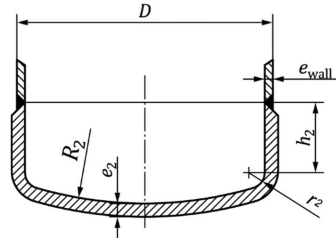
$$e_1 \geq 0,4 \cdot D_i \sqrt{\frac{2,3 \cdot 1,7 \cdot p}{R_{P0,2}}} + e_0 \quad (42)$$

$$u_1 \geq 1,3 \cdot \left( \frac{D_i}{2} - r_1 \right) \cdot \frac{2,3 \cdot 1,7 \cdot p}{R_{P0,2}} + e_0 \quad (43)$$

where

- $D_i$  is the inside diameter of the cylinder in mm;
- $e_o$  is 1,0 mm for wall and base of cylinders;
- $e_1$  is the thickness of the flat base in mm;
- $h_1$  is the height of the base wall in mm;
- $p$  is the full load pressure in megapascals;
- $r_1$  is the inside radius of the base in mm;
- $s_1$  is the thickness of the base wall in mm;
- $u_1$  is the thickness of the base at the bottom of the relieving groove in mm;
- 2,3 is the factor for friction losses (1,15) and pressure peaks (2);
- 1,7 is the safety factor referred to the proof stress.

4.13.1.2.34.15.1.2.3 5.15.1.2.3 Cambered based (see Figure 13)



Key

$D$	outer diameter of the cylinder in mm	$h_2$	height of the base wall in mm
$e_2$	thickness of the cambered base in mm	$r_2$	inside radius of the base in mm
$e_{wall}$	wall thickness of the cylinder in mm	$R_2$	radius of the camber in mm

Figure 13 — Cambered based

Conditions, see Formulae (43) to (46):

$$h_2 \geq 3,0 \cdot e_2 \quad (44)$$

$$r_2 \geq 0,15 \cdot D \quad (44)$$

$$R_2 = 0,8 \cdot D \quad (45)$$

$$e_2 \geq \frac{2,3 \cdot 1,7 \cdot p \cdot D}{R_{p0,2}} + e_0 \quad (46)$$

where

$D$  is the outer diameter of the cylinder in mm;

$e_0$  is 1,0 mm for wall and base of cylinders;

$e_2$  is the thickness of the cambered base in mm;

$h_2$  is the height of the base wall in mm;

$p$  is the full load pressure in megapascals;

$r_2$  is the inside radius of the base in mm;

$R_2$  is the inside radius of the cambered base in mm;

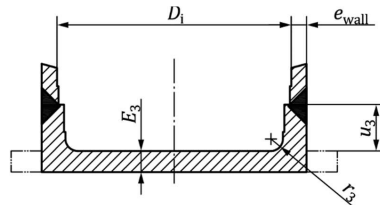
$R_{p0,2}$  is the yield strength of the material proof stress (non-proportional elongation) in newtons per square millimetre;

2,3 is the factor for friction losses (1,15) and pressure peaks (2);

1,7 is the safety factor referred to the proof stress.

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4.13.1.2.4.4.15.1.2.4 5.13.1.2.4 Flat bases with welded flange (see Figure 14)



**Key**

$D_i$	inside diameter of the cylinder in mm	$r_3$	inside radius of the base in mm
$E_3$	thickness of the flat base in mm	$u_3$	height base wall in mm
$e_{wall}$	wall thickness of the cylinder in mm		

**Figure 14 — Flat bases with welded flange**

Conditions, see Formulae (47) to (50):

$$u_3 \geq e_3 + r_3 \quad (47)$$

$$r_3 \geq \frac{e_{wall}}{3} \quad (48)$$

and  $r_3 \geq 8 \text{ mm}$  (49)

$$e_3 \geq 0,4 \cdot D_i \cdot \sqrt{\frac{2,3 \cdot 1,7 \cdot p}{R_{p0,2}}} + e_0 \quad (50)$$

where

$u_3$  is the height base wall in mm;

$e_3$  is the thickness of the flat base in mm;

$r_3$  is the inside radius of the base in mm;

$e_{wall}$  is the wall thickness of the cylinder in mm;

$D_i$  is the inside diameter of the cylinder in mm;

$p$  is the full load pressure in megapascals;

$R_{p0,2}$  is the yield strength of the material proof stress (non-proportional elongation) in newtons per square millimetre;

$e_0$  is 1,0 mm for wall and base of cylinders;

2,3 is the factor for friction losses (1,15) and pressure peaks (2);

1,7 is the safety factor referred to the proof stress.

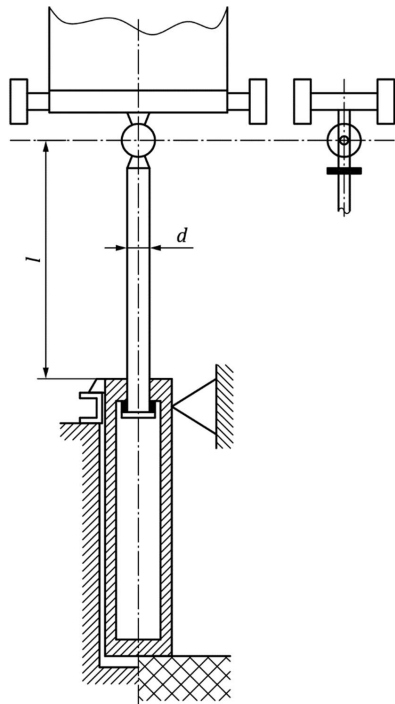
**Commented [SD205]:** Combined comments N2056

4.13.24.15.2 5.13.2 Calculations of the jacks against buckling

4.13.2.14.15.2.15.13.2.1 General

The buckling calculation shall be made on the part with least buckling resistance according to Formulae (51) to (57) as applicable.

4.13.2.24.15.2.25.13.2.2 Single acting jacks (see Figure 15)



**Key**  
 $d$  diameter of ram  
 $l$  length of ram subject to buckling

Figure 15 — Single acting jacks

$$\text{For } \lambda_n \geq 100: F_s \leq \frac{\pi^2 \cdot E \cdot J_n}{2 \cdot l^2} \quad (51)$$

$$\text{For } \lambda_n < 100: F_s \leq \left[ \frac{A_n}{2} \left[ R_{p0,2} - (R_{p0,2} - 210) \cdot \left( \frac{\lambda_n}{100} \right)^2 \right] \right] F_s \leq \frac{A_n}{2} \left[ R_m - (R_m - 210) \left( \frac{\lambda_n}{100} \right)^2 \right] \quad (52)$$

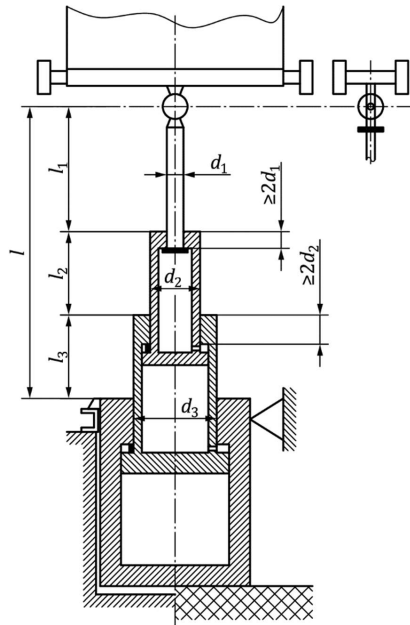
$$F_s = 1,4 \cdot g_n \cdot [c_m \cdot (P + Q) + 0,64 \cdot P_r + P_{rh}] \quad (\text{valid for rams extending in upward direction}) \quad (53)$$

where

- $A_n$  is the cross-sectional area of the material of the ram to be calculated in square millimetres ( $n = 1, 2, 3$ );
- $c_m$  is the reeving ratio;
- $E$  is the modulus of elasticity in newtons per square millimetre (for steel:  $E = 2,1 \times 10^5 \text{ N/mm}^2$ );
- $F_s$  is the actual buckling force applied in newtons;
- $g_n$  is the standard acceleration of free fall in metres per square second;
- $i_n$  is the radius of gyration of the ram to be calculated in millimetres ( $n = 1, 2, 3$ );
- $J_n$  is the second moment of area of the ram to be calculated in fourth power millimetres ( $n = 1, 2, 3$ );
- $l$  is the maximum length of rams subject to buckling in millimetres;
- $P$  is the sum of the mass of the empty car and the mass of the portion of the travelling cables suspended from the car in kilograms;
- $P_r$  is the mass of the ram to be calculated in kilograms;
- $P_{rh}$  is the mass of the ram head equipment, if any in kilograms;
- $Q$  is the rated load (mass) displayed in the car in kilograms;
- $R_m$  is the tensile strength of material in newtons per square millimetre;
- $R_{p0,2}$  is the yield strength of the material proof stress (non-proportional elongation) in newtons per square millimetre;
- $\lambda_n = \frac{l}{i_n}$  is the coefficient of slenderness of the ram to be calculated;
- 1,4 is the over pressure factor;
- 2 is the safety factor against buckling.

Commented [SD207]: Combined comment N2056

4.13.2.34.15.2.35.13.2.3T Telescopic jacks without external guidance, calculation of ram (see Figure 16)



**Key**  
 $d_1, d_2, d_3$  diameter of telescopic ram sections  
 $l$  length of unsupported section  
 $l_1, l_2, l_3$  length of telescopic ram sections subject to buckling

Figure 16 — Telescopic jacks without external guidance

$$l = l_1 + l_2 + l_3, \quad l_1 = l_2 = l_3$$

$$v = \sqrt{\frac{J_1}{J_2}}; j_3 \geq j_2 > j_1$$

(assumption for simplified calculation:  $J_3 = J_2$ )

for 2 sections:

$$\phi = 1,25 \cdot v - 0,2 \quad \text{for } 0,22 < v < 0,65$$

for 3 sections:

$$\phi = 1,5 \cdot v - 0,2 \quad \text{for } 0,22 < v < 0,65$$

$$\phi = 0,65 \cdot v + 0,35 \quad \text{for } 0,65 < v \leq 1$$

$$\lambda_e = \frac{l}{i_e} \quad \text{with } i_e = \frac{d_m}{4} \sqrt{\phi \cdot \left[ 1 + \left( \frac{d_{mi}}{d_m} \right)^2 \right]}$$

For  $\lambda_e \geq 100$

$$F_s \leq \frac{\pi^2 \cdot E \cdot J_2}{2 \cdot l^2} \cdot \phi$$

For  $\lambda_e < 100$

$$F_s \leq \frac{A_n}{2} \cdot \left[ R_{P0,2} - (R_{P0,2} - 210) \cdot \left( \frac{\lambda_n}{100} \right)^2 \right]$$

$$F_s \leq \frac{A_n}{2} \cdot \left[ R_m - (R_m - 210) \cdot \left( \frac{\lambda_n}{100} \right)^2 \right]$$

Commented [SD208]: N2056  $R_m$  to  $R_{P0,2}$

Commented [IJ209]: See N1537

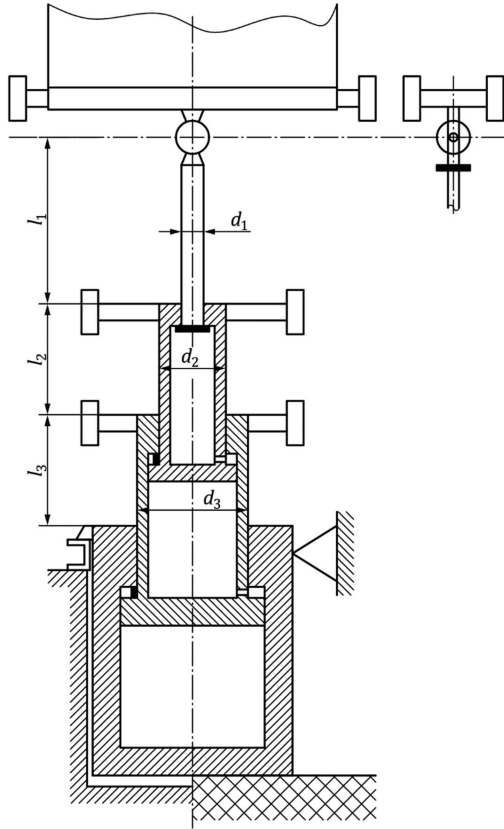
$$F_s = 1,4 \cdot g_n \cdot [c_m \cdot (P + Q) + 0,64 \cdot P_r + P_m + P_{rt}] \quad (\text{valid for rams extending in upward direction}) \quad (54)$$

where

- $A_n$  is the cross-sectional area of the material of the ram to be calculated in square millimetres ( $n = 1, 2, 3$ );
- $c_m$  is the reeving ratio;
- $d_m$  is the outside diameter of the biggest ram of a telescopic jack in millimetres;
- $d_{mi}$  is the inner diameter of the biggest ram of a telescopic jack in millimetres;
- $E$  is the modulus of elasticity in newtons per square millimetre (for steel:  $E = 2,1 \times 10^5 \text{ N/mm}^2$ );
- $F_s$  is the actual buckling force applied in newtons;
- $g_n$  is the standard acceleration of free fall in metres per square second;
- $i_e$  is the equivalent radius of gyration of a telescopic jack in millimetres;
- $i_n$  is the radius of gyration of the ram to be calculated in millimetres ( $n = 1, 2, 3$ );
- $J_n$  is the second moment of area of the ram to be calculated in fourth power millimetres ( $n = 1, 2, 3$ );
- $l$  is the maximum length of rams subject to buckling in millimetres;
- $P$  is the sum of the mass of the empty car and the mass of the portion of the travelling cables suspended from the car in kilograms;
- $P_r$  is the mass of the ram to be calculated in kilograms;
- $P_{rh}$  is the mass of the ram head equipment, if any in kilograms;
- $P_{rt}$  is the mass of the rams acting on the ram to be calculated (in the case of telescopic jacks) in kilograms;
- $Q$  is the rated load (mass) displayed in the car in kilograms;
- $R_m$  is the tensile strength of material in newtons per square millimetre;
- $R_{p0,2}$  is the yield strength of the material proof stress (non-proportional elongation) in newtons per square millimetre;
- $\lambda_e = \frac{l}{i_e}$  is the equivalent coefficient of slenderness of a telescopic jack;
- $\lambda_n = \frac{l}{i_n}$  is the coefficient of slenderness of the ram to be calculated;
- $v, \phi$  are the factors used to represent approximate values given by experimentally determined diagrams;
- 1,4 is the over pressure factor;
- 2 is the safety factor against buckling.

Commented [SD210]: Combined comment N2056

4.13.2.44.15.2.45.13.2.4 Telescopic jacks with external guidance (see Figure 17)



**Key**  
 $d_1, d_2, d_3$  diameter of telescopic ram sections  
 $l_1, l_2, l_3$  length of telescopic ram sections subject to buckling

Figure 17 — Telescopic jacks with external guidance

$$\text{For } \lambda_n \geq 100: F_s \leq \frac{\pi^2 \cdot E \cdot J_n}{2 \cdot l_n^2} \quad (55)$$

$$\text{For } \lambda_n < 100: F_s \leq \frac{A_n}{2} \left[ R_{p0,2} - (R_{p0,2} - 210) \cdot \left( \frac{\lambda_n}{100} \right)^2 \right] \quad (56)$$

$$F_s = 1,4 \cdot g_n \cdot [c_m \cdot (P + Q) + 0,64 \cdot P_r + P_{rh} + P_{rt}] \quad (\text{valid for rams extending in upward direction}) \quad (57)$$

where

- $A_n$  is the cross-sectional area of the material of the ram to be calculated in square millimetres ( $n = 1, 2, 3$ );
- $c_m$  is the reeving ratio;
- $D_m$  is the outside diameter of the biggest ram of a telescopic jack in millimetres;
- $D_{mi}$  is the inner diameter of the biggest ram of a telescopic jack in millimetres;
- $E$  is the modulus of elasticity in newtons per square millimetre (for steel:  $E = 2,1 \times 10^5 \text{ N/mm}^2$ );
- $F_s$  is the actual buckling force applied in newtons;
- $g_n$  is the standard acceleration of free fall in metres per square second;
- $i_n$  is the radius of gyration of the ram to be calculated in millimetres ( $n = 1, 2, 3$ );
- $J_n$  is the second moment of area of the ram to be calculated in fourth power millimetres ( $n = 1, 2, 3$ );
- $l_n$  is the length of ram subject to buckling in millimetres ( $n = 1, 2, 3$ );
- $P$  is the sum of the mass of the empty car and the mass of the portion of the travelling cables suspended from the car in kilograms;
- $P_r$  is the mass of the ram to be calculated in kilograms;
- $P_{rh}$  is the mass of the ram head equipment, if any in kilograms;
- $P_{rt}$  is the mass of the rams acting on the ram to be calculated (in the case of telescopic jacks) in kilograms;
- $Q$  is the rated load (mass) displayed in the car in kilograms;
- $R_m$  is the tensile strength of material in newtons per square millimetre;
- $R_{p0,2}$  is the yield strength of the material ~~proof stress (non-proportional elongation)~~ in newtons per square millimetre;
- $\lambda_n = \frac{l}{i_n}$  is the coefficient of slenderness of the ram to be calculated;
- 1,4 is the over pressure factor;
- 2 is the safety factor against buckling.

Commented [SD211]: N2056 R<sub>m</sub> to R<sub>p0,2</sub>

Commented [SD212]: Combined comment N2056

#### 4.14.16 5.14—Pendulum shock tests

##### 4.14.16.1 5.14.1—General

Pendulum shock tests shall be carried out according to the following prescriptions.

NOTE Pendulum shock test can be specified for a “family” of doors based, for example, on type and minimum/maximum dimensions.

##### 4.14.16.2 5.14.2—Test rig

###### 4.14.16.2.1 5.14.2.1 Hard pendulum shock device

The hard pendulum shock device shall be a body according to Figure 18. This body consists of a shock ring made of steel S 235 JR, according to EN 10025-2:2019 and a case made of steel E 295, according to EN 10025-2:2019. The overall mass of this body will be brought up to 10 kg ± 0,01 kg by filling with lead balls of a diameter of 3,5 mm ± 0,5 mm.

###### 4.14.16.2.2 5.14.2.2 Soft pendulum shock device

The soft pendulum shock device shall be

- a) a small-shot bag according to Figure 19 made of leather, which is filled with lead balls of a diameter of 3,5 mm ± 0,5 mm up to an overall mass of 45 kg ± 0,5 kg; or
- b) a bag according to ISO 29584:2015, 5.1

~~As an alternative the bag described in ISO 29584 may also be used.~~

###### 4.14.16.2.3 5.14.2.3 Suspension of the pendulum shock device

The pendulum shock device shall be suspended by a wire rope of approximately 3 mm diameter in such a way that the horizontal distance between the outer edge of the free hanging shock device and the panel to be tested does not exceed 15 mm ± 10 mm.

The pendulum length (lower end of the hook to reference point of the shock device) shall be at least 1,5 m.

###### 4.14.16.2.4 5.14.2.4 Pulling and triggering device

The suspended pendulum shock device shall be swung away from the panel by a pulling and triggering device and thus lifted to the falling height required in 5.14.3.24.16.3.2 and 5.14.3.34.16.3.3. The triggering device shall not give an additional impulse to the pendulum shock device in the moment of releasing.

The suspension wire rope shall be hooked to shock device without any torque to prevent spinning of device after triggering.

The suspension wire rope shall have no angle in swung position before triggering; consistent results ~~should~~ shall be realized by a triangle hooking keeping the shocking device's centre of gravity in line with the hoisting wire at triggering position.

###### 4.14.16.2.5 5.14.2.5 Test samples

5.14.2.5.1 5.14.16.2.5.1 The test samples shall be complete and shall have the intended size and fixations according to the specific application. The test samples shall be fixed to the test frame in such a way that at the fixation points, no deformations under test conditions are possible (stiff fixation).

Commented [IJ213]: See interpretation No 2

Commented [SD214]: As per WG1 comments N2046

Commented [AD215]: IR3

~~5.14.2.5.24.16.2.5.2~~ The samples shall be as to be manufactured. The samples shall be submitted to the tests in the intended manufacturing finish (machined edges, holes, etc.).

Commented [AD216]: TFHAS\_86\_v5

~~4.14.34.16.3~~ **5.14.3—Tests**

~~5.14.3.14.16.3.1~~ The tests shall be carried out at a temperature of 23 °C ± 5 °C. The panels shall be stored directly before the tests for at least 4 hours at that temperature.

~~5.14.3.24.16.3.2~~ The hard pendulum shock test shall be carried out with the device according to ~~5.14.2.14.16.2.1~~ with a falling height and test arrangement according to Figure 18 and Figure 20.

~~5.14.3.34.16.3.3~~ The soft pendulum shock test shall be carried out with the device according to ~~5.14.2.24.16.2.2~~ with a falling height and test arrangement according to Figure 19 and Figure 20.

~~5.14.3.44.16.3.4~~ The pendulum shock device shall be brought to the required falling height ~~according to the standard calling for this test~~ (e.g. ISO 8100-1:2023, ~~5.3.5.3.24.3.5.2.2~~) and released.

If it is not possible to hit the specified striking point of the relevant part of the test sample (e.g. the panel width is smaller than 240 mm), the pendulum shock device shall hit as close as possible to the ~~specified striking point~~ (see the requirements laid down in the standards calling for the use of this document (e.g. ISO 8100-1:2025)).

Commented [AD217]: TFHAS\_86\_v5

~~5.14.3.54.16.3.5~~ Only one test for each striking point is required with each of the devices called for in ~~5.14.2.14.16.2.1~~ and ~~5.14.2.24.16.2.2~~.

When both hard and soft pendulum shock tests shall be made, they shall be made on the same test sample and the hard pendulum test shall be performed first.

~~5.14.3.64.16.3.6~~ Landing doors shall be tested from the landing side. Car doors and car walls shall be tested from the car side.

~~4.14.44.16.4~~ **5.14.4 Interpretation-Assessment of the test results**

Commented [SD218]: Combined comments N2056

~~After the test, Checks—checks shall be carried out against the specification (e.g. ISO 8100-1:2023, 5.3.5.3.44.3.5.2.4) after the test according to the standard calling for this test for the following:~~

- ~~a) loss of integrity;~~
- ~~b) permanent deformation;~~
- ~~c) cracks or chips.~~

Commented [AD219]: TFHAS\_86\_v5

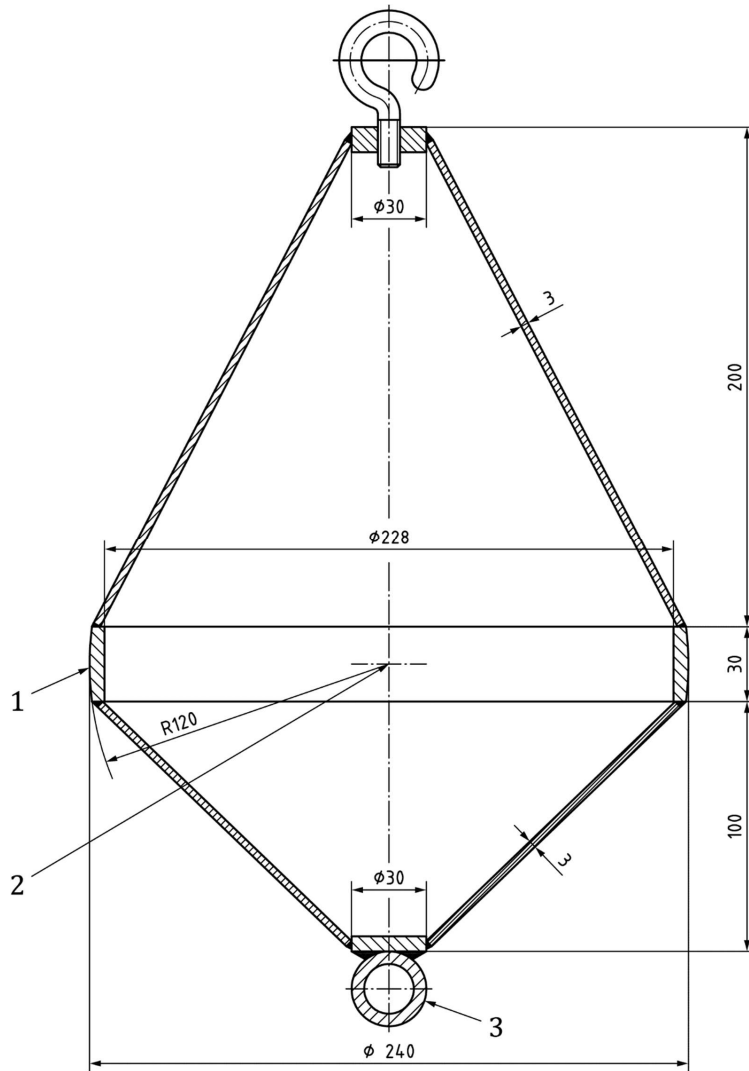
~~4.14.5~~ ~~4.16.5~~ ~~5.14.5~~ Test report

The test report shall contain at least the following information:

- a) ~~identification of the sample name and address of the organization having made the tests;~~
- b) ~~date of the tests;~~
- c) ~~dimensions and construction of the panel sample;~~
- d) ~~fixation of the panel sample;~~
- e) ~~falling height of the tests;~~
- f) ~~number of tests carried out;~~
- g) ~~test results including a reference to the clause(s) of the standard used for defining test specifications;~~
- h) ~~Reference to this document signature of the person responsible for these tests.~~

Commented [AD220]: TFHAS\_86\_v5

Dimensions in millimetres

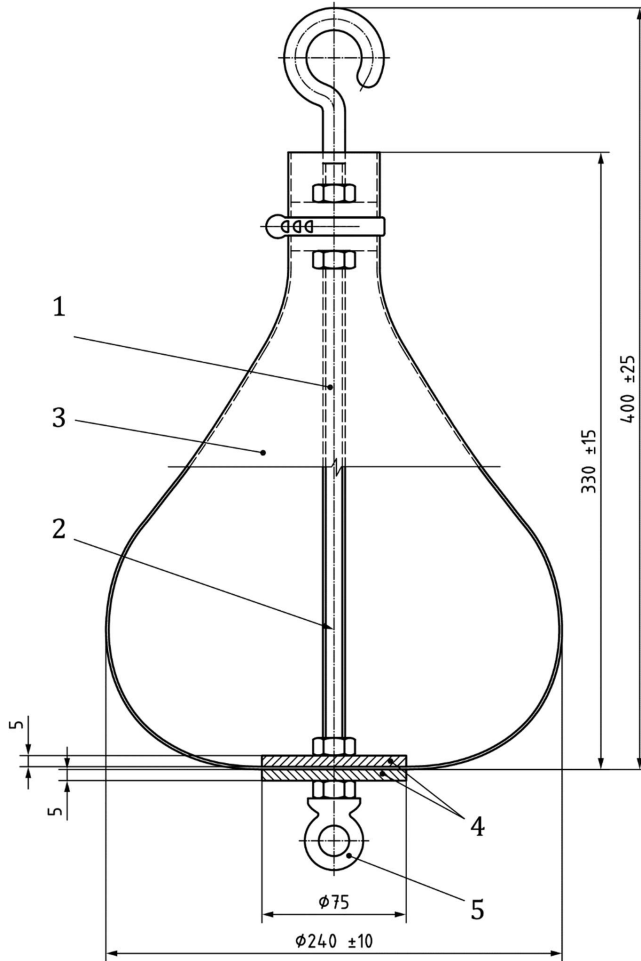


**Key**

- 1 shocking ring
- 2 reference point for measuring the falling height
- 3 triggering device attachment

**Figure 18 — Hard pendulum shock device**

Dimensions in millimetres

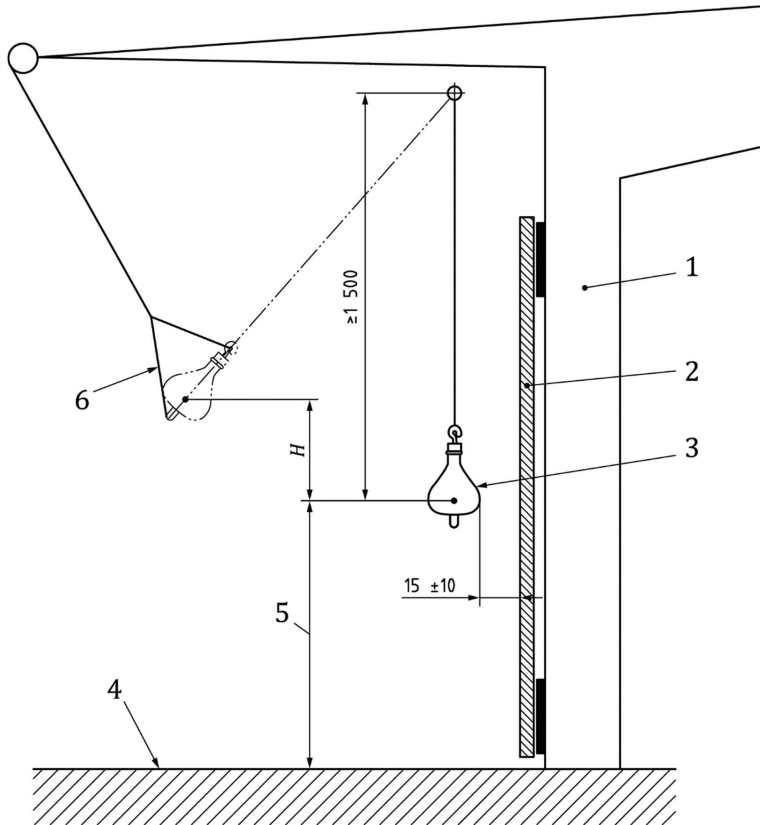


**Key**

- 1 screwed rod
- 2 reference point for measuring the falling height in the plane of the maximum diameter
- 3 leather bag
- 4 steel disk
- 5 triggering device attachment

**Figure 19 — Soft pendulum shock device**

Dimensions in millimetres



**Key**

- 1 frame
- 2 door or car wall-element to be tested
- 3 shock device
- 4 floor level with respect to the door or car wall-structure element to be tested
- 5 height of striking point: value for the height of striking points is given in relevant clauses
- 6 triangle hooking configuration as considered in [5.14.2.44.16.2.4](#)
- H* falling height

**Figure 20 — Test rig falling height**

4.15.17 5.15 ~~Electrical and~~ electronic components — ~~Failure Fault~~ exclusion

~~Failure Fault~~ exclusion shall only be considered provided that components are applied within their worst-case limits of characteristics, value, temperature, humidity, voltage and vibrations.

~~When failurefault exclusion is applied, an over-dimensioning factor of at least 1.5 shall be used for relevant operating parameters at normal operating conditions. Components shall not be operated beyond their worst case limits of characteristics, value, temperature, humidity, voltage and vibrations at any time.~~

Table 3 describes the conditions under which certain faults can be excluded.

Table 3 is not comprehensive list of possible failurefault exclusions to comply with ISO 8100-1:2023, 5.11.1.14.11.1.1. Other failurefault exclusion methods may be used as an example solid insulation according to IEC 60664 series. All failurefault exclusions shall be justified and documented.

The possible fault exclusions are not applicable for protection against electric shock. The requirements for protection against electric shock remain valid in any case (e.g. double or reinforced insulation between PELV and other circuits).

Table 3 — Exclusions of failuresfaults

Component	Possible failure-fault exclusion					Conditions	Remarks
	Open circuit	Short circuit	Change to higher value	Change to lower value	Change of function		
1 Passive components							
1.1 Resistor fixed	NO	(a)	NO	(a) (b) (c)		(a) can be excluded if: The resistor is of the film type or wire-wound single-layer type with protection to prevent unwinding of wire in the event of breakage, with axial wire connections, axial-mounted and varnished. OR Resistors in surface-mount technology must be of the thin film metal type in package types MELF, miniMELF or $\mu$ MELF. (b) Random change of value $0,5R_N < R < \infty$ , where $R_N$ is the nominal value of resistor shall be considered. (a)(c) On the surface layer of PCB below the resistor, there shall be no PCB-track and no via.(a) Only for film resistors with varnished or sealed resistance film and axial connection according to applicable IEC standards, and for wire-wound resistors if they are made of a single-layer winding protected by enamel or sealed.	
1.2 Resistor variable	NO	NO	NO	NO			
1.3 Resistor, non linear NTC, PTC, VDR, IDR	NO	NO	NO	NO			
1.4 Capacitor	NO	NO	NO	NO			

Commented [IJ221]: AH06 Proposal

Commented [KA222]: Terminology shall be aligned with following example sentence: Purpose of failure analysis is to study if fault of a component causes failure of the function.

Failure analysis

Fault exclusion

Commented [KA223]: Delete text "Components shall not be operated beyond their worst case limits of characteristics, value, temperature, humidity, voltage and vibrations at any time". Text was introduced in revision of EN 81-20 by AH6 but with further consideration AH6 decided to delete it in September 2018 meeting.

Component	Possible failure fault exclusion					Conditions	Remarks																
	Open circuit	Short circuit	Change to higher value	Change to lower value	Change of function																		
1.5 Inductive components — coil — choke	NO	(a)NO	NO	NO		(a) Short circuit can be excluded if coil is single-layered, enamelled or potted, with axial wire connections and axial-mounted.																	
2 Semiconductors																							
2.1 Diode, LED	NO	NO			NO		Change of function refers to a change in reverse current value.																
2.2 Zener Diode	NO	NO		NO	NO		Change to lower value refers to change in Zener voltage. Change of function refers to change in reverse current value.																
2.3 Thyristor, Triac, GTO	NO	NO			NO		Change of function refers to self-triggering or latching of components.																
2.4 Optocoupler, Digital isolator	NO	(a)			NO	(a) Short circuit across the isolation barrier can be excluded if: The signal isolation component is built in accordance with overvoltage category III according to IEC 60664-1:2020. Measures are taken to ensure that an internal fault of the signal isolation component cannot result in excessive temperature of its insulating material. (a) Can be excluded on condition that the optocoupler is according to IEC 60747-5-5, and the isolation voltage is at least according to table below, IEC 60664-1:2007, Table F.1:	see also ISO 13849-2 and IEC 61800-5-2. Open circuit means open circuit in one of the two basic components (LED and photo transistor). Short circuit means short circuit between them.																
						<table border="1"> <thead> <tr> <th>Voltage phase-to-earth derived from rated system voltage up to and including <math>V_{rms}</math> and D.C.</th> <th>Preferred series of impulse withstand voltages in volts for installation</th> </tr> </thead> <tbody> <tr> <td></td> <td>Category III</td> </tr> <tr> <td>50</td> <td>800</td> </tr> <tr> <td>100</td> <td>1 500</td> </tr> <tr> <td>150</td> <td>2 500</td> </tr> <tr> <td>300</td> <td>4 000</td> </tr> <tr> <td>600</td> <td>6 000</td> </tr> <tr> <td>1 000</td> <td>8 000</td> </tr> </tbody> </table>	Voltage phase-to-earth derived from rated system voltage up to and including $V_{rms}$ and D.C.	Preferred series of impulse withstand voltages in volts for installation		Category III	50	800	100	1 500	150	2 500	300	4 000	600	6 000	1 000	8 000	
Voltage phase-to-earth derived from rated system voltage up to and including $V_{rms}$ and D.C.	Preferred series of impulse withstand voltages in volts for installation																						
	Category III																						
50	800																						
100	1 500																						
150	2 500																						
300	4 000																						
600	6 000																						
1 000	8 000																						
2.5 Hybrid circuit	NO	NO	NO	NO	NO																		
2.6 Integrated circuit	NO	NO	NO	NO	NO		Change in function to oscillation, "and" gates becoming "or" gates, etc.																

Component	Possible failure-fault exclusion					Conditions	Remarks
	Open circuit	Short circuit	Change to higher value	Change to lower value	Change of function		
3 Miscellaneous							
3.1 Connectors Terminals Plugs	NO	(a)				<p>(a) The clearances and creepage distances are dimensioned at least according IEC 60664-1:2020 with the conditions: a) — The short-circuits of connectors can be excluded if the minimum values are according to the tables (taken over from IEC 60664-1) with the conditions:</p> <ul style="list-style-type: none"> <li>— overvoltage category III;</li> <li>— the pollution degree is 3;</li> <li>— the material group is III;</li> <li>— inhomogeneous field.</li> </ul> <p>The column “printed wiring material” of IEC 60664-1:2020 Table F.5 is not used. That means that the creepage distances are 4 mm and the clearances 3 mm at 2000 m altitude for 250 V<sub>rms</sub>. For other voltages and higher altitude see IEC 60664-1:2020 Tables A.2, F.1, F.2 and F.5.</p> <p>These are absolute minimum values which can be found on the connected unit, not pitch dimension or theoretical values.</p> <p>If the protection of the connector is IP 5X 54 or better, pollution degree 2 can be used, the creepage distances can be reduced to the clearance value, e.g. 3 mm for 250 V<sub>rms</sub>.</p>	
3.2 Neon bulb	NO	NO					
3.3 Transformer	NO	(a)	(ba)	(ba)		<p>(a) <del>(a)</del> — <del>(b)</del></p> <p>Can be excluded on condition that transformer complies with IEC 61558-1:2017, Clause 18, for double or reinforced insulation between windings and between windings and core.</p>	<p>Short-circuits include short-circuits of primary or secondary windings, or between primary and secondary coils.</p> <p>Change in value refers to change of ratio by partial short-circuit in a winding</p>
3.4 Fuse	NO	(a)				<p>(a) Can be excluded if the fuse is correctly rated, and constructed according to the applicable IEC standards.</p>	<p>Short circuit means short circuit of the blown fuse.</p>

Component	Possible failure fault exclusion					Conditions	Remarks
	Open circuit	Short circuit	Change to higher value	Change to lower value	Change of function		
3.5 Relay	NO	(a) (b)				<p>(a) Short-circuits between contacts, and between contacts and coil can be excluded if the relay fulfils the requirements laid down in the standards calling for the use of this document (e.g. ISO 8100-1:2023, <a href="#">5.10.3.2.24.10.3.2.2</a>).</p> <p>(b) Welding of contacts cannot be excluded. However, <del>if the relay is constructed to have mechanically forced interlocked contacts, and made according to IEC 60947-5-1:2003</del>, the assumptions laid down in the standards calling for the use of this document (e.g. ISO 8100-1:2023, <a href="#">5.10.3.1.24.10.3.1.2</a> and <a href="#">5.10.3.1.34.10.3.1.3</a>) apply.</p>	

Component	Possible failure-fault exclusion					Conditions	Remarks
	Open circuit	Short circuit	Change to higher value	Change to lower value	Change of function		
3.6 Printed circuit board (PCB)	NO	(a)				<p>(a) The short circuit can be excluded provided:</p> <p><del>As base material, EP GC with low flammability according to IEC 60893-3-1:2012, Table 1 is used. As base material, EP GC according to IEC 60893-1 is used as a minimum.</del></p> <p>The PCB is constructed according to the above requirements and the minimum values are according to the tables (taken over from The clearances and creepage distances are dimensioned at least according to IEC 60664-1:2020 with the conditions:</p> <ul style="list-style-type: none"> <li>— <del>Overtoltage category III;</del></li> <li>— The pollution degree is 3;</li> <li>— The material group is III;</li> <li>— Inhomogeneous field.</li> </ul> <p>The column "printed wiring material" of IEC 60664-1:2020, Table 4 is not used. That means that the creepage distances are 4 mm and the clearances 3 mm at 2000 m altitude for 250 V<sub>rms</sub>. For other voltages and higher altitude see IEC 60664-1:2020 †Tables A.2, F.1, F.2 and E.5.</p> <p>If the protection of the PCB is IP54 or better, and the printed side(s) is (are) coated with an ageing-resistant varnish or protective layer covering all conductor paths and for the inner layers of multilayer PCB, pollution degree 2 can be used.</p> <p>NOTE Experience has shown that solder masks are satisfactory as a protective layer.</p> <p>For multi-layer boards <del>comprised of at least 3 prepreg or other thin sheet insulating materials</del>, short circuit can be excluded <del>between conductive parts of different layers</del> can be excluded if <u>insulation material between layers fulfil following conditions: (see EN 60950-1:2006, 2.10.6.4):</u></p> <ul style="list-style-type: none"> <li>— <u>Insulation material with minimum thickness of 0.4mm; or</u></li> <li>— <u>At least 3 prepreg or other thin sheet insulating materials where the combination of pre-pregs shall fulfil reinforced insulation.</u></li> </ul>	<p>NEMA FR4 equals EP GC 202</p> <p>NEMA FR5 equals EP GC 204</p>

**Commented [KA224]:** Requirement further studied and corrected.  
Add IEC 60893-3-1 into normative references.

**Commented [SD225]:** As WG1 comments N2046 Table 3 3.6

Component	Possible failure fault exclusion					Conditions	Remarks
	Open circuit	Short circuit	Change to higher value	Change to lower value	Change of function		
3.7 Assembly of components on printed circuit board (PCB)	NO	(a)				(a) Short circuit can be excluded under circumstances where the short circuit of the component itself can be excluded and the component is mounted in a way that the creepage distances and clearances are not reduced below the minimum acceptable values as listed in 3.1 and 3.6 of this table, neither by the mounting technique nor by the PCB itself.	

In the Table:  
 The "NO" in the cell means: failure fault not excluded, i.e. shall be considered;  
 The unmarked cell means: the identified fault type is not relevant.

**4.164.18 5.16 — Design rules for programmable electronic systems SIL-rated circuits (PESSRAL)**

SIL-rated circuits shall comply with the requirements in the standard calling for the use of this standard (e.g. ISO 8100-1:2023, 5.11.2.4.11.2.1.7) and with one of the following:

- a) at least with the relevant requirements listed in Annex B.A, or
- b) the relevant requirements of IEC 61508 series of standards, with the following restrictions:
  - IEC 61508-2:2010, Table 2 and first line of Table 3 shall not be used;
  - IEC 61508-3:2010, Annex G, G.2 Limited variability configuration, limited application configurability is only permitted to be used. Demand interval shall be considered not to exceed 100 s

Programmable electronic systems shall comply with the minimum requirements of the safety functions common to all SIL's listed in Tables B.1, B.2 and B.3. In addition, specific measures required for SIL's 1, 2 and 3 are listed respectively in Tables B.4, B.5 and B.6.

See also the requirements in the standard calling for the use of this document.

~~NOTE — The IEC 61508-7:2010 clauses listed in Tables B.1 to B.6 refer to the relevant requirements in IEC 61508-2 and IEC 61508-3.~~

**5 6 Use of ISO/TS 8100-3**

ISO/TS 8100-3:2019, Clause 4, includes requirements that shall be followed when applicable for use in combination with this document.

Commented [IJ226]: See AHo6 proposal

Commented [KA227]: Word "relevant" added.

Commented [KA228]: Note deleted as it didn't bring any additional value. References in the tables are clear enough.

**Annex A**  
**(normative)**

**Model form of type examination certificate**

The examination certificate shall contain the following information:

**MODEL TYPE EXAMINATION CERTIFICATE**

Commented [AD229]: TFHAS\_86\_v5

Name of the approved body .....

.....

Type examination number .....

1 Type and make or trade name .....

2 Name and address of manufacturer .....

.....

3 Name and address of certificate holder .....

.....

4 Date of submission for type examination .....

5 Certificate issued on the basis of the following requirement .....

.....

6 Test laboratory .....

7 Date and number of laboratory report .....

8 Date of type examination .....

9 The following documents, bearing the type examination number shown above, are annexed to this certificate .....

.....

10 Any additional information .....

.....

Place ..... Date .....

Name and position of person signing the certificate .....

(Signature) .....

**Annex B**  
(normative)

**SIL-rated circuits**  
**Programmable electronic systems in safety related applications for lifts (PESSRAL)**

**A.1 Principles**

As a consequence of the detection of a failure, the SIL-rated circuit (Src) shall initiate a safe state<sup>1)</sup>.

**NOTE 1** For the definition of the safe state see other standards calling for the use of this standard (e.g. ISO 8100-1:2023, 5.11.2.1.14.11.2.1.1).

The diagnostic test time interval in order to detect a failure by online diagnostics shall be:

- for SIL3 within 24 hours<sup>2)</sup> of accumulated operation time or within the daily average operation time of the SIL-rated circuit, whichever is smaller;

**NOTE 2** Even in the presence of an undetected single failure in one channel of multiple channel systems, the SIL-rated circuit is capable to initiate a safe state within the response time due to its architecture.

- for SIL2 and SIL1 within 1 second.

**NOTE 3** Current technologies and implementations of diagnostic measures in general allow smaller time intervals.

For electromechanical components, such as relays and contactors, failures can't be detected without being operated. Therefore:

- for SIL3 electromechanical components shall be operated at least once in a month;
- for SIL2 and 1 electromechanical components shall be operated at least once in a year.

For SIL2 and SIL3 a dangerous soft-error failure rate  $\lambda_{D, soft}$  of 500 FIT/Mbit shall be considered additionally to the component's failure rate for any safety related variable information storage (e.g. memory, CPU timer and I/O registers, etc.)

Commented [KA230]: ISO reference

Commented [SD231]: Update date

Commented [AD232]: N2222 GS-070

Commented [KA233]: Clarification added.

Commented [KA234]: Use plural: components instead of component.

**A.2 B.1 Techniques and measures for failure avoidance and detection**

**Table B.1 A.1 – Common measures to avoid and detect failures – Hardware design**

<u>Object</u>	<u>Measure</u>	<u>Description of measure</u>	<u>Informative reference</u> <b>IEC 61508-7:2010</b>
<u>Component selection</u>	Over-dimensioning of hardware components	See 4.17 and other standards calling for the use of this standard (e.g. ISO 8100-1:2023 - 5.11.2.3.24.11.2.3.2 and 5.11.2.4.24.11.2.4.2).	A.2.8
<u>I/O units and interfaces incl. communication links</u>	Safeguarding of the safe state	During start-up, power failure or reset the defined safe state of the safety function(s) shall be ensured.	---
<u>Variable memory ranges in programmable electronic systems</u>	Technology to be used	Only memories built up by solid state elements shall be used. No memories with electro-mechanical operated elements (e.g. hard disks) shall be used.	---
	Method of failure detection	Variable data memory shall be tested with the applicable test measure (see Table B.7) - during start-up; - the transition into normal operation mode shall only be performed if the test has been performed successfully; - periodically at runtime.	A.5
	Safeguarding of safety related data on remote access	Direct remote access to variable memory ranges is only allowed by a safety related function which ensures safety integrity	==
<u>Invariable memory ranges</u>	Failure detection of invariable memory ranges	Program code memory as well as fixed data memory shall be tested with the applicable test measure (see Table B.6) - during start-up; - the transition into normal operation mode shall only be performed if the test has been performed successfully; - periodically at runtime.	A.4.2
<u>Invariable memory ranges (continued)</u>	Protection against modification of program code	Program code shall be stored and sealed in a way that no undetected modification can be performed on site, either by the SIL-rated circuit itself or by an external device.	



Object	Measure	Description of measure	Informative reference
<a href="#">Program</a>	Suitable programming language.	Use of C with subset and coding standard, and use of static analysis tool(s) covering the following aspects: - Boundary check - Control flow analysis (instruction coverage for architectures I + II, branch coverage for architecture III) Note: Assembler shall be used only in a limited scope, e.g. startup, run-time critical code sections, run-time background tests.	<a href="#">C.2.6.2</a>  <a href="#">C.4.1</a> <a href="#">C.4.5</a>
	Safeguarding of response time.	- Cyclic behaviour, with guaranteed maximum cycle time or time-triggered architecture. - Iteration loops shorter than response time (for example by limiting number of loops or checking execution time).	<a href="#">C.3.11</a>
	Safeguarding of unintended modification of variable data memory.	- Indexed access of arrays - Pointer access only if array boundary checks are performed. - No function calls via a pointer to a function, except assigned at startup and not being modified during runtime.	<a href="#">C.2.6.6</a>
	Safeguarding against unexpected program faults.	Defined handling of exceptions (for example division by zero, overflow, variable range checking etc.) which forces the system into a defined safe state. Plausibility checks on data (for example input patterns, input ranges, and internal data).	<a href="#">C.2.5</a>  <a href="#">C.3.1</a>
<a href="#">Bus system and I/O handling</a>	Static system architecture.	No change of logical architecture during runtime	

**Table B.3A.3 — Common measures for the design and implementation process**

Measure	Description of measure	Informative reference <a href="#">IEC 61508-7:2010</a>
Documentation of the functional, environmental and interface aspects of the application.		<a href="#">B.1.1</a> <a href="#">B.1.2</a> <a href="#">A.14</a>
Documentation of the requirements specification including the safety requirements - Structured specification  - Semiformal methods	- Creation of (sub-)requirements - Description of the interfaces - Consistency checks  Use of at least one of the measures as applicable - Logic/function block diagrams - Sequence diagrams - Finite state machines/state transition diagrams - Decision/truth tables as applicable in order to systematically partition and document the system.	<a href="#">B.2.1</a>  <a href="#">B.2.3</a> <a href="#">C.2.1</a>
Reviews of all specifications.		<a href="#">B.2.6</a>
Design documentation as required in <a href="#">5.6.14.6.1</a>	and additionally: - function description including system architecture and hardware/software interaction - software documentation including function and program flow description.	<a href="#">B.2.3</a> <a href="#">B.3.2</a> <a href="#">B.3.4</a> <a href="#">C.5.9</a>
Design review reports.		<a href="#">B.3.7</a> <a href="#">B.3.8</a> <a href="#">C.5.16</a>
Performing a safety analysis in the form of a failure mode effect and diagnostic analysis (FMEDA).	- Consideration of failures, internal (component failures) and external (via interfaces) - Application of the valid failure modes - Definition of the planned measures for failure detection and control (c.f. <a href="#">Table B.4A.4</a> to <a href="#">B.13A.13</a> ) - Assignment of component failure rates ( $\lambda_D$ )	<a href="#">B.6.6</a>
Manufacturer's test specifications and test reports:	- static code check, branch code coverage (C1), module testing, - hardware/software integration and fault insertion testing, - system testing in a real lift application - testing of relevant system configurations.	<a href="#">B.5.1</a> <a href="#">B.5.2</a> <a href="#">B.5.3</a> <a href="#">B.6.4</a> <a href="#">B.6.8</a> <a href="#">B.6.9</a> <a href="#">B.6.10</a> <a href="#">C.4.7</a> <a href="#">C.5.2</a> <a href="#">C.5.4</a> <a href="#">C.5.8</a>
Manufacturer's test specifications and test reports about environmental testing incl. EMC.	See <a href="#">5.6.34.6.3</a> and other standards calling for the use of this standard (e.g. <a href="#">ISO 8100-1:2023</a> , <a href="#">5.10.1.1.34.10.1.1.1</a> ).	<a href="#">B.6.1</a> <a href="#">B.6.2</a>

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Measure	Description of measure	Informative reference
<a href="#">Documentation about installation, configuration, operation, maintenance and testing incl. the limits for intended use.</a>	This information has to be documented in a manual, provided together with the SIL-rated circuit (See standards calling for the use of this standard (e.g. <a href="#">ISO 8100-1:2023, 7-26.2</a> ))	<a href="#">IEC 61508-7:2010</a>  <a href="#">B.4</a>
<a href="#">Design modification.</a>	Repeat and update all relevant measures based on an impact analysis describing the effects of the modification on the existing SIL-rated circuit.	<a href="#">C.5.23</a> <a href="#">C.5.25</a>
<a href="#">Implementation of requirements tracking for the development life cycle phase of the SIL-rated circuit.</a>		<a href="#">C.2.11</a>
<a href="#">Implementation of a version control for hardware and software and allowed combinations.</a>	The versions having been tested and being part of the SIL-rated circuit shall be identified.	<a href="#">C.5.24</a>
<a href="#">Determination and calculation of the safety-related parameters (response time, PFH<sub>SFC</sub>, PFD<sub>SFC</sub>).</a>	<ul style="list-style-type: none"> <li>- For the response time of a safety function see other standards calling for the use of this standard (e.g. <a href="#">ISO 8100-1:2023, 5-11-2-1-74.11.2.1.68</a>)</li> <li>- For details about PFH<sub>SFC</sub>, PFD<sub>SFC</sub> calculation see <a href="#">Table B-16A.16</a></li> <li>- For the time interval to detect a failure by online diagnostics see <a href="#">B-0A.1</a></li> </ul>	
<p><b>NOTES:</b></p> <p><a href="#">PFD<sub>SFC</sub></a>: Probability of a dangerous failure on demand (Valid for a request of the safety function less than once a year)</p> <p><a href="#">PFH<sub>SFC</sub></a>: Probability of a dangerous failure per hour (Valid for a request of the safety function more than once a year)</p>		

**A.3 B.2 Techniques and measures for failure detection and control during operation**

**Table B.4A.4 — Structure**

<u>Requirement</u>	<u>SIL</u>	<u>Measure</u>	<u>Description of measure</u>	<u>Informative reference</u> <u>IEC 61508-7:2010</u>
The structure shall be such that random failures are detected.	1	One channel structure with self-test	Even though the structure consists of a single channel, a redundant shutdown path shall be provided to ensure a safe shutdown either by the processing unit itself or by the watchdog. The hardware is built using standard techniques which do not take any special safety requirements into account.  See Table B-15A.15, for designated architecture for SIL1	Electric safety circuit A.1.1
	2	One channel with self-test and external monitoring	At least two independent shut down paths are needed so that a shut-down can be caused either by the processing unit itself or by the monitoring unit. A one channel structure with self-test and monitoring consists of a separate hardware monitoring unit which, independent of the application, periodically receives test data from the system which might result from self-test procedures.  Additional special hardware facilities support self-test functions for failure detection. For example, this could be a hardware unit which cyclically monitors the output for a certain bit pattern according to the watch-dog principle.  See Table B-15A.15, for designated architecture for SIL2	A.3.3
	3	Two channels or more with comparison	Two-channel safety related design consists of two independent and feedback-free functional units. This allows the specified functions to be processed independently in each channel. For a two-channel SIL-rated circuit exclusively designed for the function of one safety device the design of the channels may be identical in terms of hardware and software. In the case of a two-channel SIL-rated circuit used for complex solutions (e.g. combinations of several safety functions) and where the processes or conditions are not definitely verifiable, diversity for hardware and software should be considered.  The structure includes a function which compares internal signals (e.g. bus comparison) and/or output signals which are relevant to safety functions in order to aid failure detection.  At least two independent shut down paths are needed so that a shut-down can be caused either by the channels themselves or by the comparator. The comparison itself also shall be subject to the failure recognition.  See Table B-15A.15, for designated architecture for SIL3	A.2.5

**Table B.5A.5 — Processing Units**

Requirement	SIL	Measure	Description of measure	Informative reference IEC 61508-7:2010
Failures in processing units, which can lead to incorrect results, shall be detected.	1	Self-test by software	All the functions of the processing unit, which are used in the safety related application, shall be tested cyclically. These tests can be combined with the test of the sub-components, e.g. memories, I/O's etc. The failure detection is realised entirely by additional software functions which perform self-tests using at least two complementary data patterns (for example 55hex and AAhex).	A.3.1
	2	Software self-test supported by hardware for one-channel structure	Additional special hardware facilities support self-test functions to detect failure. For example, this could be a hardware unit which cyclically monitors the output of a certain bit pattern according to the watch-dog principle.	A.3.3
		Self-test by software	The failure detection is realised entirely by additional software functions which perform self-tests using a data pattern (for example walking-bit pattern) which tests the physical storage (data and address registers) and the instruction decoder.	A.3.2
	3	Reciprocal comparison by software for two-channel structure	Two processing units exchange data (input state(s), output state(s), program sequence information, diagnostic test results) reciprocally. A comparison of the data is carried out using software in each unit.	A.3.5

NOTES:  
 A measure for a SIL3 can be used also for SIL2 and SIL1; a measure for a SIL2 can also be used also for SIL1.  
 If more than one measure is indicated for a specific architecture, the measures are equivalent alternatives.

**Table B.6A.6 — Invariable Memory Ranges**

Requirement	SIL	Measure	Description of measure	Informative reference IEC 61508-7:2010
Incorrect information modification shall be detected.	1 + 2	Block safety with CRC	This procedure calculates a <del>32-bit</del> 32-bit signature using a cyclic redundancy check (CRC-32) algorithm. It is the "signature" of the memory block and is stored non-volatile during production. The signature is re-computed in later tests and compared with the one already stored.	<del>A.4.4 (32-bit)</del> 3
		Word saving with multi-bit redundancy	Every word of memory is extended by several redundant bits to produce a modified Hamming code with a Hamming distance of at least 4. Every time a word is read, checking of the redundant bits can determine whether or not a corruption has taken place.	A.4.1
	3	Block safety procedure with block replication	The memory is split up into two memory ranges. The second memory range contains the inverted information of the first memory range. The first memory range is periodically compared with the second one.	A.4.5
		Block safety with CRC	This procedure calculates a <del>32-bit</del> 32-bit signature using a cyclic redundancy check (CRC-32) algorithm. It is the "signature" of the memory block and is stored non-volatile during production. The signature is re-computed in later tests and compared with the one already stored.	A.4.4 (32-bit)

NOTES:  
 A measure for a SIL3 can be used also for SIL2 and SIL1; a measure for a SIL2 can also be used also for SIL1.  
 If more than one measure is indicated for a specific architecture, the measures are equivalent alternatives.

**Commented [KA237]:** Replace A.4.3 with A.4.4 as 32-bit CRC is referenced in A.4.4.  
**Commented [KA236]:** Memory replaced with memory block.

**Table B-7A.7 — Variable Memory Ranges**

Requirement	SIL	Measure	Description of measure	Informative reference
				<a href="#">IEC 61508-7:2010</a>
Global failures during addressing, writing, storing and reading shall be detected.	1 + 2	Word-saving with multi-bit redundancy	Every word of memory is extended by several redundant bits to produce a modified Hamming code with a Hamming distance of at least 4. Every time a word is read, checking of the redundant bits can determine whether or not a corruption has taken place.	<a href="#">A.5.6</a>
		Check via test pattern against static or dynamic faults	The memory range to be tested is initialised by a uniform byte stream. The first byte is then inverted and the remaining memory area is inspected to ensure that the remaining byte stream is correct. After this, the first byte is re-inverted to return it to its original value, and the whole procedure is repeated for the next byte. A second run of the "wandering byte model" is carried out with an inverse byte stream pre-assignment.	<a href="#">A.5.2</a>
	3	Inspection checks	<p>In the RAM test "galpat", the memory is first initialized uniformly (i.e. all zeros or all ones). The first bit of the memory to be tested is then inverted and all the remaining bits of the memory are inspected to ensure that their contents are correct. After every read access to one of the remaining bytes, the inverted bit is also checked. This procedure is repeated for each bit in the memory. A second run is carried out with the opposite initialisation.</p> <p>The "transparent galpat" test is a variation of the above procedure: Instead of initialising all bits of the memory, the existing memory content is left unchanged and CRC signatures are used for failure detection. The first bit of the memory is selected, and the CRC signature S1 of all remaining bytes of the memory is calculated. The bit to be tested is then inverted and the CRC signature S2 of all the remaining bytes is recalculated. (After every read access to one of the remaining bytes, the byte with the inverted bit is also checked.) CRC signature S2 is compared with CRC signature S1. The bit under test is re-inverted to re-establish the original contents, and the CRC signature S3 of all the remaining bytes is re-calculated and compared with CRC signature S1. All other bits of the memory are tested in the same manner.</p> <p>In order not to impact response time negatively, this test can be executed in slices.</p> <p>If time consumption is too long for an acceptable start-up period, the RAM test method March C- transparent symmetric test as an alternative method at start-up is acceptable. In this case and where the cycle time for a full execution of the "transparent galpat" is longer than the expected operation time (operation in shifts) the galpat test needs to be resumed at power-up from that point where it has been stopped at power-down.</p>	<a href="#">A.5.3</a>
	Block safety procedure with block replication	The memory is split up into two memory ranges. The second memory range contains the inverted information of the first memory range. The first memory range is periodically compared with the second one.	<a href="#">A.5.7</a>	

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Requirement	SIL	Measure	Description of measure	Informative reference
Detection of Soft Errors	2 + 3	Block safety procedure with block replication	The memory is split up into two memory ranges. The second memory range contains the inverted information of the first memory range. Whenever a content of the first memory range is used, the integrity of that content is checked by comparison with the inverted content of the second memory range.	<a href="#">IEC 61508-7:2010</a> <a href="#">A.5.7</a>
		Block safety with CRC	This procedure calculates a signature using a cyclic redundancy check (CRC) algorithm of the memory block to be protected, whenever the content is modified. It is the "signature" of the memory block and is stored separately. Whenever a content of the protected memory block is used, its integrity is checked by re-computing the signature and comparing it with the one already stored.	<a href="#">A.4.4</a>
	3	Cross comparison between two channels	Safety-relevant data is exchanged between the two channels and compared.	
<p>NOTES:</p> <p>A measure for a SIL3 can be used also for SIL2 and SIL1; a measure for a SIL2 can also be used also for SIL1.</p> <p>If more than one measure is indicated for a specific architecture, the measures are equivalent alternatives.</p> <p>For block safety with CRC a CRC-16 may be applied up to a max. memory block size of 1024 Bytes, otherwise a CRC-32 shall be applied.</p>				

**Table B.9A.8 — I/O Units and Interfaces**

Requirement	SIL	Measure	Description of measure	Informative reference
				<a href="#">IEC 61508-7:2010</a>
Static failures and cross talk on I/O lines as well as random and systematic failures in the data flow shall be detected.	1 + 2 + 3	Test pattern	By applying a test pattern – superimposed to the I/O-signal – the quasi-static I/O is being made dynamic in order to allow failure detection (e.g. stuck.at). For a single digital I/O-signal simple pulses are sufficient. For more than one digital I/O-signal the pulses shall be separated in time in order to be able to detect cross-talk. For analogue I/O-signals the test patterns (test values) shall cover the whole analogue range in adequate steps with respect to the required accuracy.	A.6.1
		Multi-channel parallel input	Use of two or more redundant inputs in order to detect random failures based on comparison (voting) of the input signal levels and/or their temporal behaviour. This measure is only effective if the input signals change during the diagnostic test interval and signal separation against short circuit between the parallel inputs is ensured.	A.6.5
		Multi-channel parallel output	Use of two or more redundant outputs in order to detect random failures based on comparison (voting) of the output signal levels and/or their temporal behaviour. This measure is only effective if the output signals change during the diagnostic test interval and signal separation against short circuit between the parallel outputs is ensured.	A.6.3
		Monitored output	Use of an independent input signal derived from the output signal in order to detect random failures based on comparison of the input signal level and the expected output signal level and/or their temporal behaviour. This measure is only effective if the output signal changes during the diagnostic test interval and signal separation against short circuit between the output and input signal is ensured.	A.6.4
<p>NOTES:</p> <p>A measure for a SIL3 can be used also for <del>SH-2</del>SIL2 and SIL1; a measure for a SIL2 can also be used also for SIL1. If more than one measure is indicated for a specific architecture, the measures are equivalent alternatives.</p>				

**Table B-9A.9 — On-board Safety Related Data Communication Links of SIL-rated circuits**

Requirement	SIL	Measure	Description of measure	Informative reference <a href="#">IEC 61508-7:2010</a>
Detect failures caused by a defect in the information transfer in 1:n on-board / back-plane communication links	1	One-bit hardware redundancy	Parallel or serial byte oriented (8-bit) communication using a parity bit for failure detection	A.7.1
	2	Multi-bit hardware redundancy	Parallel or serial (multi-)byte (n x 8-bit) oriented communication using more than one bit for failure detection providing a Hamming Distance at least 4.	A.7.2
	3	Transmission redundancy	Serial (multi-)byte (n x 8-bit) oriented communication.  Each transmission consists of two transmission cycles. In the first transmission cycle the information is transmitted non-inverted while in the second transmission cycle the same information is transmitted bit-inverted.	A.7.5
		Information redundancy	Serial (multi-)byte (n x 8-bit) oriented communication  The transmission uses a cyclic redundancy check (CRC) algorithm for failure detection.	A.7.6
<p>NOTES:</p> <p>A measure for a SIL3 can be used also for SIL2 and SIL1; a measure for a SIL2 can also be used also for SIL1. If more than one measure is indicated for a specific architecture, the measures are equivalent alternatives.</p>				

**Table B-10A.10 — Clock**

Requirement	SIL	Measure	Description of measure	Informative reference <a href="#">IEC 61508-7:2010</a>
Failures in clock generation for processing units like frequency modification or break down shall be detected.	1	Watchdog with separate time base without time-window	Timing elements with a separate time base (for example watch-dog timer) externally to the unit being monitored. The timing elements are periodically triggered to monitor the unit's behaviour and the plausibility of the program sequence. It is important that the triggering points are correctly placed in the program. The timing elements are not triggered at a fixed period, but a maximum time-out interval is specified.	A.9.1
	2	Watchdog with separate time base and time-window	Timing elements with a separate time base (for example watch-dog timer) externally to the unit being monitored. The timing elements are periodically triggered to monitor the unit's behaviour and the plausibility of the program sequence. It is important that the triggering points are correctly placed in the program. A lower and upper time-out limit is given.	A.9.2
	3	Combination of temporal and logical monitoring of program sequences	This facility, monitoring the program sequence, is retriggered only if the sequence of the program sections is executed within the response time.  See also <a href="#">Table -B.5</a> , measure 'Reciprocal comparison by software for two-channel structure'.	A.9.4
<p>NOTES:</p> <p>A measure for a SIL3 can be used also for SIL2 and SIL1; a measure for a SIL2 can also be used also for SIL1. If more than one measure is indicated for a specific architecture, the measures are equivalent alternatives.</p>				

**Table B.11A.11 — Program Sequence**

Requirement	SIL	Measure	Description of measure	Informative reference <a href="#">IEC 61508-7:2010</a>
Wrong program sequence and inappropriate execution time of the safety related functions shall be detected.	1 + 2 + 3	Combination of timing and logical monitoring of program sequence	Use of an independent temporal facility (for example a watch-dog timer with separate time base) which is monitoring the program execution. This facility shall be re-triggered only if all functions required performing the safety function(s) and all diagnostic functions are executed correctly with respect to sequence by at least one checkpoint per function.  Note: The temporal facility shall not be triggered by an interrupt procedure except in combination with other program sequence conditions.	A.9.4
<p>NOTES:</p> <p>A measure for a SIL3 can be used also for SIL2 and SIL1; a measure for a SIL2 can also be used also for SIL1. If more than one measure is indicated for a specific architecture, the measures are equivalent alternatives.</p>				

**Table B.12A.12 — Power Supply**

Requirement	SIL	Measure	Description of measure	Informative reference <a href="#">IEC 61508-7:2010</a>
A voltage outside the specified operating voltage range shall be detected	1 + 2 + 3	Voltage control (secondary) with safety shut-off	To monitor the secondary voltages and initiate a safe condition if the voltage is not in its specified range.	A.8.2
<p>NOTES:</p> <p>A measure for a SIL3 can be used also for SIL2 and SIL1; a measure for a SIL2 can also be used also for SIL1, however the target DC<sub>sc</sub> shall be applied. If more than one measure is indicated for a specific architecture, the measures are equivalent alternatives.</p>				

**Table B.13A.13 — Inter-board Safety Related Data Communication Links of SIL-rated circuits**

Requirement	SIL	Measure	Description of measure	Informative reference
Structure			Any communication shall be based on a point-to-point request-response or time-stamped principle. The components shall have a direct interconnection	<del>IEC 61784-3:2021</del>
Failure detection of failures caused by a defect in the information transfer between the SIL-rated components				
- Corruption		Data integrity assurance	The transmitted message, consisting of the safety related information, the sequence number resp. time-stamp and the connection authentication information (if applicable) shall be protected using a cyclic redundancy check (CRC) algorithm for failure detection.	5.3.2 + 5.4.7
- Unintended repetition		Sequence number	A 16-bit sequence number is integrated into each message being transmitted. The sequence number is incremented for every message and checked by the receiver against continuity. After the full range of the 16-bit is reached, the sequence number re-starts.	5.3.3 + 5.4.2
- Incorrect sequence		Sequence number		5.3.4 + 5.4.2
- Loss		Sequence number		5.3.5 + 5.4.2
- Insertion		Sequence number		5.3.7 + 5.4.2
- Unacceptable delay		Time expectation	Time-stamped principle: The receiver checks that at least one communication cycle is performed successfully and the received time-stamp does not exceed a predetermined expectation with a deviation which shall be smaller than the response time in case of failure, so that in case of a violation, the SIL-rated component transitions into safe state within the response time in case of failure. Request-response principle: The transmitter checks that at least one successful request-response communication cycle is performed successfully and does not exceed a predetermined time interval which shall be smaller than the response time in case of failure, so that in case of a violation, the SIL-rated component transitions into safe state within the response time in case of failure.	5.3.6 + 5.4.3  5.3.6 + 5.4.4
- Masquerade		Different data protection	If the communication link is also used for non-safety related (NSR) communication, the safety related (SR) message shall have a different length than the NSR message. If the NSR communication is using a CRC, the CRC of the SR communication shall use a different CRC. <del>CRC of the SR shall be different than the CRC of the communication link. Example Ethernet communication link SR shall not use same CRC as used for Ethernet link.</del>	5.3.8 + 5.4.9
- Addressing		Connection authentication	Messages may have a unique source and/or destination identifier that describes the logical address of the safety related participant.	5.3.9 + 5.4.5

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Requirement	SIL	Measure	Description of measure	Informative reference
Black channel	1	$\lambda_{SetSrc} \leq 1 * 10^{-7} h$	The residual error rate $\lambda_{SetSrc}$ of any logical connection of each safety function shall be $\leq 2\%$ of the max. PFH <sub>src</sub> allowed for the target architecture.	5.8 <a href="#">IEC 61784-3:2021</a>
	2	$\lambda_{SetSrc} \leq 1 * 10^{-8} h$	In case of dual channel communication (physical or time redundant) the logical connection's residual error rates $\lambda_{SetSrc}$ of the associated safety function can be multiplied.	
	3	$\lambda_{SetSrc} \leq 1 * 10^{-9} h$	For the determination of the application specific residual error rate of a SIL-rated communication link see <a href="#">Table B.17A.17</a> .	
NOTES:				
PFH <sub>src</sub> : Probability of a dangerous failure on demand (Valid for a request of the safety function less than once a year) of the SIL-rated circuit				
PFH <sub>src</sub> : Probability of a dangerous failure per hour (Valid for a request of the safety function more than once a year) of the SIL-rated circuit				

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### A.4 B.3 Functional Safety Management

Table B.14A.14 — Functional Safety Management Measures

Measure	Description of measures	Informative reference
<a href="#">Quality measurement measures</a>		
— <a href="#">Project description</a>	— <a href="#">Name(s) of the product(s)</a>	<a href="#">7.2</a>
	— <a href="#">Objective of the project</a>	<a href="#">7.3</a>
— <a href="#">Project organization</a>	— <a href="#">What does/do the product(s) intend to achieve</a>	
	— <a href="#">Description of roles, responsibilities and functions involved in the project for internal and external organizations</a>	<a href="#">6.2.1</a>
— <a href="#">Roles</a>	— <a href="#">Project related organizational chart of internal and external organizations involved in the project</a>	
	— <a href="#">List of all persons involved in the project with their roles</a>	<a href="#">6.2.1</a> <a href="#">6.2.3</a>
— <a href="#">Competencies</a>	— <a href="#">Documented evidence about competence of the assigned persons performing the assigned task(s) and about the use of tools based on training(s) and experience.</a>	<a href="#">6.2.13</a> <a href="#">6.2.14</a> <a href="#">6.2.15</a>
	— <a href="#">Assignment of responsibilities regarding creation and verification of work products</a>	<a href="#">6.2.1</a> <a href="#">6.2.3</a>
— <a href="#">Communication</a>	— <a href="#">Documentation how and by which means the members of the project and how the involved organizations of the project communicate with each other regularly</a>	<a href="#">6.2.2</a> <a href="#">6.2.4</a>
	— <a href="#">How is ensured that all members of the project have access to the actual (same) database</a>	<a href="#">6.2.2</a> <a href="#">6.2.4</a>
<a href="#">Modifications</a>	— <a href="#">The development activities shall be tailored with respect to the planned modifications, based on an impact analysis</a>	<a href="#">6.2.8</a>
<a href="#">Configuration Management</a>	— <a href="#">All parts (HW and SW) building the product shall be clearly determinable; in case of configurable systems, compatibility between system components shall be identified.</a>	<a href="#">6.2.10</a>
<a href="#">Suppliers</a>	— <a href="#">Suppliers shall have a proper quality management system (e.g. ISO 9001).</a>	<a href="#">6.2.17</a>

Measure	Description of measures	Informative reference IEC 61508-1:2010
Lifecycle	<ul style="list-style-type: none"> <li>- Relevant life cycle phase with respect to the <del>type examination</del> verification of an SIL-rated circuit is the development phase of the SIL-rated circuit.</li> <li>- Nevertheless the product/user documentation shall cover the risks of subsequent phases such as production, installation, operation, maintenance and decommissioning.</li> </ul>	6.2.18
Functional Safety Assessment	<ul style="list-style-type: none"> <li>- Assessment of the functional safety is performed by <del>an</del> independent body.</li> </ul>	8
Verification	<ul style="list-style-type: none"> <li>- Planning and execution of verification activities independent from the creator.</li> </ul>	7.18
Tools	<ul style="list-style-type: none"> <li>- Listing of all tools and its versions generating any output which goes directly into the product or which are being used to test or verify the design or executable code of the product. For these tools                             <ul style="list-style-type: none"> <li>▪ a bug list shall be available.</li> <li>▪ an evidence of about 2 years of increased confidence from use shall exist.</li> <li>▪ the version of a tool shall not be changed unless justified.</li> </ul> </li> </ul>	B.3.5 C.4.4

**A.5 B.4 Designated architectures and calculation formulas**

**Table B.15A.15 — Designated architectures**

Requirement	SIL	Architecture
<p>The structure shall be such that the required Safe Failure Fraction will be achieved in line with the applicable failure detection and control measures as required by Tables B.5A.5 to B.12A.12.</p>	1	
	2	
	3	
<p>Notes:  S, S1, S2: - Input device, e.g. sensor  L, L1, L2: Logic  O, O1, O2: Output device, e.g. relay (safety function)  im: Interconnecting means  m: Monitoring  c: Cross monitoring  WD: Watchdog  OWD: Output of WD (shut-down only, not safety function)  TMU: Test and monitoring unit  OTMU: Output of TMU (shut-down only, not safety function)</p>		

**Table B-16A.16 — Calculation of safety-related parameters**

Requirement	SIL	Formula
Sufficiently low probability of a dangerous failure on demand (PFD <sub>src</sub> ) and probability of a dangerous failure per hour (PFH <sub>src</sub> )	1	$PFD_{SrcSLO} = 0.25\lambda_D T_1$ $PFH_{SrcSLO} = 0.5\lambda_D$
	2	$PFD_{SrcSLO} = 0.1\lambda_D T_1$ $PFH_{SrcSLO} = 0.2\lambda_D$
	3	<p>Sensor subsystem:</p> $PFD_{SrcS} = 0.0027(\lambda_D T_1)^2 + 0.005\lambda_D T_1$ $PFH_{SrcS} = 0.081\lambda_D^2 T_1 + 0.01\lambda_D$ <p>Logic subsystem:</p> $PFD_{SrcLO} = 0.003(\lambda_D T_1)^2 + 0.0025\lambda_D T_1$ $PFH_{SrcLO} = 0.0903\lambda_D^2 T_1 + 0.005\lambda_D$ <p>Sum:</p> $PFD_{SrcSLO} = PFD_{SrcS} + PFD_{SrcLO}$ $PFH_{SrcSLO} = PFH_{SrcS} + PFH_{SrcLO}$
<p>NOTES:</p> <p>PFD: Probability of a dangerous failure on demand (Valid for a request of the safety function less than once a year)</p> <p>PFH: Probability of a dangerous failure per hour (Valid for a request of the safety function more than once a year)</p> <p>Src. SLO: SIL-rated circuit's sensor or logic+output</p> <p>Src. S: SIL-rated circuit's sensor</p> <p>Src. LO: SIL-rated circuit's logic+output</p> <p>T1: Proof test interval; for the value see other standards calling for the use of this standard (e.g. ISO 8100-1:2023, 5.11.2.4.34.11.2.4.3)</p> <p>The formulas for SIL1 and SIL2 are applicable for the SIL-rated circuit's sensor part as well as for the SIL-rated circuit's logic part including its output elements</p> <p>For SIL3 individual formulas are to be applied to the SIL-rated circuit's sensor part (Src. S), and the SIL-rated circuit's logic part (Src. L) including its output elements</p> <p>The formulas for SIL3 assume an architecture consisting of two identical channels</p> <p>For the component failure rates preferably manufacturer's failure rates shall be used, or if not available IEC 61709:2017 shall be used</p> <p>For SIL1 and SIL2 <math>\lambda_D</math> is derived – dependent on the formula being applied, by adding all component's <math>\lambda_D</math> identified by the FMEDA (see Table B.3) either of the sensor plus the logic (Src. SL) or, on the one hand for the sensor (Src. S) and on the other hand for the logic (Src. LO)</p> <p>For SIL3 <math>\lambda_D</math> is derived – dependent on the formula being applied, by adding the individual <math>\lambda_D</math> of all components identified by the FMEDA (see Table B.3) in the considered part of the Src (Src. SLO, Src. S, Src. LO)</p> <p><sup>1)</sup> Sum of the probabilities for the sensor and the logic subsystems. For the component failure distribution of <math>\lambda_D</math> and <math>\lambda_S</math> a share of 50%/50% has been applied.</p> <p>The formulas assume a common cause failure fraction of 10% for the sensor subsystem and 5% for the logic subsystem. As a result of the measures acc. tables B.4 to B.12 to be applied for a SIL 1 measure a DC of 50%, for a SIL 2 measure a DC of 80% and for a SIL 3 measure a DC of 90% has been assumed.</p> <p>NOTE: WD / OWD / MTU / OMTU have not been included in the calculation of PFH/PFD, but all other measures apply.</p>		

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**Table B.17A.17 — Calculation of the residual error rate of a SIL-rated communication link**

Requirement	SIL	Formula	Value to be achieved for the SIL-rated communication link
Sufficiently low residual error rate of the SIL-rated communication link	1 + 2 + 3	$\lambda_{S_{rcel}} = 2^{-r} v m$	<p>SIL1: <math>\lambda_{S_{rcel}} \leq 1 * 10^{-7} h^{-1}</math></p> <p>SIL2: <math>\lambda_{S_{rcel}} \leq 1 * 10^{-8} h^{-1}</math></p> <p>SIL3: <math>\lambda_{S_{rcel}} \leq 1 * 10^{-9} h^{-1}</math></p>
<p>NOTES:</p> <p><math>\lambda_{S_{rcel}}</math>: Residual error rate per hour of the SIL-rated communication link with respect to the bit error probability</p> <p>Sel: SIL-rated communication link</p> <p>r: number of bits of the proper CRC polynomial</p> <p>v: Maximum sample rate of messages per hour</p> <p>m: Maximum number of logical connections for the safety function</p> <p>A proper CRC shall be used. A CRC polynomial can be considered to be proper when both the most significant bit and the least significant bit are always '1'.</p>			

**Table B.18A.18 — List of practices and rules of structured programming**

Measure	Obligation	Description of measure	Informative reference IPA/SEC ESCR 3.0
<b>Reliability 1: Initialize areas and use them by taking their sizes into consideration.</b>			
Use areas after initializing them.	M	Automatic variables shall be initialized at the time of declaration, or the initial values shall be assigned just before using them.	R1.1.1
		const variables shall be initialized at the time of declaration.	R1.1.2
Describe initializations without excess or deficiency	M	Arrays with specified number of elements shall be initialized with values that match the number of the elements.	R1.2.1
		Initialization of enumeration type (enum type) members shall be by either: not specifying any constants; specifying all the constants; or specifying only the first member.	R1.2.2
Pay attention to the range of the area pointed by a pointer.	HR	Integer addition to or subtraction from (including ++ and --) pointers shall not be made; Array format with [ ] shall be used for references and assignments to the allocated area. (2) Integer addition to or subtraction from (including ++ and --) pointers shall be made only when the pointer points to the array and the result must be pointing within the range of the array.	R1.3.1
	M	Subtraction between pointers shall only be applied to pointers that address elements of the same array.	R1.3.2
	M	Comparison between pointers shall be used only when the two pointers are both pointing at either the elements in the same array or the members of the same structure.	R1.3.3
	M	The restrict type qualifier shall not be used.	R1.3.4
<b>Reliability 2: Use data by taking their ranges, sizes and internal representations into consideration.</b>			
Make comparisons that do not depend on internal representations.	M	Floating-point expressions shall not be used to perform equality or inequality comparisons.	R2.1.1
	M	Floating-point variable shall not be used as a loop counter.	R2.1.2
	HR	memcmp shall not be used to compare structures and unions.	R2.1.3

Measure	Obligation	Description of measure	Informative reference IPA/SEC ESCR 3.0
When values such as logical values are defined as a range, do not make a judgment by finding whether or not a value is equivalent to any particular value (representative value) within this range.	HR	Comparison with a value defined as true shall not be made in expressions that examine true or false.	R2.2.1
Use the same data type to perform operations or comparisons.	M	Unsigned integer constant expressions shall be described within the range that can be represented with the result type.	R2.3.1
	M	When using conditional operator (?: operator), the logical expression shall be enclosed in parentheses ( ) and both return values shall be the same type.	R2.3.2
	M	Loop counters and variables used for comparison of loop iteration conditions shall be the same type.	R2.3.3
Describe code by taking operation precision into consideration.	HR	When the type of an operation and the type of the destination to which the operation result is assigned (assignment destination) are different, the operation shall be performed after casting them to the type of expected operation precision.	R2.4.1
	HR	When performing arithmetic operations or comparisons of expressions mixed with signed and unsigned, an explicit cast to the expected type shall be performed.	R2.4.2
Do not use operations that have the risk of information loss.	M	When performing assignments (=operation, actual arguments passing of function calls, function return) or operations to data types that may cause information loss, they shall be first confirmed that there are no problems, and a cast shall be described to explicitly state that they are problem-free.	R2.5.1
	M	Unary operator '-' shall not be used in unsigned expressions.	R2.5.2
	M	When ones' complement (~) or left shift (<<) is applied to unsigned char or unsigned short type data, an explicit cast to the type of the operation result shall be performed.	R2.5.3
	HR	The right-hand side of a shift operator shall be zero or more, and less than the bit width of the left-hand side.	R2.5.4
Use types that can represent the target data.	M	(1) The types used for bit fields shall only be signed int or unsigned int. If a bit field of 1-bit width is required, unsigned int type shall be used, and not the signed int type. (2) The types used for bit fields shall be signed int, unsigned int or Bool. If a bit field of 1 bit width is required, unsigned int type or Bool type shall be used. (3) The types used for bit fields shall be signed int, unsigned int, Bool, or those allowed by the compiler that are either enum or the type that specifies signed or unsigned. If a bit field of 1-bit width is required, the type that specifies unsigned or Bool type shall be used.	R2.6.1
	M	Data used as bit sequences shall be defined with unsigned type, and not with the signed type.	R2.6.2

Measure	Obligation	Description of measure	Informative reference IPA/SEC ESCR 3.0
Pay attention to pointer types.	M	(1) Pointer type shall not be converted to other pointer type or integer type, and vice versa, with the exception of mutual conversion between "pointer to data" type and "pointer to void*" type. (2) Pointer type shall not be converted to other pointer type or integer type with less data width than that of the pointer type, with the exception of mutual conversion between "pointer to data" type and "pointer to void*" type. (3) Pointer type shall not be converted to other pointer type or integer type with less data width than that of the pointer type, with the exception of mutual conversion between "pointer to data" type and "pointer to other data" type, and between "pointer to data" type and "pointer to void*" type.	R2.7.1
	M	A cast shall not be performed that removes any const or volatile qualification from the type addressed by a pointer.	R2.7.2
	M	Comparison to check whether a pointer is negative or not shall not be performed.	R2.7.3
R2.8 Write in a way that will enable the compiler to check that there are no conflicting declarations, usages and definitions.	M	Functions with no parameters shall be declared with a void type parameter.	R2.8.1
	M	(1) Functions shall not be defined with a variable number of arguments (2) When using functions with a variable number of arguments, «they shall be used after documenting the intended behaviors based on the compiler used.»	R2.8.2
	M	One prototype declaration shall be made at one place from where it can be referenced by both the function calls and function definition.	R2.8.3
<b>Reliability 3: Write in a way that ensures intended behavior.</b>			
Write in a way that is conscious of area size.	HR	(1) In an extern declaration of an array, the number of elements shall always be specified. (2) In an extern declaration of an array, the number of elements shall always be specified, except for extern declarations of arrays that correspond to the array definition that includes initialization and has omitted the number of elements.	R3.1.1
	M	Iteration conditions for a loop to sequentially access array elements shall include the decision to whether the access is within the range of the array or not.	R3.1.2
	M	The size of the array initialized with a designated initializer shall be clearly indicated.	R3.1.3
	M	Variable length array type shall not be used.	R3.1.4
	M	(1) sizeof operator shall not be applied to pointer-type variable. (2) sizeof operator shall not be applied to array-type argument.	R3.1.5
Prevent operations that may cause runtime error from falling into error cases.	M	Operations shall be performed after confirming that the right-hand side expression of division or remainder operation is not 0.	R3.2.1
	M	Destination pointed by a pointer shall be referenced to after checking that the pointer is not the null pointer.	R3.2.2
Check the interface restrictions when a function is called.	M	If a function returns error information, then that error information shall be tested.	R3.3.1
	M	The function shall check if there are constraints on parameters before starting to process.	R3.3.2
Do not perform recursive calls.	M	Functions shall not call themselves, either directly or indirectly.	R3.4.1

Measure	Obligation	Description of measure	Informative reference IPA/SEC ESCR 3.0
Pay attention to branch conditions and describe how to handle cases that do not follow the predefined conditions when they occur.	M	«The else clause shall be written at the end of an if-else if statement. If it is known that the else condition does not normally occur, the description of the else clause shall be either one of the following: (i) An exception handling process shall be written in the else clause. (ii) A comment specified by the project shall be written in the else clause.»	R3.5.1
	M	«The default clause shall be written at the end of a switch statement. If it is known that the default condition does not normally occur, the description of the default clause shall be either one of the followings. «(i) An exception handling process shall be written in the default clause. (ii) A comment specified by the project shall be written in the default clause.»	R3.5.2
	HR	Equality operators (==) or inequality operators (!=) shall not be used for comparisons of loop counters. (<=, >=, <, or > shall be used.)	R3.5.3
Pay attention to the order of evaluation.	M	Variables whose values are changed in an expression shall not be referred to or modified in the same expression.	R3.6.1
	M	Function calls with side effects and volatile variables shall not be described more than once in a sequence of actual arguments or binary operation expressions.	R3.6.2
	HR	sizeof operator shall not be used in expressions that have side effect.	R3.6.3
Be careful with how to access the shared data in programs that use threads or signals.	M	For concurrent processing, volatile shall not be used as synchronization primitive.	R.3.1.1.1
	M	The bit fields that may be allocated in the same memory space shall not be accessed by multiple threads or shall be exclusively controlled properly.	R.3.1.1.2
<b>Maintainability 1: Keep in mind that others will read the program</b>			
Do not leave unused descriptions.	HR	Unused functions, variables, parameters, typedefs, tags, labels or macros shall not be declared (defined).	M1.1.1
	HR	Sections of code should not be "commented out".	M1.1.2
Do not writing confusingly.	HR	(1) Only one variable shall be declared in one declaration statement (avoid multiple declarations.) (2) Automatic variables of the same type used for the similar purposes may be declared in one declaration statement, but variables with initialization and variables without initialization shall not be mixed.	M1.2.1
	M	Suffixes shall be added to constant descriptions that can use them to indicate appropriate types. Only an uppercase letter "L" shall be used for a suffix indicating a long type integer constant.	M1.2.2
Do not write in an unconventional style.	HR	Expressions evaluating to true or false shall not be described in switch (expression).	M1.3.1
	M	The case labels and default label in a switch statement shall be described only in the compound statement (excluding nested compound statements) within the body of the switch statement.	M1.3.2
	M	The types shall be explicitly described for definitions and declarations of functions and variables.	M1.3.3
Write in a style that clearly specifies the operator precedence.	M	Expressions described at the right hand and left hand of && and    operations shall be either simple variables or expressions enclosed with (. However, if only && operations or only    operations are successively combined, it is not necessary to enclose each && and    expression with ( ).	M1.4.1
	M	«Usage of parentheses to explicitly indicate operator precedence shall be defined.»	M1.4.2

Measure	Obligation	Description of measure	Informative reference IPA/SEC ESCR 3.0
Explicitly describe the operations that are likely to cause misunderstanding when they are omitted.	M	A function identifier (function name) shall only be used with either a preceding "&", or with a parenthesized parameter list, which may be empty.	M1.5.1
Use one area for one purpose.	M	Variables shall be prepared for each purpose.	M1.6.1
	HR	(1) Unions shall not be used. (2) If unions are used, the same members that are assigned values shall be referenced.	M1.6.2
Do not reuse names.	HR	The rules below shall be followed for name uniqueness. 1. An identifier declared in an inner scope shall not hide an identifier declared in an outer scope. 2. A typedef name shall be a unique identifier. 3. A tag name shall be a unique identifier. 4. Identifiers that define objects or functions with external linkage shall be unique. 5. Identifiers that define objects or functions with internal linkage should be unique. 6. No identifier in one name space should have the same spelling as an identifier in another name space, with the exception of structure member and union member names.	M1.7.1
	M	Names for functions, variables and macros in the standard library shall not be redefined or reused. In addition, those macro names shall not be undefined.	M1.7.2
	M	Names (variables) that start with an underscore shall not be defined.	M1.7.3
Do not use language specifications that are likely to cause misunderstanding.	HR	The right-hand operand of a logical && or    operator shall not contain side effects.	M1.8.1
	HR	C macros shall only expand to a braced initializer, a constant, a parenthesised expression, a type qualifier, a storage class specifier, or a do-while-zero construct.	M1.8.2
	M	#line shall not be used, unless it is automatically generated by a tool.	M1.8.3
	M	Sequences of three or more characters starting with ?? and alternative tokens shall not be used.	M1.8.4
	M	A sequence starting with zero (0) that is two or more digits long shall not be used as a constant.	M1.8.5
When writing in an unconventional style, explicitly state its intention.	HR	If statements that do nothing need to be intentionally described, comments or empty macros shall be used to make them noticeable.	M1.9.1
	HR	«(The unified style of writing infinite loops shall be defined.)»	M1.9.2
Do not embed magic numbers.	HR	A meaningful constant shall be used after defining it as a macro.	M1.10.1
Explicitly state the area attributes	M	Read-only areas shall be declared as const type.	M1.11.1
	M	Areas that may be updated by other execution units shall be declared as volatile.	M1.11.2
Correctly describe the statements even if they are not compiled.	HR	Correct code shall be described even if it is going to be deleted by the preprocessor.	M1.12.1

Measure	Obligation	Description of measure	Informative reference IPA/SEC ESCR 3.0
		<b>Maintainability2: Write in a style that can prevent modification errors.</b>	
Clarify the grouping of structured data and blocks.	M	If arrays and structures are initialized with values other than 0, their structural form shall be indicated by using braces '{ }'. Data shall be described without any omission, except when all values are 0.	M2.1.1
	HR	The body of if, else if, else, while, do, for, and switch statements shall be enclosed into blocks.	M2.1.2
Localize access ranges and related data.	M	Variables used only in one function shall be declared within the function.	M2.2.1
	M	Variables accessed by several functions defined in the same file shall be declared with static in the file scope..	M2.2.2
	M	Functions that are called only by functions defined in the same file shall be static.	M2.2.3
	HR	enum shall be used rather than #define when defining related constants.	M2.2.4
		<b>Maintainability3: Write programs simply.</b>	
Do structured programming.	HR	For any iteration statement, there shall be at most one break statement used for loop termination.	M3.1.1
	HR	(1)The goto statement shall not be used. (2) When using a goto statement, the destination to jump to shall be the label declared after the goto statement that is in the same block or within the block enclosing the goto statement.	M3.1.2
	M	(1) Each case clause and default clause in a switch statement shall always end with a break statement. (2) If the case clause or default clause in a switch statement is not going to be ended with a break statement, «a project-specific comment shall be defined» and that comment shall instead be inserted.	M3.1.4
	M	(1) A function shall end with one return statement. (2) A return statement to return in the middle of processing shall be written only in case of recovery from abnormality.	M3.1.5
One statement should have one side effect.	HR	(1) Comma expressions shall not be used. (2) Comma expressions shall not be used, other than in expressions for initializing or updating in for statements.	M3.2.1
	M	Multiple assignments shall not be written in one statement, except when the same value is assigned to multiple variables.	M3.2.2
Separately describe expressions with different purposes.	M	The three expressions of a for statement shall be concerned only with loop control.	M3.3.1
	M	Numeric variables being used within a for loop for iteration counting shall not be modified in the body of the loop.	M3.3.2
	M	(1) Assignment operators shall not be used in expressions to examine true or false. (2) Assignment operators shall not be used in expressions to examine true or false, except for conventionally used notations.	M3.3.3
Do not use complicated pointer operations.	M	Three or more pointer indirections shall not be used.	M3.4.1
		<b>Maintainability: Write in a unified style.</b>	
Unify the coding styles.	HR	«Conventions regarding the style of using, such as, the braces '{ }', indentation and space shall be defined.»	M4.1.1
Unify the style of writing comments.	HR	«Convention regarding the style of writing file header comments, function header comments, end of line comments, block comments and copyright shall be defined.»	M4.2.1
Unify the naming conventions.	HR	«Convention for naming external variables and internal variables shall be defined.»	M4.3.1
	HR	«Convention for naming files shall be defined.»	M4.3.2

Measure	Obligation	Description of measure	Informative reference IPA/SEC ESCR 3.0
Unify the contents to be described in a file and the order of describing them.	HR	«The descriptive contents of header files (declarations, definitions, etc) and the order they are described in shall be defined.»	M4.4.1
Unify the contents to be described in a file and the order of describing them.	HR	«The descriptive contents of source files (declarations, definitions, etc) and the order they are described in shall be defined.»	M4.4.2
	HR	To use or define external variables or functions (except for functions used only in the file), the header file describing their declarations shall be included.	M4.4.3
	HR	External variables shall not be defined in multiple locations.	M4.4.4
	HR	Variable definitions or function definitions shall not be described in a header file.	M4.4.5
	M	Header files shall be descriptively capable of handling redundant inclusions. «The descriptive method to achieve this capability shall be defined.»	M4.4.6
	Unify the style of writing declarations.	HR	(1) In a function prototype declaration, all the parameters shall not be named (types only). (2) In a function prototype declaration, all the parameters shall be named. In addition, the types of the parameters, their names and the type of the return value shall be literally the same as those of the function definition.
HR		Structure tags and variables shall be declared separately.	M4.5.2
Unify the style of writing null pointers.	M	NULL shall be used for the null pointer. NULL shall not be used for anything other than the null pointer.	M4.6.1
Unify the style of writing preprocessor directives.	M	The body and parameters of a macro that includes operators shall be enclosed with parentheses ( ).	M4.7.1
	HR	#else, #elif or #endif that correspond to #ifdef, #ifndef or #if shall be described in the same file, and «their correspondence relationship shall be clearly stated with a comment defined in the project».	M4.7.2
	HR	defined(macro_name) or defined macro_name shall be used to check whether the macro name has already been defined by #if or #elif.	M4.7.3
	M	Macros shall not be #define'd or #undef'd within a block.	M4.7.5
	HR	#undef shall not be used.	M4.7.6
	HR	Controlling expression of #if or #elif preprocessing directive shall be evaluated as 0 or 1.	M4.7.7
	<b>Maintainability5: Write in a style that makes testing easy.</b>		
Write in a style that makes it easy to investigate the causes of problems when they occur.	HR	«The rules for writing the code for setting debug options and for recording logs in release modules shall be defined.»	M5.1.1
	HR	(1) The # and ## preprocessor operators should not be used. (2) A macro parameter immediately following a # operator shall not immediately be followed by a ## operator.	M5.1.2
	HR	Function shall be used rather than using function-like macro.	M5.1.3
Be careful when using dynamic memory allocations.	M	Dynamic memory shall not be used.	M5.2.1

Measure	Obligation	Description of measure	Informative reference IPA/SEC ESCR 3.0
<b>Portability 1: Write in a style that is not dependent on the compiler.</b>			
Do not use functionalities that are advanced features or implementation-defined.	HR	(1) Functionalities not specified in the language standard shall not be used. (2) If functionalities not specified in the language standard are used, «the functionalities used and their usage shall be documented.»	P1.1.1
	M	«All usage of implementation-defined behavior shall be documented.»	P1.1.2
	M	To use a program written in another language, «its interface shall be documented and its usage shall be defined.»	P1.1.3
Use only the characters and escape sequences defined in the language standard.	M	To use characters other than those defined in the language standard for writing a program, the compiler specifications shall be confirmed, and «their usage shall be defined.»	P1.2.1
	HR	Only escape sequences defined in the language standard shall be used.	P1.2.2
Confirm and document data type representations, behavioral specifications of advanced functionalities and implementation-dependent parts.	M	Simple char type (that does not specify the signedness) shall be used only for storing character values. If a process that depends on signedness (implementation-defined) is required, unsigned char or signed char that specifies its signedness shall be used. Note: use <stdint.h> header and types	P1.3.1
	HR	The members of an enumeration type (enum) shall be defined with values that can be represented as int type.	P1.3.2
	HR	(1) Bit fields shall not be used. (2) bit fields shall not be used for data whose bit positions are meaningful. (3) «If it is being relied upon, the implementation-defined behavior and packing of bit fields shall be documented.»	P1.3.3
For source file inclusion, confirm the implementation-dependent parts and write in a style that is not implementation-dependent.	M	The #include directive shall be followed by either a <file-name> or "filename" sequence.	P1.4.1
	HR	«The usage of <> format and "" format for #include file specification shall be defined.»	P1.4.2
	M	Characters '\, ", /*, // and : shall not be used for file specification in #include.	P1.4.3
Write in a style that does not depend on the environment used for compiling.	M	The absolute path shall not be written for #include file specification.	P1.5.1
	HR	sizeof shall be used to determine the size of a type or variable.	P1.5.2

Measure	Obligation	Description of measure	Informative reference IPA/SEC ESCR 3.0
<b>Portability 2: Localize the code that has a problem with portability.</b>			
Localize the code that has a problem with portability.	HR	When assembly language programs are called from C language, «how to localize such parts shall be defined» ,such as, by expressing them as functions or inline functions of C language that contain only inline assembly language code or describing them using macros.	P2.1.1
	HR	(1) The basic types (char, int, long, long long, float, double and long double) shall not be used. Instead, the types defined by typedef shall be used. «The types defined by typedef that are used in the project shall be defined.» (2) When using any of the basic types (char, int, long, long long, float, double and long double) in a form that is dependent on its size, the type defined by typedef for each of these basic types shall be used. «The types defined by typedef that are used in the project shall be defined.»	P2.1.3
<p><b>NOTES:</b></p> <p>Obligation:</p> <p>M: The technique or measure is required (mandatory);</p> <p>HR: The technique or measure is highly recommended. If this technique or measure is not used then the rationale behind not using it shall be detailed;</p> <p>Rules which can be selected from several alternatives are indicated in column 'Description of measure' with brackets, e.g.(1), (2)</p> <p>Specific rules that need to be defined for each project or rules that need to be prescribed in a document are enclosed by « ».</p>			

## A.1 Common measures

**Table B.1 — Common measures to avoid and detect failures — Hardware design**

No.	Object	Measure	Reference to IEC 61508-7:2010
1	Processing unit	Use of watch dog.	A.9
2	Component selection	Use of components only within their specifications	
3	I/O units and interfaces incl. Communication links	Defined safe state in the event of power failure or reset	
4	Power supply	Defined safe shut-off state in case of over-voltage or under-voltage	A.9.2
5	Variable memory ranges	Use of only solid-state memories.	
6	Variable memory ranges	Read/write test of variable data memory during boot procedure	
7	Variable memory ranges	Remote access only to informative data (e.g. statistics)	
8	Invariant memory ranges	No possibility to change the program code, either automatically by the system or remote intervention	

No.	Object	Measure	Reference to IEC 61508-7:2010
9	Invariant memory ranges	Test of program code memory and fixed data memory during boot procedure with a method at least equivalent to sum check	A.4.2

Table B.2 — Common measures to avoid and detect failures — Software design

No.	Object	Measure	Reference to IEC 61508-7:2010
1	Structure	Program structure (i.e. modularity, data handling, interface definition) according to the state of the art (see IEC 61508-3).	B.3.4/C.2.1 C.2.9/C.2.7
2	Boot procedure	During boot procedures a safe state of the lift shall be maintained.	
3	Interrupts	Limited use of interrupts: Use of nested interrupts only if all possible sequences of interrupts are predictable.	C.2.6.5
4	Interrupts	No triggering of watchdog by interrupt procedure except in combination with other program sequence conditions.	A.9.4
5	Power down	No power down procedures, such as saving of data, for safety related functions.	
6	Memory management	Stack manager in the hardware and/or software with appropriate reaction procedure.	C.2.6.4/ C.5.4
7	Program	Iteration loops shorter than system reaction time, e.g. by limiting number of loops or checking execution time.	
8	Program	Array pointer offset checks, if not included in the used programming language.	C.2.6.6
9	Program	Defined handling of exceptions (e.g. divisions by zero, overflow, variable range checking etc.) which forces the system into a defined safe state.	
10	Program	No recursive programming, except in well tried standard libraries, in approved operating systems, or in high-level language compilers. For these exceptions separate stacks for separate tasks shall be provided and controlled by a memory management unit.	C.2.6.7
11	Program	Documentation of programming library interfaces and operating systems at least as complete as the user program itself.	
12	Program	Plausibility checks on data relevant to safety functions e.g. input patterns, input ranges, and internal data.	C.2.5/C.3.1
13	Program	If any operational mode can be invoked for testing or validation purposes normal operation of the lift shall not be possible until this mode has been terminated.	IEC 61508-1:2010, 7.7.2.1

No.	Object	Measure	Reference to IEC 61508-7:2010
14	Communication system (external and internal)	Reach a safe state with due consideration to the system reaction time in a bus communication system with safety functions in case of loss of communication or a fault in a bus participant.	A.7/A.9
15	Bus system	No reconfiguration of the CPU-bus system, except during the boot procedure. NOTE—Periodical refresh of the CPU-bus system is not considered as being reconfiguration.	C.3.13
16	I/O handling	No reconfiguration of I/O lines, except during the boot procedures. NOTE—Periodical refresh of the I/O configuration registers is not considered as being reconfiguration.	C.3.13

**Table B.3 — Common measures for the design and implementation process**

No.	Measure	Reference to IEC 61508-7:2010
1	Assessment of the functional, environmental and interface aspects of the application	A.14/B.1
2	Requirement specification including the safety requirements	B.2.1
3	Reviews of all specifications	B.2.6
4	Design documentation as required in 5.6.1 and in addition: — function description including system architecture and hardware/software interaction; — software documentation including function and program flow description	C.5.9
5	Design review reports	B.3.7/B.3.8, C.5.16
6	Check of reliability using a method such as failure mode and effect analysis (FMEA)	B.6.6
7	Manufacturer's test specification, manufacturer's test reports and field test reports	B.6.1
8	Instruction documents incl. limits for intended use	B.4.1
9	Repeat and update of above mentioned measures if the product is modified	C.5.23
10	Implementation of version control of hardware and software and its compatibility.	C.5.24

## B.1 A.1—Specific measures

Table B.4—Specific measures according to SIL 1

Components and functions	Requirements	Measures	see No. in B.7	Reference to IEC 61508-7:2010
Structure	The structure shall be such that any single random failure is detected and the system shall go into a safe state.	One channel structure with self-test, or - - two channels or more with comparison.	M 1.1 - - M 1.3	A.3.1 - - A.2.5
Processing units	Failures in processing units, which can lead to incorrect results, shall be detected. If such a failure can lead to a dangerous situation the system shall go into a safe state.	Failure correcting hardware, or - self-test by software, or comparator for two-channel structure, or - reciprocal comparison by software for 2-channel structure.	M 2.1 - M 2.2 M 2.4 - - M 2.5	A.3.4 - - A.3.1 A.1.3 - - A.3.5
Invariant memory ranges	Incorrect information modification, i.e. all odd bit or 2-bit failures and some 3-bit and multi-bit failures shall be detected at the latest before the next travel of the lift.	The following measures refer only to a one-channel structure: - - one-bit redundancy (parity-bit), or - - block safety with one-word redundancy.	- - - - M 3.5 - - M 3.1	- - - - A.5.5 - - A.4.3
Variable memory ranges	Global failures during addressing, writing, storing and reading as well as all odd bit and 2-bit failures and some 3-bit failures and multi-bit failures shall be detected at the latest before the next travel of the lift.	The following measures refer only to a one-channel structure: - - Word-saving with multi-bit redundancy, or - - check via test pattern against static or dynamic faults.	- - - - M 3.2 - - M 4.1	- - - - A.5.6 - - A.5.2
I/O units and interfaces incl. communication links	Static failures and cross talk on I/O lines as well as random and systematic failures in the data flow shall be detected at the latest before the next travel of the lift.	Code safety, or - test pattern.	M 5.4 - M 5.5	A.6.2 - A.6.1

Components and functions	Requirements	Measures	see No. in B.7	Reference to IEC 61508-7:2010
Clock	Failures in clock-generation for processing units like frequency modification or break down shall be detected at the latest before the next travel of the lift.	Watchdog with separate time base, or reciprocal monitoring.	M 6.1 - M 6.2	A.9.4
Program sequence	Wrong program sequence and inappropriate execution time of the safety related functions shall be detected at the latest before the next travel of the lift.	Combination of timing and logical monitoring of program sequence	M 7.1	A.9.4

NOTE—As a consequence of the detection of a failure, a safe state of the lift shall be maintained.

**Table B.5 — Specific measures according to SIL 2**

Components and functions	Requirements	Measures	see No. in B.7	Reference to IEC 61508-7:2010
Structure	The structure shall be such that any single random failure is detected with due consideration to the system reaction time and that the system goes into a safe state.	One channel with self-test and monitoring, or	M 1.2	A.3.3
		- two channels or more with comparison.	M 1.3	A.2.5
Processing units	Failures in processing units, which can lead to incorrect results, shall be detected with due consideration to the system reaction time. If such a failure can lead to a dangerous situation the system shall go into a safe state.	Failure correcting hardware, and	M 2.1	A.3.4
		- software self-test supported by hardware for one-channel structure, or	M 2.3	A.3.3
		- comparator for 2-channel structure, or	M 2.4	A.1.3
		- reciprocal comparison by software for 2-channel structure.	M 2.5	A.3.5
Invariant memory ranges	Incorrect information modification, i.e. all odd-bit or 2-bit failures and some 3-bit and multi-bit failures shall be detected with due consideration to the system reaction time.	The following measures refer only to a one-channel structure:	-	-
		-	-	-
		-	-	-
		Block safety with one-word redundancy, or	M 3.1	A.4.3
		- word-saving with multi-bit redundancy.	M 3.2	A.5.6

Components and functions	Requirements	Measures	see No. in B.7	Reference to IEC 61508-7:2010
Variable memory ranges	Global failures during addressing, writing, storing and reading as well as all odd bit and 2-bit failures and some 3-bit failures and multi-bit failures shall be detected with due consideration to the system reaction time.	The following measures refer only to a one-channel structure: - - Word-saving with multi-bit redundancy, or - - check via test pattern against static or dynamic faults.	- - - - M 3.2 - - M 4.1	- - - - A.5.6 - - A.5.2
I/O units and interfaces incl. communication links	Static failures and cross talk on I/O lines as well as random and systematic failures in the data flow, shall be detected with due consideration to the system reaction time.	Code safety, or - - test pattern.	M 5.4 - M 5.5	A.6.2 - A.6.1
Clock	Failures in clock generation for processing units like frequency modification or break down shall be detected with due consideration to the system reaction time.	Watchdog with separate time base, or - - reciprocal monitoring.	M 6.1 - - M 6.2	A.9.4
Program sequence	Wrong program sequence and inappropriate execution time of the safety-function shall be detected with due consideration to the system reaction time.	Combination of timing and logical monitoring of program sequence.	M 7.1	A.9.4

NOTE—As a consequence of the detection of a failure, a safe state of the lift shall be maintained.

**Table B.6—Specific measures according to SIL 3**

Components and functions	Requirements	Measures	see No. in B.7	IEC 61508-7:2010 reference
Structure	The structure shall be such that any single random failure is detected with due consideration to the system reaction time and that the system goes into a safe state.	2 channels or more with comparison.	M 1.3	A.2.5
Processing units	Failures in processing units, which can lead to incorrect results, shall be detected with due consideration to the system reaction time.  If such a failure can lead to a dangerous situation the system shall go into a safe state.	Comparator for two channels, or - - reciprocal comparison by software for 2-channel structure.	M 2.4 - - M 2.5	A.1.3 - - A.3.5

Components and functions	Requirements	Measures	see No. in B.7	IEC 61508-7:2010 reference
Invariant memory ranges	Incorrect information modification, i.e. all 1-bit or multi-bit failures, shall be detected with due consideration to the system reaction time.	Block safety procedure with block replication, or	M-3.3	A.4.5
		-	-	-
		block safety with multi-word redundancy.	M-3.4	A.4.4
Variable memory ranges	Global failures during addressing, writing, storing and reading as well as static bit failures and dynamic couplings shall be detected with due consideration to the system reaction time.	Block safety procedure with block replication, or	M-4.2	A.5.7
		-	-	-
		inspection checks such as "Galpat".	M-4.3	A.5.3
I/O units and interfaces incl. communication links	Static failures and cross-talk on I/O lines as well as random and systematic failures in the data flow, shall be detected with due consideration to the system reaction time.	Multi-channel parallel input and	M-5.1	A.6.5
		-	-	-
		multi-channel parallel output, or	M-5.3	A.6.3
		-	-	-
		output read back, or	M-5.2	A.6.4
		-	-	-
Clock	Failures in clock generation for processing units like frequency modification or break down shall be detected with due consideration to the system reaction time.	Watchdog with separate time base, or	M-6.1	A.9.4
		-	-	-
		reciprocal monitoring.	M-6.2	-
Program sequence	Wrong program sequence and inappropriate execution time of the safety function shall be detected with due consideration to the system reaction time.	Combination of timing and logical monitoring of program sequence.	M-7.1	A.9.4

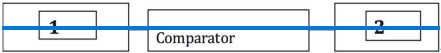

NOTE – As a consequence of the detection of a failure, a safe state of the lift shall be maintained.

### B.2 A.1 – Descriptions of possible measures

Table B.7 contains descriptions of possible measures which are considered to be helpful when fulfilling the requirements laid down in the standards calling for the use of this document (e.g. ISO 8100-1:2019, 5.11.2.6).

Table B.7—Description of possible measures to failure control

Components and functions	Measure No.	Description of measures
Structure	<b>M.1.1</b>	<p><b>One channel structure with self-test</b></p> <p>Description: Even though the structure consists of a single channel, redundant output paths shall be provided to ensure a safe shutdown. Self-tests (cyclical) are applied to the sub-units of the PESSRAL at time intervals which may be application dependent. These tests (e.g. CPU tests or memory tests) are designed to detect latent failures which are independent of the data flow. A detected failure shall cause the system to go into a safe state.</p>
	<b>M.1.2</b>	<p><b>One channel structure with self-test and monitoring</b></p> <p>Description: A one channel structure with self-test and monitoring consists of a separate hardware monitoring unit which, independent of the application, periodically receives test data from the system which might result from self-test procedures. In case of incorrect data, the system shall go into a safe state. At least two independent shut-down paths are needed so that a shutdown can be caused either by the processing unit itself or by the monitoring unit.</p>
	<b>M.1.3</b>	<p><b>Two channels or more with comparison</b></p> <p>Description: Two channel safety-related design consists of two independent and feedback-free functional units. This allows the specified functions to be processed independently in each channel. For a two-channel PESSRAL exclusively designed for the function of one safety device the design of the channels may be identical in terms of hardware and software. In the case of a two-channel PESSRAL used for complex solutions (e.g. combinations of several safety functions) and where the processes or conditions are not definitely verifiable, diversity for hardware and software should be considered. The structure includes a function which compares internal signals (e.g. bus comparison) and/or output signals which are relevant to safety functions in order to aid failure detection. At least two independent shut-down paths are needed so that a shutdown can be caused either by the channels themselves or by the comparator. The comparison itself also shall be subject to the failure recognition.</p>
Processing units	<b>M.2.1</b>	<p><b>Failure correcting hardware</b></p> <p>Description: Such units can be realized using special failure recognizing or failure correcting circuit techniques. These techniques are known for simple structures.</p>
	<b>M.2.2</b>	<p><b>Self-test by software</b></p> <p>Description: All the functions of the processing unit, which are used in the safety-related application shall be tested cyclically. These tests can be combined with the test of the sub-components, e.g. memories, I/O's etc.</p>

Components and functions	Measure No.	Description of measures
	M.2.3	<p><b>Software self-test supported by hardware</b></p> <p>Description: A special hardware facility is used for the failure detection which supports the self-test functions. For example, a monitoring unit which checks the periodic output of certain bit patterns.</p>
	M.2.4	<p><b>Comparator for 2 channel structures</b></p> <p>Description:</p>  <p>Two channels with hardware comparator:</p> <p>a) The signals of both processing units are compared using a hardware unit cyclically or continuously. The comparator can be an externally tested unit or designed as a self-monitoring device or</p> <p>b) The signals of both channels are compared using a processing unit. The comparator can be an externally tested unit or designed as a self-monitoring device.</p>
	M.2.5	<p><b>Reciprocal comparison of 2 channels</b></p> <p>Description:</p>  <p>Two redundant processing units are used which exchange safety relevant data reciprocally. A comparison of the data are carried out by each unit.</p>
Invariant memory ranges (ROM, EPROM...)	M.3.1	<p><b>Block safety procedure with one word redundancy (e.g. signature formation via ROM with single word width)</b></p> <p>Description: In this test, the contents of the ROM are compressed by a certain algorithm to at least one memory word. The algorithm e.g. cyclic redundancy check (CRC), can be realized using hardware or using software.</p>
	M.3.2	<p><b>Word saving with multi-bit redundancy (e.g. modified hamming code)</b></p> <p>Description: Every word of the memory is extended by several redundant bits to produce a modified hamming code with a hamming distance of at least 4. Every time a word is read, one can determine whether a corruption has taken place by checking the redundant bits. If a difference is found, the system shall go into a safe state.</p>
	M.3.3	<p><b>Block safety procedure with block replication</b></p> <p>Description: The address space is equipped with two memories. The first memory is operated in the normal manner. The second memory contains the same information and is accessed in parallel to the first. The outputs are compared and a failure is assumed if a difference is detected. In order to detect certain kinds of bit errors, the data shall be stored inversely in one of the two memories and inverted once again when read. In the software procedure, the contents of both memory areas are compared cyclically using a program.</p>

Components and functions	Measure No.	Description of measures
-	M.3.4	<p><b>Block safety procedure with multiword redundancy</b></p> <p>Description: This procedure calculates a signature using a CRC algorithm, but the resulting value is at least two words in size. The extended signature is stored, recalculated and compared as in a single word case. A failure message is produced if a difference occurs.</p>
-	M.3.5	<p><b>Word saving one-bit redundancy (e.g. ROM monitoring with parity bit)</b></p> <p>Description: Every word of the memory is extended by one bit (the "parity" bit) which completes each word to an even or odd number of logical 1's. The parity of the data word is checked each time it is read. If the wrong number of 1's is found, a failure message is produced. The choice of even or odd parity should be made such that whichever of zero word (nothing but 0s) and the one word (nothing but 1's) is the more unfavourable in the event of failure, then that word is not a valid code. Parity can also be used to detect addressing failure, when the parity is calculated for the concatenation of the data word and its address.</p>
Variable memory ranges	<p>M.4.1</p> <p>M.4.2</p> <p>M.4.3</p>	<p><b>Check via test pattern against static or dynamic faults, e.g. RAM test "walkpath"</b></p> <p>Description: The memory range to be tested is initialised by a uniform bit stream. The first cell is then inverted and the remaining memory area is inspected to ensure that the background is correct. After this, the first cell is re-inverted to return to its original value and the whole process is repeated for the next. A second run of the "wandering bit model" is carried out with an inverse background pre-assignment. If a difference occurs the system shall go into a safe state.</p> <p><b>Block safety procedures with block replication, e.g. double RAM with hardware or software comparison</b></p> <p>Description: The address space is equipped with two memories. The first memory is operated in the normal manner. The second memory contains the same information and is accessed in parallel to the first. The outputs are compared and a failure is assumed if a difference is detected. In order to detect certain kinds of bit errors, the data shall be stored inversely in one of the two memories and inverted once again when read. In the software procedure, the contents of both memory areas are compared cyclically using a program.</p> <p><b>Inspection to check for static and dynamic failures e.g. "GALPAT"</b></p> <p>Description:</p>

Components and functions	Measure No.	Description of measures
-	-	<p>a) — RAM test “galpat”: An inverse element is written into the standard pre-assigned memory and then all the remaining cells are inspected to ensure that their contents are correct. After every reading access to one of the remaining cells, the inversely described cell is also inspected and read in addition to this. This process is repeated for every cell. A second run is carried out with an inverse pre-assignment. A failure is assumed if there is a difference; or</p> <p>b) — Transparent “galpat” test: At the beginning of the test, a “signature” is formed using software or also hardware regarding the content of the memory range to be tested and this is stored in the register; this corresponds to the pre-assignment of the memory in the galpat test. The contents are now written into the test cell in an inverted way and inspect the contents of the remaining cells.</p>
-	-	<p>The contents of the test cell are also read after every reading access to one of these cells. Since the contents of the remaining cells is indeed unknown, their contents are not inspected individually, but by forming a signature once again. After this first run for the first cell, a second run for this cell takes place with contents which have been inverted several times — therefore contents which are real again. Thus, the original contents of the memory are re-established. All the other memory cells are tested in the same manner. A failure is assumed if there is a difference.</p>
I/O units and interfaces	M.5.1	<p><b>Multi-channel parallel input</b> Description: This is a data flow dependent comparison of independent inputs complying with a defined tolerance area (time value).</p>
-	M.5.2	<p><b>Output read back (monitored output)</b> Description: This is a data flow dependent comparison of outputs with independent inputs complying with a defined tolerance area (time, value). The failure cannot always be related to the defective output.</p>
-	M.5.3	<p><b>Multi-channel parallel output</b> Description: This is a data flow dependent output redundancy. Failure recognition takes place directly via the technical process or via external comparators.</p>
-	M.5.4	<p><b>Code safety</b> Description: This procedure protects the input and output information with regard to coincident failures and systematic failures. It provides data flow dependent failure recognition of the input and output units with information redundancy or/and time redundancy.</p>
-	M.5.5	<p><b>Test pattern (model)</b> Description: This is a data flow independent cyclical test of input and output units carried out with the aid of defined testing pattern to compare observations with the corresponding expected values. The testing pattern information, the testing pattern reception and testing pattern evaluation shall be independent from each other. It shall be assumed that all possible input patterns are tested.</p>

Components and functions	Measure No.	Description of measures
Clock	M.6.1	<b>Watch dog with separate time base</b> <b>Description:</b> Hardware timer with separate time base triggered by correct operation of the program.
	M.6.2	<b>Reciprocal monitoring</b> <b>Description:</b> Hardware timer with separate time base triggered by the correct operation of the program of the other processor
Program sequence	M.7.1	<b>Combination of timing and logical monitoring of program sequence</b> <b>Description:</b> A time-based facility monitoring the program sequence is retriggered only if the sequence of the program sections is executed correctly.

**Annex C**  
(informative)

**Example for calculation of guide rails**

**C.1B.1C.1 General**

**C.1.1B1.1** The following example is used to explain the calculation of the guide rails, [based on a lift with guide rails which extend to the pit floor and a single acting safety gear](#).

**C.1.2B.1.2** The following symbols for the dimensions in the lift are used with a Cartesian coordinates system for all possible geometrical cases:

$C$	is the car centre;
$D_x$	is the car dimension in X-direction, car depth;
$D_y$	is the car dimension in Y-direction, car width;
$h$	is the distance between car guide shoes;
$l$	is the distance between brackets;
$P$	are the masses of the empty car and components supported by the car, i.e. part of travelling cable, compensating ropes/chains (if any), etc. in kilograms;
$Q$	is the rated load in kilograms;
$S$	is the car suspension;
$x_C, y_C$	is the position of the car centre (C) in relation to the guide rail cross coordinates;
$x_i, y_i$	is the position of the car door, $i = 1, 2, 3$ or $4$ ;
$x_P, y_P$	is the position of the car mass (P) in relation to the guide rail cross coordinates;
$x_Q, y_Q$	is the position of the rated load (Q) in relation to the guide rail cross coordinates;
$x_S, y_S$	is the position of the suspension (S) in relation to the guide rail cross coordinates;
$1, 2, 3, 4$	is the centre of the car door 1, 2, 3 or 4;
$\longrightarrow$	is the direction of loading.

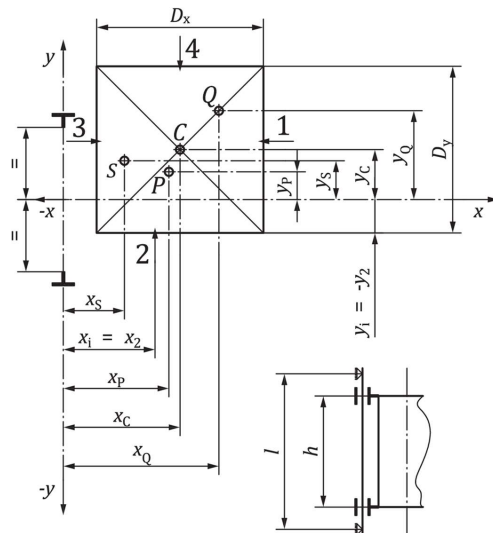


Figure C.4B.1 — Load distribution in lift car — General case

C.4.3B.1.3 The following symbols are used in Formulae (C.4B.1) to (C.30B.30), see C.2B.2 and Figure C.4B.1:

- A is the cross-sectional area of a guide rail in square millimetres;
- c is the width of the connecting part of the foot to the blade in millimetres;
- $\delta_{perm}$  is the maximum permissible deflection in millimetres;
- $\delta_x$  is the deflection in the X-axis in millimetres;
- $\delta_y$  is the deflection in the Y-axis in millimetres;
- $\delta_{str-x}$  is the deflection of the **fixings (brackets, separation beams)building structure** in the **xX**-axis in millimetres;
- $\delta_{str-y}$  is the deflection of the **fixings (brackets, separation beams)building structure** in the **yY**-axis in millimetres;
- E is the modulus of elasticity in newtons per square millimetre;
- $M_{aux}E_{aux}$  is the force in a guide rail due to auxiliary equipment in newtons;
- $F_p$  is the push through forces of all brackets at one guide rail (due to normal settling of the building or shrinkage of concrete) in newtons;
- $F_s$  is the vertical force acting on the car sill due to loading and unloading, in newtons;
- $F_v$  is the vertical force on a guide rail of the car, counterweight or balancing weight in newtons;
- $F_x$  is the supporting force in the X-axis in newtons;
- $F_y$  is the supporting force in the Y-axis in newtons;
- $g_n$  is the standard acceleration of free fall in metres per square second;
- $I_x$  is the second moment of area **inrelated to** the X-axis in fourth power millimetres;
- $I_y$  is the second moment of area **inrelated to** the Y-axis in fourth power millimetres;
- $k_1$  is the impact factor for the type of safety gear used;

Commented [AD245]: Aligned with definition in 5.10.6

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- $k_2$  is the impact factor for the running condition;
- $k_3$  is the impact factor for auxiliary parts and other operational scenarios;
- $M_g$  is the mass of one line of guide rails in kilograms;
- $M_m$  is the bending moment in newtons millimetres;
- $M_x$  is the bending moment ~~in related to the xX~~-axis, in newtons millimetres;
- $M_y$  is the bending moment ~~in related to the yY~~-axis, in newtons millimetres;
- $n$  is the number of guide rails;
- $\sigma$  is the combined stress in newtons per square millimetre;
- $\sigma_k$  is the buckling stress in newtons per square millimetre;
- $\sigma_m$  is the bending stress in newtons per square millimetre;
- $\sigma_F$  is the local flange bending stress in newtons per square millimetre;
- $\sigma_{perm}$  is the permissible stress in newtons per square millimetre;
- ~~$\delta_{str-x}$  is the deflection of the building structure fixings (brackets, separation beams) in the X-axis in millimetres;~~
- ~~$\delta_{str-y}$  is the deflection of the building structure fixings (brackets, separation beams) in the Y-axis in millimetres;~~
- $\sigma_x$  is the bending stress ~~in related to the xX~~-axis in newtons per square millimetre;
- $\sigma_y$  is the bending stress ~~in related to the yY~~-axis in newtons per square millimetre;
- $W_x$  is the modulus of cross sectional area ~~in related to the xX~~-axis in cubic millimetres;
- $W_y$  is the modulus of cross sectional area ~~in related to the yY~~-axis in cubic millimetres;
- $\omega$  is the omega value.

Commented [SD249]: As WG1 comments N2046

Commented [SD250]: As WG1 comments N2046

Commented [SD251]: Combined comments N2056

Commented [AD252]: Double entry deleted

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Commented [SD254]: As WG1 comments N2046

Commented [SD255]: As WG1 comments N2046

Commented [SD256]: As WG1 comments N2046

**C.2B.2C.2** General configuration for lifts with safety gear

**C.2.1B.2.1 C.2.1** — Safety gear operation

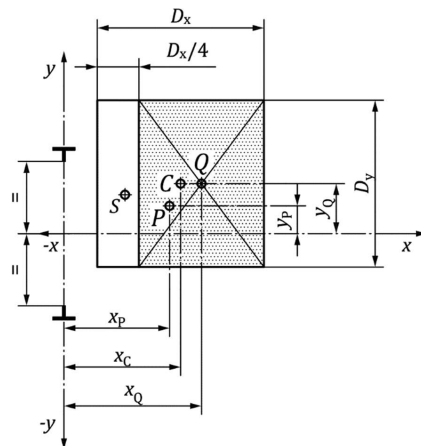
**C.2.1.1B.2.1.1 C.2.1.1** — Bending stress

a) Bending stress relative to the **yY**-axis of the guide rail due to guiding force:

$$F_x = \frac{k_1 \cdot g_n \cdot (Q \cdot x_Q + P \cdot x_P)}{n \cdot h}, \quad M_y = \frac{3 \cdot F_x \cdot l}{16}, \quad \sigma_y = \frac{M_y}{W_y} \tag{C.1B.1}$$

b) Bending stress relative to the **xX**-axis of the guide rail due to guiding force:

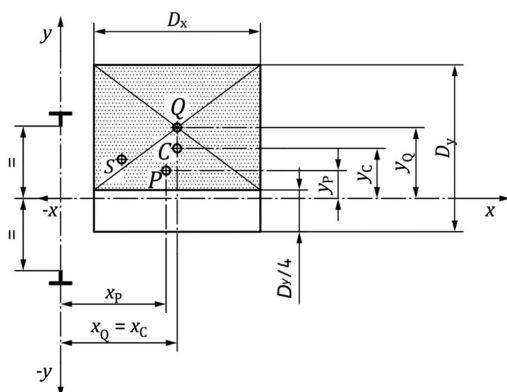
$$F_y = \frac{k_1 \cdot g_n \cdot (Q \cdot y_Q + P \cdot y_P)}{\frac{n}{2} \cdot h}, \quad M_x = \frac{3 \cdot F_y \cdot l}{16}, \quad \sigma_x = \frac{M_x}{W_x} \tag{C.2B.2}$$



NOTE 1:  $x_Q = x_C + D_x/8$ .

NOTE 2:  $y_Q = y_C$ .

**Figure C.2B.2** — Safety gear operation — Load distribution in lift car — Case 1 relative to **xX**-axis



NOTE 1:  $x_Q = x_C$ .

NOTE 2:  $y_Q = y_C + D_y/8$ .

Figure C.3B.3 — Safety gear operation — Load distribution in lift car — Case 2 relative to **y**-axis

**C.2.1.2B.2.1.2 C.2.1.2** Buckling

$$F_v = \frac{k_1 \cdot g_n \cdot (P+Q)}{n} + M_g \cdot g_n + F_p \tag{C.B.3}$$

$$\sigma_k = \frac{(F_v + k_3 \cdot F_{aux}) \cdot \omega}{A} \quad \sigma_k = \frac{(F_v + k_3 \cdot M_{aux}) \cdot \omega}{A} \tag{C.B.4}$$

**B.2.1.3 C.2.1.3** Combined stress<sup>4</sup>

These figures/formulae apply to both load distribution cases 1 and 2, see C.2.1.1B.2.1.1. If  $\sigma_{perm} < \sigma_m$ , the figures for 5.10.2.24.10.2.2 can be used in the interest of minimum guide rail dimensions applies.

**Combined bending**

$$\sigma = \sigma_m = \sigma_x + \sigma_y \leq \sigma_{perm} \tag{C.B.5}$$

**Combined bending and compression**

$$\sigma = \sigma_m + \frac{F_v + k_3 \cdot F_{aux}}{A} \leq \sigma_{perm} \quad \sigma = \sigma_m + \frac{F_v + k_3 \cdot M_{aux}}{A} \leq \sigma_{perm} \tag{C.B.6}$$

**Combined bending and buckling**

$$\sigma = \sigma_k + 0,9 \cdot \sigma_m \leq \sigma_{perm} \tag{C.B.7}$$

Commented [AD257]: Moved from footnote 4 and clarified.

Commented [IJ258]: See N1555

<sup>4</sup>—These figures apply to both load distribution cases 1 and 2, see C.2.1.1B.2.1.1. If  $\sigma_{perm} < \sigma_m$ , the figures for 5.10.2.24.10.2.2 can be used in the interest of minimum guide rail dimensions.

**B.2.1.4 C.2.1.4 Flange bending<sup>5</sup>**

These figures formulae apply to both load distribution cases 1 and 2, see C.2.1.4B.2.1.1.

$$\sigma_F = \frac{1,85 \cdot F_x}{c^2} \leq \sigma_{perm} \quad , \text{ or} \quad (\text{C.B.8})$$

$$\sigma_F = \frac{6 \cdot F_x \cdot (h_1 - b - f)}{c^2 \cdot [l + 2 \cdot (h_1 - f)]} \leq \sigma_{perm} \quad (\text{C.B.9})$$

Commented [AD259]: Moved from footnote 5 and aligned

**B.2.1.5 C.2.1.5 Deflections<sup>6</sup>**

These figures formulae apply to both load distribution cases 1 and 2, see C.2.1.4B.2.1.1.

$$\delta_x = 0,7 \frac{F_x \cdot l^3}{48 \cdot E \cdot I_y} + \delta_{str-x} \leq \delta_{perm} \quad (\text{C.B.10})$$

$$\delta_y = 0,7 \frac{F_y \cdot l^3}{48 \cdot E \cdot I_x} + \delta_{str-y} \leq \delta_{perm} \quad (\text{C.B.11})$$

Commented [AD260]: Moved from footnote 6 and aligned

**C.2.2B.2.2 C.2.2 Normal operation, rRunning**

Commented [AD261]: Aligned with change in 8100-1

**C.2.2.1B.2.2.1 C.2.2.1 Bending stress**

a) Bending stress relative to the yY-axis of the guide rail due to guiding force:

$$F_x = \frac{k_2 \cdot g_n \cdot [Q \cdot (x_Q - x_S) + P \cdot (x_P - x_S)]}{n \cdot h}, \quad M_y = \frac{3 \cdot F_x \cdot l}{16}, \quad \sigma_y = \frac{M_y}{W_y} \quad (\text{C.B.12})$$

b) Bending stress relative to the xX-axis of the guide rail due to guiding force:

$$F_y = \frac{k_2 \cdot g_n \cdot [Q \cdot (y_Q - y_S) + P \cdot (y_P - y_S)]}{\frac{n}{2} \cdot h}, \quad M_x = \frac{3 \cdot F_y \cdot l}{16}, \quad \sigma_x = \frac{M_x}{W_x} \quad (\text{C.B.13})$$

Load distribution:

Case 1 relative to the xX-axis (see C.2.1.1Figure C.2 B.2).

Case 2 relative to the yY-axis (see C.2.1.1Figure C.3 B.3).

**C.2.2.2B.2.2.2 C.2.2.2 Buckling Stress**

$$F_v = M_g \cdot g_n + F_p \quad (\text{C.B.14})$$

$$\sigma_k = \frac{(F_v + k_s \cdot M_{Fax}) \cdot \omega}{A} \quad (\text{C.B.15})$$

<sup>5</sup> These figures apply to both load distribution cases C.2.1.1B.2.1.1.

<sup>6</sup> These figures apply to both load distribution cases C.2.1.1B.2.1.1.

~~C.2.2.3~~**B.2.2.3** ~~C.2.2.3~~ Combined stress<sup>7</sup>

~~These figures/formulae apply to both load distribution cases 1 and 2, see C.2.2.1B.2.2.1. If  $\sigma_{perm} < \sigma_m$ , the figures for 5.10.2.24.10.2.2 can be used in the interest of minimum guide rail dimensions applies.~~

**Commented [AD262]:** Moved from footnote 7 and clarified

Combined bending

$$\sigma_m = \sigma_x + \sigma_y \leq \sigma_{perm} \quad (\text{C.B.16})$$

Combined bending and compression

~~$$\sigma = \sigma_m + \frac{F_v + k_3 \cdot F_{aux}}{A} \leq \sigma_{perm} \quad \sigma = \sigma_m + \frac{F_v + k_3 \cdot M_{aux}}{A} \leq \sigma_{perm} \quad (\text{C.B.17})$$~~

Combined bending and buckling

~~$$\sigma = \sigma_k + 0,9 \cdot \sigma_m \leq \sigma_{perm} \quad (\text{C.B.18})$$~~

~~B.2.2.4~~ **B.2.2.4** Flange bending<sup>8</sup>

~~These figures/formulae apply to both load distribution cases 1 and 2, see C.2.1.1B.2.1.1.~~

**Commented [AD263]:** Moved from footnote 8 and aligned.

~~$$\sigma_F = \frac{1,85 \cdot F_x}{c^2} \leq \sigma_{perm}, \text{ or} \quad (\text{C.B.1819})$$~~

~~$$\sigma_F = \frac{6 \cdot F_x \cdot (h_1 - b - f)}{c^2 \cdot [l + 2 \cdot (h_1 - f)]} \leq \sigma_{perm} \quad (\text{C.B.1920})$$~~

~~C.2.2.4B.2.2.5~~ **C.2.2.5** Deflection<sup>9</sup>

These figures apply to both load distribution cases 1 and 2, see C.2.1.1B.2.1.1.

$$\delta_x = 0,7 \frac{F_x \cdot l^3}{48 \cdot E \cdot I_y} + \delta_{str-x} \leq \delta_{perm} \quad (\text{C.B.2021})$$

$$\delta_y = 0,7 \frac{F_y \cdot l^3}{48 \cdot E \cdot I_x} + \delta_{str-y} \leq \delta_{perm} \quad (\text{C.B.2122})$$

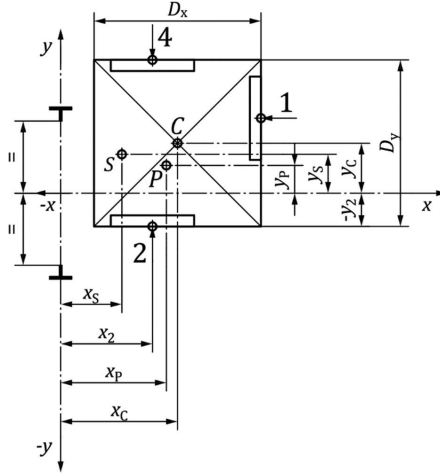
<sup>7</sup>—~~These figures apply to both load distribution cases C.2.2.1B.2.2.1. If  $\sigma_{perm} < \sigma_m$ , the figures for 5.10.2.24.10.2.2 can be used in the interest of minimum guide rail dimensions.~~

<sup>8</sup>—~~These figures apply to both load distribution cases C.2.1.1B.2.1.1.~~

<sup>9</sup>—~~These figures apply to both load distribution cases C.2.1.1B.2.1.1.~~

**C.2.3B.2.3 C.2.3 Normal operation, loading and unloading**

Commented [AD264]: Aligned with changes in 8100-1



**Figure C.B.4 — Normal operation — Loading distribution**

Commented [AD265]: Aligned with changes in 8100-1

**C.2.3.1B.2.3.1 C.2.3.1 Bending stress**

a) Bending stress relative to the **yY**-axis of the guide rail due to guiding force:

$$F_x = \frac{g_n \cdot P \cdot (x_P - x_S) + F_S \cdot (x_i - x_S)}{n \cdot h}, \quad M_y = \frac{3 \cdot F_x \cdot l}{16}, \quad \sigma_y = \frac{M_y}{W_y} \quad (\text{C.B.2223})$$

b) Bending stress relative to the **xX**-axis of the guide rail due to guiding force:

$$F_y = \frac{g_n \cdot P \cdot (y_P - y_S) + F_S \cdot (y_i - y_S)}{\frac{n}{2} \cdot h}, \quad M_x = \frac{3 \cdot F_y \cdot l}{16}, \quad \sigma_x = \frac{M_x}{W_x} \quad (\text{C.B.2324})$$

**C.2.3.2B.2.3.2 C.2.3.2 Buckling**

$$F_V = M_g \cdot g_n + F_p \quad (\text{C.B.2425})$$

$$\sigma_k = \frac{(F_V + k_3 \cdot M F_{aux}) \cdot \omega}{A} \quad (\text{C.B.2526})$$

**C.2.3.3B.2.3.3 C.2.3.3 Combined stress<sup>10</sup>**

If  $\sigma_{perm} < \sigma_m$ , the figures for 5.10.2.24.10.2.2 can be used in the interest of minimum guide rail dimensions applies.

Commented [AD266]: Moved from footnote 10 and aligned

**Combined bending**

$$\sigma = \sigma_m = \sigma_x + \sigma_y \leq \sigma_{perm} \quad (\text{C.B.2627})$$

**Combined bending and compression**

$$\sigma = \sigma_m + \frac{F_y + k_3 \cdot F_{aux}}{A} \leq \sigma_{perm} \quad \sigma = \sigma_m + \frac{F_y + k_3 \cdot M_{aux}}{A} \leq \sigma_{perm} \quad (\text{C.B.2728})$$

**Combined bending and buckling**

$$\sigma = \sigma_k + 0,9 \cdot \sigma_m \leq \sigma_{perm} \quad (\text{C.B.29})$$

**C.2.3.4B.2.3.4 C.2.3.4 Flange bending**

$$\sigma_F = \frac{1,85 \cdot F_x}{c^2} \leq \sigma_{perm}, \text{ or} \quad (\text{C.B.2830})$$

$$\sigma_F = \frac{6 \cdot F_x \cdot (h_1 - b - f)}{c^2 \cdot [l + 2 \cdot (h_1 - f)]} \leq \sigma_{perm} \quad (\text{C.B.2931})$$

**C.2.3.5B.2.3.5 C.2.3.5 Deflections**

$$\delta_x = 0,7 \frac{F_x \cdot l^3}{48 \cdot E \cdot I_y} + \delta_{str-x} \leq \delta_{perm} \quad (\text{C.B.32})$$

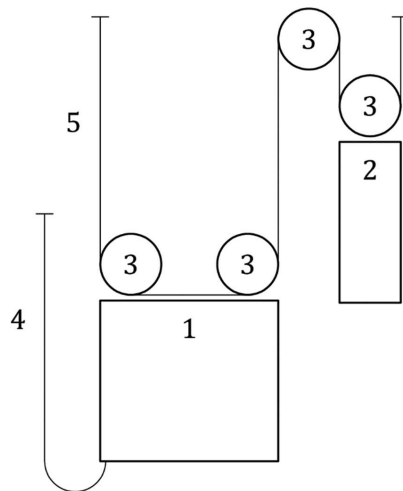
$$\delta_y = 0,7 \frac{F_y \cdot l^3}{48 \cdot E \cdot I_x} + \delta_{str-y} \leq \delta_{perm} \quad (\text{C.B.3033})$$

<sup>10</sup> If  $\sigma_{perm} < \sigma_m$ , the figures for 5.10.2.24.10.2.2 can be used in the interest of minimum guide rail dimensions.

**Annex D**  
(informative)

**Calculation of traction — Example**

For the example according to Figure D.1C.1 Formulae (D.1C.1) to (D.8C.8) apply.



**Key**

- 1 car
- 2 counterweight
- 3 pulley
- 4 travelling cable
- 5 suspension means

**Figure D.1 — Example 2:1, no compensation means**

Car loading condition

Car loaded with 125 % rated load at lowest landing, no friction considered.

$$T_1 = \frac{(P + 1,25 \cdot Q)}{2} \cdot g_n + M_{SRcar} \cdot g_n$$

(D.1C.1)

$$T_2 = \frac{M_{cwt}}{2} \cdot g_n$$

(D.2C2)

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Emergency braking condition

Minimum friction due to pulleys and guiding force assumed

a) Car loaded with rated load at lowest landing

$$T_1 = \frac{(P+Q)}{2} \cdot (g_n + a) + M_{SRcar}(g_n + 2 \cdot a) + \left[ \frac{m_{p_{car.1}} \cdot \left(\frac{v_{p.1}}{v}\right)^2 \cdot a}{r} \right] + \left[ \frac{m_{p_{car.2}} \cdot \left(\frac{v_{p.2}}{v}\right)^2 \cdot a}{r} \right] + \frac{m_{p_{car.2}} \cdot a}{2} - \frac{FR_{car}}{2} \quad (D.3C.3)$$

$$T_2 = \frac{M_{cwt}}{2} \cdot (g_n - a) - \left[ \frac{m_{p_{cwt.1}} \cdot \left(\frac{v_{p.1}}{v}\right)^2 \cdot a}{r} \right] + \frac{FR_{cwt}}{2} \quad (D.4C.4)$$

$$\mu = \frac{0,1}{1 + \frac{v}{10}} \quad \mu = \frac{0,1}{1 + \frac{v}{10}}$$

b)

e)b) Empty car at highest landing

$$T_1 = \frac{M_{cwt}}{2} \cdot (g_n + a) + M_{SRcwt}(g_n + 2 \cdot a) + \left[ \frac{m_{p_{cwt.1}} \cdot \left(\frac{v_{p.1}}{v}\right)^2 \cdot a}{r} \right] - \frac{FR_{cwt}}{2} \quad (D.5C.5)$$

$$\mu = \frac{0,1}{1 + \frac{v}{10}} + \frac{m_{p_{cwt.1}} \cdot 1 \cdot a}{2} - \frac{FR_{cwt}}{2}$$

$$T_2 = \frac{(P+M_{Trav})}{2} \cdot (g_n - a) - \left[ \frac{m_{p_{car.1}} \cdot \left(\frac{v_{p.1}}{v}\right)^2 \cdot a}{r} \right] - \left[ \frac{m_{p_{car.2}} \cdot \left(\frac{v_{p.2}}{v}\right)^2 \cdot a}{r} \right] - \frac{m_{p_{car.2}} \cdot a}{2} + \frac{FR_{car}}{2} \quad (D.6C.6)$$

Counterweight stalled condition

Empty car at highest position, no friction considered.

$$T_1 = \frac{(P+M_{Trav})}{2} \cdot g_n \quad (D.7C.7)$$

$$T_2 = M_{SRcwt} \cdot g_n \quad (D.8C.8)$$

Note: For elastomeric coated alternative suspension means lifting of car or counterweight in a stalled condition shall be prevented by an electric safety device in conformity with EN81-20:2018, 5.5.3.1 d)

Commented [SD267]: Combined comments N2056 & EN 81:50:2020 Annex D

Commented [SD268]: Combined comments N2056 & EN 81:50:2020 Annex D

Commented [SD269]: Combined comments N2056 & EN 81:50:2020 Annex D

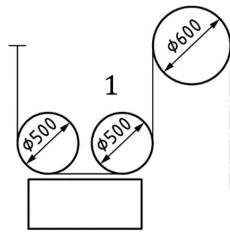
Commented [SD270]: As WG1 comments N2046

**Annex D**  
Annex E  
(informative)

**Equivalent number of pulleys,  $N_{equiv}$  — Examples**

**NOTE** For suspension means other than steel wire ropes in steel/cast iron traction sheaves these examples are not applicable

Commented [SD271]: Consistency in NOTE format



**Key**

1 car side

**Figure E.1 — 2 to 1 roping — V grooves**

$$\gamma = 40^\circ$$

$$N_{equiv(t)} = 10 \quad (\text{according to Table 21})$$

$$K_p = (600 / 500)^4 = 2,07$$

$$N_{equiv(p)} = 2,07 \cdot (2+0) = 4,14$$

$$N_{equiv} = 10 + 4,14 = 14,14$$

NOTE: No reversed bend because of moving pulley.

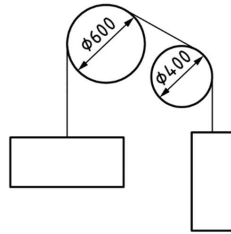


Figure E.2 — 1 to 1 roping — Undercut U grooves

$$\beta=90^\circ$$

$$N_{equiv(t)}=5 \text{ (according to Table 21)}$$

$$K_p=(600/400)^4=5,06$$

$$N_{equiv(p)}=5,06 \cdot (1+0)=5,06$$

$$N_{equiv}=5+5,06=10,06$$

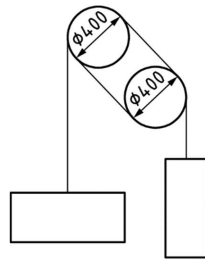


Figure E.3 — 1 to 1 roping (double wrap) — U grooves

$$N_{equiv(t)}=1+1$$

$$K_p=1$$

$$N_{equiv(p)}=1 \cdot (1+1)=2$$

$$N_{equiv}=2+2=4$$

NOTE The rope passes traction sheave and secondary sheave 2 times.

**Annex E**  
(informative)

**Relationship between ISO ~~22559-18100-20~~ and ISO 8100-2**

The requirements of this document are not intended to prevent the use of systems, methods, devices or components of equivalent or superior safety, strength, effectiveness, durability, etc. to those prescribed by this document, provided that the equivalency of the system, method, device, or component can be verified. ISO ~~22559-18100-20~~ and national implementations should be consulted for further information.

**Annex ZA**  
(informative)

**Relationship between this European Standard and the essential requirements of Directive 2014/33/EU aimed to be covered**

This European Standard has been prepared under a Commission’s standardization request “M/549 C(2016) 5884 final” to provide one voluntary means of conforming to requirements of Directive 2014/33/EU of the European Parliament and of the Council of 26 February 2014 on the harmonisation of the laws of the Member States relating to lifts and safety components for lifts (recast).

Once this standard is cited in the Official Journal of the European Union under that Directive, compliance with the normative clauses of this standard given in Table ZA.1 and Table ZA.2 confers, within the limits of the scope of this standard, a presumption of conformity with the corresponding essential requirements of that Directive, and associated EFTA regulations.

**Table ZA.1 — Correspondence between this European Standard and Annex I of Directive 2014/33/EU**

Essential health and safety requirements of Annex I to Directive 2014/33/EU	Clause(s)/sub-clause(s) of this EN	Remarks/Notes
1.1	See below Table ZA.2	Referring to the application of Directive 2006/42/EC
<del>1.4.2</del>	<del>5.4</del>	<del>Type examination of overspeed governors</del>
<del>1.4.4</del>	<del>5.11, 5.12</del>	<del>Evaluation of traction and safety factor on suspension ropes for electric lifts</del>
<del>1.6.4</del>	<del>5.6, 5.175, 5.186</del>	<del>Type examination of safety circuits containing electronic components and/or programmable electronic systems (PESSRAL), Electronic components – Failure exclusion,</del>
<del>2.3</del>	<del>5.2, 5.14</del>	<del>Type examination of landing and car door locking devices, Design rules for programmable electronic systems (PESSRAL)</del>
<del>3.2</del>	<del>5.3, 5.7, 5.8, 5.9, 5.10</del>	<del>Type examination of safety gear, ascending car overspeed protection means, unintended car movement protection means, rupture valve/one-way restrictor. Guide rails calculation</del>
<del>3.3</del>	<del>5.5</del>	<del>Type examination of buffers</del>
<del>6.1</del>	<del>4.2.3, 4.3.5, 4.4.3, 4.5.4, 4.6.4, 4.7.5, 4.8.5, 4.9.1.6</del>	

**Commented [AD272]:** Type examination is not Annex I of LD. 1.4.2 is covered by 8100-1.

**Commented [AD273]:** 1.4.4 is covered by 8100-1

**Commented [AD274]:** 1.6.4 is covered by 8100-1

**Commented [KA275]:** Paragraph numbering changed.

**Commented [AD276]:** 2.3 is covered by 8100-1

**Commented [AD277]:** Type examination is not Annex I of LD. 3.2 is covered by 8100-1.

**Commented [AD278]:** Type examination is not Annex I of LD. 3.3 is covered by 8100-1.

Table ZA.2 — Correspondence between this European Standard and Annex I of Directive 2006/42/EC

Essential health and safety requirements of Annex I to Directive 2006/42/EC	Clause(s)/sub-clause(s) of this EN	Remarks/Notes
<del>1.1.2 (a)</del>	<del>4, 5, 6</del>	
<del>1.1.2 (c)</del>	<del>4, 5, 6</del>	
<del>1.1.2</del>	<del>5.1</del>	<del>General requirements</del>
<del>1.2</del>	<del>5.6.5, 15.5.16</del>	<del>Control Systems</del>
<del>1.3.2</del>	<del>5.10, 5.13, 5.14</del>	<del>Risk of break-up during operation</del>
<del>4.1.2.2</del>	<del>5.10</del>	<del>Guide rails calculation</del>
<del>4.1.2.3</del>	<del>5.10, 5.13, 5.14</del>	<del>Mechanical strength</del>

Commented [AD279]: new instruction by CCMC

Commented [AD280]: 1.2 is covered by 8100-1

Commented [AD281]: 1.3.2 is covered by 8100-1

Commented [AD282]: Not relevant, see MD guide

Commented [AD283]: 4.1.2.3 is covered by 8100-1

**WARNING 1** — Presumption of conformity stays valid only as long as a reference to this European Standard is maintained in the list published in the Official Journal of the European Union. Users of this standard should consult frequently the latest list published in the Official Journal of the European Union.

**WARNING 2** — Other Union legislation may be applicable to the product(s) falling within the scope of this standard.

## Bibliography

- [1] ISO 8100-20:2018, *Lifts for the transport of persons and goods — Part 20: Global essential safety requirements (GESRs)*
- [2] ISO 12100:2010, *Safety of machinery — General principles for design — Risk assessment and risk reduction* [2] ISO 13849-2:2012, *Safety of machinery — Safety-related parts of control systems — Part 2: Validation*
- [3] ISO/TS 8100-3:2019, *Lifts for the transport of persons and goods — Part 3: Requirements from other Standards (ASME A17.1/CSA B44 and JIS A 4307-1/JIS A 4307-2) not included in ISO 8100-1 or ISO 8100-2*
- [4] IEC 60747 5-5, *Semiconductor devices — Discrete devices — Part 5-5: Optoelectronic devices — Photocouplers*
- [5] IEC 60950 1:2006, *Information technology equipment — Safety — Part 1: General requirements*
- [6] IEC 61249 (all parts), *Materials for printed boards and other interconnecting structures*
- [4] IEC 61508-1:2010, *Functional safety of electrical/electronic/programmable electronic safety-related systems — Part 1: General requirements*
- [5] IEC 61784-3:2021, *Industrial communication networks - Profiles - Part 3: Functional safety fieldbuses - General rules and profile definitions* IEC 61508-2, *Functional safety of electrical/electronic/programmable electronic safety-related systems — Part 2: Requirements for electrical/electronic/programmable electronic safety-related systems*
- [9] IEC 61508 3, *Functional safety of electrical/electronic/programmable electronic safety-related systems — Part 3: Software requirements*
- [6] IEC 61508-7:2010, *Functional safety of electrical/electronic/programmable electronic safety-related systems — Part 7: Overview of techniques and measures*
- [11] IEC 61558 1:2005, *Safety of power transformers, power supplies, reactors and similar products — Part 1: General requirements and tests*
- [12] IEC 62326 1, *Printed boards — Part 1: Generic specification*
- [13] EN/TS 81 11, *Safety rules for the construction and installation of lifts — Basics and interpretations — Part 11: Interpretations related to EN 81 family of standards*
- [7] IPA/SEC ESCR 3.0, *Embedded System development Coding Reference guide [C Language Edition]*

**Commented [KA284]:** [3] IEC 60068-2-14 moved to normative reference

**Commented [KA285]:** [4], Optocoupler standard deleted from the list as it is not anymore referenced.

**Commented [KA286]:** [5], IEC 60950-1 standard will be withdrawn by the end of 2020.

**Commented [KA287]:** [6] Deleted because it is not anymore referenced. It is replaced by IEC 60893-3-1 which has been included into normative references.

**Commented [KA288]:** [7] – [9] IEC 61508 parts 1, 2 and 3 moved to normative references.

**Commented [KA289]:** [11] IEC 61558-1 moved to normative references.

**Commented [KA290]:** [12] Deleted as reference is now to standard IEC 60893-3-1 which has been included into normative references.

**Commented [KA291]:** Informative reference in the B.18