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Comparison of worldwide lift safety standards —

Part 2: Hydraulic lifts (elevators)

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British Standards

National foreword

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— present to the responsible international/European committee any enquiries on the interpretation, or proposals for change, and keep UK interests informed;

— monitor related international and European developments and promulgate them in the UK.

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TECHNICAL REPORT

ISO/TR 11071-2

Second edition
2006-04-15

Comparison of worldwide lift safety standards —

Part 2: **Hydraulic lifts (elevators)**

Comparaison des normes mondiales de sécurité des ascenseurs —

Partie 2: Ascenseurs hydrauliques

Reference number
ISO/TR 11071-2:2006(E)

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Foreword

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

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

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

In exceptional circumstances, when a technical committee has collected data of a different kind from that which is normally published as an International Standard ("state of the art", for example), it may decide by a simple majority vote of its participating members to publish a Technical Report. A Technical Report is entirely informative in nature and does not have to be reviewed until the data it provides are considered to be no longer valid or useful.

ISO/TR 11071-2 was prepared by Technical Committee ISO/TC 178, *Lifts, escalators and moving walks*.

This second edition cancels and replaces the first edition (ISO/TR 11071-2:1996), and amendment 1 (ISO/TR 11071-2:1996/Amd. 1:1999), which have been technically revised.

ISO/TR 11071 consists of the following parts, under the general title *Comparison of worldwide lift safety standards*:

— *Part 1: Electric lifts (elevators)*

— *Part 2: Hydraulic lifts (elevators)*

Introduction

Introduction to 1996 edition

At the 1981 plenary meeting of ISO/TC 178, work was started on a comparison of CEN standard EN 81/1 with the American, Canadian, and USSR lift safety standards. In 1983, Working Group 4 was officially formed to carry out the task of preparing cross reference between the relevant sections of these standards and to analyze the differences on selected subjects. The goal at that time was to prepare a technical report which would provide reference information to assist national committees when reviewing and revising individual standards which may initiate a gradual convergence of the technical requirements. In 1984, the study was expanded to include the Council for Mutual Economic Assistance (CMEA) safety standard. That report, ISO/TR 11071-1, *Comparison of worldwide lift safety standards — Part 1: Electric lifts (elevators),* was published 1990-12-01.

In 1989, the charge to WG 4 was expanded to include hydraulic lifts. Since there was no standard for hydraulic lifts in the Russian Federation, and the CMEA standard was being phased out of use, this Part 2 of the comparison is generally limited to the ASME, CEN, and CSA standards. The Japan Elevator Association was invited to add their standards to this comparison, however, no response to this request was received.

This report is intended to aid standards writers in developing their safety requirements, and to help standard users understand the basis for the requirements as they are applied throughout the world.

This report is not intended to replace existing safety standards. Conclusions are arrived at in some cases, but only where there is unanimity amongst the various experts. In other cases, the reasons for the divergent views are expressed.

This report must be read in conjunction with the various safety standards, as it was often necessary to summarize the requirements for the sake of clarifying the comparisons. Further, the information contained in this report does not necessarily represent the opinions of the standards writing organizations responsible for the development of the safety standards which are being compared, and they should be consulted regarding interpretations of their requirements (see Annex B).

Introduction to this edition

After the original publication (1996) of this technical report, including American, Canadian and European data and thereto Supplement 1 (1999-08-01), which added Australian and Japanese data, has been revised or amended. The recommendations in the form of “agreed upon points” stated in the first edition have also affected the revisions of the national standards.

The original report and amendment have been widely used by lift industry and standards writing organizations, including the ISO Technical Committee 178. Users have expressed need for an updated and consolidated version of the document, in particular the comparison tabulations. With the Resolution 208/2002, the ISO/TC 178 requested WG4 to consolidate original publications, including Supplements and “to update comparison tables in ISO/TR 11071 with data from the most recently published standards for lifts and to republish both documents, Part 1 and Part 2 with updated tables and with minimum changes to the narrative sections”.

The narrative sections of the original publication, in particular assumptions, historical backgrounds, observations and suggestions as well as the points agreed upon were the result of extensive work of the ISO/TC 178 Working group 4. ISO/TC 178 is currently working on a new series of ISO documents under the general title *Safety requirements for lifts (elevators)*. In that process the updated comparison tables are being used as reference. Extensive work on complete re-write of the narrative sections was not deemed necessary. However, republication of the text with only minor editorial changes would help readers to understand the background to the safety concerns being addressed in the current national standards. However, because of recent (2000) harmonization of ASME and CSA Codes, it was necessary to replace the quoted rule numbers with those in the current Codes In most sentences the ASME and CSA. I some other cases quoted references are updated in a NOTE following the narrative section or sentence.

All quoted requirement referenced in all tables (CEN, ASME/CSA, Japan and SA) are up to date.

Comparison of worldwide lift safety standards —

Part 2:
Hydraulic lifts (elevators)

1 Scope

This Technical Report consists of a comparison of the requirements of selected topics as covered by the following worldwide safety standards (excluding regional or national deviations):

a) CEN European Standard EN 81-2:1998, *Safety rules for the construction and installation of lifts — Part 2: Hydraulic lifts*;

b) ASME A17.1:2004, Safety Code for Elevators and Escalators and CSA B44:2004, Safety Code for Elevators;

c) Japan - Building Standard Law of Japan (BSLJ);

d) Standards Australia:

— AS 1735-1:2003, *Lifts, Escalators and Moving Walks — Part 1: General Requirements*;

— AS 1735-3:2002, *Lifts, Escalators and Moving Walks — Part 3: Passenger and Goods Lifts — Electro-hydraulic*.

This Technical Report applies to hydraulic lifts only, both of the direct and indirect acting type.

It should be noted that, in addition to the above listed standards, lifts must conform to the requirements of other standards (for example, standards covering mechanical, structural, and electrical equipment; building codes, and environmental regulations). Some of the standards will be referred to in this Technical Report.

2 Terminology

2.1 Lifts and elevators

2.1.1 The CEN term *lift* corresponds to the ASME and CSA term *elevator*. These terms are used inter-changeably in this report.

2.1.2 For the purposes of this report, unless otherwise specified, the terms *passenger lift* and *freight lift* correspond to the following terms used in other Standards:

Term used in this report	**Correspond to terms used in the following standards***	
	CEN	ASME and CSA
Passenger lift	Lift except goods passenger lift	Passenger elevator & freight elevator permitted to carry passengers
Freight lift	Goods passenger lift**	Freight elevator

* See the definitions in the applicable Standards.

** This term is used only to enable comparisons to be made later in this report. It does not indicate recognition of the term “freight lift” by CEN.

2.2 Hydraulic terminology

2.2.1 Difference

There are some notable differences in the standards respecting hydraulic lift terminology as shown in the Table 1, Column A and B.

2.2.2 Agreed-upon points, re: hydraulic terminology

The differences should be eliminated or minimized through proposed changes to ASME and CSA Standards, as shown in Table 1, Column D.

If approved by ASME and CSA Committees, the proposed changes would eliminate major differences between CEN and North American Standards.

Column C gives the description of the equipment that a term (listed in Column A, B, or D) embraces.

In addition to “hydraulic machine”, ASME and CSA propose to introduce the term “hydraulic driving machines” hydraulic driving machines”. The terms are needed to differentiate between “electric” and “hydraulic” driving machines all covered in one ASME and CSA Standard. This is not necessarily applicable to CEN, as the electric and hydraulic lifts are covered by two separate standards.

2.2.3 Terminology in this report

In this report, the CEN terminology will be used, with the ASME and CSA terms in brackets if different.

Table 1 — Hydraulic Terminology

Column A	Column B	Column C	Column D
CEN	ASME & CSA Current	Description	Agreed upon points: ASME & CSA proposed changes
Direct acting lift	Direct plunger hydraulic elevator	—	Direct acting hydraulic elevator [a]
Indirect acting lift	Roped hydraulic Elevator	—	No change
Machine	—	Pump, motor, valves	Hydraulic Machine [b]
Jack	Driving machine	Cylinder and ram	Hydraulic jack [c]
Ram	Plunger or piston	—	Plunger (ram) or piston
Base	Head/bottom (Includes plunger end cap as well)	Cylinder end cap	No change
Valves:			
Non-return	Check	—	No change
Pressure relief	Pump relief	—	No change
Direction	Control	—	No change
Rupture	ASME-Safety CSA-Rupture	—	No change

NOTE ASME and CSA adopted terms:

[a] “direct-acting”.

[b] “hydraulic machine".

[c] “hydraulic jack”.

2.3 Working pressure vs full load pressure

ASME and CSA use *working pressure* (WP), which is defined as the pressure at the hydraulic driving machine when lifting the car and its rated load at rated speed, or with class C2 loading, when leveling up with maximum static load.

CEN defines *full load pressure* (FLP) as the static pressure exerted at the piping directly connected to the jack, the car with the rated load being at rest at the highest landing level.

CEN Annex K, clause K.1.1 recognizes that friction losses as a result of fluid flow are on the order of 15 %; thus a factor of 1,15 is included in their factor of safety determination.

NOTE CEN reference to “Clause 12, NOTE 1” in this clause and through the 1996 edition of this document has been replaced with reference to “Annex K, Clause K1.1” in this edition.

Thus, ASME WP = 1,15 x (CEN FLP).

2.4 Other terms

Additional terminology, where there is a difference between the CEN and the ASME and CSA standards, is shown in Table 2:

NOTE Since ASME and CSA are now harmonized they will be shown through this edition in a column under title “ASME and CSA” or “ASME/CSA”.

Table 2 — Terminology

CEN	ASME and CSA
Docking operation	Truck zone operation
Electric safety device	Electrical protective device
Fixings	Fastenings
Landing door	Hoistway door
Mains	Main power supply
Reeving ratio	Roping ratio
Instantaneous safety gear	Type A safeties (instantaneous safeties)
Progressive safety gear	Type B safeties (progressive safeties)
Pulley	Sheave
Safety gear	Safeties
Well	Hoistway

2.5 Abbreviations

The following abbreviations are used in this report:

FOS = Factor of safety or safety factor.

YP = Yield point.

WP = Working pressure.

UTS = Ultimate tensile strength.

FLP = Full load pressure.

NOTE See also list of abbreviations in item 4.1.2.

3 Basis for lift safety standards development (basic assumptions)

3.1 Historical background

3.1.1 All lift safety standards assume certain things as being true, without proving them as such, and stipulate safety rules that are based on these assumptions.

3.1.2 No standard, however, clearly spells out the assumptions used. The CEN committee analyzed its standard and summarized in the document CEN/TC10/WG1 N99 (see Annex C) the assumptions that, in the opinion of the committee, were used in the CEN standard.

3.1.3 The CEN assumptions were compared with assumptions implicitly built into other safety standards. It has been indicated that:

a) some assumptions apparently used in the CEN standard were not listed in the document referred to in CEN/TC10/WG1 N99;

b) some assumptions used in other standards differ from those in CEN/TC10/WG1 N99.

3.1.4 Using CEN/TC10/WG1 N99 as a model, the following list of assumptions (see 3.3 through 3.9 in this report) has been developed, which could be used as a basis for future work on safety standards.

The CEN assumptions 5 (related to car speed) and 7 (related to restrictors) as listed in Annex C have not been considered for adoption in this report, since they are deemed to be design parameters.

Further, CEN assumption 2 is adopted in this report as assumption 1 and CEN assumption 6 as assumption 3(c) in order to be consistent with Part 1 of this report.

In summary, CEN assumptions 1, 3, 4, 8, 9, and 10 correspond to assumptions 1, 2, 3, 4, 5, and 6 in this report. Assumption 7 is not covered in the CEN document.

3.2 General

3.2.1 Listed in 3.3 through 3.9 (except as noted) are those things specific to lifts that are assumed as true, although not yet proven or demonstrated as such, including:

a) functioning and reliability of lift components;

b) human behaviour and endurance; and

c) acceptable level of safety and safety margins.

3.2.2 Where the probability of an occurrence is considered highly unlikely, it is considered as not happening.

3.2.3 Where an occurrence proves that an assumption is false, it does not necessarily prove that all other assumptions are false.

3.2.4 The assumptions should be subject to periodic review by standards writing organizations to ensure their continuing validity – considering accident statistics, as well as such things as changes in technologies, public expectations (e.g. product liability), and human behaviour.

3.3 Assumption 1 — safe operation assured to 125 % of rated load

Safe operation of lifts is assured for loads ranging from 0 to 100 % of the rated load. In addition, in the case of *passenger lifts* (see 2.1.2), safe operation is also assured for an overload of 25 %; however, it is not necessary to be able to raise this overload nor to achieve normal operation (rated load performance).

3.3.1 Rationale for Assumption 1

3.3.1.1 All safety standards limit the car area in relation to its rated capacity (load and/or number of persons) in order to minimize the probability of inadvertent overloading. However, it is recognized that the possibility of an overloading of up to 25 % still exists on *passenger lifts*. To eliminate any hazard for passengers, safe operation must be assured, but not necessarily normal operation.

3.3.1.2 In the case of *freight lifts*, no overloading is anticipated. It is assumed that designated attendants and freight handlers will adhere to instructions posted in cars and will not overload them.

3.3.2 Assumption 1 as applied in current standards

3.3.2.1 Currently CEN does not specifically require a 25 % overload safety margin; however, the design requirements provide for that level of safety.

ASME and CSA requirements 3.16 and 2.16.8 specifically require that safety be assured on *passenger lifts* in the case of 25 % overload.

3.3.2.2 With exceptions given in 3.3.2.5, the ratio of the rated load to the car platform area for passenger lifts is equal (± 5 %) in all standards for the range of 320 to 4 000 kg, and in that respect, universality of the assumption #1 is achieved.

However, the assumed average weight of a passenger differs: 75 kg (CEN) and 72,5 kg (ASME and CSA).

3.3.2.3 Furthermore, the rated load to car platform area ratio is different for *freight lifts*.

CEN (non-commercial vehicle with instructed users)	200 kg/m^2
ASME/CSA (general freight Class A)	244/240 kg/m^2
(motor vehicle Class B)	146/145 kg/m^2
(industrial truck Class C)	244/240 kg/m^2

3.3.2.4 The CEN standard contains two tables showing the ratio between the rated load and the maximum available car area (for *passenger lifts*), see Table 3.

The CEN Table "1.1" corresponding to the requirements for electric lifts is based on the rationale explained in 3.3.1.1 and was taken into consideration when formulating the statement in 3.3.2.2.

3.3.2.5 The CEN Table "1.1 A", acceptable for Goods passengers lifts, is based on the rationale that where there is a low probability of the car being overloaded with persons, the available area of a hydraulic lift may be increased up to therein specified maximum, provided that additional safety measures are taken to ensure the safe interruption in the lift operation. Such measures include:

a) a pressure switch to prevent a start for a normal journey when the pressure exceeds the full load pressure by more than 20 %;

b) the design of the car, car sling, car-ram connection, suspension means, car safety gear, rupture valve, clamping or pawl device, guide rails, and buffers must be based on a load resulting from CEN Table "1.1";

c) the design pressure of the jack and the piping shall not be exceeded by more than 1,4.

Starting point for CEN Table "1.1A" was the comparison of safety factors of driving systems on electric traction lifts versus hydraulic lifts. On hydraulic lifts the safety factor for the car suspension means and supporting structure is at least 3 times higher than that of the traction driving systems, when friction between the suspension ropes and the grooves of the drive sheave is taken into account. Consequently, the safety risk of unintended car movement downwards due to the overloading on hydraulic lifts is significantly lower than on electric traction lifts.

Furthermore, assuming that the car weight is equal to the rated load, in that case an overload of x % on the electric traction lift would correspond to only x/2 % overload for the hydraulic system.

NOTE This is true for machine power only; not for e.g. safety gear operation, guide rails dimensioning, etc.

For car areas up to 5 m^2, the required rated load in CEN Table "1.1 A" for a hydraulic lift may be 1,6 times less than the rated load according to CEN Table 1.1.

NOTE 1.6 is an ISO-standard number R5. This is important in view of the rated loads according to ISO 4190-1 1999, *Lift (US: Elevator) installation — art 1: Class I, II, III and VI lifts,* e.g. a Goods passengers lift with 5 m^2 available car area requires 2 500 kg rated load in the case of an electric lift, and 1 600 kg in the case of a hydraulic lift. For car areas bigger than 5 m^2 there is no mathematical background.

See Table 3 for an abbreviated comparison of the CEN Tables.

Table 3 — CEN Tables

Rated Load	Maximum Car Area		Increase in Car Area "1.1 A" over "1.1"
	CEN Table 1.1	CEN Table 1.1 A for Goods passengers lifts	
kg	m^2	m^2	%
400	1,17	1,68	44
800	2,00	2,96	48
1 200	2,80	4,08	46
1 600	3,56	5,04	42
over 1 600, add	N/A	0,40/100 kg	N/A
2 000	4,20	6,64	58
2 500	5,00	8,84	73
over 2 500, add	0,16/100 kg	0,4/100 kg	250

3.3.2.6 Lift components that are normally designed to withstand, without permanent damage, overloads greater than 25 % (such as ropes, guides, sheaves, buffers, disconnect switches) are not considered in this comparison.

NOTE 3.3.2.6 CEN Assumption 2 (see Annex C) is not a new assumption, but rather one of the methods as to how Assumption 1 is applied in the CEN standard.

3.4 Assumption 2 - failure of electric safety devices

The possibility of a failure of an electric safety device complying with the requirement(s) of a lift safety standard is not taken into consideration.

Since national safety rules for lifts may be based on different assumptions (some are listed below), universality of Assumption 2 may be questioned.

3.4.1 Rationale for Assumption 2

Reliability and safety performance of lift components designated as electric safety devices is assured if designed in accordance with rules contained in a given lift safety standard. However, the design rules may be based on different assumptions.

3.4.2 Assumption 2 as applied in current standards

Most methods of assuring performance reliability of electric safety devices are similar in present standards. There are, however, differences and inconsistencies, as detailed in section 11.

Section 11.1.3 deals in particular with discrepancies in assumptions implied in requirements for design of electric safety devices.

3.5 Assumption 3 - failure of mechanical devices

a) With the exception of items listed below, a mechanical device built and maintained according to good practice and the requirements of a standard comprising safety rules for lifts is assumed not to deteriorate to the point of creating hazards before the failure is detected.

NOTE National practices and safety rules may be different, such as safety factors. See sections 4.1.3 and 4.2.1 of this report;

b) the possibility of the following mechanical failures shall be taken into consideration:

1) rupture of car suspension means;

2) rupture and slackening of any connecting means such as safety related auxiliary ropes, chains and belts where the safety of normal lift operation or the operation of a safety related standby component is dependent on such connections;

NOTE Since 2000, overspeed valve is required by ASME and CSA when flexible hoses are used and when elevator is located in seismic risk zones 2 or greater;

3) small leakage in the hydraulic system (jack included);

c) the possibility of a car or counterweight striking a buffer at a speed higher than the buffer's rating is not taken into consideration;

d) the possibility of a simultaneous failure of a mechanical device listed above and another mechanical device provided to ensure safe operation of a lift, should the first failure occur, is not taken into consideration.

NOTE 1 The Working Group could not agree upon adopting the CEN Assumption 4.3 (see Annex C) requiring that “the possibility of rupture in the hydraulic system (jack excluded) shall be taken into consideration”;

NOTE 2 Presently, this assumption is implemented only in CEN by requiring a rupture valve or similar devices, while CSA assumes the rupture of flexible hoses only and in that case only, the rupture valve is required. In ASME, the overspeed valve (safety valve) is only required in seismic risk zones 2 or greater.

NOTE 3 The CEN rupture valve protects only in the case of rupture of piping, not the cylinder. The USA's experience indicates that most problems arise from the rupture of cylinders rather than piping;

NOTE 4 Refer to section 10 and table 12 in this Report for detailed comparison of requirements for free fall and excessive speed protection.

3.5.1 Rationale for Assumption 3

3.5.1.1 Although recent accident records do not support the assumption in 3.5 (b)(1), most safety standards (including those studied in the preparation of this report) still assume that the risk of suspension means failure, in particular wire ropes and chains, exists.

3.5.1.2 With the assumption in 3.5 (b)(2) it is recognized that the listed components could deteriorate to the point of creating a direct or potential hazard (by making a safety related standby component inoperative) before the deterioration is detected.

3.5.2 Assumption 3 as applied in current standards

3.5.2.1 CEN (9.5.1) clearly assumes failure of suspension means, while ASME and CSA requirement 3.17 imply that safety gear must be able tostop, or at least slow down, a free falling car.

3.5.2.2 Standards differ significantly in regard to the rupture or slackening of connecting means. Only CEN seems to be consistent in adopting this assumption. Some standards are inconsistent, e.g. ASME and CSA requirement 2.25.2.3.2 anticipate failure of tapes, chains or ropes operating normal terminal stopping devices, but they do not anticipate failure of an overspeed governor rope. Only CEN (9.10.2.10.3) assumes the possibility of governor rope failure.

3.5.2.3 All standards have adopted the assumption that the possibility of a car or counterweight striking buffers at a speed higher than the buffer's rating is not taken into consideration.

3.5.2.4 All standards have adopted the assumption that the possibility of a simultaneous failure of a mechanical device mentioned in Assumption 3 and another mechanical device provided to ensure safe operation of a lift, should the first failure occur, is not taken into consideration.

3.5.2.5 All standards require an anti-creep system based on assumption 3.5 (b)(3).

3.6 Assumption 4 - imprudent act by users

A user may in certain cases make one imprudent act, intentionally made to circumvent the safety function of a lift component without using special tools. However, it is assumed that:

a) two imprudent acts by users will not take place simultaneously; and

b) an imprudent user's act and the failure of the backup component designed to prevent the safety hazard resulting from such imprudent acts will not take place simultaneously (e.g. a user manipulating an interlock and a safety circuit failure).

3.6.1 Assumption 4 as applied in current standards

All three standards are based on this assumption.

3.7 Assumption 5 - neutralization of safety devices during servicing

If a safety device, inaccessible to users, is deliberately neutralized in the course of servicing work, the safe operation of the lift is no longer assured.

3.7.1 Rationale for Assumption 5

If a mechanic, while servicing a lift, neutralizes or circumvents a safety device (e.g. bypassing door interlocks using a jumper cable or readjusting overspeed governor) safe lift operation cannot be assured.

While it is assumed that lifts will be designed to facilitate ease of servicing work and that service mechanics will be equipped with adequate instructions, tools and expertise to safely service lifts, it is recognized that "fail-safe" service work can never be assured solely by the design of a lift.

3.7.2 Assumption 5 as applied in existing standards

3.7.2.1 All three standards are based on this assumption.

3.7.2.2 The standards, however, differ in requirements for the “tools” that must be provided by the design of a lift in order to facilitate ease and safety of servicing work. All standards require stop switches on the car roof, in the hoistway pit and pulley room, and also means for inspection operation from the car top. The standards differ in the following:

a) CEN (7.7.3.2) requires “emergency unlocking device” to be provided for every landing door, while ASME (111.9 & 111.10) and CSA (2.12.9 & 2.12.10) require such a device only on two landings and permit it on all other landings.

NOTE ASME and CSA Codes (2.12.6) now require unlocking devices on every landing;

b) only CSA (3.12.1.4) requires “bypass switches” to be provided in the machine room, which would bypass interlocks or car-door-contact, disconnect normal operation and enable car-top-inspection operation, in order to facilitate the mechanic's servicing of faulty interlocks or car-door contacts.

NOTE Now ASME/CSA require bypass switches (see 2.26.1.5 in current Codes);

c) only CEN (5.9) requires lighting of the hoistway.

3.8 Assumption 6 - horizontal forces exerted by a person

One person can exert either of the following horizontal forces at a surface perpendicular to the plane at which the person stands:

a) static force - 300 N;

b) force resulting from impact - 1 000 N.

Static forces of short time duration may be exerted by the simultaneous deliberate acts of several people located immediately adjacent to each other at every 300 mm interval along the width of a surface.

3.8.1 Rationale for Assumption 6

It is assumed that a person leaning against a vertical surface will exert these forces at that surface. It is further assumed that more than one person can exert this force on a surface simultaneously. Only by relating a force to the width of a surface on which it can be exerted, can a realistic design requirement be obtained.

3.8.2 Assumption 6 as applied in current standards

From Table 4 it is obvious that forces assumed in the standards are different.

Table 4 — Assumption 6 (horizontal forces exerted by a person) as applied in current standards

Assumptions	CEN	ASME and CSA	SA Part 1	SA Part 3	Japan
1.0 **Static force**					
1.1 Landing doors	300 N (7.2.3)	2 500 N [2.11.11.5.7]	300 N (7.2.3)	1.2 kN (12.2 & AS 1735.2 12.4.1	No spec
1.2 Car enclosure	300 N (8.3.2.1)	330 N [2.14.1.3]	300 N (8.3.2.1)	330 N (23.1 & As1735.2 23.18)	No spec
2.0 **Impact on:**					
2.1 Landing doors	Pendulum shock test when glass is used (7.2.3.3) See Note	5 000 N [2.11.11.8]	Pendulum shock test when glass is used (7.2.3.3) See Note	No spec.	No spec
2.2 Car enclosure	Pendulum shock test when glass is used (8.3.2.2).	No spec.	Pendulum shock test when glass is used (8.3.2.2).	No spec.	No spec.
3.0 **Force distribution**	Evenly distributed over an area of 5 cm^2 (for the 300 N) at any place, and at both sides (for doors) See Note	100 mm x 100 mm [2.11.11.5.7] and 300 mm x 300 mm [2.11.11.8]	Evenly distributed over an area of 5 cm^2 (for the 300 N) See Note	Door - 0.1m^2 Car wall – 50 mm x 50mm	No spec
NOTE The pendulum shock tests – Hard and Soft – required are described in Annex J of EN81-2: 1998.					

3.9 Assumption 7 – retardation

A person is capable of withstanding an average vertical retardation of 1 g (9,81 m/s^2) and higher transient retardations.

3.9.1 Rationale for assumption 7

The retardation which can be withstood without injury varies from person to person. Historically, the values used in the standards (see table 5) have not been shown to be unsafe for a vast majority of people.

NOTE See 3.9.3 regarding retardation limits on *emergency car stops.*

3.9.2 Assumption 7 as applied in current standards

Table 5 gives a comparison of requirements based on the assumed safe retardation rates. Major differences are noted in relation to rupture valves, plunger stops, and emergency speed limits.

No standard limits retardation in the case of car stops initiated by an electrical safety device.

Table 5 — Assumption 7 (retardation) as applied in current standards

Assumption	CEN	ASME and CSA	SA*		Japan
			Part 1	Part 3	
Maximum Average Retardation*					
Progressive Safety Gear	1 g (9.8.4) [in free fall and full load]	1 g [2.17.2.2.2] [with counterweight attached]	1 g (9.8.4)	1g (33.1)	1g in vertical direction and 0.5g in horizontal direction (BSL-EO Art 129-10 item 2 parag.1)
Progressive Clamping Device	1 g, when full load (9.9.4)	1 g @ rated load. 2 g peak > 0.04 s [3.17.3.5]	1 g (9.9.4)	N/A	N/A
Oil Buffers	1 g (10.4.3.2) Full Load; Type-Examination	1g [3.22] and [2.22.4.1.1]	1 g (10.4.3.2)	1 g (9.1.5.2)	1g in vertical direction and 0.5g in horizontal direction(BSL-EO Art 129-10 item 2 parag.1)
Rupture valve	1 g (12.5.5.1)	1 g [3.19.4.7.5(b)] 2.5 g peak > 0.04 s [3.19.4.7.5(c)]	1 g (12.5.5.1)	No spec.	N/A
Plunger stops	1 g (12.2.3.3.2)	Rules require ETSR cut speed to 0.25 m/s	1 g (12.2.3.3.2)	1 g (7.2.6)	No spec.
Emergency speed limit	No spec.	1 g [3.25.2.2.2]	No spec.	No spec	No spec.
Emergency car stops	No spec.	1 g for certain EPD stops [3.26.4.2]	No spec.	No spec	No spec.
Maximum retardation					
Safety gear	No spec.	No spec	No spec.	No spec	No spec.
Buffers	> 2,5 g (10.4.3.2)	> 2,5 g [2.22.4.2]	> 2,5 g (10.4.3.2)	>2,5 g (9.1.5.3)	> 2,5 g *t* = < 0.04 s (JEAS-517)
(*if t = Duration*)	*t* =< 0,04 s	*t* =< 0,04 s	*t* =< 0,04 s	*t* =< 0,04 s	

* NOTE: Maximum average retardation levels exceeding 1 g can occur with a lightly loaded lift during safety or buffer application.

** NOTE: SA data apply to indirect lifts only.

NOTE 1 g = 9,81 m/s^2.

3.9.3 Agreed-upon points

All Standards should consider retardation limits on emergency stops initiated by an electrical safety device, albeit based on bio-mechanical studies.

4 Approach to design safety for hydraulic components

4.1 Historical Background

4.1.1 Philosophical differences

This section concentrates on differences between the CEN and ASME requirements for the design of hydraulic components. Reference to the CSA standard is made where it differs from ASME.

NOTE The second sentence is not valid any more because since 1996 there are no difference between ASME and CSA design requirements for hydraulic components any more.

a) Differences in both design philosophy and design formulae lead to different cylinders and rams, valves, pipes, and fittings when designed to CEN and ASME standards. Philosophical differences are as follows:

   1) ASME uses the ultimate tensile strength subject to a minimum percentage elongation of the material as a design criterion;

   2) CEN uses the 0,2 % proof stress yield point as the design criterion. Percentage elongation is not considered;

   3) the working pressure is differently defined in ASME and CEN;

   4) the factors of safety used are also different;

b) the differences are demonstrated by examples as illustrated by the following comparisons:

   1) thickness of cylinder walls of single stage jacks (4.1.4);

   2) thickness of flat cylinder base/head (4.1.5);

   3) thickness of semi-elliptical cylinder head/cambered base (4.1.6);

   4) thickness of ram wall for buckling (4.1.7).

4.1.2 Nomenclature

The following nomenclature is used in the two different standards:

Item	Units*	CEN	ASME
Working pressure	kPa	—	p
Full load pressure	MPa	p	—
Inside diameter of cylinder	mm	D_i	d
Diameter of flat head	mm	—	d
Inside diameter of skirt	mm	D_i	D
Outside dia. of cylinder, pipe	mm	D	D
Wall thickness, cylinder	mm	e_{cy1}	t
Wall thickness, flat bottom	mm	e_1	t
Wall thickness, semi-elliptical	mm	e_2	t
Additional wall thickness	mm	e_0	C
Design or allowable stress	kPa	—	S

Item	**Units***	**CEN**	**ASME**
0.2 % proof stress	$N/mm^2/kPa$	$Rp_{0.2}$	Y.P.
Tensile strength	N/mm^2	R_m	—
Modulus of elasticity	N/mm^2	E	—
Cross-sectional area of plunger	mm^2/m^2	An	A
Slenderness ratio	(dimensionless)	λ	—
Maximum unsupported ram length	mm	1	L
Radius of gyration	mm	—	R
Acceleration of gravity	m/s^2	g_n	—
Reeving (roping) ratio	(dimensionless)	Cm	—
Mass of empty car	kg	P_3	—
Rated load in car	kg	Q	—
Mass of ram	kg	Pr	—
Mass of ram head equipment	kg	Prh	—
Design load on ram	N	F_5	—
Actual load on ram	N	F	—
Second moment of ram area	Mm^4	J_n	—

* If two entries, then the first applies to CEN, the second to ASME.

4.1.3 Factor of Safety Comparison

ASME and CSA clause 8.2.8.5.1 (editions since 2000) requires:

1) for tensile, compressive bending and torsional loading, the plunger, cylinder and connecting couplings shall have a factor of safety not less than 5 based on ultimate tensile strength (UTS);

2) for pressure calculations of the components that are subject to fluid pressure, including the plunger, connecting coupling, control valves, cylinder, and rigid piping shall have a factor of safety (FOS) not less than that calculated from:

$$F = \frac{5,04}{E - 2,8} + 2,7 \quad \text{(A)}$$

where

F = Minimum FOS based on 0,2 % proof stress yield point. The minimum allowable F shall be 3;

E = Percentage Elongation in 50 mm gauge length as per ASTM Standard E8, expressed as a whole number (eg, 20 % = 20 and 5 % = 5). The minimum allowable E shall be 5.

The allowable stress to be used for pressure calculations, according to ASME and CSA 8.2.8.5.2 (2000 and later editions), shall be determined as follows:

$$S = \frac{Y.P}{F} \tag{B}$$

where

S = Allowable stress (kPa);

Y.P = Yield point based on 0,2 % proof yield stress;

F = FOS per formula (A).

CEN (12.2.1.1.1) requires that rams and cylinders be designed with a FOS of 3,91 (2,3 x 1,7), based on the 0,2 % proof stress (YP) and the *full load pressure* (FLP).

For calculations of tensile, compressive, bending and torsional loads the following relationship between ASME and CEN requirements can be established:

$R_{p0.2}$ = 0,2 % proof stress

ASME WP = 1,15 (CEN FLP)

ASME FOS = 5 (ASME Working Stress)

CEN FOS = 3,91 (CEN working stress at FLP) or

= 3,4 (ASME working stress at WP)

Therefore:

UTS $\geqslant$ 5 ASME working stress

YP $\geqslant$ 3,4 ASME working stress

(0,2 % proof stress = YP)

Nominal equality of ASME and CEN requirements would occur if:

$$\frac{UTS}{YP} = \frac{5}{3,4} = 1,47$$

However, the formulae employed are different in the two codes, so the comparison is more complex.

For comparisons of stresses due to pressure it is necessary to determine the FOS from the formula (A) and the allowable stress from formula (B).

Examples of the differences between CEN and ASME/CSA are presented in the following sections 4.1.4 through 4.1.7.

NOTE 4.1.3 For further observations and suggestions regarding the factor of safety, refer to Section 4.2.1 and 4.2.4.

4.1.4 Cylinder wall thickness of single stage jacks

According to ASME and CSA (2000 and later edition, rule 8.2.8.2, the cylinder wall thickness of a single stage jack is calculated with the following formula:

$$t = \frac{pd}{2S} \tag{1}$$

where

d inside diameter;

p working pressure;

S working (or allowable) stress;

t minimum wail thickness.

From CEN Annex K:

$$e_{cyl} \geq \frac{2,3 \times 1,7}{R_{p0.2}} p \cdot \frac{D}{2} + e_0 \tag{2}$$

where

e_{cyl} wall thickness;

p full load pressure;

D outside diameter;

e_0 1,0 mm.

It was noted that e_0, may be 0,5 in some cases;

however it was agreed to leave it at 1,0 for the sake of simplicity.

For a valid comparison, the two formulae should be written as close, as possible in the same form, using common parameters.

As the full load pressure (p) in Equation (2) is in fact the static pressure of the system (P_s), and, based on Section 2.3 in this report, the working pressure (p) in Equation (1) may be written as p = 1,15 (P_s), consequently Equation (1) may be rewritten as follows:

$$t = \frac{1,15}{2} \cdot \frac{P_s \times d}{S} \tag{1a}$$

$$t = 0,575 \cdot \frac{P_s \times d}{S}$$

Recognizing that $D = d + 2_{cyl}$, Equation (2) may be rearranged in terms of the inside diameter as follows:

$$e_{cyl} \geqslant \frac{1,96 P_s \times d + e_0 R_{p0.2}}{R_{p0.2} - 3,91 P_s} \tag{2a}$$

In order to establish difference in the cylinder wall thickness when calculated per ASME versus CEN formula, the following is assumed:

a) the cylinder is made of material having

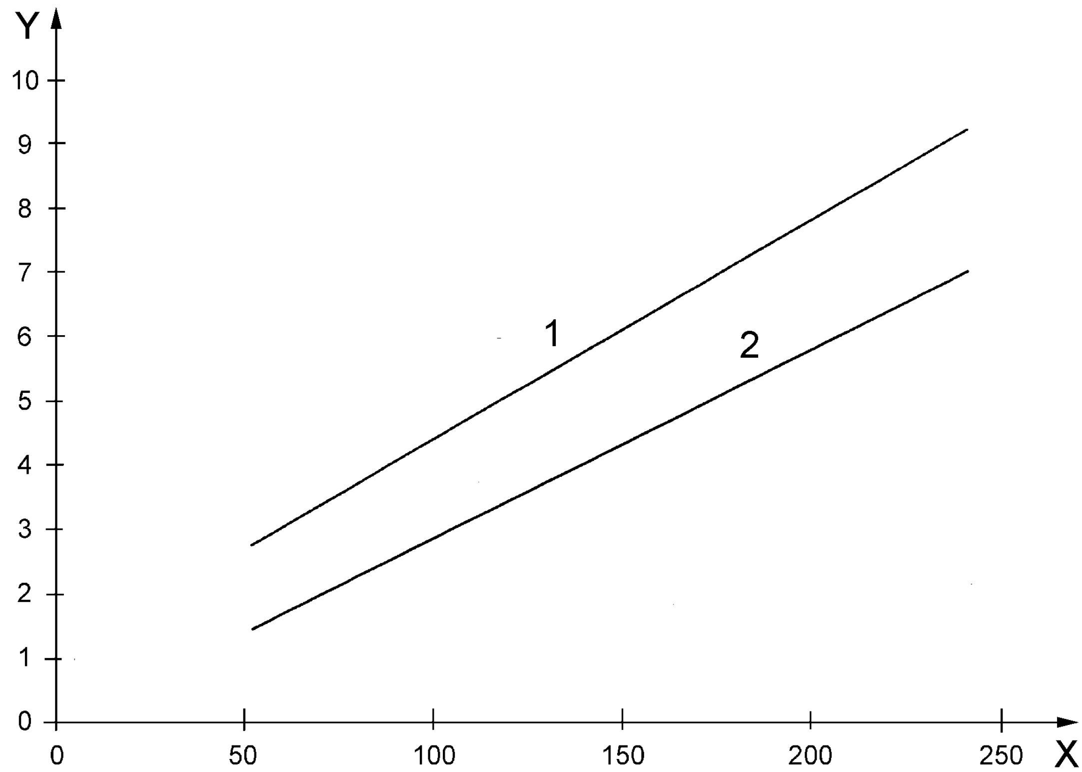
   Y.P. = $R_{p0.2}$ = 187,5 Mpa; and

   E= 14,8

b) the static pressure of the system is P_s = 3 Mpa From formula (A) F = 3,125, and from formula (B) S = 60 MPa.

The wall thickness is calculated in formulae (1a) and (2a) and plotted against cylinder inner diameter in Figure 1.

The graphs show that for a practical range of cylinder diameters the wall thickness required by CEN is always greater than that by ASME. and CSA.



Key

X cylinder inner diameter (mm) - Working pressure 3 MPa, Yield point = 187,5 MPa

Y minimum wall thickness (mm)

1 CEN

2 ASME

Figure 1 — Variation of Required Wall Thickness with Cylinder Diameter

4.1.5 Thickness of flat cylinder base/head

ASME and CSA requirement 8.2.8.3(a) requires that the wall thickness of a flat unreinforced head be designed according to the formula:

$$t = d\sqrt{\frac{p}{4S}} \quad (3)$$

For p = 1,15 P_s

$$t = 0{,}536d\sqrt{\frac{p_s}{S}} \quad (3a)$$

CEN Annex K, for flat base with relieving groove, gives the following formula for the cylinder base thickness:

$$e_1 \geq 0{,}4D_i\sqrt{\frac{2{,}3 \times 1{,}7\,p}{R_{p0.2}}} + e_0 \quad (4)$$

or, if simplified

$$e_1 \geq 0{,}791D_i\sqrt{\frac{Ps}{R_{p0.2}}} + e_0 \quad (4a)$$

Where

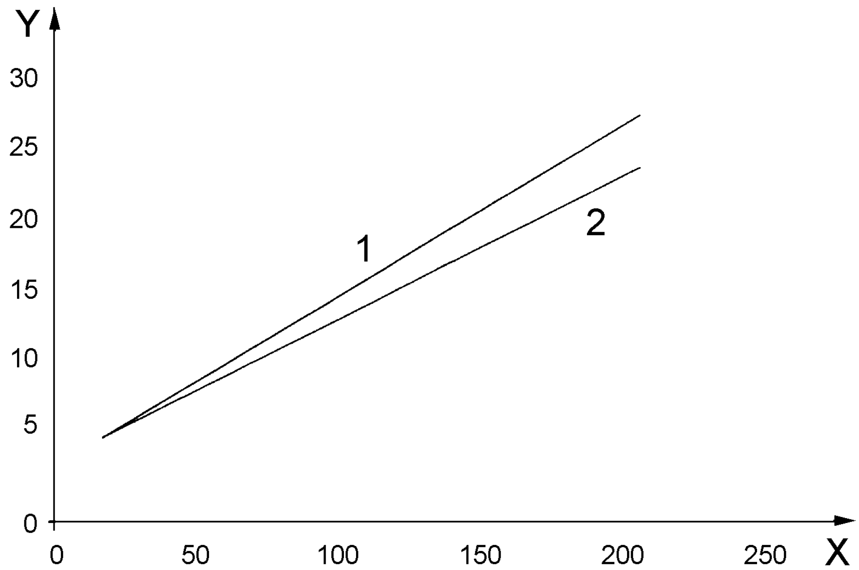
D_i = inner diameter of the cylinder;

e_1 = cylinder base thickness.

Using the same material and assuming the same static pressure as in section 4.1.4, Equations (3a) and (4a) may be plotted on a common axis, as shown in Figure 2.

It is evident that for cylinder inner diameters greater than about 60 mm, the ASME requires a greater wall thickness than the CEN.

This result is perhaps reasonable in that the stress relieving groove would help to reduce stress concentrations in the CEN case.



Key

X cylinder inner diameter (mm) - Working pressure 3 MPa, Yield point = 187,5 MPa

Y minimum wall thickness (mm)

1 ASME

2 CEN

Figure 2 — Variation of Required Thickness of Flat Cylinder Base/Head with Cylinder Inside Diameter

4.1.6 Thickness of Semi-Ellipsoidal Cylinder Head/Cambered Base

The case of dished seamless ellipsoidal heads is dealt with in ASME and CSA requirement 8.2.8.3(c).

CEN Annex K, covers the *case* of cambered bases. The cambered shape approximates an ellipsoidal form.

The ASME and CSA requirement for the wall thickness is given by the following formula:

$$t = \frac{5pD}{6S} \quad (5)$$

where D = inside diameter of the skirt.

For p = 1,15 P_s

$$t = 0{,}958\frac{P_s D}{S} \quad (5a)$$

The wall thickness in CEN is given by the following formula:

$$e_2 \geqslant \frac{2{,}3 \times 1{,}7p}{R_{p0.2}}\left(\frac{D}{2} - e_0\right) \quad (6)$$

where D = outside diameter.

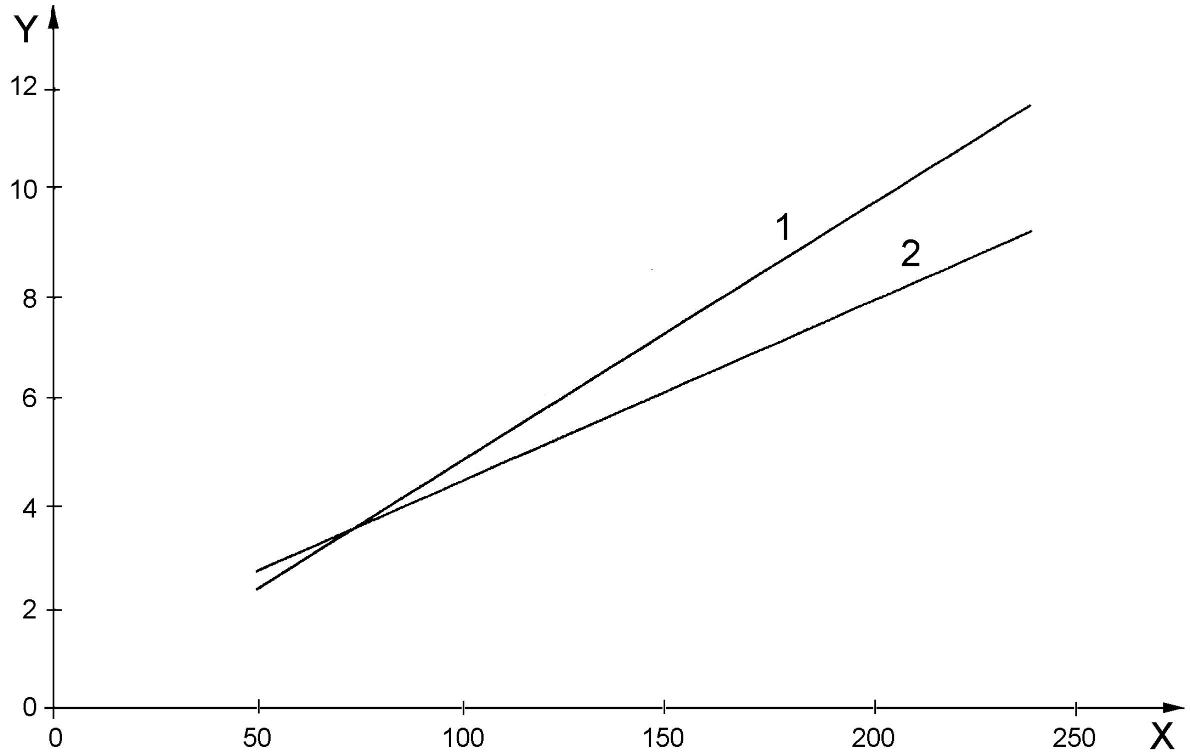
Substituting (D_i + 2e_2) for D and simplifying the following relationship results in:

$$e_2 \geqslant \frac{1{,}955pD_i + R_{p0,2}}{R_{p0,2} - 3{,}91p} \quad (6a)$$

where D_i = inside diameter.

Using the same material and assuming the same static pressure as in Section 4.1.4, the head wall thickness, calculated with formulae (5a) and (6a), may be plotted as shown in Figure 3.

For values of the inside diameter in excess of 75 mm, the wall thickness required by ASME exceeds that required by CEN. This result may in part be due to geometric differences between the two configurations, but is consistent with the findings in section 4.1.5.



Key

X cylinder inner diameter (mm) - Working pressure 3 MPa, Yield point = 187,5 MPa

Y bottom thickness (mm)

1 ASME

2 CEN

Figure 3 — Variation of Elliptical Bottom Thickness with Cylinder Inside Diameter

4.1.7 Thickness of Ram Wall for Buckling

Both the CEN and the ASME standards recognize the elastic stability of rams as a limitation on elevator load. Guidelines are provided to determine the safe strokes for given loading, geometry, and end conditions. The approach to calculation in both standards is essentially on the lines of the conventional Euler analysis, with a factor of safety built into the formulae for long slender rams. For shorter, stockier rams, the limitation of compressive strength of the ram is recognized in the formulae.

The design of rams not subject to eccentric loading is covered by ASME and CSA requirement 8.2.8.1.1.

The relationships between the total load (W), the ram cross sectional area (A), the ram unsupported length (L), and the radius of gyration (R) are expressed as two separate equations, one for a slenderness ratio of L/R $<$ 120, the other for L/R $>$ 120.

For L/R $<$ 120 the following formula applies:

$$\frac{W}{A} = 9{,}773 \times 10^7 - 3{,}344 \times 10^2 \left(L/R\right)^2 \quad (7)$$

For L/R > 120, this relationship becomes:

$$\frac{W}{A} = \frac{6{,}552 \times 10^{11}}{(L/R)^2} \tag{8}$$

CEN –Annex K, gives the following formulae for the calculation of rams against buckling (for nomenclature, refer to 4.1.2):

For $\lambda n < 100$:

$$F_5 \leqslant \frac{A_n}{2}\left[R_m - (R_m - 210)\cdot\left[\frac{\lambda n}{100}\right]^2\right] \tag{9}$$

where

$$F_5 = 1{,}4 g_n [C_m (P_3 + Q) + 0{,}64\, P_r + P_{rh}] \tag{10}$$

$$\text{i.e.: } F_5 = 1{,}4\ F \tag{10a}$$

where

$$F > g_n\ [C_m(P_3+Q)+0{,}64P_r+P_{rh}]$$

Therefore from (9) + (10a):

$$\frac{F}{A_n} \leqslant \frac{1}{2{,}8}\left[R_m - (R_m - 210)\cdot\left[\frac{\lambda n}{100}\right]^2\right] \tag{9a}$$

For $\lambda n \geq 100$:

$$F_5 = \frac{\pi^2 \times E \times J_n}{2 \times L^2} \tag{11}$$

Therefore

$$\frac{F}{A_n} \leqslant \frac{\pi^2 \times E \times J_n}{2{,}8 \times L^2 \times A_n} \tag{11a}$$

Equation (11a) may be further simplified to resemble (8):

$$\frac{F}{A_n} = \frac{7{,}28 \times 10^{11}}{(L/R)^2} \tag{11b}$$

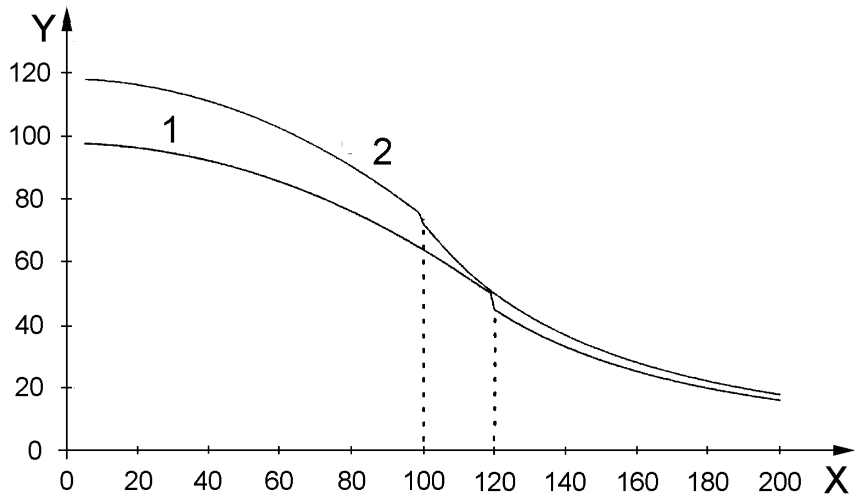
NOTE F/A_n is the equivalent of W/A, or $F = W$ and $A = A_n$.

For purposes of illustration, the combination of Equation (7) and (8) is compared to the combination of Equations (9a) and (11b), for a steel having ultimate tensile strength of R_m = 331 MPa.

This direct comparison of CEN and ASME is shown on Figure 4.

It is noteworthy that both the CEN and the ASME plots show smooth curves of similar shape. The L/R ratio of 120 for ASME and 100 for CEN defines the point of inflection in each curve. For higher values of L/R, the ASME and CEN curves are very close, the ASME curve giving more conservative values of load by about 11 %. The differential between the two is independent of material strength. For lower values of L/R (i.e. L/R < 100), the differential between the ASME and CEN increases as the L/R ratio decreases.

This reflects the particular value chosen for the material strength. Thus, a lower material strength would bring the curves closer together. The ASME curve assumes a fixed material strength; hence, the constant coefficients in Equation (7).



Key

1 ASME

2 CEN

X L/R UTS = 331 MPa

Y W/A (MPa)

W total load

L free length of ram

A cross sectional area of ram

R radius of gyration of ram

Figure 4 — Comparison of Buckling Criteria

4.1.8 Buckling of Ram - Special Cases

4.1.8.1 Plungers with varying cross sectional area, according to ASME and CSA requirement 8.2.8.1.1(d), must be designed with factors of safety of not less than 3 based on accepted elastic stability analysis. CEN does not specifically address this issue.

4.1.8.2 ASME and CSA requirement 8.2.8.1.2 deals with the specific situation of rams subject to bending as a result of eccentric loading in addition to buckling loads. This situation is not covered by CEN, as clause 12.2.2.1 requires a flexible connection between the car and the ram. (See also 5.1.1 and 5.2.1 of this report.)

4.1.9 Wall thickness of rigid pipes

According to ASME and CSA requirement 8.2.8.4, the minimum wall thickness of rigid pipes is calculated on the basis of allowable stress (see formula (B)), using same formula (1a) as for cylinders, except that the following wall thickness must be added on:

C = 0 mm, for plain pipes (unreduced wall).

C = 1,25 mm, for threaded pipes up to 9,5 mm inside diameter.

C = actual depth of thread, for threaded pipes in excess of 9,5 mm inside diameter.

C = actual depth of groove, for grooved pipes.

CEN (Annex K) bases calculations of rigid-pipe-wall thickness on proof stress, using the same formula (2a) as for cylinders, in which the added on wail thickness is:

e_o = 1 mm, for pipes between the cylinder and the rupture valve;

e_o = 0,5 mm, for other pipes.

4.1.10 Strength of flexible hoses

Burst strength of flexible hoses is established as

Follows:

ASME and CSA

3.19.3.3.1: 10 × working pressure (WP)

CEN (12.3.3.1): 8 × full load pressure (FLP)

Since WP = 1,15 FLP (see 2.3 in this report), the required factor of safety (FOS), relating to the full load pressure and burst pressure, is 11,5 in ASME and 8,0 in CEN

4.1.11 Capacity of pressure relief valve

The pressure relief valve has to be adjusted to limit the pressure to the following:

ASME and CSA

3.19.4.2.1: 150 % WP

CEN (12.5.3): 140 % FLP, or

170 % FLP in the systems with high internal losses

Considering the relationship WP/ILP established in Section 2.3, one *can* find that ASME requires higher capacity of the relief valve, or:

$$\frac{\text{ASME}}{\text{CEN}} = \frac{150\,\% \cdot 1{,}15}{140\,\%} = 123\,\%$$

However, for the systems with “high internal losses” the requirements in both standards are approximately the same, or:

$$\frac{\text{ASME}}{\text{CEN}} = \frac{150\,\% \cdot 1{,}15}{170\,\%} = 101\,\%$$

4.2 Observations and suggestions by individual experts

4.2.1 Observations: Factor of Safety and ductility (reference 4.1.3)

4.2.1.1 High ductility materials preferred

One expert suggested that all safety standards should provide an incentive for the use of high ductility materials for hydraulic components in order to reduce the probability of failures. For that reason, all standards should link the factor of safety to the percentage elongation of material, as is the case in ASME and CSA requirement 8.2.8.5.

4.2.1.2 Rationale behind the suggestion in 4.2.1.1

Expressing the failure criteria in safety standards in terms of the proof stress (or yield point) only could tempt the designer to use materials of high strength and low ductility, as these are low cost. However, low ductility materials have a greater scatter in their mechanical strength, and if overloaded could fail without significant permanent deformation.

It is important to have yielding of the material on hydraulic systems so that leakage will precede catastrophic failure and provide visual indication of an impending problem.

The use of high strength materials without consideration of the ductility of the material could mislead the designer and could result in an unsafe design. This has relevance to the CEN Code.

4.2.1.3 Background to the suggestion 4.2.1.1

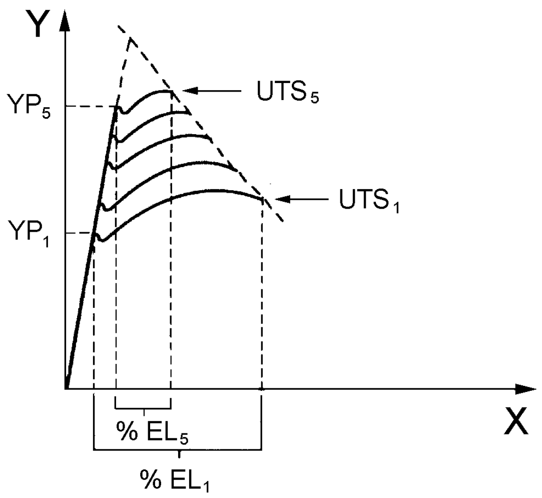
a) Introduction

It is customary when performing an engineering analysis of a loaded device that the stresses be determined, a failure criteria selected, the material strength determined and factor of safety applied. In the case of ASME, CEN, and CSA standards, differences can occur in all of these parameters; hence very different designs and margins of safety are likely. This study focuses on the failure criteria and the factor of safety to be applied according to the requirements in current standards.

b) Failure criteria - CEN approach

CEN requires the use of the 0,2 % proof stress yield point as the failure criterion. There is no consideration for the ductility of the material, i.e. its deformation beyond the yield point. In general, ductile materials have a greater difference between the yield point and the rupture point than brittle materials.

This is illustrated in Fig 5, which shows the variation of yield point against percentage elongation for materials which may be hardened to different strength values. The figure shows the typical reduction of percentage elongation or permanent deformation before rupture as the yield point is raised. The yield point effectively approaches the ultimate tensile strength until the material ruptures almost immediately after it is overloaded.



Key

YP yield strength

UTS ultimate tensile strength

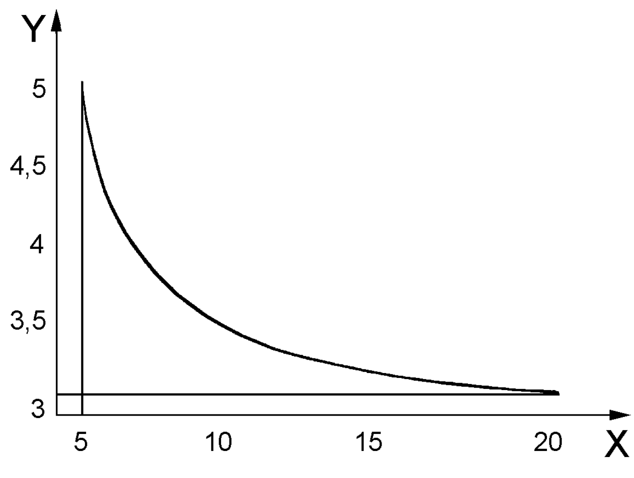
EL elongation

Figure 5 — Effect of increased Strength on Elongation

c) Failure criteria - CSA and ASME approach

ASME and CSA

requirement 3.18.2.1make the factor of safety (F) a function of the percentage elongation as shown in formula (A) in Section 4.1.3 of this report The relationship is illustrated in Fig 6, which shows that, the greater the material ductility, the smaller the factor of safety is permitted.



Key

X elongation percent (E)

Y safety factor on yield point (F)

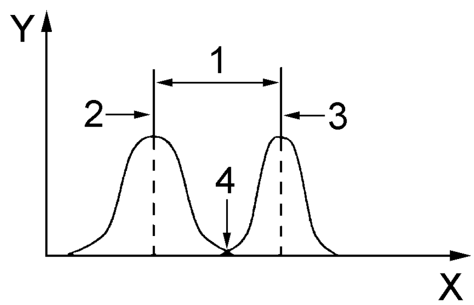
F 5,04/(E-2,8) + 2,7 valid for $E \geqslant 5$ and $F \geqslant 3$

Figure 6 — Relationship Between Factor of Safety and Percentage Elongation

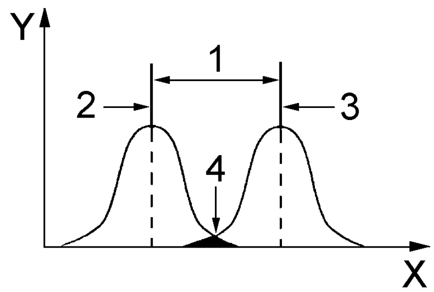
d) Probability of failure

The purpose of applying a factor of safety (FOS) is to reduce the risk of failure to an acceptably low level. Risk may be quantified as the probability of failure under load. Fig. 7 illustrates the probability of failure of two materials, each possessing the same nominal yield point and subject to the same nominal loading. Stress is plotted on the horizontal axis and probability of occurrence on the vertical axis. The shape of the loading distribution reflects the uncertainty in the applied load, while the shape of the material strength distribution reflects the variability from piece to piece in the material.

The nominal factor of safety is the ratio of the mean strength to the mean stress in each combination. The shaded area, i.e. the overlap of the distributions, represents the cases where load stress exceeds material strength and failure will occur. It is evident that the greater the FOS, the smaller the overlap area will be. However, a finite probability of failure always exists.



a Ductile material



b Brittle material

Key

X probability

Y stress

1 margin of safety

2 mean stress

3 mean strength

4 small overlap in case of a) ductile material
large overlap in case of b) brittle material

Figure 7 — Probability of Failure

e) Advantages of Ductile Materials

The ductility of the material affects the shape of the material strength distribution curve. Thus less ductile materials have greater scatter of their yield points and ultimate tensile strengths. Thus the probability of failure is higher with brittle materials than ductile materials with the same mean strength and factor of safety. Moreover, in the case of hydraulic elevators, the use of ductile materials (which allow a substantial degree of deformation before rupture) is particularly desirable. The deformation, in the event of overload, would allow joints to leak with the resultant dissipation of the pressure, rather than a sudden rupture.

4.2.1.4 Example for FOS: Cylinder Wall Thickness

Calculations were made for four various cylinder materials used in Finland, Russia and U.S.A. (see table 6) in order to illustrate differences in the resulting design of a cylinder, when calculations are based on CEN, ASME or CSA requirements for:

f) cylinder wall thickness, per Section 4.1.4, formulae (1a) and (2); and

g) factor of safety, per section 4.1.3 in this report.

The following conditions were assumed:

— working pressure 3,5 MPa

— inside diameter (ASME & CSA formulae) 125 mm

— outside diameter (CEN formula) 135 mm

As illustrated in table 6, the resulting wall thickness, when calculated in accordance with CEN rules, is 72 to 90% greater than when calculated per CSA or ASME rules.

Table 6 — Illustrative examples of wall thickness for 4 materials

Data for Materials					**Wall Thickness** (mm)				
Source Country	Material	UTS MPa	0,2 % PS MPa	Elong. %	CEN	ASME and CSA	SA		Japan
U.S.A.	ASTM								
	A53-88a	330	205	> 20	5,5	3,7	5,5		No spec
	Grade A								
U.S.A.	ASTM								
	A53-88a	415	240	> 20	4,8	3,1	4,8		No spec
	Grade B								
Finland	DIN 17100	510	353	22	3,6	2,2	3,6		No spec
Russia	35 GOST 1050	520	310	20	4,0	2,4	4,0		No spec

4.2.1.5 Comments on FOS and suggestions in 4.2.1.1

Other experts commented on the suggestions in 4.2.1.1 and the background information in 4.2.1.3 regarding the safety factors and ductility of materials:

a) it was noted that differences between ASME and CEN design approaches are not limited to hydraulic equipment but to all mechanical components in general. With respect to the CEN's not referring to ductility of materials, it was stated that a designer would not be permitted to use any material but only those that have been subjected to tests in accordance with non-elevator rules or Standards.

Another expert stated that more consideration should be given to hydraulic equipment because of the risk of leakage, It was recognized that "codes of practice" (such as DIN) exist in Europe, where appropriate materials, of certain ductility, are suggested, but the expert maintained that a better approach is to interrelate the ductility and strength. This would become a universally acceptable method if introduced in all elevator safety standards.

b) One expert who agreed that failure of ductile materials would result in leakage rather than catastrophic failure (car drop) expressed concern for damage to the environment by the leaking oil.

Another expert suggested that the failure of brittle materials would result in both the unsafe condition and damage to the environment.

c) It was suggested that CEN does not include *all* rules but rather assumes that all general basic design rules, not specific to lifts, are known to and followed by each elevator design engineer.

Another expert stated that basic general engineering practices may prove insufficient for a particular elevator component and for that reason safety factors have been introduced in ASME and CSA, based on experience.

Another expert reiterated that a fixed safety factor is not a fully satisfactory solution. A better approach is one based on the probability of failure, as in CSA and ASME.

4.2.1.6 Should Factor of Safety be Specified?

a) Several experts suggested that all standards, including CEN, should contain specific rules regarding factors of safety;

b) another expert indicated that CEN does not normally specify factors of safety except for equipment which is specific to the lift industry (e.g., hoisting ropes). The necessary information can be found in the standards relating to structural steel or mechanical construction, such as the standard for the bolts industry;

c) the following ranges of factors of safety are commonly used:

   1) for structures, from 4 if the material has an elongation of 20 % or more to 10 if the material has an elongation of less than 10 %;

   2) for machinery, from 8 if the material has an elongation of 20 % or more to 12 if the material has an elongation of less than 10 %.

4.2.2 Observations: Cylinder Wall Thickness (reference 4.1.4)

4.2.2.1 Background to CEN formula

Regarding the CEN formula (2) in Section 4.1.4, an expert representing CEN explained

a) Factor 2,3 is the product of 1,15 (friction losses) and 2 (pressure peak). The pressure peak factor should take into account the acceleration peaks and stresses created by activation of a rupture valve or when the plunger is stopped at its ring;

b) the denominator $R_{p0.2}/1,7$ corresponds to UTS/5 in ASME, but as they are different, the calculated wall thicknesses are different;

c) "added on" wall thickness e_o, should compensate for tolerances of the material and also the affects of corrosion on buried cylinders;

d) formula (2) was adopted from rules for pressure vessels, where pressure in all directions is present.

4.2.2.2 Differences in thickness affected by e_o

a) To analyze differences between the ASME and CEN formulae for cylinder wall thickness (see formulae (1a) and (2a) in section 4,1.4), the safe static pressure (P_s), that a cylinder can withstand, was calculated:

For ASME:

$$P_s = \frac{tS}{0{,}575d} \qquad 1(b)$$

For CEN:

If e_{cy1} = t then formula (2a) can be written as follows:

$$P_s \leq \frac{(t - e_o)R_{p0.2}}{1{,}955\ (d + 2t)} \qquad 2(b)$$

According to section 4.1.3 of this report, if the percentage elongation is E = 10, then from formula (A) factor of safety is F= 3,4.

The allowable stress, from formula (B) is:

$$S = \frac{Y.P.}{F} = \frac{Y.P.}{3{,}4} = \frac{R_{p0.2}}{3{,}4}$$

Thus $R_{p0.2}$ = 3.4S. Consequently, formula (2b) may be written as follows:

$$P_s \leq \frac{(t - e_s)S}{0{,}575(d + 2t)} \qquad (2c)$$

b) comparison of formulae (1b) and (2c) shows that the formulas are similar, except that CEN formula has "added on" wall thickness of $e_{,o}$ = 1 mm and is based on the “outside” (d + 2t) instead of the "inside" diameter (d);

c) because of these differences, the static pressure would differ as follows:

For S = 60 Mpa

D = 100 mm

T = 5 mm

e_o = 1 mm

Resulting static pressure is:

Per ASME: P_s = 5,2 Mpa

Per CEN: P_s = 3,8 Mpa

d) Both formulae are based on the thin-walled approximation of Lame's Theorem, which assumes uniform distribution of radial and tangential stresses, provided that the wall thickness is small compared to the cylinder diameter. ASME formula (1b) is identical to the thin-walled cylinder rule.

4.2.2.3 Tests to verify factors used in formulae

To establish oil pressure and decelerations under various operating conditions, tests were carried out on the following elevator:

Capacity : 8 persons

Speed : 0,45 m/s

Type : indirect acting

Floors : 5

Test Results:

Operating Condition	Pressure (MPa)	
	Up	Down
No load:		
Rupture valve activated	—	4,5
Full load:		
Static	3,8	3,8
Acceleration	4,7	3,5
Rated speed	4,5	3,6
Slowdown	4,3	3,9
Emergency stop	5,0	5,0
Rupture Valve	—	5,7

Full load on rupture valve	Declaration (m/s^2)
Ram declaration	1,6
Car declaration	3,2

Analysis:

The pressure peak of 5,7 MPa is measured when the full load is stopped by the activation of the rupture valve.

For the same operating condition on this elevator, calculated pressure, using CEN formula is 7,5 MPa.

When compared with the measured static full load pressure of 3,8 MPa, then the pressure peak factor is:

Measured peak/static pressure = 5,7/3,8 = 1,5

Calculated peak/static pressure = 7,5/3,8 = 1,96

The tests indicate that the highest pressure peak factor on this elevator is 1,5. The CEN formulae, however, incorporate a pressure peak factor of 2 (see 4.2.2.1a) to provide for the worst cases.

4.2.2.4 Recommendations for cylinder design formulae

a) The CEN "added-on" wall thickness e, should be deleted because:

— there is no scientific justification;

— thicker wall can only delay and not prevent any corrosion damage;

— corrosion affects only buried cylinders while the formula is applicable to all lifts;

— the "minimum thickness" is normally used in calculations, therefore e_o need not compensate for negative tolerances in the cylinder materials.

NOTE 4.2.2.4 The minimum wall thickness of piping is the value obtained from the relevant material Standard specification, when eccentricity of the outside and inside diameters to the centerline of the pipe is considered; and the manufacturing tolerances on diameters are given values that predict the thinnest wall, e.g., the CSA and ASME Codes refer to ASTM standards. CEN should reference a similar Standard;

b) the CEN formula should be based on the "inside" cylinder diameter, rather than "outside", to be consistent with the theory of elasticity.

4.2.3 Observations: Thickness of Flat Cylinder Base/Head (Reference 4.1.5)

4.2.3.1 Analysis of CEN & ASME Formulae for Base/Head

Figures 2 and 3 show that the thickness of the cylinder base or head is greater when calculated per ASME formulae (3) than per CEN formulae (4), which is opposite to the case with the cylinder wall thickness, as shown in Figure 1.

To analyze the differences, formulae (3) and (4) *can* be rewritten, as shown in the following formulae (3b) and (4b), assuming that:

If for ASME:

$p = 1{,}15\ P_a$ (based on Section 2.3)

$S = \frac{Y.P.}{F}$ (formula B in 4.1.3)

where P_s is static full load pressure

$$\text{then } t = 0{,}5d\sqrt{\frac{1{,}15P_s}{S}} \qquad 3(b)$$

The CEN formula (4) can be rewritten in a similar form by making the following substitutions;

$p = P_s$

$e_1 = t$

$D_i = d$

$R_{p0.2}$ = Y.P. = FS (from formula B in 4.1.3)

F = 3,4 (from formula A, assuming E = 10)

$R_{p0.2} = 3{,}4S$

then $(t-e_o) = 0{,}4d\sqrt{\frac{1{,}15P_s}{S}}$ 4(b)

The difference is created by the CEN "added-on" wall thickness e_o and the choice of factors, 0,4 versus 0,5.

Recognized machinery handbooks give the following corresponding formula:

$$t = 0{,}434d\sqrt{\frac{1{,}15P_s}{S}} \qquad (13)$$

where the factor 0.434 is the result of

$$\sqrt{0{,}24\left(\frac{\pi}{4}\right)} = 0{,}434$$

For discussion on the subject of “e_o” refer to section 4.2.2.

4.2.3.2 Recommendation for cylinder base/head

CEN and ASME should adopt the “textbook factor” of 0,434 and the CENs e_o should be deleted.

4.2.4 General Comments on Design Approach

4.2.4.1 Loading Assumptions

Ratio of 1,15 for the CEN “full-load pressure” to the ASME "working pressure", stated in section 4.1.3 of this report, has been verified as realistic through several tests on actual lifts.

4.2.4.2 Materials

CEN formulae and tables are applicable to steel, but that is not explicitly stated in the standard.

ASME is even less specific. It, indeed, requires materials with elongation exceeding 5 %, but the use of higher elongations is encouraged by formula for factor of safety (see formula A in Section 4.1.3).

Consequently, the standard should specify the kind of material for which the formulas are valid (e.g., by giving examples).

4.2.4.3 Safety Factor

ASME specifies a safety factor that is linked to ductility of the material by a formula, and takes into consideration the working pressure, without any considerations of dynamic factors.

CEN specifies a low safety factor of 1.7, but requires that the worst anticipated loading condition be taken into considerations such as “full load pressure” and “dynamic factors”.

With respect to the dynamic factor of 2, required for “pressure peaks” in CEN formulae (see factor 2,3 in formulae (2), (4) & (6) and section 4.2.1 in this report), it is noted that tests, presented in section 4.2.2.3 of this report, have recorded this factor to be 1,5. However, it is possible that it may reach 2 on some lifts. Consequently, the CENs dynamic factor of 2 is justified.

The “friction losses” factor of 1,15, the portion of the factor 2,3, while verified by tests as correct, should not be taken into consideration in the calculations that are based on the pressure peaks in the down direction, such as the sharp stops by rupture valves, because in such cases the friction losses act in the opposite direction and therefore represent a negative factor.

4.3 Points agreed upon

4.3.1 Standards should encourage the use of ductile materials for hydraulic components by linking the factor of safety to the percentage elongation of materials.

4.3.2 Formulae for calculation of the cylinder wall thickness and rigid pipe wall thickness should be based on the inside diameter.

4.3.3 Standards should require that ail calculations be based on the “minimum wall thickness” (see definition in 4.2.2.4a) rather than nominal and should not contain any “add-on” thickness.

4.3.4 The “textbook factor of 0,434 should be used in the formulae for the thickness of the flat cylinder base or head, instead of currently used factors 0,4 and 0,5.

4.3.5 Current design practice is based on the use of steel for cylinders, rams and piping. All Codes should indicate that only steel is acceptable for this purpose. The relevant Standards for the material should be referenced in each Code.

NOTE The intent is not to prohibit the use of other materials; however, at this time there are no data available for other materials.

5 Driving Machines and jacks (plungers and cylinders)

5.1 Historical background

This section concentrates on the differences between the CEN and ASME/CSA requirements for driving machine components including plungers and cylinders.

5.1.1 Connection between ram and frame on direct acting elevators

ASME and CSA permit the connection to be either flexible or rigid. CEN Clause 12.2.2.1 requires that the connection between the ram and the car frame be flexible.

ASME and CSA requirement 3.18.1.1 require all connections of the ram to the car frame to withstand any forces resulting from the ram stop. The connection shall be capable of carrying in tension the weight of the plunger (ram) with a factor of safety of not less than 4. Flexible connections shall be capable of restricting vertical movement to no more than 20 % of the buffer stroke. Rigid connections shall be capable of transmitting the full eccentric load, where applicable, with a factor of safety of 4, when imposed on the platform by the load with a leading edge deflection of not more than 19 mm (ASME and CSA requirement 3.18.2.3).

5.1.2 Indirect acting Lifts

Indirect acting drives are now permitted in all standards. They were not permitted in the ASME standards from 1955 to 1989. Many serious accidents, related to high speed water-hydraulic machines with up to a 12:1 roping ratio, practically eliminated this type of drive from the North America market and consequently from the ASME standards. In the meantime, modem oil-hydraulic machines were developed with all of the inherently unsafe technical problems of water-hydraulics eliminated.

Refer to Table 7 for a comparison of the requirements in the standards. While ASME limits the roping ratio to 1:2, this does not preclude the use of a 2:4 ratio.

Table 7 — Comparison of requirements for indirect acting lifts

Requirement	CEN	ASME and CSA [3.18.1.2]	Part 1	SA Part 3	Japan
Driving machine (jack) to be vertical	No spec	Yes [3.18.1.2.1]	No spec.	No spec.	No spec.
Minimum number of ropes per jack	2 (9.1.3)	2 - General Case [3.18.1.2.1] 1 - Special Case w/ 3 or more jacks per car. [3.18.1.2.2]	2(9.1.1)	2 (17.2)	2 for each car
Maximum roping ratio	No spec.	1:2 [3.18.1.2.4]	No spec.	No spec.	No spec.
Moving element of ram to be guided	Yes (12.2.2.4)	Traveling sheave [3.18.1.2.8]	Yes (12.2.2.4)	No spec.	No spec.
Slack rope device required	Yes (12.13)	Yes [3.18.1.2.7]	Yes (12.13)	Yes	Yes (2000 MOC Notice No.1423 item 5 parag.2)
Safety factor for - ropes	12 (9.2.2)	6,65 11,9 [2.20.3]	12 (9.2.2)	10 -9.5 mm dia 12 – 8 mm dia (17.2)	Refer to table 10 (suspension ropes chains)
- chains	10 (9.2.5)	Not permitted	10 (9.2.5)* (restrictions on use of chains 10 m travel; 0.3 m/s; 6m² max platform)	10 (17.3.6) (restrictions on use of chains 10 m travel; 0.3 m/s; 6 m² max platform)	Refer to table 10 (suspension ropes chains)
Maximum rated speed	1 m/s* (1.3)	No limit	1 m/s* (1.3) (0.3 m/s max for chains)	0.3 m/s (17.3)	No limit

* EN81/2 specifies requirements for lifts with rated speed up to 1,0 m/s only. For lifts with higher rated speeds, additional measures have to be taken which are not specified in the Standard.

5.1.3 Multiple jacks

CEN (12.1.2) requires hydraulic interconnection of multiple jacks to ensure pressure equilibrium. There is no equivalent requirement in ASME or CSA.

5.1.4 Counterweights

CEN (12.1.3) requires that if a counterweight is used, its mass should be calculated to ensure that if the ropes snap, the pressure in the cylinder does not exceed twice the full load pressure. There is no equivalent requirement in ASME or CSA.

ASME and CSA requirement 3.6.2 require counterweight safeties only where there is occupied space below. There is a corresponding requirement in CEN (5.5.2b).

5.1.5 Rams

5.1.5.1 Ram joints

ASME and CSA requirement 3.18.2.3 require that ram joints carry the weight of sections below the joint, with a FOS of at least 4, transmit the compressive load, with a FOS of at least 5, withstand forces from ram stops at the end of the stroke, and resist eccentric load.

CEN (12.2.2.3) requires that the joints support the suspended ram and any dynamic forces. No specific factor of safety is mentioned.

5.1.5.2 Hollow Ram subject to external pressure

ASME and CSA requirement 3.18.2.5 specifically requires that hollow rams shall not be subject to a working pressure greater than that calculated by the following formula:

Where $t/d < 0{,}023$

$$p = 2296\left[1-\sqrt{1-1600\left(\frac{t}{d}\right)^2}\right]$$

where $t/d > 0{,}023$

$$p = 199200\ \frac{t}{d} - 3185$$

where

d = external finished diameter (mm)

p = working pressure, (kPa)

t = finished wall thickness (mm)

CEN does not give any corresponding formulae.

5.1.5.3 Ram-follower guide. ASME and CSA requirement 3.18.2.7 permit the use of a follower guide to support the ram so that its maximum unsupported length (L) meets the requirements mentioned in Section 4.1.7 of this report. The follower device requires an interlock that will stop the elevator if the unsupported length is exceeded. CEN does not reference an equivalent device.

5.1.6 Cylinders. Differences in design aspects of cylinders are dealt with in some detail in Section 4.1 of this report. Some other specific differences are discussed below.

5.1.6.1 Safety bulkheads for cylinders. ASME and CSA rule 3.18.3.4 require the use of a safety bulkhead in the form of a double cylinder bottom for cylinders installed below ground. The inner bottom requires a small orifice to allow oil leakage in the event of a failure of the outer bottom. The orifice is to be sized to ensure a descent speed of between 0,025 m/s and 0,076 m/s. The safety bulkhead is not required if a double cylinder is used (one inside the other).

The intent of the ASME/CSA requirements is to assure safe descent of the lift in the case of a cylinder bottom rupture caused by corrosion.

CEN does not have an equivalent requirement.

5.1.6.2 Protection of cylinder/jacks installed below ground. All standards require protection from corrosion of cylinder/jacks that extend into the ground, but the protection means are different.

ASME and CSA requirement 3.18.23.8 requires one or more of the following: (1) monitored catholic protection; (2) coating that will withstand the installation process; or (3) a protective casing. CEN (12.2.4.1) requires a protective tube.

ASME and CSA corrosion protection requirements for cylinders as well as for underground piping (see 6.1.1.1g in this report) were introduced in response to the USA Environmental Protection Act in order to minimize oil spill.

CSA and CEN requirements for cylinder corrosion protection were introduced with the intent of protecting elevator passengers from the hazards created by overspeeding or free-falling car.

5.1.7 Limitation of the ram (plunger) stroke

All standards require stops to prevent the ram (plunger) from leaving the cylinder and to maintain the required top-of-car clearance. Requirements for stopping means are different.

ASME and CSA requirements 3.18.4 and 3.25.2 requires metal stop and/or other means to be provided at one end of the plunger and at the packing head end of the cylinder. The stops must be capable of stopping an up-traveling plunger at its maximum speed (or reduced speed under special condition) under full load pressure.

NOTE See also ASME and CSA rule 3.25.2.

CEN (12.2.3) references one of the following means:

a) a cushion stop, which (i) is an integral part of the jack, or (ii) consists of one or more devices external to the jack (12.2.3.3); or

b) by shutting off the hydraulic supply to the jack by means of a mechanical linkage between the jack and a valve (12.2.3.2.b).

In either case, including the breakage or stretch of the mechanical linkage [see (b)], the car average deceleration must be $\leqslant$ 1,0 g, and on indirect plunger lifts, the deceleration must not slacken the ropes or chains. The intent is to eliminate harsh stops.

For the same reasons ASME and CSA requirement 3.25.2 requires that a terminal speed limiting device slow the car own to 0,51 m/s at a deceleration rate of not greater than 1 g prior to striking the mechanical stop.

5.1.8 Telescopic jacks

CEN (12.2.5) covers the requirements for telescopic jacks. Rules are provided to ensure that:

a) successive sections do not exit the cylinders;

b) distances between successive guiding yokes and between highest yoke and *car* in a direct acting elevator are at least 0,3 m;

c) each stage has a bearing length of at least 2 times ram diameter;

d) mechanical or hydraulic synchronizing means are used;

e) an electric device prevents start if the pressure exceeds full load pressure by more than 20 % for hydraulically synchronized rams;

f) for synchronization by means of ropes or chains the following requirements apply: (1) at least 2 ropes or chains with a minimum FOS of 12 or 10; (2) rules regarding protection of pulleys; and (3) a device to prevent downward overspeed by more than 0,3 m/s above rated speed if the synchronizing means fail.

In addition, CEN (12.2.1.1.2) gives special rules for calculation of the elements of telescopic jacks with hydraulic synchronization, requiring that the “full load pressure” be replaced by the “highest pressure” which occurs in the elements due to the hydraulic synchronization. Furthermore, CEN notes that "it may be possible that, due to incorrect adjustment of the hydraulic synchronizing means, abnormally high pressure condition may arise during installation".

ASME and CSA requirement 8.2.8.1.4 addresses telescopic jacks only with respect to values L and R in formulas (7) and (8) shown in 4.1.7 of this report. The ASME rule also requires "follower guides" (see 5.1.5.3 in this report) if plunger has more than two sections.

5.2 Observations and suggestions by individual experts

5.2.1 Connections between ram and car frame (reference 5.1.1 of this report)

a) Standards should not mandate types of construction (flexible or rigid);

b) rigid connections should be acceptable as long as rigidity is taken into account in the design. The standards should not preclude something only because it is hard to calculate;

c) if rigid connections are to be allowed in a standard, then design requirements must be specified, including modified buckling formulae, with due consideration to all forces in specific directions. CEN has opted for not permitting such connections;

d) one expert referred to ASME Rule 302.2c(2) that specifies design requirements for the case of eccentric loading, while Rule 1302.1(b) gives a modified buckling formula;

e) other experts suggested that the moment resulting from eccentric loading is normally transferred to guide rails and does not affect the plunger connection. It is only on elevators without car-frame that this eccentric moment or bending stresses need be considered.

5.2.2 Indirect acting lifts (reference 5.1.2 of this report)

a) ASME/CSA's limitation of the roping ratio to 1:2 is an unnecessary design restriction;

b) lack of any limitation on the roping ratio may result in the use of high ratios which in turn may result in unsafe installations;

c) one must consider that CEN limits the lift speed to 1,0 m/s (CEN-12.8.1) and no designer would select a high ratio for such a low speed;

d) CEN requires a smaller factor of safety for chains than for ropes because the devices are used on low speed lifts;

e) CEN, however, does not limit the speed when chains are used.

NOTE The maximum speed covered by EN 81-2 is defined in its scope, 1.3.g).

5.2.3 Multiple Jacks (reference 5.1.3 of this report)

One expert contended that the pressure equalization requirements in CEN are not justified and unnecessarily restrict design.

5.2.4 Counterweights (reference to 5.1.4 of this report)

ASME and CSA standards should relate the weight of the counterweight and the pressure in the cylinder should the counterweight separate from the car.

5.2.5 Rams/plungers (reference 5.1.5 of this report)

In regard to ram joints (5.1.5.1), one expert noted that the only difference in requirements is that there is no factor of safety specification in CEN. Another expert used the USA experience with the failure of ram seams to underline the need for factor of safety requirements in elevator standards rather than relying on general engineering practice.

In regard to ram-follower guides (5.1.5.3), one expert suggested that a designer will opt for ram guides using common engineering principles as currently required in ASME.

It was suggested a requirement for safe design of ram-guides, to ensure that they do not fail, would be more appropriate than a requirement for interrupting the elevator operation should the guides fail.

In regard to hollow rams subjected to external pressure (5.1.5.2), it was suggested that CEN should also introduce corresponding requirements.

5.2.6 Corrosion Protection of Cylinders (reference 5.1.6 of this report)

Steel cylinders buried underground are subject to corrosion due to electrochemical action between the anodic cylinder and the catholic ground.

Groundwater serves as the electrolyte in the process. The effect of unchecked corrosion is cylinder degradation and loss of hydraulic oil, hence a decrease in safety, and contamination of the environment. The rate of corrosion depends upon the local electrical potentials, the corrosive nature of the groundwater and the relative sizes of anode and cathode areas. Corrosion may be reduced or prevented by:

a) encasing the cylinder in a rigid casing of a material such as PVC. If the space between casing and cylinder is empty, casing should be designed to withstand a static head of water from ground level to the bottom of the casing;

b) sheathing taping or otherwise protecting the cylinder with a robust protective barrier that will withstand handling and installation;

c) monitored cathodic protection.

The CEN requirements for corrosion protection of cylinders installed below ground, and other environmental protection regulations, may influence, in some European countries, the installation of new hydraulic lifts with buried cylinders.

5.2.7 Limitations of the ram/plunger stroke (reference 5.1.7 of this report)

ASME and CSA should consider limiting the average car retardation to less than 1 g when the plunger reaches its uppermost stop.

This may not be necessary, since ASME and CSA requirement 3.25.2 requires emergency terminal speed limiting devices when the up direction car speed exceeds 0,51 m/s. A stop at slow speed will not be harsh.

5.2.8 Telescopic jacks (reference 5.1.8 of this report)

5.2.8.1 General comments

CEN rules for telescopic jacks were developed based on analysis of many accidents involving lifts with telescopic plungers. The German, Swedish, and Italian national standards were used as models for CEN rules.

This type of drive has rarely been used in North America.

5.2.8.2 Rationale for CEN rules on hydraulic synchronization for telescopic jacks

a) Concept of hydraulic synchronization.

The hydraulic synchronization is based on the equality of F_R (area of the ring) with F_K (area of the bottom of the ram). This equality ensures that ram B is moved over the same distance as ram A due to displacing a volume of oil from the ring into its inside. See Figure 8.

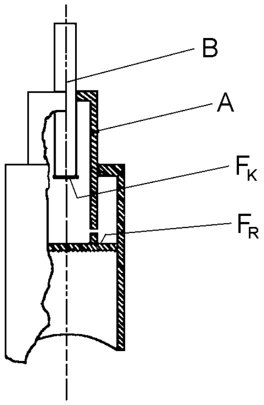


Figure 8 — Telescopic jack - Concept of hydraulic synchronization

b) Possible problems

It cannot be ensured that the synchronization remains unchanged during a longer period of operation.

Reasons for changes of the synchronization are mainly:

1) the equality of the areas is not correct, due to bad design;

2) failures made during filling up and venting the system, due to inadequate installation and maintenance;

3) transportation of oil from a compartment with lower pressure into the next with higher pressure based on local increase of pressures in the cavity of seals. In other words, the pressure within the cavity of a seal may be higher than the pressure in the compartment above or below the seal, in which case the oil would be pumped into the seal (characteristic of the system).

4) failures of seals;

5) differences in frictions in the compartments.

One has to consider the possibility of one stage of the jack reaching its mechanical stops earlier than others. A further extension of the jack is then no longer possible. If in this situation the pump is still running, since the car has not yet reached its intended position, the system is then submitted to increased pressures, which could be beyond the permissible values set by the relief valve.

When the cylinder wall thickness e_{cyl}, is calculated for a single stage, using the formula (2) in section 4.1.4 of this report, the only pressure that needs to be considered is p = full load pressure with the car in the top landing.

However, for telescopic jacks with hydraulic synchronization, one has to consider pressure P_{GL}:

P_{GL} = Normal full load pressure occurring in one section due to obstructed synchronized movement of another section.

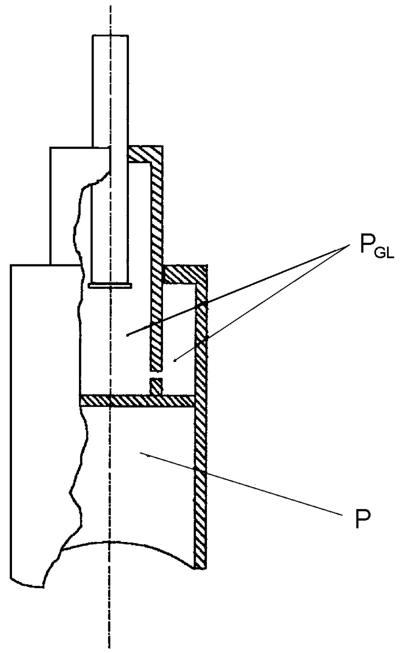


Figure 9 — Hydraulic jack — pressure

The problem can be solved by designing the compartment's wall thickness based on the pressures arising from the changes in synchronization. The difference between normal operation and the operation with the incorrect synchronization is demonstrated in Figures 10 and 11.

The following symbols are used in the figures:

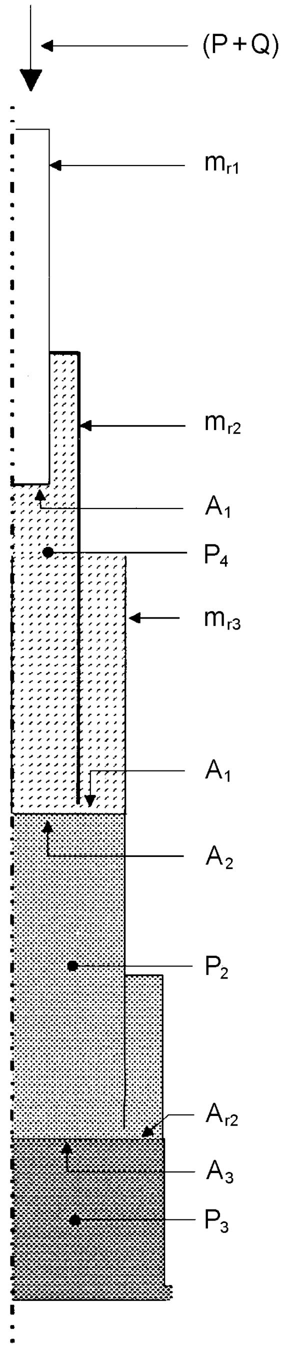
F = Mass of the car

Q = Rated load

M = Mass of the piston

A = Area

A_R = Area at a ring



Pressure in individual compartment is as follows

$$P_1 = \frac{(F + Q + m_{ri})\ g}{A_1}$$

$$P_2 = \frac{P_1(A_1 + A_{R1}) + m_{r2} \cdot g}{A_2}$$

Since $A_1 = A_{R1}$ (synchronized movement); follows:

$$P_2 = \frac{P_1 \cdot 2 \cdot A_1 + m_{r2} \cdot g}{A_2}$$

And by substituting P_1, follows

$$P_2 = \frac{2(F + Q + m_{r1}) + m_{r2}}{A_2} \cdot g$$

$$P_3 = \frac{P_2(A_2 + A_{R2}) + m_{r3} \cdot g - P_1\ A_{R1}}{A_3}$$

Since $A_2 = A_{R2}$ (synchronized movement), and by substituting P_2 and P_1, follows:

$$P_3 = \frac{3(F + Q + m_{r1}) + 2m_{r2} + m_{r3}}{A_3} \cdot g$$

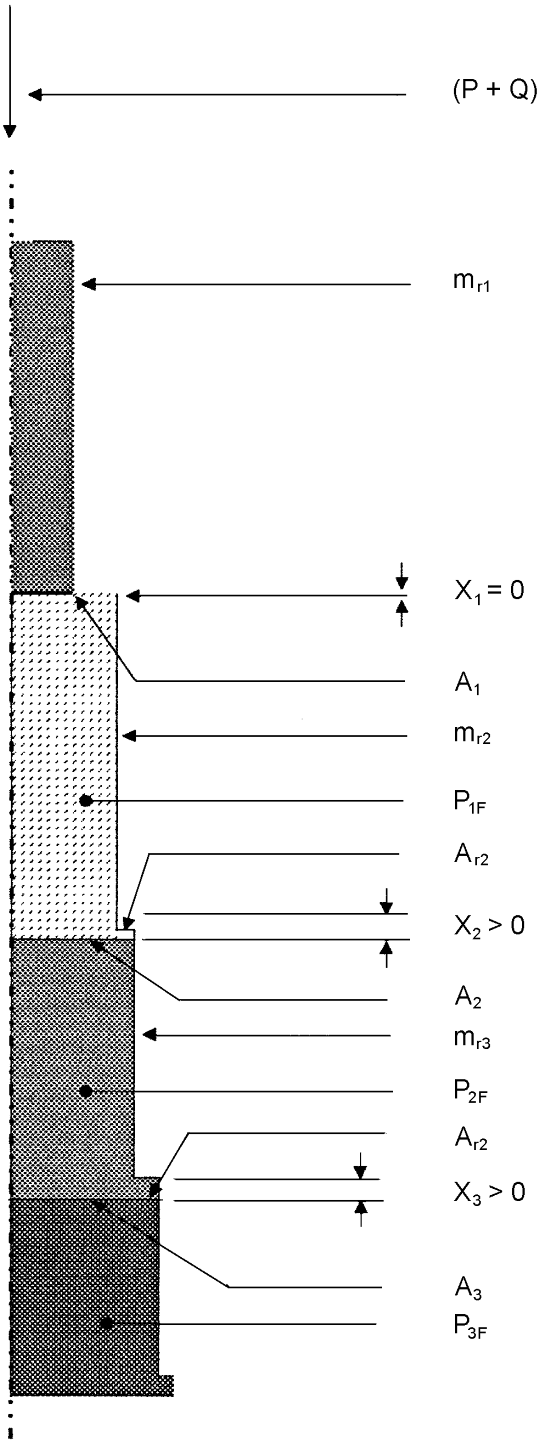
For commonly used telescopic jacks with the hydraulic synchronization means the relation is:

$A_1 : A_2 : A_3 \sim 1 : 3:7$

And

$P_1 : P_2 : P_3 \approx 2{,}4 : 1{,}6 : 1$

Figure 10 — Normal Operating Condition of Telescopie Jack with Hydraulic Synchronization



1) Situation: The top section engages its stop first: when pressure in the 1st stage reaches the level corresponding to the maximum relief valve pressure, the pressure in the 3rd stage P_{F3} is:

$$P_{3F} = f \cdot P_3$$

where f ⩾ 1,4 is the max. relief pressure factor according to CEN (see 4.1.9c, in this report)

From the equation for balanced condition:

$$f \cdot P_3 \cdot A_3 = P_{2F} \cdot A_{R2} + g\,(F + Q + m_{r1} + m_{r2} + m_{r3})$$

follows:

$$P_{2F} = \frac{1}{A_{R2}}\left[f \cdot P_3 \cdot A_3 - g\left(F + Q + m_{r4} + m_{r2} + m_{r3}\right)\right]$$

and from equation:

$$P_{2F} \cdot A_2 = P_{1F} \cdot A_{R1} + g\,(F + Q + m_{r1} + m_{r2})$$

and by substituting P_{2F}, and also by taking that $A_{R1} = A_2$ follows:

$$P_{1F} = \frac{1}{A_{R1}}[f \cdot P_3 \cdot A_3 - 2g(F + Q + m_{r4} + m_{r2}) - g \cdot m_{r3}]$$

2) The most critical situation: when during installation F + Q = 0

3) Critical situation on an installed lift: when Q = 0 In that case:

If $P_{IF} \leqslant 2{,}3^* P_1$ … There is no safety risk

If $P_{IF} > 2{,}3^* P_1$ … The cylinder wall thickness must be recalculated with P_{IF} as follows:

$$e^*_{cyl} \geq \frac{1.7\,P_{IF}}{R_{p0.2}} \times \frac{D}{2} + e^*_o$$

*NOTE Refer to 4.2.2.1(a) regarding factor 2,3; to 4.1.4, formula(2) regarding e_{cyl}; and refer to 4.2.2 and 4.3.2 regarding e_o.

Figure 11 — Normal Operating Condition of Telescopie Jack with Hydraulic Synchronization

c) The Most Critical Situation

The most critical situation occurs when the uppermost stage reaches its end stops first. The pump is then pumping oil into the cylinder with a pressure according to the setting of the pressure relief valve. That pressure increases from stage to stage depending on the cross section of different compartments.

The equation P_{IF} = … in Figure 11 shows that the external masses (car and rated load) as well as the internal masses (rams) reduce the pressure. For that reason, CEN (NOTE 1 to 12.2.1.1.2) regards the situation as most critical where, during the installation of a lift, the telescopic jack is completely extended before the car is installed.

5.2.8.3 Discussion

ASME and CSA rule 3.26.7 for recycling operation of telescopic plungers, combined with rule for car runbys, provides for re-synchronization of telescopic plungers, when the system is out of synchronism.

This, however, does not remove the risk of pressure increase beyond the relief valve setting. Therefore, ASME and CSA should introduce adequate design requirements in order to reduce the safety risk.

5.3 Points agreed upon

5.3.1 Multiple jacks (reference 5.1.3 of this report)

All standards should require that means be provided to ensure the synchronous motion of multiple jacks and not require pressure equalization. The ultimate goal is to ensure that level movement of the car is achieved under any loading condition.

5.3.2 Counterweights (reference 5.1.4 of this report)

All standards should relate the weight of the counterweight to the pressure in the cylinder should the counterweight separate from the car.

5.3.3 Rams subject to external pressure (reference 5.1.5.2 of this report)

All Standards should have specific requirements for calculation of rams subjected to external pressure, corresponding to ASME formula.

5.3.4 Ram-follower guides (reference 5.1.5.3 of this report)

All Standards should require means to ensure safe operation of ram-follower guides, if used.

5.3.5 Limitation of car retardation (reference 5.1.7 of this report)

All standards should consider limiting the average car retardation when the plunger reaches its uppermost stops.

5.3.6 Telescopic jacks (reference 5.1.8 of this report)

All standards should address the principles contained in 5.1.8(b) through (f), however, not necessarily in detail.

5.3.7 Hydraulic synchronization (reference 5.2.8 in this report)

Due to failure of hydraulic synchronization, the working pressure in one stage may reach the relief valve setting before the other stages reach intended position. As a result, the pressure in other stages may increase beyond previously calculated values.

All Standards should take into consideration the risk of this happening on telescopic jacks with hydraulic synchronization.

6 Valves, Piping and Fittings

6.1 Historical background

6.1.1 Pipes and fittings

Table 8 illustrates a comparison of the CEN, ASME and CSA requirements for pipes and fittings.

The following are further comments on these requirements.

6.1.1.1 Pipes in general

a) Suited to use of fluid

CEN 12.3.1.1(a) requires piping to be appropriate for the fluid used. ASME and CSA do not address this item; however, due to common usage of petroleum based hydraulic fluids, conventional piping and fittings material have been compatible.

b) Installed as to avoid stress

CEN 12.3.1.1(b) requires piping and fittings to be designed and installed to avoid stresses due to fixing, tension or vibration. ASME and CSA requirement 3.19.2.3 requires piping to be supported so as to eliminate stresses, particularly as a result of vibration.

c) Protection against damage

Although there are no requirements in ASME or CSA as in CEN, common practice in North America positions piping such that it will not be stepped upon or stepped over by someone needing to service the equipment. This would also make it unlikely to be damaged by failing objects or other mechanical means.

d) Accessibility for inspection

CEN has requirements for all piping, while ASME and CSA requirement 3.19.3.2 only has requirements for grooved pipe fittings. Permanent joints in piping without elastomeric seals have not been known to leak or deteriorate. Therefore, there is no need that these be accessible for inspection. Piping installed below ground does not include seals or other elements potentially requiring service or replacement. Grooved pipe fittings are the only fittings with elastomeric seals in common use. CSA does not address this subject.

e) Piping passing through walls

ASME and CSA requirement 3.19.3.3 prohibit flexible piping from passing through walls. Rigid piping may pass through the walls. It is common practice that no fittings are used within the wall. It is also common practice that there is clearance between the piping and the hole in the wall.

f) Grooved pipe fittings

ASME has additional requirements for grooved fittings with elastomeric seals because they have been known to leak or otherwise fail if not properly designed, manufactured or correctly installed.

Quick release devices which could be unintentionally released by a qualified or unqualified individual could be dangerous and are therefore not permitted. CEN and CSA have no corresponding requirements.

g) Protection of piping from corrosion

Corrosion of underground piping is a common problem where groundwater or moisture is present.

This can lead to a dangerous condition if the piping corrodes through or bursts as a result of being weakened. Leaking hydraulic fluids into the ground can also lead to pollution. Only ASME and CSA requirement 3.19.5 addresses piping corrosion protection. CEN does not permit installation of piping below ground.

h) Threading of pipes

ASME and CSA have specific restrictions on threading of pipes.

i) Welding

ASME and CSA requirement 3.19.3.1 refer to established standards for welding and welders.

6.1.1.2 Rigid piping and fittings

Studies presented in Section 4 of this report have shown a comparison between the ASME/CSA code and the CEN standard in terms of the differences that could occur in cylinder or piping design as a result of different formulae being applied (see Clause 4.1.9).

6.1.1.3 Flexible hose and fittings between cylinder and non-return or down valve

Differences between ASME and CSA versus CEN are influenced by the conditional requirement for them in the former and the inclusion of one in the latter standard.

CSA requires that the hose and fittings be marked with the manufacturer's name. ASME references SAE J517. This standard calls for the manufacturer's identification and other criteria.

Table 8 — Pipes and fittings - Comparison of requirements

Requirement	CEN	ASME and CSA	Part 1 SA	Part 3 SA	Japan
(1) Pipes in general	(12.3.1)	[3.19.1]	(12.3.1)	(7.4.1)	
(1a) suited to used fluid	Yes	Flexible hose only [3.19.3.3.1(c)]	Yes	Yes	No Spec.
(1b) installed as to avoid stress	Yes	Yes [3.19.2.3]	Yes	Yes (7.4.1.3)	Yes (guide line of anti-earthquake design and execution)
(1c) protected against damage	Yes	No spec.	Yes	Yes (7.4.1.3)	Yes guide line of anti-earthquake design and execution)
(1d) accessible for inspection	Yes	Grooved pipe fittings only [3.19.3.2.1]	Yes	Yes only (7.4.2.2)	Yes (BSL-EO Art. 129-9 item 1 parag. 4&5)
(1e) if through floor or walls, then protected and capable of being dismantled for inspection	Yes	No spec	Yes	No joints in walls and ducts (7.4.2.2)	No Spec.
(1f) grooved pipe fittings, additional	No spec.	Yes [3.19.1.4] and [3.19.3.2.1]	No spec.	No	No spec
(1) installed per manuf. spec.		Yes [3.19.3.3.2]			No spec
(2) will not permit separation if sealing fails		Yes [3.19.3.3.2]			No Spec.
(3) devices for (2) removable with special tools, not with quick release levers or toggles		Yes [3.19.5]			No Spec.
(1g) Buried piping below ground to be protected from corrosion (see 5.1.6.2 of this report)	Not permitted (12.3.1.2)	Yes [3.19.3.1]	Not permitted (12.3.1.2)	No	No spec.
(1h) Threading of pipes permitted	No spec.	Yes [3.19.3.1]	No spec.	No spec.	No spec.
(1i) Specific requirements for welding	No spec.	Only schedule 40 and greater [3.19.2.2]	No spec.	No Spec	No spec.
(1j) Allows threading for pipe above certain wall thickness		Only schedule 40 and greater [3.19.2.2]			
(2) Rigid pipe and fittings	(12.3.2)	[3.19.2]	(12.3.2)	(7.4.2)	
(2a) between cylinder and non-return or down valve	Yes	supply piping	Yes	Figure 7.5.5	No spec
(1) design pressure	2.3 x full load pressure		2.3 x full load pressure	Table 7.4(5)	
(2) design formula (per section 4.1.4 of this report)	Formula (2) *+1,0 or 0,5 mm	Formula [8.2.8.4] and [8.2.8.5]	Formula (2) *+1,0 or 0,5 mm	Table 7.4	
(2b) between rupture and non-return or down valve	Calculated with additional FOS=1,3 if used to synchronize telescopic jacks with more than 2 stages		Calculated with additional FOS = 1,3 if used to synchronize telescopic jacks with more than 2 stages	Table 7.4(5)	No spec

Table 8 — (*continued*)

Requirement	CEN	ASME and CSA	Part 1	SA Part 3	Japan
(2c) between cylinder and rupture valve	Calculated with cylinder pressure	Additional Safety Factor multiplier of 1.5 [3.19.4.7.4]	Calculated with cylinder pressure	Table 7.2	No spec
(3) Flexible hoses and fittings, if between cylinder and non-return or down valve	(12.3.3)	[3.19.3.3]	(12.3.3)	(7.2.3.2)	Flexible hose is permitted in minimum length of necessary (Explanation of 2000 MOC Notice No.1414 item 3 parag.2) 6.0 in normal condition 4.0 at safety devices actuated (2000- MOC Notice No.1414 item 3 parag.2)
(3a) design factor of safety	8 (flexible hose only)	10 [3.19.3.3.1(b)]	8 (flexible hose only)	Table 7.4	
(3b) pressure required to withstand in test	5 x full load pressure	5 x working pressure [3.19.3.3.1(b)]	5 x full load pressure plus alternative[+]		No spec
(3c) hoses marked with: (1) trade mark	Yes	[3.19.3.3.1(e)] Yes [3.19.3.3.1(e)(1) & (2)]	Yes	No	No spec
(2) test pressure	Yes	Yes [3.19.3.3.1(3)]	Yes		No spec
(3) date of test	Yes	No, date of installation [3.19.3.3.1(e)(5)]	Yes		No spec
(4) replacement date	No specification	No spec. - rupture valve must be used with hoses [3.19.3.3.1(f)]	No specificatio n		No spec
(3d) bending	Per manufacturer' s instructions	Per SAE standard [3.19.3.3.1(c)]	Per manufactur er's instructions	Yes (7.4.3.1)	To conform to JIS B 8360 (explanation of 2000- MOC Notice No.1414 item 3 parag.2)
(3e) installation in hoistway through walls	Yes (12.3.1.2)	Not permitted [3.19.3.3.1(a)]	Yes (12.3.1.2)	Yes (7.4.3.2)	Not permitted
(3f) fittings of non-reusable type only	No spec.	Yes [3.19.3.3.1(d)]	No spec.	(7.4.3.1) AS 8791	No spec

* Formula (2) in TR 11071-2.

6.1.2 Valves

Table 9 illustrates a comparison of the CEN, ASME and CSA requirements. The following are further comments on these requirements.

6.1.2.1 Shutoff valve

NOTE Major revision to this and next clause to show current ASME requirements.

CEN (12.5.1), ASME and CSA (3.19.4.1) require this valve on every lift. It must be located in the machine room, according to CEN, ASME and CSA.

Manual operation is required in ASME and CSA. No specification in CEN.

6.1.2.2 Non-return (check) valve

ASME and CSA requires a check valve and its general location is upstream of the relief valve.

CEN, ASME and CSA require a similar check valves.

6.1.2.3 Pressure relief valve

There is no difference between CEN, ASME and CSA regarding the relief valve location.

Differences in the requirements for the relief valve operation partially stem from differences in the definitions of working pressure.

ASME and CSA rules for sealing of relief valves were requested by inspectors in North America following certain instances of maladjustment subsequent to initial installation. CEN intentionally decided not to require sealing.

Centrifugal pumps are not commonly used in the industry, so any differences in requirements in this area are not important issues.

6.1.2.4 Direction valves

CEN, unlike ASME and CSA, has separate rules for UP direction and DOWN direction valves.

Switches with spring loaded contacts would fail-safe if compression springs broke, since the spring.

remains physically entrapped. Tension springs become ineffective if they break. The CEN reference to compression springs for its valves indicates a consistency of thinking.

6.1.2.5 Rupture valve

CEN gives detailed requirements for rupture valves where used for protection against excessive speed.

ASME and CSA (8.4.11.2) require this valve type, referred to as “overspeed valve”, when elevator is in seismic risk zone 2 or greater as an alternative to a car safety or when a flexible hose is used between the check valve and the jack. When used, the overspeed valve must be mounted within 600 mm of the jack.

NOTE Refer also to Section 10 in this Report.

6.1.2.6 Manual lowering valve

Location is essentially the same in all standards. Common practice with current elevators is to incorporate the manual lowering valve on the unit control valve body.

ASME and CSA standards do not require the valve to be operated by a continuous manual force and protected against involuntary action as CEN does; It is common practice to have a threaded manual lowering valve in North America.

Some types which can be involuntarily operated or left open do exist.

There are significant differences in lowering speed - 0,3 m/s in CEN, versus 0,1 m/s in ASME and 0,25 m/s in CSA.

On indirect acting lifts, where slack rope or chain can occur, CEN specifically prohibits opening of this valve when the pressure is below the minimum operating pressure. This is not required in ASME and CSA; however, the intended protection is achieved by the “low pressure switch” (see 6.1.2.7).

6.1.2.7 Low pressure switch

A low pressure switch, required in ASME and CSA when the cylinder top is located above the storage tank, is not required in CEN.

6.1.2.8 Over pressure switch

CEN requires that on telescopic jacks with hydraulic synchronization, an electric device is required to prevent operation of the lift when the pressure exceeds the full load pressure by more than 20 %.

There are no corresponding rules in ASME and CSA.

6.1.2.9 Restrictor

CEN has rules for restrictors when used as a protection against excessive speed in the case of a major leakage in the hydraulic system (see also Section 10 in this report).

There are no corresponding rules in ASME and CSA.

6.1.2.10 Type testing of valves

Only ASME and CSA (see 3.19.4.6 and 3.17.4.7) require control valves to be subjected to the type testing and certification process which includes:

1) endurance test: 100 000 operating cycles

   (5 to 24 s) at rated pressure;

2) leakage test at 1,5 times rated working pressure

   (1 to 24 h) with 300 kPa;

3) strength test at 5 times rated working pressure;

4) electrical tests.

CSA considers that the working pressure rating of a control valve is extremely impractical, if not impossible, to verify by the review of the design or by the inspection of a hydraulic lift. Unlike CEN, CSA and ASME do not require protection against excessive speed, should the control valve fail.

Therefore, type testing under conditions achievable only in a laboratory is required.

Table 9 — Valves comparison of requirements

Requirement	CEN	ASME and CSA	SA Part 1	SA Part 3	Japan
(1) Shutoff valve (1a) where required	[12.5.1] Every lift	[3.19.4] Every elevator	[12.5.1] Every lift	(7.5.9) Yes	No spec.
(1b) location	Between cylinder & non-return valve; in machine room	In supply line to cylinder; in machine room	Between cylinder & non-return valve; in machine room	Between Cylinder and down direction valve	
1(c) manually operated	No spec.	Yes	No spec.	No Spec	
(2) Non-return (check) valve) location	[12.5.2] Between pump & shut-off valve	[3.19.4.3] No spec.	[12.5.2] Between pump & shut-off valve	[7.5.3] No spec.	No spec.
(2b) capable of holding rated load when:					
(1) pressure drops below min. operating pressure	Yes	Yes	Yes	Yes	125 %(150 %for freight elevator with C_2 loading) (explanation of 2000- MOC Notice No.1414 item 3 parag.2)
(2) pump stops	No spec.	Yes	No spec.	Yes	125 %(150 %for freight elevator with C_2 loading) (explanation of 2000- MOC Notice No.1414 item 3 parag.2)
(2c) activated by pressure from jack and at least one guided compression spring and/or gravity	Yes	No spec.	Yes	No spec.	No spec.
(3) Pressure (pump) relief valve	[12.5.3]	[3.19.4.2]	[12.5.3]	[7.5.2.1]	
(3a) location	Between pump & non-return valve	Between pump & check valve [3.19.4.2.1(a)]	Between pump & non-return valve	between pump and check valve	Between pump and check valve (explanation of 2000- MOC Notice No.1423 item 4 parag.2)
(3b) valve cannot be shutoff from hydraulic system	No spec.	Yes [3.19.4.2.1(a)]	No spec.	Yes (7.5.2.2)	Yes (explanation of 2000- MOC Notice No.1423 item 4 parag.2)
(3c) fluid to be returned to tank	Yes	No spec.	Yes	Yes	No spec.
(3d) Setting		No spec.		125 % (7.5.2.3)	To prevent pressure exceeding 150 % of WP (2000- MOC Notice No.1423 item 4 parag.2)

Table 9 — (*continued*)

Requirement	CEN	ASME and CSA	SA Part 1	SA Part 3	Japan
(3e) requirements for operation (NOTE See 2.3 in this report for relationship between FLP and WP	Adjusted to limit pressure to 140 % FLP or up to 170 % FLP (if high internal losses), but in that case, all hydraulic equip. including jack and buckling to be calculated at 170/140 x FLP	To a maximum of 150 % WP [3.19.4.2.1(b)]	Adjusted to limit pressure to 140 % FLP or up to 170 % FLP (if high internal losses), but in that case, all hydraulic equip. including jack and buckling to be calculated at 170/140 x FLP	No spec. 125 % and full load working pressure	To prevent pressure exceeding 150 % of WP (2000- MOC Notice No.1423 item 4 parag.2)
(3f) sealing	No spec.	If adjustable, must be sealed [3.19.4.2.1(c)]	No spec.	Yes if not on pump in tank	No spec.
(3g) exceptions for centrifugal pump	No spec.	Yes [3.19.4.2.2]	No spec.	Yes	No spec.
(4) Direction valves (4a) hold open electrically	[12.5.4] Yes	[3.26.6] Yes	[12.5.4] Yes	[7.5.8] Yes	 No spec.
(4b) down direction valve activation	By pressure from jack and at least one guided compression spring per valve	See (d)	By pressure from jack and at least one guided compression spring per valve	Yes by at least on guided compression spring	No spec.
(4c) up direction valve activation	Special requirements if only one contactor used to interrupt power to motor, in that case the by-pass valve must be used	See (d)	Special requirements if only one contactor used to interrupt power to motor, in that case the by-pass valve must be used	No spec.	No spec.
(4d) springs activating electrically operated valves	See (b)	Must be of compression type [3.22.6.1]	See (b)	No spec.	No spec.
(5) Rupture valve (5a) To be used as one of the methods of protection against excessive speed	[12.5.5 Yes, per 9.5 of CEN	[8.4.11.2] (seismic risk zone 2 or higher only) [3.19.3.3.1(f)} when flexible hoses are used	[12.5.5+ Yes, per 9.5 of CEN	[7.5.5] Yes for all lifts	No spec.
(5b) Requirements for stopping car	Rated speed + 0,3 m/s with retardation max. 1 g	Yes [3.19.4.7.5]	Rated speed + 0,3 m/s with retardation max. 1g or allow car to sink at min. 0,02 m/s max. 0,05 m/s	Close to allow car to sink at min. 0,02 m/s max. 0,05 m/s or stop and hold car.	No spec.
(5c) Accessible for inspection and adjustment	Yes	No - but there are type test, marking and sealing req'mts.[3.19.4.6.1], 3.19.4.6.2] and [3.19.4.7.6]	Yes	No spec	No spec.

Table 9 — (*continued*)

Requirement	CEN	ASME and CSA	SA Part 1	SA Part 3	Japan
(5d) be integral to cylinder, or directly or close to cylinder	Yes	Yes [3.19.4.7.3(a)} and [3.19.4.7.3(b)]	Yes	Yes	No spec.
(5e) Special requirements for lifts with several jacks	If jacks operate in parallel, only one required; otherwise, must be interconnected	Yes [3.19.4.7.3(b)]	If jacks operate in parallel, only one required; otherwise, must be interconnected	Yes	No spec.
(6) Manual lowering valve	[12.9.1]	[3.19.4.4]	[12.9.1]	[7.5.6]	
(6a) location	In machine room	On or adjacent to control (up and down) valve	In machine room	In machine room	No spec.
(6b) must be identified	Yes [15.15]	Yes	Yes [15.15]	Yes	No spec.
6(c) operated by continuous manual force and protected against involuntary action	Yes	No spec.	Yes	Yes	No spec.
(6d) maximum speed	0,3 m/s	0,10 m/s	0,3 m/s	0,3 m/s	No spec.
(e) additional requirements for indirect plunger elevators	Not openable when low pressure to prevent slack rope	See (7)	Not openable when low pressure to prevent slack rope	Yes not sink enough to cause slack rope	No spec.
(7) low pressure switch	No spec	[3.26.8] Must be installed if cylinder top is above top of storage tank to prevent operation of lowering valve should pressure drop	Yes (12.15+)	Yes (7.5.7)	No spec.
(8) Over pressure switch on telescopic jacks to prevent operation if full load pressure exceeded by 20 %.	[12.2.5.5] Yes	No spec.	[12.2.5.4] Yes	No spec	No spec.
(9) Restrictor A method of protection against excessive speed	[12.5.6] Yes	No spec.	[12.5.6] Yes	Flow. Restrictor Yes (7.5.5)	No spec.

6.1.3 Hydraulic components other than pipes and valves

6.1.3.1 Filters

CEN (12.5.7) requires the use of a filter between the shutoff valve and the down valve. The type and purpose of the filter is not stated. No such requirement exists in ASME.

6.1.3.2 Checking the pressure

CEN (12.6) requires a pressure gauge to be connected between the non-return valve or down-valve and the shutoff valve; a gauge shutoff valve between the main circuit and the connection to the pressure gauge; and a specific internal thread for the connection.

ASME and CSA rule 3.19.4.5 requires a pressure gauge fitting with a shutoff valve on or adjacent to the control valve.

6.1.3.3 Fluid level in the tank

CEN (12.7) requires easy check of the fluid level in the tank. ASME and CSA (3.24.2) corresponds to CEN and requires that minimum liquid level be indicated.

6.1.3.4 Speed

CEN (12.8) covers rated speed of up to 1.0 m/s based on the market requirements in Europe. Note that in Europe, even 1,00 m/s speed is not frequent. There are no corresponding statements in ASME or CSA.

6.1.3.5 Hand pumps for emergency operation

CEN (12.9.2) requires a hand pump to be permanently installed on lifts fitted with a safety gear or a clamping device (see section 10 in this report) in order to allow evacuation of passengers, as the car cannot be lowered by means of the lowering valve.

This pump cannot be connected between the non-return or down valve and shutoff valve. A valve should limit the pressure. ASME and CSA (3.17.1) requires a means to lift the car hydraulically whenever safeties are used. CSA does not cover this subject

NOTE For manual emergency car lowering, refer to *Table 9, item (6), in this report.*

6.1.3.6 Checking of the car position

In conjunction with the manual emergency operation of the car [see Table 9, item (6), and 6.1.3.5 in this report], CEN (12.9.3) requires, under specific conditions, provision for checking the car position from the machine room. There are no corresponding requirements in ASME or CSA.

6.1.3.7 Motor run-time limiter

CEN (12.12) requires a motor run-time limiter to stop the motor should it remain energized longer than 60 s from the time the lift requires for a full travel upwards. The device must be of the manual reset type. ASME and CSA requirement (3.26.9) permits a pump run timer to be used as a low oil protection device.

However, pump run timers are not a requirement in ASME or CSA.

6.1.3.8 Protection against overheating of fluid

CEN (12.13) requires a temperature detecting device to stop the machine and keep it stopped as long as the temperature of the fluid exceeds a pre-set value.

It is not a safety device. Automatic reset is permitted. There are no corresponding requirements in ASME or CSA.

6.2 Observation with suggestions by individual experts

6.2.1 Pipes and fittings

The following changes to the standards have been recommended by several experts.

6.2.1.1 Pipes in general

a) Suited to use of fluid (ref. 6.1.1.1a)

Due to possible use of fluids other than petroleum based, it would be beneficial if the ASME and CSA codes were modified to include a statement regarding compatibility.

b) Protection against damage (ref. 6.1.1.1c)

ASME and CSA should consider the addition of requirements for protection against specific events leading to damage of pipes.

It was noted that the CEN rule (12.3.1.1c) is imprecise.

c) Accessibility for inspection (ref. 6.1.1.1d)

CEN 12.3.1.2 should be clarified in regard to what type of fittings should be accessible for inspection.

The wording does not specifically state that all fittings and portions of the piping are included.

One expert maintained that CEN clearly requires that all pipes and fittings must be accessible for inspection.

d) Piping passing through walls (ref. 6.1.1.1e)

Some experts recommended that the ASME and CSA codes be amended to specifically state that fittings not be placed within the wall, and that a specific clearance be provided to ensure that the piping is clear of the hole in the wall.

Other experts feel that all standards should allow fittings in walls if there is some means to detect failure.

e) Grooved pipe fittings (ref. 6.1.1.1f)

An expert recommended that all standards should include specific requirements for grooved pipe fittings, corresponding to ASME and CSA requirement 3.19.3.2, such as: (1) accessible for disassembly and inspection; (2) so constructed that the failure of sealing element will not permit separation of the parts connected; (3) be removable by special tools only, and not of the quick-release or toggle type.

CEN experts did not consider it necessary since the lift, designed per CEN, is equipped with the rupture valve to prevent excessive speed should a fitting fail.

CEN (rule 12.5.5.3), however, permits installation of flanges, and also pipes with welded, flanged or threaded connections, between the cylinder and the rupture valve. All other connection types, including "grooved type" fittings, are explicitly banned.

Since North American experts have proven through design analysis and practical use that grooved fittings are more reliable than flanged or threaded fittings, several experts suggested that CEN should allow use of grooved type fittings under conditions specified in ASME and CSA requirement 3.26.9.

f) Protection of piping from corrosion (ref: 6.1.1.1g)

It is recommended that CSA and CEN amend their codes to provide protection for buried piping against underground corrosion.

CEN experts did not see need for amendments to CEN, since that standard effectively prohibits installation of pipes below ground, with CEN Rule 12.3.1.2.

6.2.1.2 Rigid piping and fittings (ref. 6.1.1.2)

Refer to 4.1.9 in this report and also 4.3.

6.2.1.3 Flexible hose and fittings between cylinder and non-return or down valve (ref. 6.1.1.3)

The premise of whether a rupture valve is used or not should be addressed under the discussion of Assumption 3, Failure of Mechanical Devices, as it has broad fundamental implications.

NOTE Refer also to Section 10 of this report regarding failure assumptions.

CEN does not specify replacement date, type of fittings that may or may not be used, or design criteria for couplings, because safety back up to all those components is provided by the rupture valve.

Furthermore, specifying replacement intervals could be construed as restricting trade. However, one CEN country does require the replacement of flexible hoses every 10 years on lifts without a rupture valve.

6.2.2 Valves

The following observations and recommendations for changes to the standards have been made by several experts.

6.2.2.1 Shutoff valve (ref. 6.1.2.1)

Two experts rationalized differences between CEN and ASME rules. Common practice in Europe is to have a high proportion of holeless hydraulic lifts.

Therefore, having a shutoff valve in the machine room would help to prevent spilling of a large amount of oil when the power pack is serviced. That is not the case in the USA, where most cylinders are below ground. However, most lifts in the USA are provided with this valve on a voluntary basis.

ASME should have rules similar to CSA (4.19.2.4).

6.2.2.2 Non-return (check) valve (ref. 6.1.2.2)

ASME and CSA should define location of the check valve.

Two experts suggested that standards should not specify design details of the check valve, as is the case in CEN (12.5.2.3). Standards should specify performance only.

One expert, however, considers that the CEN rule (see item 2(c), Table 9 in this report) is very important and recommends it for inclusion in all Standards.

6.2.2.3 Pressure relief valve (ref. 6.1.2.3)

The problem of different definitions of working pressure and their effect on requirements for operation of the relief valve and on requirements for design of piping, cylinder and other valves should be resolved as a single complete exercise (see also 6.1.1 and 6.2.1).

6.2.2.4 Direction valves (ref. 6.1.2.4)

CEN experts consider the CEN rules (12.5.4) for direction valves of particular importance for safety.

The requirement that closing of the down-valve be affected by the pressure from the jack and by at least one guided compression spring makes it fail-safe.

Other experts maintained that, should the down-valve-fail, the safety can be assured by the electrically operated non-return (check) valve that is in series with the down valve. This, however, is not required in any standard.

CSA ensures operational reliability of control valves through type-testing requirements (see 6.1.2.10 in this report).

6.2.2.5 Rupture valve (ref. 6.1.2.5)

One expert suggested that all standards should require rupture valves to guard against excessive speed. All standards, including CEN, should require type testing and certification of rupture valves, because their performance cannot be tested on an actual installation.

NOTE 6.2.2.5 See also 6.2.1.3 and Section 10 regarding need for rupture valves.

6.2.2.6 Manual lowering valve (ref. 6.1.2.6)

A speed of 0,3 m/s permitted in CEN and 0,25 m/s in CSA under manual control without direct visual feedback of elevator motion is considered by some experts to be excessive. A speed of 0,1 m/s has been found to be adequate. CEN and CSA should re-evaluate this operating speed for worldwide harmonization.

Other experts note that CEN requires identification in the machine room of when the car is in the leveling zone. The standard leveling speed for electric lifts is also 0,3 m/s. Since the doors are assumed to be closed, this speed is not excessive.

The rationale for CEN prohibiting (Clause 12.9.1.5) opening of the lowering valve, should the slack rope condition occur on indirect acting lifts, was questioned since the car safety would stop a “free falling” car and hence remove any safety hazard.

That would be the case with lifts built under the CSA or ASME standards which require a governor-operated safety on every indirect acting lift. CEN, however, permits car safeties operated by a “safety rope”, which may completely lose its function under the slack rope condition (refer to Section 10 in this report).

Similar safety problems may be created by opening the lowering valve on a direct-acting lift whose car is equipped with safety-rope operated safeties, should the car “hang-up”. It is believed that the safety-rope would eventually activate the car safety in this case, which may not necessarily be the case on indirect-acting lifts.

6.2.2.7 Low pressure switch (ref. 6.1.2.7)

Two experts suggested that for holeless hydraulic elevators without slack rope trip (e.g. telescopics), fluid should not be capable of being drained from a stuck elevator.

One expert did not feel the need for a low pressure switch, since the lift cannot fall if the cylinder is filled with oil and the packing does not leak. If, however, the packing leaks, that would be discovered during regular maintenance, because such lift would have ongoing problems with leveling. Consequently, he would not support addition of the low pressure switch requirement in CEN.

6.2.2.8 Over pressure switch (ref. 6.1.2.8)

The safety function of this switch, required in CEN, was questioned. If the failure of the relief valve is anticipated, then such switch should be required on every lift, not only on telescopic jacks.

Furthermore, the switch does not reduce the pressure but rather stops the lift and "preserves" the high pressure in the system.

Consequently, the overpressure switch should not be required.

6.2.2.9 Type testing of valves (ref. 6.1.2.10)

In support of the CSA requirement for type testing of valves, one expert noted that out of the first three valve models, tested in accordance with this new CSA rule, introduced in 1990, one failed. Today, both ASME and CSA now require type testing of control valves (see 3.19.4.6) and overspeed valves (see 3.17.4.7).

He suggested that all lifts that are not provided with protection against car descent as described in Section 10.1.5 and Table 12 should have their control valves certified as required in ASME and CSA requirement 3.19.4.6.

The CEN approach was explained. Only “ultimate” safety devices are tested, and not operating devices, such as the control valve. According to CEN, the rupture valve is a safety device. Introduction of the rupture valve testing requirement is under consideration.

6.2.3 Hydraulic components other than pipes and valves

6.2.3.1 Filters (ref. 6.1.3.1)

One expert suggested that a major leakage in the down valve, initiated by foreign objects in the oil, may cause the car to leave open landing doors, since the re-leveling device, operating at 0,3 m/s speed, may not be able to prevent such obvious safety hazard. Therefore filters are needed for the safety reason. He recommended that filters be required in all standards.

Another expert expressed difficulties in meeting this CEN requirement. The intent may be right but the CEN clause, as worded, does not fulfill the objective.

One expert suggested that the rule should read:

> “Measures should be taken to assure that particles cannot enter the oil circuit”.

6.2.3.2 Speed (ref. 6.1.3.4)

One expert suggested that CEN should have additional rules for lifts exceeding 1,0 m/s speed, e.g. to require progressive safety gear.

6.2.3.3 Hand pump for emergency operation (ref. 6.1.3.5)

One expert interpreted the ASME rule as permitting pumps but not necessarily limiting them to hand operated pumps. He agreed however, that ASME should require that the device for emergency operation be permanently installed.

Another expert pointed out an additional safety feature of the pump. It helps to eliminate the slack rope condition on indirect acting lifts before the operation of the car is reinstated.

The CEN requirement that every lift must be provided with a permanently installed pump was questioned on the ground of the economic cost versus safety benefits. Why can one pump in a machine room not be used for all elevators powered from that machine room, provided that each lift is fitted with pump connections?

6.2.3.4 Checking of the car position (ref. 6.1.3.6)

One expert traced the origin of this CEN (12.9.3) rule to the German Standards. Dining emergency evacuation of electric elevators it is possible to establish from the machine room when the car is at a landing. That was not the case with hydraulic machines. However, now that CEN does not permit door-less cars and limits the speed of emergency operation at 0,3 m/s, this requirement might be redundant.

6.2.3.5 Motor run-time limiter (ref. 6.1.3.7)

One expert noted that this CEN (12.12) requirement does not aim at protecting the safety of passengers but rather the materials by preventing the continuous pumping of oil.

ASME considers introducing requirement (306.15) for means, such as oil level sensor or a pump-run timer, that would interrupt the elevator operation should the oil level fail below the minimum. The means would cause the *car* to travel to the bottom landing and the landing door to close, before the operation is shut down.

The CEN (12.12) requirement was questioned from the safety viewpoint. It requires the pump motor to be stopped. Anti-creep device becomes inoperative.

Consequently, the car may creep away from a landing with open doors.

6.2.3.6 Protection against overheating of fluid (ref.6.1.3.8)

One expert elaborated on the rationale for this CEN (12.13) rule. A lift may not be designed for the number of cycles it actually operates at, resulting in the overheating of oil.

ASME and CSA considers introducing a requirement for oil tank temperature shutdown (3.26.3.1.5(f)). It would be classified as an electrical protective device.

The CEN (12.13) rule was questioned. It does not set the temperature values nor tolerances. The temperature detecting device cannot necessarily be inspectable on site.

6.3 Points agreed upon re valves, piping and fittings

6.3.1 Pipes and fittings (ref. 6.1.1 & 6.2.1)

6.3.1.1 Suited to used fluid

All standards should include a requirement that piping and fittings and all other components of a hydraulic system be appropriate to the hydraulic fluid used, corresponding to CEN (12.3.1.1a).

6.3.1.2 Protection against damage

All standards should require that piping, fittings and all components of a hydraulic system be protected against damage, in particular of mechanical origin, corresponding to CEN (12.3.1.1c).

6.3.2 Valves

6.3.2.1 Shutoff valve (ref. 6.1.2.1 & 6.2.2.1)

All standards should require a shutoff valve that is manually operated or at least suitable for manual operation.

6.3.2.2 Non-return (check) valve (ref. 6.1.2.2 and 6.2.2.2)

All standards should specify location of the check valve.

6.3.2.3 Pressure relief valve (ref. 6.1.2.3 & 6.2.2.3)

All standards should specify that the relief valve cannot be shut off from hydraulic systems, and that the fluid should be returned to tank.

6.3.2.4 Manual lowering valve (ref. 6.1.2.6 & 6.2.2.6)

All standards should require the lowering valve to be operated by a continuous manual force and protected against involuntary action.

All standards should prevent unintentional draining of fluid from the cylinder in a stuck elevator. It is a good precaution for a holeless elevator and even more so for a roped hydraulic elevator with the safety gear set.

6.3.2.5 Low pressure switch (ref. 6.1.2.7 & 6.2.2.7)

All standards should require a device to make lowering and down-valves inoperative should the pressure at the top of the cylinder drop below a predetermined pressure on lifts where the cylinder top is installed above the top of the tank. This is presently required in ASME and CSA (3.26.8).

6.3.2.6 Overpressure switch (ref. 6.1.2.8 & 6.2.2.8)

CEN rule (12.2.5.5) for overpressure switch on telescopic jacks should be deleted.

6.3.2.7 Type testing of valves (ref. 6.1.2.10 and 6.2.2.9)

All standards should require certification of control valves similar to ASME and CSA 3.19.4.6 and 3.17.4.7, if installed on lifts that are not provided with protection against car descent with excessive speed.

6.3.3 Hydraulic components other than pipes and valves

6.3.3.1 Hand pump for emergency operation (ref. 6.1.3.5 & 6.2.3.3)

a) For lifts whose cars are fitted with a safety gear, standards should require a provision of a permanently installed auxiliary pump, or as a minimum, provision for connection of a pump;

b) the standard should permit a hand or power operated pump;

c) all standards should limit the speed at which the pump for emergency operation may move the car;

d) standards should restrict the pressure during the emergency operation to the lift's relief-valve pressure.

6.3.3.2 Checking of the car position (ref. 6.1.3.6 and 6.2.3.4)

There is no safety justification for the “checking of the car position” requirement in CEN Rule 12.9.3.

7 Ropes and chains

7.1 Historical background

This section concentrates on comparison of requirements for suspension ropes and chains when used on hydraulic lifts. Reference may be made to requirements for electric lifts to illustrate differences from those for hydraulic lifts (refer to Table 10).

7.1.1 Minimum number of ropes (item 1 in Table 10)

All standards require at least 2 ropes for suspension of car on indirect acting lifts and also for connections between car and counterweight, if provided.

CEN (9.1.3a), ASME, and CSA (3.18.1.2) stipulate that 2 ropes per jack of machine must be provided rather than per car.

Comparison with requirements for electric lifts Indicate, that CEN consistently requires 2 ropes, while ASME and CSA require a minimum of 3 for traction lifts.

7.1.2 Minimum rope diameter (item 2 in Table 10)

ASME and CSA impose a minimum of 9,5 mm.

CEN accepts 8 mm.

7.1.3 Minimum sheave/rope ratio (item 4 in Table 10)

All codes agree with a ratio of 40:1.

7.1.4 Minimum safety factor (item 5 in Table 10)

Both ASME and CSA use variable safety factors for suspension ropes, from 7,6 to 11,9, depending on the rope speed. CEN uses a fixed factor: 12.

Comparison with requirements for electric lifts shows that ASME and CSA require the same factor of safety on hydraulic lifts, while CSA permits a lower factor of safety on hydraulic than equivalent electrical lifts.

CSA and ASME specify 7 as the minimum factor of safety for ropes used for car-counterweight connection. CEN does not specify FOS for such ropes.

According to CEN (9.2.2):

$$\text{FOS} = \frac{\text{Minimum Braking Load}}{\text{Maximum Force in Rope}}$$

The maximum force in a rope is calculated when the loaded car is stationary at the lowest level, taking into consideration: number of ropes, reeving factor and mass of the car, the rope and the portion of traveling cable, as well as the rated load or design load (see 3.3.2.5(b) in this report).

CEN also defines the "minimum breaking load of a lifting rope" and requires that to be confirmed by a rupture test.

According to ASME and CSA (2.20.3):

$$\text{FOS} = \frac{S \cdot N}{W}$$

where

N = number of runs of rope under load. For 2:1 roping, N shall be two times the number of ropes used, etc.;

S = manufacturer's rated breaking strength of one rope;

W = maximum static load imposed on all car ropes with the car and its rated load at any position in the hoistway.

ASME and CSA do not require any test-proof for S.

7.1.5 Chains (items 6-8 in Table 10)

CEN (9.1.1) allows use of steel chains with parallel links (galle type) and roller chains for suspension of cars and counterweights. Minimum number of chains per jack is 2. Safety factor of 10 is lower than for ropes (12).

ASME and CSA do not allow any type of suspension means other than steel wire ropes.

Tableau 10 — Suspension ropes and chains

Requirement	**CEN**	**ASME/CSA**	**Part 1 SA**	**Part 2**	**Japan**
Suspension ropes on hydraulic lifts (and electric lifts, where marked*)					
1. Minimum number of ropes:					
a) On hydraulic lifts					
- On indirect acting lifts	2 (9.1.3a)	2 [3.18.1.2]	2(9.1.1a)	2 (17.1)	2 (BSL-EO Art. 129-4 item 3 parag. 2)
- Per jack (machine)	Yes	Yes - except 1 if 3 or more jacks/car	Yes	Yes	No spec.
- Between car and balancing weight	2 (9.1.3b)	2 [3.20]	2(9.1.1b)	2	No spec.
b) On electric lifts*					
- Traction lifts*	2 (EN81-1)*	3 [2.20.4]*	2(EN81-1)*	3	2 (BSL-EO Art. 129-4 item 3 parag. 2)
- Drum lifts*	2 (EN81-1)*	3 [2.20.4]*	2(EN81-1)*	2	2 (BSL-EO Art. 129-4 item 3 parag. 2)
2. Minimum rope diameter	8,0 mm (9.1.2 a)	9,5 mm [2.20.4]	8,0 mm(9.1.2)	8.0 (Table 17.1)	10 mm,(8mm for the elevator with rated speed not more than 0.5m/s, rated load not more than 2000N and maximum rise of 10 m) (2000- MOC Notice No.1414 item 2 parag.3)
3. Minimum outer wire diameter	No spec	0,61 mm [2.20.4]	No spec	No spec	No spec.
4. Minimum sheave/rope ratio	40 (9.2.1)	40 (208.2)	40(9.2.1)	40	40 except following cases 36 for the arc of contact not more than 90° and elevator with rated speed of not more than 0.75m/ s., rated load of not more than 3100N, and rise of up to 13m. 30 for the elevator with rated speed of not more than 0.5m/ s., rated load not more than 2000N, and rise of up to 10m. (2000-MOC Notice No.1414 item 2 parag.3 (3)

Table 10 — *(continued)*

Requirement	CEN	ASME/CSA	Part 1 SA	Part 2	Japan
Suspension ropes on hydraulic lifts (and electric lifts, where marked*)					
5. Minimum factor of safety for ropes					Condition / At installation / During use: Normal: 5 / 4 Safety device actuated: 2.5 / 2.5 Critical safety factor: 2.5 / 2.5
a) On hydraulic lifts * suspension ropes[88]	12 (9.2.2)	same as electric [3.18.1.2]	12 (9.2.2)	12 for 8 mm dia. Ropes 10 for 9.5 mm dia. rope (Table 17.1 in AS1735 part 3.)	(2000-MOC Notice No 1414 item 2 parag.3)
balancing weight ropes	12 (9.2.2)	7 [3.20]	12(9.2.2)	Same as above	No spec
b) On electric lifts* (passenger lifts only for ASME & CSA)	16 with 2 ropes* 12 with 3+ ropes* 12 for drum* (EN81:1)	7,6-11,9* Increases with rope speed [2.20.3]	16 with 2 ropes* 12 with 3+ ropes* 12 for drum* (EN81:1)	10 to 11.9 depending on speed (Table 17.5 in AS1735 part 2.)	Condition & Machine type / At installation / During use: Normal - traction: 5 / 4 - drum: 5 / 4 Safety device actuated - traction: 3.2 / 2.5 - drum: 2.5 / 2.5 Critical safety factor - traction: 3.2 / 2.5 - drum: 2.5 / 2.5 (2000-MOC Notice No 1414 item 2 parag.3)

Table 10 — *(continued)*

Requirement	CEN	ASME/CSA	Part 1 SA	Part 2	Japan
Suspension ropes on hydraulic lifts (and electric lifts, where marked*)					
Suspension chains on hydraulic lifts					
6. Minimum number of chains					
per jack	2 (9.1.3 a)	Not permitted	2 (9.2.5)+ (restrictions on use of chains 10 m travel; 0.3 m/s; 6m^2 max platform)	2(17.3) (restrictions on use of chains 10m travel; 0.3 m/s; 6m^2 max platform)	2
between car and balancing weight	2 (9.1.3b)	[2.20.1]	2 see conditions above	2 see conditions above	No spec
7. Type of chains	Steel parallel link or roller type (9.1.1)	N/A	Steel parallel link or roller type (9.1.1)	- Simplex with Pitch □15mm - Multiplex with pitch □12mm - Leaf in accordance with ISO 4347	Roller chain (2000-MOC Notice No 1414 item 3 parag.3)
8. Minimum factor of safety for chains	10 (9.2.5)	N/A	10 (9.2.5)	10 (17.3.6)	Same as rope

* This data is applicable to Electric Lifts.

**NOTE

1) The calculation method was changed in the revised BSL-EO as per the following.

$$SF_N = \frac{N_c \times N_R \times F_0}{\alpha_1 \times (L+P)} \qquad SF_S = \frac{N_c \times N_R \times F_0}{\alpha_2 \times (L+P)} \qquad \text{(in revised BSL-EO)}$$

$$SF = \frac{N_C \times N_R \times F_0}{L+P} \qquad \text{(in former BSL-EO)}$$

Where

SF	safety factor;
SF_N	safety factor in normal operation;
SF_S	safety factor at safety devices actuated;
α_1	the factor to convert the load moving up and down to static load under normal operation (=2);
α_2	the factor to convert the load of moving up and down to static load if safety device actuated (=2);
L	total dead load suspended ropes or chain;
P	load in the car (rated load);
F_0	breaking strength of rope or chain;
N_R	number of rope or chain;
N_C	factor of roping (1 for 1:1 roping, 2 for 2:1 roping);

2) All load of the part moving up and down shall be convert to static load using α_1:and $\alpha_{2/}$;

3) Safety factor of “at installation” means the value calculated based on the breaking strength of new rope;

4) Safety factor of “during use” means the value calculated based on the remaining breaking strength of the rope when the wear of the rope reaches to the reference of replacement;

5) α_1: and α_2 are able to change depending to characteristic of the elevator by approval of the Minister of Land, infrastructure and transportation, although it is stipulated in 2000-MOC Notice No. 1414 item 2 parag. 1 and item 3 parag.1;

6) Critical Safety factor is the safety factor when one of the suspension rope breaks, and calculated following formula.

$$CSF_I = \frac{N_c \times (N_R - 1) \times F_0}{\alpha_1 \times (L + P)}$$

$$CSF_S = \frac{N_c \times (N_R - 1) \times F_0 \times 0{,}8}{\alpha_2 \times (L + P)}$$

Where

CSF_I critical safety factor at installation;

CSF_s critical safety factor during use.

7.2 Observations and suggestions by individual experts

7.2.1 Minimum number of ropes (ref. 7.1.1.1)

Two independent ropes per jack or machine controlled by a slack-rope device are sufficient.

7.2.2 Minimum rope diameter (ref. 7.1.2)

This is an essential factor for the life time of ropes.

Experience has shown that it is much more difficult to reach the same quality level, in manufacturing, with small ropes than with relatively bigger ones.

The relative variation of dimensions (ovality, change of diameter, etc) is one of the major causes of strand breaking.

CEN accepts 8 mm, while ASME and CSA require 9,5 mm. For optimal life time, the minimum rope diameter could be related to the rope's speed, traveled distance, etc., although there is no theoretical justification, only the knowledge that it is difficult to produce good ropes that have small diameter.

NOTE This last statement is no longer relevant in 2004.

7.2.3 Safety factor (ref. 7.1.4)

Experience tells that very few complete suspension ruptures happen for lifts. However, since rope load is only one element generating wear and risk of breaking, together with fatigue, specific pressure, etc., the optimum safety factor should be somewhat variable, depending on the number and type of bending, the “mileage”, and the rope grade.

7.2.4 Maximum specific rope pressure (ref.EN81-1)

This is a critical issue which should be addressed by all codes. CEN (EN81-1, Section 9, Note 2) is the only code which limits the specific pressure in the grooves, but the formula leads to somewhat too strong limitations and ignores essential factors like materials used, material hardness, ropes construction and distance traveled, all items which should be covered.

NOTE The limitation of the specific pressure has been abandoned in the 1998 version of EN 81-1, and replaced by the calculation of the minimum safety factor, which considers grooves profiles and other parameters, as per 7.2.3.

Other experts suggested that standards should recognize the use of plastic pulleys because of two identified problems: they may break; the rope wires break on the side facing groove rather than on opposite side, as is the case with steel pulleys.

7.3 Points agreed upon re ropes and chains

NOTE 1 The working group decided to study the subject of suspension means and related issues (traction, rope pressure, etc.) in the second edition of ISO/TR 11071-1.

NOTE 2 The study has not been completed due to the introduction of new technologies on the lift rope market.

8 Capacity and loading

8.1 Historical background

One of the objectives of this section is to present the derivation of the equations as they emerged in the ASME A17.1 Code many years ago. Another objective is to explain why the ASME A17.1 Code has the same loading intensity for traction and hydraulic elevators, while the CEN has different passenger loading intensities for these 2 types of elevators, in the case of Goods Passenger lifts (not for passenger lifts).

Because of the historical background, the units used in the following paragraphs are in the imperial system.

NOTE 8.1 For comparison of the current ASME, CEN and CSA requirements for Rated Load versus Car Inside Area, refer to Sections 3.3.2.1 to 3.3.2.5 in this report.

8.1.1 Historical background to ASME rules

8.1.1.1 Introduction

a) With the passage of time, the basis for the present method of establishing the capacity of passenger elevators as a function of inside net cab floor area has become somewhat obscured;

b) the validation of the specific numerical values used in quantifying the equations is beyond the scope of this section.

8.1.1.2 General discussion

a) The early code-writers based the loading intensity requirements on the fact that, with the larger size elevators, there is an increase in intensity, since the larger the elevator, the more people tend to crowd together;

b) extensive research is necessary to document the origin of the values used in Section 8.1.1.3(a). However, some of the loading intensity data published in the early 1930's by the steel companies in the US noted the various local building codes specified minimum live loads for office buildings as 100 psf (New York City, 1932), 100 psf (Chicago, 1924), 100 psf (Philadelphia, 1930), just to cite a few. (NOTE: psf = pounds per square foot.) These values are consistent with the A17 value of 99,0 psf at an area of 50 sq. ft, given below in Section 8.1.1.3(a)(2);

c) the A17 formulas were developed in the era of attendant elevators where the elevator operator could control the passenger loading. Following the introduction of elevators without operator in the car, the code-writers found it necessary to provide for the 25 % passenger elevator overload, covered by A17.1(see 2.16.9 in 2004 Code);

d) Table 11 shows the Chart, “Power Passenger Elevators - Capacity and Loading: A17.1 Code Rule History”. This Chart traces the inclusion of rated load criteria, starting with the 1921 edition of the A17.1 Code, up to and including the A17.1-1993 edition and its Addenda;

e) prior to the publication of the A17.3-1942 Supplement, the Code user was provided with a set of mathematical curves, expressed in terms of total elevator capacity as a function of the area and capacity per unit area, ie, the intensity of loading as a function of the car area. These curves are shown in Figure 12;

f) A17.3-1942 Supplement, Rule 217a, introduced a logarithmetic equation which gave the rated capacity of the elevator as a non-linear function of the inside floor area. The previous set of mathematical curves were retained to facilitate the graphical determination of the desired values;

g) the 1955 edition of the A17.1 Code embodied a major rewrite to the A17.1-1937 Code together with the 1942 Supplement. 2 second degree equations were developed to express the rated load as a function of inside cab area, thus superseding the single equation which was introduced in 1942. (see Figure 13).

Table 11 — Power Passenger Elevator - Capacity and Loading A17.1 Code Rule History

A17.1 Code edition/ suppl.	Min. rated load, W (lbs.)		Minimum uniform distributed load, W_{min} (psf)			Minimum passenger Wgt. (lbs)	Applicable rules	Passenger overload criteria	Area measure-ment plane
	$0 \leqslant A \leqslant 50$	$A > 50$	$0 \leqslant A \leqslant 50$	$50 \leqslant A \leqslant 120$	$A > 120$				
1921	75A		75				207a 207b2	n/a	Unspecified
1925	Per rule 217a, curve A		Per rule 217, curve B		100		217a 316b		
1931									
1937									
1942	$60A + 70A\left(1 - \frac{1}{e^{0,0166A}}\right)$ or (rule 217, curve A, Fig. 4 or 4A)		$130\text{-}70e^{-0,1666A}$ or (rule 217, curve B, Fig. 4 or 4A)				217a 217c		
1955						150 (1)	207.1 316.1 207.9(Exc.1) 1200.1		
1957							207.1 316.1 207.4 (Exc.1) 207.9 1200.1	25 %	
1960							207.1 316.1 207.4 (Exc.1) 207.8 1200.1		
1965							207.1 316.1 207.4 (Exc.1) 207.8 1300.1		
1971	$0,667A^2 + 66,7A$ (3)	$0,0467A^2 + 125A - 1367$ (3)	$\frac{2}{3}(A + 100)$	$0,0467A + 125 - \frac{1367}{A}$					
1978 (2)							207.1 301.10 207.8 207.4(Exc.1) 1300.1		36" above floor
1981									
1984									
1987						Not specified	207.1 301.10 207.8 1300.1		
1990									

Notes:

(1) Under emergency condition, freight elevators can be used to carry passengers not greater than W/150.

(2) +5 % tolerance allowed on inside net area of car without changing load rating.

(3) Tabulated values per Table 207.1 and graphs per Fig. 1200.1 (1995-1960) and Fig. 1300.1 (>1960).

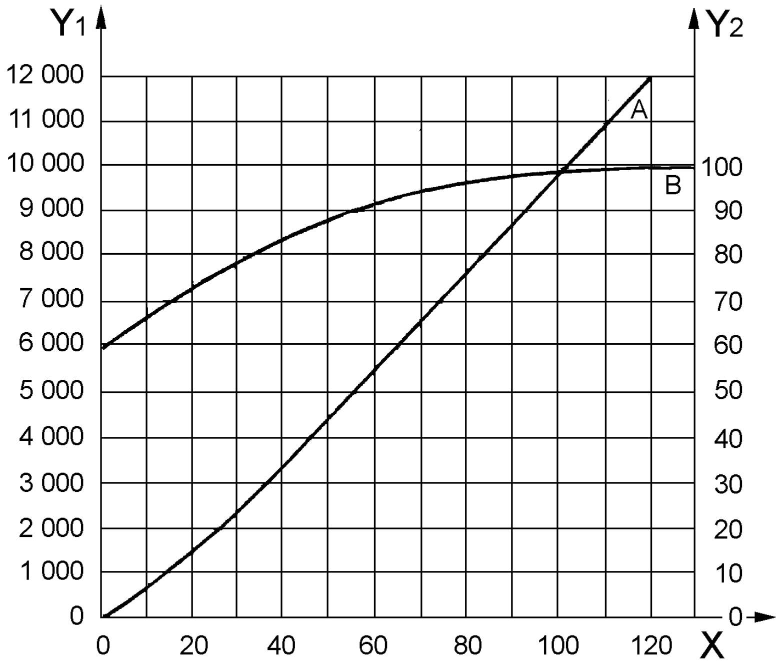
Symbols:

A = Net inside platform area (ft^2)

W = Minimum rated load (lbs)

Requirement 2.16 Capacity and Loading

a) The contact load of a power passenger elevator in pounds shall be not less than the amount given by curve A, Fig. 4, corresponding to the effective platform area of the car. (O).



Key

A total capacity

B capacity per sq. ft.

X effective area of platform (sq. ft.)

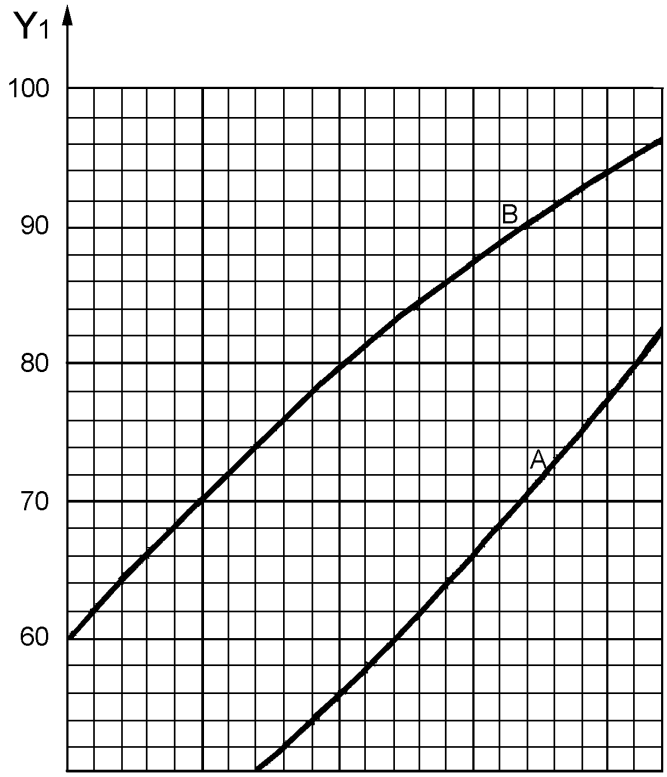
Y1 total passenger elevator capacity (lb)

Y2 effective platform area capacity (lb per sq. ft.)

Fig. — Plot showing passenger-elevator carrying capacity corresponding to effective platform area

NOTE For passenger elevators having effective platform areas above 120 sq. ft., the contract load shall be not less than 100 lb per sq.ft.

ASA A17.3-1942



Key

A contract load

B load per sq. ft.

Y1 load per sq. ft. in lb (curve B)

Fig. 4 — Contract load graph for effective platform areas from 0 to 50 Sq Ft

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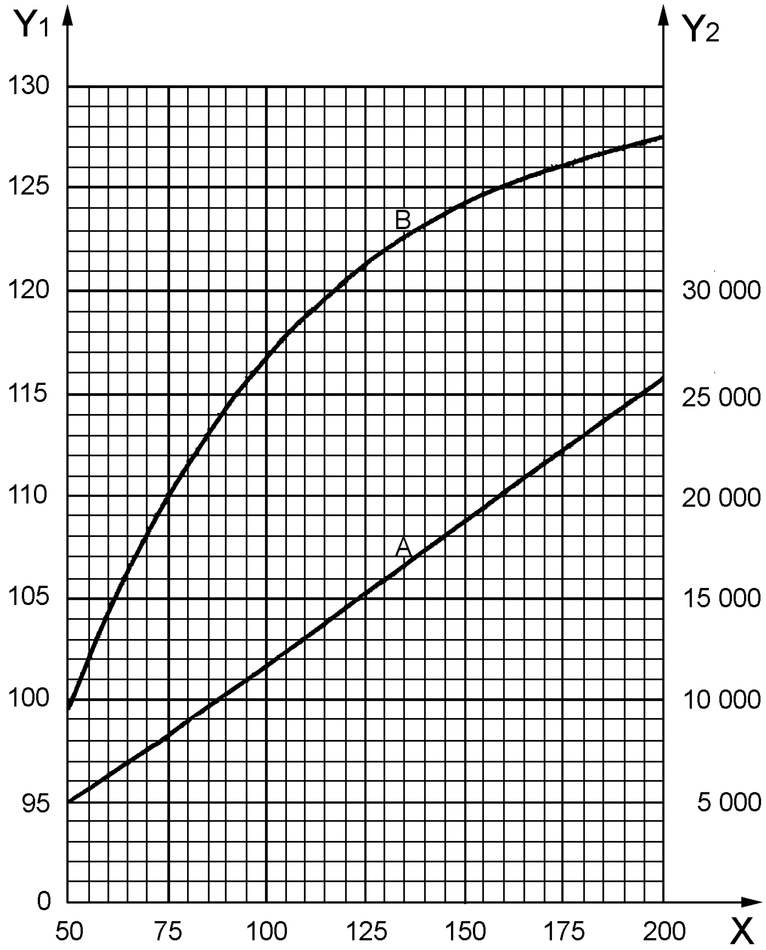


Key

A contract load

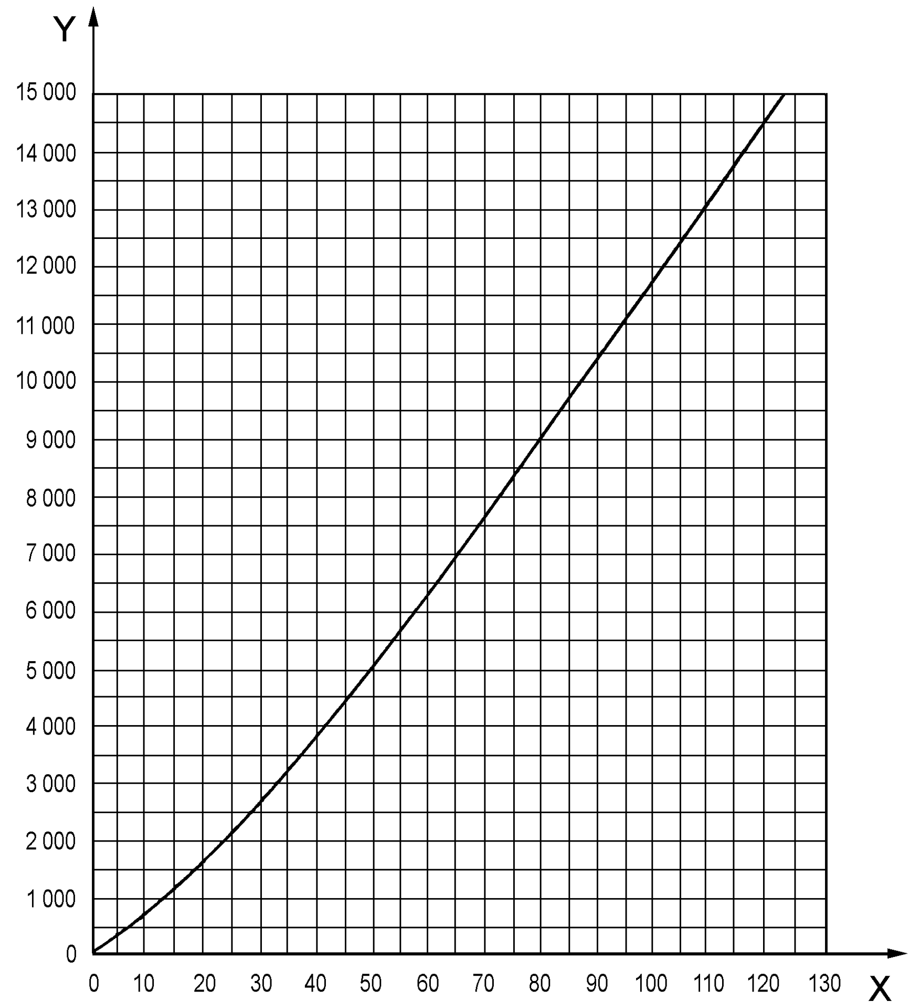
B load per sq. ft.

Y1 load per sq. ft. in lb (curve B)

Y2 contract load of passenger elevators in lb (curve A)

Fig. 4 — Contract load graph for effective platform areas from 50 to 200 Sq Ft

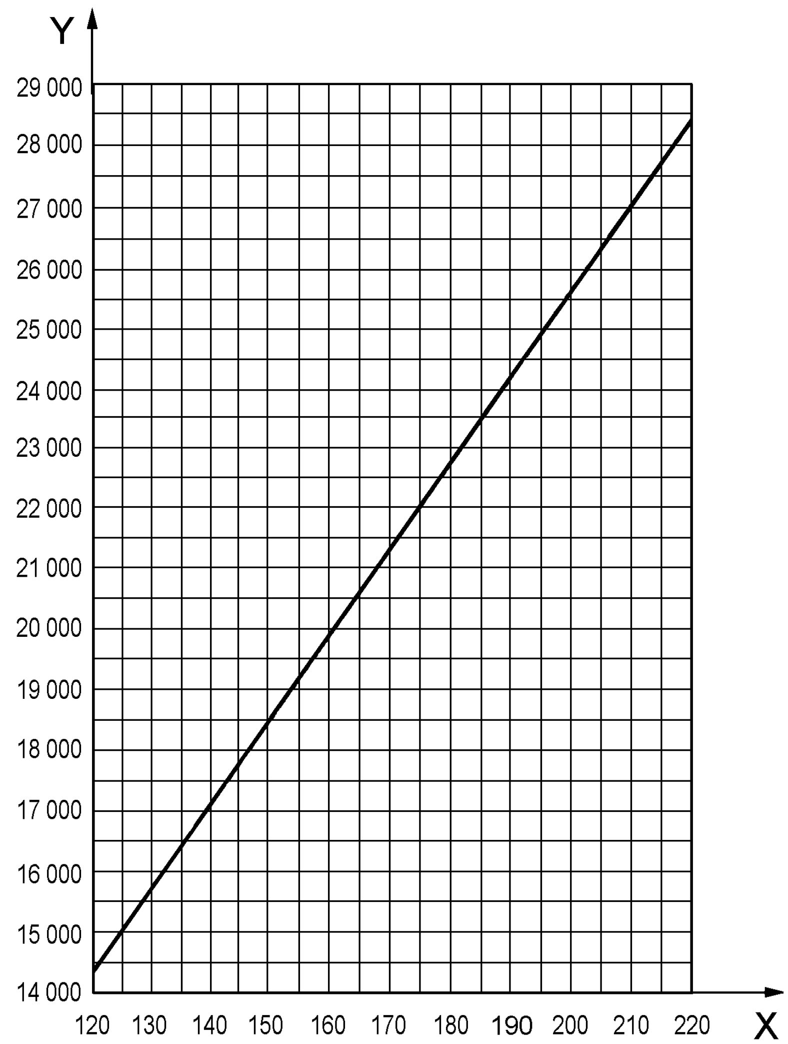
Figure 12 — Capacity and Loading of Passenger Elevators According to 1925-1942 Editions of A17.1 Code



Key
X inside net platform area, ft^2
Y rated load, lb

NOTE 1 lb = 0,454 kg 1 ft^2 = 9,29E – 0,2 m^2

Figure 1300.1 (1) — Minimum rated loads for passenger elevators



Key
X inside net platform area, ft^2
Y rated load, lb

NOTE 1 lb = 0,454 kg 1 ft^2 = 9,29E – 0,2 m^2

Figure 1300.1 (2) — Minimum rated loads for passenger elevators

Figure 13 — Capacity and Loading of Passenger Elevators According to 1991 Edition of A17.1a Code

8.1.1.3 Derivation

a) The following values were obtained graphically from the Curves in Figures 4 and 4A of the A17.3-1942 Supplement to the A17.1-1937 Code (see Table 11 in this report):

1) 60,0 psf @ 0,0 ft^2

2) 99,0 psf @ 50,0 ft^2

3) 116,7 psf @ 100,0 ft^2

4) 127,5 psf @ 200,0 ft^2

5) 130,0 psf @ ∞

a) Notations:

W = rated load (lbs)

A = inside net floor area (ft^2)

B,C & D = Constants

e = Base of Natural Logarithm

psf = lb/ft^2

b) Since the curves for the loading intensity in the early editions of the A17.1 Code were shown as non-linear, a general equation of the following form was selected:

$$\frac{W}{A} = B + C_e{}^{DA} \quad (1)$$

c) When W/A = 60 and A = 0, both of which come from the Curve Figure 4, (1) becomes

B + C = 60 (2)

d) When W/A = 130, a = ∞, and D must be negative, so that

B = 130 and C = 70 (3)

e) Substituting the values from (3) and (1) yields the expression

$$\frac{W}{A} = 130 - \frac{70}{e^{DA}} \quad (4)$$

f) When A = 100, the load intensity, W/A = 116.7 so that (4) becomes

13,3 e^{100D} = 7C (5)

g) From which,

D = 0,0166 (6)

h) Substituting (6) in (4) yields the expression

$$\frac{W}{A} = 130 - \frac{70}{e^{0,0166A}} \qquad (7)$$

i) Rearranging (7) yields the expression

$$W = 130A - \frac{70A}{e^{0,0166A}} \qquad (8)$$

j) The 1st term on the right-hand side of (8) may be expressed as

$$130\text{A} = 60\text{A} + 70\text{A} \qquad (9)$$

k) Substituting (9) in (8) yields the expression

$$W = 60A + 70A - 70A\left(\frac{1}{e^{0,0166A}}\right) \qquad (10)$$

l) From which

$$W = 60A + 70A\left(1 - \frac{1}{e^{0,0166A}}\right) \qquad (11)$$

which is the equation noted in the A17.3-1942 Supplement.

8.1.2 Historical background to CEN rules

8.1.2.1 Introduction

m) The disadvantage of a traction elevator relative to drum or hydraulic drives is the non positive mechanical connection between the car and the stopping device (brake, valves). A higher degree of risk in terms of platform overloading is inherent with traction systems;

n) almost up to the middle of the 20th century, this risk was addressed by the following:

1) calculation of the traction requirements taking into account a certain overload;

2) tests on the installed lift with overload in the car;

3) use of the lift only with the help of a lift guide (attendant).

8.1.2.2 Traction Lifts

a) The invention of the "Selbstfahrer Steuerung" (automatic control) ie, button control used by the passengers, required technical means to reduce the risk of overloading. Experience showed that it was not realistic to assume that passengers were aware of the risk of overloading by the number of persons in the car. The easiest way to achieve this aim was to limit the available car area in relation to the persons to be transported and to assume a mass of 75 kg per person. This was done in Germany in 1941 and subsequently modified in 1967. The 1967 modification accomplished the following:

1) A reduction of the values established in 1941; and

2) differentiating the requirements between lifts with traction drives and those with other driving systems, such as direct-acting hydraulics. The basis for this was that the overloading by persons in lifts with driving systems other than traction does not create the same level of risk, since the car will not fall, and the possibility of the driving system to raise the overload is limited. By contrast, an

overload to a traction elevator could cause the traction, brake, or both, to fail, with a high probability that the car would descend;

b) The safety factors of the suspensions and the other supporting structures are at least 3 times higher than the ability of a given configuration of a traction sheave to hold the car by friction between the ropes and their grooves.

8.1.2.3 Hydraulic lifts

a) The cost of power consumption in Germany was also an issue. For this reason, there is a different loading for hydraulic elevators on the basis that there is less likelihood of overloading a hydro;

b) during the writing of the hydraulic part of the CEN Code (EN 81-2), the German delegation proposed that the German value of 200 kg/m2 be adopted into the EN 81-2. Other delegations were not in favour of that, but finally a compromise was reached by introducing Table 1.1A and additional requirements in the Clauses 8.2.2.1, 8.2.2.2 and 8.2.2.3. Besides that, in EN 81-1 as well as in EN 81-2, a car designed with 200 kg/m^2 is possible for the transportation of private motor cars (see EN 81-1, 8.2.3 and EN 81-2, 8.2.4);

c) there is less risk in overloading a hydraulic elevator. Therefore, the different loadings for traction elevators and hydraulic elevators, as given by EN 81-2 Tables 1-1 and 1-1A respectively, emerged. (Refer to Table 3 in this report for comparison of CEN Tables 1.1 and 1.1A).

NOTE The above is no longer relevant for 1998 version of EN 81-2. The following item (d) is added in 1998 editions of EN 81-1 and –2;

d) the ratio car load/car area is the same. The Table 1.1A is only of possible application for hydraulic Good Passengers lifts

8.2 Observations and suggestions by individual experts

8.2.1 While the entire subject of capacity and loading has historically been treated in safety codes as one and the same, it might be more meaningful in the future writing of safety codes to cover loading as a separate issue from capacity. One refers more appropriately to the traffic-handling capability, whereas the other refers to the maximum carrying capacity, which has a direct bearing on safety.

8.2.2 While the ASME and CSA loading per passenger (72.5 kg in Appendix D of 2000 edition of ASME/CSA Code) is lower than the CEN value (75 kg), the overall elevator rated capacity is very close, since ASME/CSA does not presently account for the possibility of loading in the door sill area, whereas CEN does.

8.2.3 Cultural differences affect the elevator loading. As an example, in some areas, people tend to refrain from jamming themselves into an elevator already occupied by several passengers.

8.2.4 Changing demographics, coupled with advances in food processing, nutrition, etc. have resulted in the general population of taller and heavier people. The trend is toward heavier people occupying the same floor area as did the shorter people of yesteryear. Passenger loading intensities per floor area are increasing. The unknown is – by how much?

8.2.5 Demands of society have caused a change in the demographics of the workplace as evidenced by current practices, in which not only do business and professional people carry attaché cases, filled with paper, but also with advent of laptop computers many people are carrying heavier accompanying weights between the office and home, as well as to business meetings. While it can be argued that the physical space required for these carrying cases, etc. increases the individual space per passenger and that the resulting density might remain the same, nevertheless, in many instances, people can vertically stagger the carrying heights of their cases, which results in 2 people with 2 bags fitting into the horizontal space of 2 people plus 1 bag. The trend is clearly toward increased loading intensity per passenger.

8.2.6 Aircraft and insurance companies may be able to provide some up-to-date information on weights of people.

8.3 Points agreed upon

8.3.1 In view of the intended scope (See 8.1, above) and the necessity of more fundamental research, the complete treatise on capacity and loading, including number of passengers, will be addressed in the revision to ISO/TR 11071-1, since it pertains to all elevators, not just hydraulics.

NOTE This sentence has been left in this Part 2 of ISO/TR11071 Regardless that it was to be moved in Part 1.

8.3.2 The car floor area located within the entrance threshold should be included in calculations of inside area of the car in all codes.

8.3.3 Passenger weights should reflect the changing demographics, which include trends in increasing body weights and the weights of accompanying bags.

8.3.4 No further conclusions on passenger loading intensities could be reached at this time due to the lack of up-to-date biomechanical studies regarding the above issues.

9 Spaces and clearances

9.1 Historical background

9.1.1 Comparison of requirements

The comparison of requirements for spaces and clearances is in Annex A, Table A1. The following are comments on the discrepancies between the requirements with references to item numbers in the table.

9.1.2 Guided travel of car and counterweight

While CEN qualifies the length of "guided travel of car" (item 1.1 in Table A.1), other standards use performance language to specify that the car shoes shall not leave their guides. The same applies to the guided travel of the counterweight (item 2.1 in Table A.1).

9.1.3 Free height above car roof

Requirements for the free height above a specific area of the car roof are expressed differently, but the end results are similar.

Only CEN requires the clearance to include the gravity stopping distance for indirect-acting lifts.

Requirements for other clearances are quite different and in one case (item 1.3 in Table A.1) range from 150 mm in ASME and CSA for some equipment provided there is 600 mm from the crosshead to the highest obstruction.

9.1.4 Refuge space on car top

There are major differences in the requirements for the size and location of the refuge space on the *car* top (item 3 in Table A.1). While ASME requires that one face of the rectangular block be located on the car roof, CEN and CSA appear to permit the location of this imaginary block anywhere above the car top equipment. ASME requires a minimum height of 1,07 m for refuge space. This dimension may be only 0,6 m according to CSA. Minimum height is 1,035 m for an indirect-acting lift having 1 m/s speed, according to CEN. That height corresponds to the ASME requirement of 1.07 m.

NOTE The above Clause is not updated with recent harmonization of ASME and CSA Codes.

9.1.5 Bottom runby

There is no requirement for a car and counterweight bottom runby (item 4 in Table A 1) in CEN, while the minimum and maximum runbys are specified in ASME and CSA.

Bottom car runby is defined as "the distance between the car buffer striker plate and the striking surface of the car buffer when the car floor is level with the bottom terminal landing".

Bottom counterweight runby is defined as "the distance between the counterweight buffer striker plate and the striking surface of the counterweight buffer when the car floor is level with the top terminal landing".

9.1.6 Pit clearances and refuge space

While the basic vertical clearance (item 5.1 in Y Table A 1) varies slightly from 0.5m in CEN to 0.61 in ASME and CSA, conditions for exceptions to this rule (items 5.2 to 5.5) are extremely complex and different.

Refuge space (item 5.6) is required in CEN, ASME and CSA.

9.1.7 Well to car-entrance-side clearances

There are no major discrepancies in requirements.

Since only CEN permits cars without car doors (item 6.1 in Table A.l), clearances are not shown in the table for that case.

9.1.8 Horizontal well clearances

ASME and CSA specifies five various clearances, and CEN only two. According to ASME (see item 1.5 in the table) the clearance between cars in a multiple well may be as low as 51 mm, while CENs minimum is 300 mm.

9.1.9 Machine room clearances

There are no major differences in requirements, except that CEN permits trap door for access to the machine room, while it is prohibited in ASME and CSA (item 8.7).

CEN contains all requirements for machine room clearances. ASME and CSA refer to national electrical codes (item 8.1).

9.2 Observations and suggestions by individual experts

9.2.1 Refuge spaces on car top (ref. 9.1.4)

One expert noted that all of the standards require enough space on the car top to safely accommodate only one person. This assumption, however, is not stated.

9.2.2 Bottom car runby (ref. 9.1.5)

The following rationale for ASME and CSA requirements regarding bottom car runby was presented by an expert:

a) the ASME and CSA requirements recognize that the elevator car may overrun the bottom landing due to controller/sensor inaccuracies or due to mechanical issues such as rope stretch. It is intended that the car will not strike the buffer due to a runby of the bottom landing;

   unnecessary impact on the buffers could cause emotional trauma or discomfort to passengers;

b) the required runby is 152 mm for installations using oil buffers; however, this may be reduced where pit depth is limited or where inadequate top clearances are available to achieve the required runby. In the case of spring returned oil buffers, ASME and CSA requirement 2.4.2.1(b) permits compression of the buffer up to 25 % of the stroke and allows elimination of the runby for these type of oil buffers;

c) for the case of spring buffers, or solid bumpers, the required runby is 152 mm, without exceptions in the case of hydraulic lifts;

d) for the case of hydraulic elevators with a typical rated speed below 1,0 m/s, it is usual to use spring buffers. For this case, 152 mm bottom runby is always required. It is generally felt that less accurate control of hydraulic elevators, oil compression during loading/unloading, temperature variations which affect oil expansion and seal friction are all factors which affect leveling accuracy at the bottom landing. Adequate runby is required to ensure that unnecessary harsh stops are avoided;

according to CEN experts, CEN implicitly requires the bottom car runby, by requiring the final limit switches to stop the car before it reaches the buffers. This rule indeed does not apply to hydraulic lifts. However, good design practice is to allow approximately 100 mm space between the car and buffers when the car is at the bottom landing;

a car landing on buffers may cause discomfort to passengers, but in no case would such an occurrence endanger passenger's safety. For that reason, CEN has deliberately omitted any requirements regarding runbys;

another expert suggested that CEN should at least state that a car should not land on buffers when at the bottom landing, since that is deemed a good engineering practice.

9.2.3 Horizontal well clearances (ref. 9.1.8)

The need for various horizontal well clearances (item 7) should be re-examined. The rules could be replaced with a simple performance requirement, stating that the movement of the car or counterweight shall not be obstructed, considering their relative displacement caused by wear, tear, deflection, type of use, or by the design of their guiding means.

9.2.4 Reduction in dimensions

While there are differences in hoistway running clearances, refuge spaces, etc. between the various standards, there is no evidence to support any contention that these are deficient in providing safety.

Further, there would be no sound reason to propose a reduction to present numerical values without inviting resistance by field employees and possible government intervention.

9.3 Points agreed upon

9.3.1 Bottom car runby (ref. 9.1.5, 9.2.2)

All codes should require bottom car runby sufficient to prevent the car from striking the buffer when stopping at the bottom landing. This is current practice in Europe and is required in ASME.

9.3.2 Pit refuge spaces (ref. 9.1.6)

For consistency with car top refuge space requirements, all standards should specify requirements for pit refuge spaces (Table A.1, item 5.6), which are presently covered only in CEN, ASME and CSA.

9.3.3 Refuge spaces (ref. 9.2.1)

The minimum dimensions for a refuge space are intended to provide adequate space on top of or beneath the elevator car for one person only when a moving car reaches the extreme limits of travel.

9.3.4 Prudent design

Regardless of clearances specified, designers must also consider construction tolerances, effects of loading, and wear to assure that the movement of the car and counterweight are not affected.

10 Protection against free-fall, excessive speed and creeping

10.1 Historical background

10.1.1 Terminology

For interpretation of terminology used in Table 12, Column C in relation to the protection methods, one should refer to applicable standards.

For comparison of requirements pertinent to safety gears and overspeed governors, one should refer to sections 8 and 9 in ISO/TR 11071-1:1990.

10.1.2 Comparison of requirements

Table 12 gives comparison of requirements in CEN, ASMI/CSA Standards and in this edition are added SA and Japanese requirements as related to:

a) assumed safety hazards, i.e. car free fall, car descent with excessive speed, car creeping from landing and counterweight free fall (Column A in the table).

b) anticipated mechanical failures that may cause the safety hazards (Column B in the table); and c) methods of protection against the hazards explicitly mentioned in the standards as being acceptable.

Section 3.5 in this report deals with anticipated mechanical failures in general terms. Some of the failures may be repeated in Column B in order to show their relationship with the "assumed hazards" and the "methods of protection" in each standard.

The following are comments on the requirements in CEN, ASME, and CSA standards and on the discrepancies between the requirements with references to item numbers in Table 12.

Table 12 — Protection against Free Fall, Excessive Speed and Creeping

Columns A: Assumed - safety HAZARD and equipment FAILURE causing such hazards						Columns B: Standards give the following acceptable PROTECTION methods against the hazards and related failures stated in Columns A					
	CEN	**ASME/CSA**	**SA** Part 1	**SA** Part 3	**Japan**	**METHODS**	**CEN**	**ASME/ CSA**	**SA** Part 1	**SA** Part 3	**Japan**
1. CAR FREE FALL on direct or indirect type lift – assumed?											
1.1 DIRECT acting lift due to rupture of jack	No	No		No	No	1.1 Not applicable since not required in any standard	-	-		-	-
1.2 Indirect acting lift due to suspension failure	Yes (Table 3)	Yes (3.17.1) & (3.17.3)	Yes (Table 2) & (9.8.1.2)	Yes (Table (35(A))	Yes (2000-MOC Notice No.1423	1.2a Safety gear and governor	Yes (9.8 & 9.10.2)	Yes (3.17.1 & 2.17.7)	Yes (9.8 & 9.10.2*)	Yes (Table 35(A))	Yes (2000-MOC Notice No.1423 item 2 pr.4)
						1.2b Safety gear tripped by suspension failure	Yes (9.8 & 9.10.3)	No (3.17.7 & 2.17.1)	Yes (9.8 & 9.10.3)	Yes (Table 35(A))	Yes (2000-MOC Notice No.1423 item 5 pr.2)
						1.2.c Safety gear tripped by safety rope	Yes (9.8 & 9.10.4)	No (3.17.7 & 2.17.1)	Yes (9.8 & 9.10.4)	Yes (Table 35(A))	No spec
						1.2d Safety gear inertia operated	No	No	No	Yes (Table 35(A))	No
2 CAR DESCENT with excessive speed due to RUPTURE in hydraulic system (jack excluded) – Is this hazard and cause assumed?						2a Safety gear and governor	Yes (9.8 & 9.10.2)	Yes (8.4.11 .4) See NOTE 1 bellow	Yes (9.8 & 9.10.2*)	Yes (Table 35(A))	Yes (2000-MOC Notice No.1423 item 5 pr.2)
2.1 DIRECT acting lift	Yes (9.5.1) (Table 3)	Yes (8.4.11.2) See NOTE 1 bellow	Yes (9.5.1)	Yes (Table 35(A))	Yes (7.5.5)	2b Rapture or safety valve	Yes (12.5.5)	Yes (8.4.11 .2) NOTE 1 below	Yes (12.5.5*)	Yes (7.5.5)	No
2.2 Indirect acting lift					No	2c Restrictor	Yes (12.5.6)	No	Yes (12.5.6)	No	No
3. CREEPING from a landing due to small LEAKAGE in hydraulic system, including jack – Is this hazard and cause assumed?						3a Safety gear tripped by downward movement	Yes (9.8 & 9.10.5)	No	Yes (9.8 & 9.10.5)	No	No
3.1 Creeping	Yes	Yes	Yes	Yes	No	3b Clamping device tripped by downward movement	Yes (9.9 & 9.10.5)	No	Yes (9.9 & 9.10.5)	No	No

Table 12 — (*continued*)

Columns A: Assumed - safety HAZARD and equipment FAILURE causing such hazards						Columns B: Standards give the following acceptable PROTECTION methods against the hazards and related failures stated in Columns A					
	CEN	**ASME/CSA**	**SA** Part 1	**SA** Part 3	**Japan**	**METHODS**	**CEN**	**ASME/ CSA**	**SA** Part 1	**SA** Part 3	**Japan**
3.2 Creeping by more than	120 mm (9.5.1)	25 mm (3.26.3)	120 mm (9.5.1)	150 mm (Table 34.1)	Yes (9.5) Yes (31.4) - Yes (7.5.4)	3c Pawl device	Yes (9.11)	No	Yes (9.11)	Yes (9.5)	No
						3d Electric anticreep system	Yes (14.2.1.5)	Yes (3.26.3)	Yes (14.2.15)	Yes (31.4)	Yes (2000-MOC Notice 1429 item 2 parag. 2)
						3e Plunger gripper	No	Yes (3.17.3)	No	-	No
						3f Door lock valve	-	-		Yes (7.5.4)	No spec
4. BALANCING WEIGHT FREE FALL into accessible spaces underneath its path due to:											
4.1 BWT suspension failure	Yes (9.6.1) & (5.5 b)		Yes (9.6.1) & (5.b)	Yes		4a BWT safety gear tripped by:	Yes (9.6.1)	Yes (3.6.2)	Yes (9.6.1)	Yes	Yes
						- Governor	Yes (9.6.2a)	No	Yes (9.6.2a)	Yes	Yes (Explanation of BSL-EO Art. 129-7
		Yes (3.6.2) & (3.6.2)			Yes (Explanation of BSL-EO Art. 129-7)	- Suspension failure	Yes (9.6.2b)	Yes (3.6.2)	Yes (9.6.2b)	Yes	Yes
						- Safety rope	Yes (9.6.2c)	No	Yes (9.6.2c)	Yes (33.2)	N/A
4.2 BWT path obstructed resulting in slackening of its suspension	No		No	Yes (43(d))		4b CWT safety gear tripped by slackening of ropes	No	Yes (3.6.2)	No	Yes (34(d))	Yes (Explanation of BSL-EO Art. 129-7
NOTE 1 "Yes" only for lifts in seismic Zone 2 or greater											

10.1.3 Car free fall on direct acting lifts (item 1.1)

Standards do not assume the hazard of car free fall on direct acting lifts.

Failure of the car-jack connection or rupture of the jack or any other failure resulting in car free fall is not anticipated because of various precautions required in the standards, such as:

- the requirement for corrosion protection of cylinders;
- when installed in the ground, required in all;
- standards (refer to Section 5.1.6.2 in this report);
- the requirement for double wail cylinders or at least;
- double cylinder bottoms in ASME and CSA;

- standards (refer to section 5.1.6.1 in this report);
- design requirements for connection between ram and car (see 5.1.1 and 5.2.1 in this report);
- calculation of ram pressure requirement (see section 5 in this report);
- fixed end stops inside the cylinders (see 5.1.7 and 5.2.7 in this report).

10.1.4 Car free fall on indirect acting lifts (item 1.2)

All standards assume as possible the safety hazard arising from the car free fall on an indirect acting lift that may be caused by failure in the car suspension.

10.1.5 Car descent with excessive speed (item 2)

Only CEN anticipates ruptures in components of a hydraulic system, except in the jack, on any hydraulic lift and requires protection against the car descending with excessive speed on every lift.

ASME and CSA anticipates the same type of failure only on lifts in seismic zone 2 or greater or those with flexible hoses installed.

CEN mentions three protective methods as acceptable, ASME two, and CSA only one (they are listed in Column C in Table 12).

10.1.6 Creeping from a landing (item 3)

All standards envision the hazard of a car creeping away from a landing (with landing door open or not locked), that may be initiated by a small leakage in any component of the hydraulic system, including the jack.

CEN tolerates creeping of up to 120 mm. ASME and CSA tolerate 25 mm only.

CEN has requirements for four various methods of protection against the car creeping from a landing, while ASME and CSA recognize only the "electric anti-creep system".

10.1.7 Counterweight free fail (item 4)

For lifts having accessible spaces underneath the Counterweight, all standards consider free fall of the counterweight to be a safety hazard which may be caused by the counterweight suspension failure (item 4.1).

In CEN, the acceptable protective method is a counterweight safety gear that may be operated by three different means. ASME and CSA recognize safety gears operated only by a speed governor.

In addition, ASME and CSA require protection against slackening of the counterweight suspension (item 4.2), should the movement of the counterweight be obstructed, aiming at reducing the height of its possible free fall and minimizing the probability of suspension failure.

10.1.8 Methods of protection

CEN has requirements for various methods of protection against a specific type of hazard. In addition, CEN (Clause 9.5.3) permits other devices or combinations of devices and means of their actuation provided they give at least the same safety level.

ASME and CSA require a specific protection method against a specific type of hazard.

10.2 Observations and suggestions by individual experts

NOTE While references to SA and Japan standards have been added in Table 12 in this edition, their requirements have not been discussed in this section 10.2.

10.2.1 All standards should clearly list safety hazards against which the precautions must be provided, as in the case of CEN (Clause 9.5.1).

10.2.2 All standards should explicitly list failures that must be assumed as possible and hazards that may be created by such failures. Column B in Table 12 is compiled mainly on the basis of deductions from the requirements pertaining to the methods of protection.

10.2.3 One expert suggested that there is no justification for differences in assumptions regarding the probability of the rupture in the hydraulic system as illustrated in item 2.1 of Table 12 and the associated safety hazard of car descent with excessive speed (item 2 in the table).

All standards should compare records on accident history or theoretical risk analysis and harmonize their requirements.

10.2.4 This, however, may not be necessary.

There are two approaches to assuring safety;

1) to provide devices that can not fail under specified operating conditions;or

2) to provide a redundant or standby device to preserve safety should the prime device fail.

Which approach should be implemented in a standard is more a question of economics (simplification of design, use of standard components etc) than of safety.

CEN has opted for the second approach. It requires installation of a rupture valve, or a governor operated safety gear, or a restrictor (see Table 12, column C, items 2 a), b), c)). If any of those devices is provided, then the requirements for the design of all components between the cylinder and the pump can be simplified, since their failure would not create a safety hazard due to the car descent with excessive speed.

ASME and CSA have opted for the first solution, which necessitates strict rules for design of various components that may be located between the cylinder and the pump, such as:

— flexible hoses and fittings (see 6.1.1.3 and 6.2.1.3);

— grooved pipe fitting (see 6.2.1.1 f));

— type testing of control valves (see 6.1.2.10 and 6.2.2.9).

10.2.5 It was suggested that in the interest of harmonization, this report should recommend a preferred approach. The majority of experts, however, disagreed, suggesting that both the CEN and ASME/CSA methods for assuring safety (for preventing car descent with excessive speed) are viable. It would be more appropriate to allow all the methods in each standard rather than recommending a change one way or another.

10.2.6 It was recognized that the operational effectiveness of a rupture valve cannot be verified by a simple calculation or a test on an installed lift. One expert suggested that the rupture valves should be subjected to type testing and examination procedures similar to those for safety gears (see EN 81-2, Appendix F3).

10.3 Points agreed upon

10.3.1 Whilst CEN, ASME and CSA standards employ different methods for preventing unsafe car descent with excessive speed, they all appear to achieve equivalent safety. Consequently, all standards should be expanded to include proven methods from CEN, ASME and CSA.

11 Electrical devices

11.1 Historical Background

11.1.1 Comparison of requirements for electric safety and protective devices

The comparison of requirements in existing standards for electric safety or electrical protective devices is shown in items 1 to 31 and 41 to 44 of Table A2 in Annex A.

Where malfunctioning of an elevator component may create a serious hazard for lift users (e.g. door non-closing), the operation of such components is checked by an “electric safety device” (see Table 2 for ASME and CSA corresponding term). An electric safety device may be required also to ensure safety of lift mechanics (e.g. stop switch on the car top).

Furthermore, where a lesser hazard (e.g. door closing kinetic energy exceeding a limit) may be created, a “protective device” (see NOTE “D” following table As) is required.

Major differences in Table A2 are noted in the following items:

1	Check on closed position of pit access doors
2	Check on closed position of landing door panels which are not locked and indirectly related by ropes to the locked panel
8.3	Checking of car and landing door by-pass (not required by CEN/ASME)
20	Check on slack rope (chain) on indirect lifts (not required by CSA)
24	Requirements for electric safety devices (see also 11.1.3 of this report)
26(a)	Checking of leveling and anti-creep position limits (not required by ASME)
26(c)	Checking of leveling and anti-creep speed (not required by CEN/ASME)
27(c)	Checking of inspection speed (not required by CEN/ASME)
27(a)	Inspection operation switch
31.1	Final limit switches
31.3	Terminal slow-down devices
45.0	Electrical equipment and wiring
45.1	Certification of electrical equipment
45.11	Overcurrent protection
45.14	Grounding
45.15.0	Applicable standards (IEC, CENELEC, ANSI/UL, CSA-C22.2)
46.1	Standby Power
46.2	Firefighters' Service

11.1.2 Comparison of other electric requirements

The comparison of requirements regarding electric socket outlets, lighting, signals and emergency alarm devices is shown in items 32 through 35 in Table A2 of Annex A.

11.1.3 Design of electric safety devices

11.1.3.1 Contacts with positive separation

Most standards assume that only a contact opened by positive separation of its circuit-breaking devices (CEN) or a contact positively opened mechanically (ASME and CSA) may be sufficiently reliable to be used as an electric safety device.* CEN (14.1.2.2.1) requires such contacts on all electric safety switches.

ASME and CSA requirement 3.26.4 requires that contacts in electrical protective devices* listed must be positively opened mechanically

*NOTE 11.1.3.1 See Table 2 regarding terms “electric safety device” and “electrical protective devices”.

11.1.3.2 Redundancy type circuits

CEN (14.1.1.1) lists all envisioned faults in the electric equipment which must not, on their own, be the cause of a dangerous malfunction of a lift. The list of faults includes voltage drop, non-attraction and non-separation of the moving armature of a relay or contactor, non-opening and non-closing a circuit, etc.

ASME and CSA (3.26.6) considers the non-closing of an electric circuit as a dangerous fault and requires that stopping of the car in response to activation of any electrical protective device must not depend on the completion or maintenance of an electric circuit.

However, ASME (306.9c) considers non-release of a magnetically operated switch, contactor or relay and an accidental ground as a dangerous fault only in circuits on which the car stopping depends in response to opening of hoistway/car door interlocks or contacts.

It also considers any failure (including non-attraction, non-release, non-opening, short, etc) of a magnetically operated switch, contactor or relay, or failure of any static control device, or a single ground, to be a dangerous fault and requires necessary measures (redundancy) in circuits controlling the car stopping in response to activation of any electrical protective device. Redundancy is also required in circuits controlling car leveling and inspection speed and limits of the leveling zone.

11.1.3.3 Checking of redundancy

CEN (14.1.2.3.3a) assumes that a redundancy type circuit can fail by subsequent failure of one component after another and therefore requires continuous or cyclical checking of redundancy. CEN does not consider the possibility of the second failure occurring after the first and before the lift has been stopped by cyclical checking, but does consider the possibility of two failures occurring in more than one circuit arising from a single cause, and for that reason requires measures to minimize such risk (14.1.2.3.3 d)).

ASME and CSA requirements in Section 3.26 requires designing for the possibility of a second failure occurring before the first is visually detected and manually corrected (by service mechanics) and also that there is no risk of two simultaneous failures and requires that the car must not restart normal operation after a fault listed in 3.12.9 (c) occurs.

11.1.3.4 Stopping the machine

CEN (12.4) gives detailed requirements as to how the stop of the machine must be controlled in the case of operation of an electric safety device:

a) for upwards motion, the supply for the electric motor must be interrupted by either:

   1) at least two independent contactors having main contacts in series in the motor supply circuit; or

   2) one contactor if the supply to the by-pass valves [see item (4)(c) in Table 9 in this report] is controlled by two electrical devices connected in series in the valve supply circuit;

b) for downwards motion, the supply to the down valves must be interrupted either:

   1) by at least 2 electrical devices connected in series; or

   2) directly by the electric safety device;

c) if any of the contactors or electrical devices fails to open, a further start shall be prevented (checking of redundancy).

ASME and CSA do not contain corresponding requirements, but it appears to be covered indirectly in ASME and CSA requirements 3.26.1.

11.1.3.5 Devices overriding door safety devices

Item 8 in Table A2 shows the related requirements.

CEN strictly prohibits installation of any device that would override the car or landing door electric safety devices other than the exceptions listed in CEN Clause 7.7.2.2.

ASME and CSA (Item 8.1) allow installation of hoistway access switches that would enable mechanic's or inspector's entry into the hoistway by moving car with doors open.

In addition, ASME and CSA (Item 8.2) requires installation of car-door and landing-door bypass switches in the machine room which permit a mechanic to bypass the car-door and/or landing door electric safety devices and simultaneously disconnect all modes of lift operation, except the inspection operation. The intent is to enable service mechanics to troubleshoot the door safety circuit and/or repair faulty door devices without installing unauthorized jumpers or bridging devices.

Furthermore, ASME and CSA recognizes the risk of unauthorized overriding of door devices as well as the risk of failure of door devices, that could enable operation of the lift with car or landing or both doors open. To minimize the safety risk, ASME and CSA (Item 8.3 in Table A2) requires "car door monitoring system", which would prevent the lift operation should the car door be open, while the circuits incorporating the car-door or landing door electrical protective devices or both are closed.

11.1.4 Anti-creep leveling devices

The following differences are noted:

a) CEN (14.2.1.2) allows a leveling device to be used as one of the various possible protective methods against creeping. ASME and CSA 3.26.3) require the anti-creep leveling devices on each hydraulic lift;

b) the speed limit in CEN is 0.3 m/s, while in ASME and CSA 0,76 and 0,8 m/s. These are the same limits as for electric lifts;

c) ASME and CSA require the device to maintain the car within 25 mm of the landing, while CEN (9.5.1) tolerates creeping up to 120 mm;

d) ASME and CEN (14.2.1.5.1) specify that the device must function irrespective of the position of the hoistway door;

e) only CEN (14.2.1.5.2) requires automatic dispatching of the car to the lowest landing if not used for a period of 15 min. The intent is that the car is as much as possible stopped at the lowest landing, where creeping is limited to a non-dangerous amount by the buffers. This was included because there was opposition to the anti-creep leveling device as a means against creeping, due to the fact that it only works when electric power is available;

f) CEN (14.2.1.5.4) requires a notice in the car, “Close Door”, if manually operated, and an inscription near the main switch, “switch off only when car is at the lowest landing”;

g) ASME and CSA (3.26.4) specify the electric protective devices the activation of which must disconnect the anti-creep device and those which must not.

11.1.5 Recycling operation

ASME and CSA (3.26.7) permit "recycling operation" on multiple or telescopic plungers. This type of operation lowers the car below the bottom landing in order to restore the relative vertical position. Detailed conditions are specified.

This type of operation was necessary because of internal leakage on some early telescopic plungers which were not originally designed for elevators.

11.1.6 Certification of electrical equipment

To reduce the risk to property and persons from fire and electric shock, all equipment has to be submitted for examination and testing to an approved testing agency (laboratory) to certify that the equipment conforms to the appropriate standards established under the provisions of ASME and CSA (Item 45.1 in this document). Only low voltage Class 2 (not more than 30 V rms or 42,4 V peak) is exempted.

There is no such requirement in CEN.

11.2 Observations and suggestions by individual experts

11.2.1 Standards should be specific in defining the role and performance of electric safety devices versus electrical protective devices, including criteria for their design to achieve expected operational reliability (Table A.2, item 24).

11.2.2 One expert suggests that safety standards should neither request nor permit switches for overriding landing door interlocks. Another expert suggests that the switch is a safer tool provided for use by mechanics than a jumper on interlock contacts (Table A.2, item 8).

11.2.3 Both the limits of the leveling zone and leveling speed should be checked by an electric safety device (Table A.2, item 26).

11.2.4 While all standards require redundancy type circuits which incorporate electric safety devices, they are still significantly different with respect to the “checking of redundancy” requirements (see 11.1.3.3).

11.2.5 One expert suggested that all safety standards were deficient in not addressing the failure of a door reopening device, since it is not considered an electric safety device.

Another expert expressed concern whether a door protective device can be made “fail safe” to satisfy criteria for a safety device. Reopening cannot be “fail safe” because it requires closing of a circuit and “closing” is not considered “fail safe”.

11.2.6 One expert suggested that safety standards must require type testing and certification of electrical circuits designed to incorporate electric safety devices, where conformance with applicable standards in particular redundancy requirements) cannot be easily verified either through the review of schematic diagrams or during a field inspection.

11.2.7 The rationale for CEN tolerating creeping up to 120 mm (see 11.1.4) was to enable use of pawl devices as anti-creep protective means. In addition, maintaining the car within 25 mm of the landing may cause the hydraulic system to overheat and ultimately shut down the power supply.

11.2.8 One expert suggested that all standards should require automatic dispatching of the car (see 1 1.1e) on lifts with manually operated landing doors.

11.2.9 All electrical equipment, with the exception of low voltage equipment, should be submitted for examination and testing to an acceptable laboratory to certify that the equipment conforms to the appropriate electrical standards established under the CEN, ASME, and CSA provisions.

11.2.10 The standards should be harmonized so that the technical and safety requirements address the hazards (risks) associated throughout the life cycle of lifts.

11.3 Points agreed upon

11.3.1 Electric safety and electrical protective devices should be mentioned twice in every lift safety standard first, in the rule dealing with the lift component or feature which needs checking by a safety or protective device; and then again in the sections dealing with electric safety and electrical protective devices.

11.3.2 Safety standards should require car door interlocks where the lift well is not fully enclosed (e.g. observation lifts) and where car-entrance-to-hoistway-wall clearances exceed a prescribed limit (see item #2 in Table A.2).

11.3.3 Where an unlocked door panel is connected to a locked panel only by rope, chain, or similar means, the closed position of the unlocked panel should be checked electrically (Table A.2, item 6).

11.3.4 Where redundancy is required in an electrical circuit, the standards should require that the redundant nature of the circuit be automatically verified either continuously or on a regular basis.

11.3.5 Detecting the failure of a door reopening device, with the intent of preventing doors from closing in an unsafe manner, should be addressed by all lift safety standards.

NOTE 1 For the title and edition of the standards compared, refer to section 1 of this report.

NOTE 2 Rules on which entries in the tabulations are based are indicated in parenthesis.

Legend:

Notation	**Meaning**
No spec	There is no rule covering the specific subject

N/A The question is not applicable to the specific standard for various reasons

Annex A
(informative)

Tabulations

NOTE 1 For the title and edition of the standards compared, refer to section 1 of this report.

NOTE 2 Rules on which entries in the tabulations are based are indicated in parenthesis.

Legend:

Notation	Meaning
No spec	There is no rule covering the specific subject
N/A	The question is not applicable to the specific standard for various reasons

Table A.1 — Spaces and clearances (Related to Section 9 of TR 11071 Part 2)

REQUIREMENT	CEN	ASME and CSA	JAPAN	Part 1	SA Part 3
1. Top car clearances (with ram in its ultimate position)	[5.7.1]	[3.44] and [3.45]		[5.7.1]	[8.1.4]
1.1 Guided travel of car (m) Min.**	$0,1 + 0,035^* V_m^2$	> 0 [2.23.8]	No spec.	$0,1 + 0,035^* V_m^2$	0,1m [8.1.3]
1.2 Free height above a specific area of the car roof (m) Min.	$1 + 0,035^* V_m^2$ in area in item 3.1	1100 mm in area in item 3.1 [3.4.7]	1 200 mm during maintenance use (2000-MOC Notice No.1423 item 4 pr.2 and item 5 pr.2)	$1 + 0,035^* V_m^2$ in area in item 3.1	1.0m Direct acting (8.1.4) 1.035 m suspended (roped) (8.2.4)
1.3 Well roof to car crosshead (m) Min.**	$0,3 + 0,035^* V_m^2$	0,15	For direct acting lift: H = S + 2.5 (cm) For indirect acting lift $H = S + \frac{V^2}{706} + 2.5$ (cm) H: Top clearance (cm) S: stroke margin of plunger (cm) V: rated speed (m/min) (2ooo-MOC Notice No 1423 item 4 &5)	$0,3+0,035^* V_m^2$	Direct Acting If Xhead encroaches over car □100 mm 300 mm If Xhead encroaches over car > 100 mm 600 mm Suspended (Roped) If Xhead encroaches over car □ 100 mm 330 mm If Xhead encroaches over car □ 100 mm 635 mm
1.4 Well roof to highest equipment on car top (except items in 1.5) (m) Min.	same as 1.3	0,15	Same as 1.3	same as 1.3	300mm direct 330mm suspended
Well roof to guide shoes, rope attachments, door header of vert. sliding doors (m) Min.	$0,1 + 0,035^* V_m^2$	No. spec.	No spec.	$0,1+0,035^* V_m^2$	100mm direct 135mm suspended

"*to be continued*"

Table A.1 (*continued*)

REQUIREMENT	CEN	ASME and CSA	JAPAN	Part 1	SA Part 3
1.6 Well roof to ram-head assembly (m) Min.	0,1	No. spec.	No spec.	0,1	335mm
2. Top counterweight clearance (with car on compressed buffers)	[5.7.1.2]	[3.46]	No spec.	[5.7.1.2]	[8.1.6] [8.2.6]
2.1 Guided travel of counterweight (m) Min.	$0,1+0,035^* V_d^2$	[3.46]	No spec.	$0,1+ 0,035^* V_d^2$	-
2.2 Well roof to counterweight Min.	No spec.	152mm	No spec.	No spec.	150 mm
3. Refuge space on car top	[5.7.1.1(d)]	[3.47]		[5.7.1.1(d)]	[8.1.4] [8.1.5]
3.1 Minimum area (m^2)	0,12 (8.13.2)	0,42	No spec	0,12 (8.13.2+) (lesser dimension 300 mm & position specified)	0,12 (lesser dimension 300 mm & position specified)
3.2 Minimum height (m)	$1 + 0,035\ V_m^2$	1.10	1.2m (2000-MOC Notice No.1423 item 4 parag.2 and item 5 parag.2)	$1 + 0,035\ V_m^2$	1.0m
3.3 Minimum block (m^3)	0,5 x 0,6 x 0,8		No spec.	0.5 x 0.6 x 0.8	No spec

"*to be continued*"

Table A.1 (*continued*)

REQUIREMENT		CEN	ASME and CSA	JAPAN	SA Part 1	SA Part 3	SA Part 1	SA Part 3
4. Runby of car & counterweight			[3.4.2], [3.4.3] and [3.4.6]		**Direct acting [8.1.2]**		**Indirect acting [8.2.2]**	
4.1 Bottom car runby								
for down operating speed								
0 < 0.51 m/s	Min.	No spec.	75 mm	70 mm	No spec.	25 mm	No spec.	25 mm
1.0 > 0.51 m/s	Min.	No spec.	proportional between 75 & 150 mm	150 mm		25 mm		25 mm
> 1.0 m/s	Min.	No spec.	150 mm	150 mm		N.A		N.A.
for any speed	Max.	No spec.	600 mm	600 mm (JIS A 4302 4.3.4)		300 mm		
4.2 Top car runby		No spec.		No spec	No spec.	[8.1.3]	No spec.	[8.2.5]
for up rated speed								
0 > 0.51m/s	Min.	Sufficient to allow limit switch to operate before ram comes in contact with cushioned stop	75 mm 76 mm	No spec.		100 mm w/o hyd cush, 75mm with hyd cush.		-
1.0 > 0.51m/s	Min.	Same	proportional between 75 & 150 mm	No spec		150 mm w/o hyd cush. 100mm w hyd cush.		-
> 1.0m/s	Min.	Same	150mm	No spec		N/A		N/A
for any speed	Max.	No spec.	600mm	No spec		N/A		N/A

"*to be continued*"

Table A.1 (*continued*)

REQUIREMENT	CEN	ASME and CSA	JAPAN	SA Part 1	SA Part 3	SA Part 1	SA Part 3
4.3 Bottom COUNTERWEIGHT runby = distance car travels above top landing until plunger stops plus the following Min.	No spec.	150mm	No spec.	No spec.	150mm	No spec.	plus rope stretch
5. Pit clearances - With car on fully compressed buffers:	[5.7.2.3]	[3.4.1]		5.7.2.3 +		8.1.1.2/.3 & 8.2.1.2/.3	
5.1 Pit floor and the lowest portion of car structure (except items in 5.2) Min.	0,5m (except item 5.2a)	600 mm (except item 5.2b)	No spec	0,6m	0.38m	0.6m	0.38m
5.2a Pit floor to guideshoes or rollers, safety gear blocks, pawl device, toe guards, vertical car door Min.	0,1m	> 0	No spec	0.1 m	0.05 m	0.1 m	0.05 m
5.2b Any equipment on car if located within X mm from any side of car platform, and any equipment on car or travelling with car and any equipment mounted in pit within Z mm horizontally from either side of the car frame centre-line parallel to guiderails, clearance to pit floor or to car structure.	see items 5.2a, 5.3 & 5.5	X = 300 mm Z = 300 mm clear >0	No spec	see items 5.2a, 5.3 & 5.5			300mm

"*to be continued*"

Table A.1 (*continued*)

REQUIREMENT	CEN	ASME and CSA	JAPAN	Part 1	SA Part 3
5.3 Parts in pit, e.g. jack supports, pipes, fittings to car (except items in 5.2) Min.	0,3m	> 0	No spec	0,3m	0,45 m to u/s of car platform, except 0,35 m to u/s of car under-beams and buffer striker plates
5.4 On inverted jacks, pit floor (or equipment in pit) to down travelling ram-head Min.	0,5m	see item 5.2b	No spec	0,5m	No spec.
except, if the space is screened Min.	0,1m	No other spec.		0,1m	No spec.
5.5 On direct acting telescopic jack lifts, pit floor to lowest guiding yoke of the jack Min.	0,5m	see items 5.1 & 5.2b	No spec	0,5m	Item 5.1 applies 600mm
5.6 Sufficient space for a rectangular block or refuge space (m^3)	0,5 × 0,6 × 1,0 resting on any face	600 mm × 1 200 mm × 600 mm in height or 450 mm × 900 mm × 1 070 in height	No spec	0,6 (H) × 0,5 × 1,3	0,6(H) × 0,5 × 1,3
-With car at its upmost position (with fully compressed cushioned stop of jack)	[5.7.2.4]	[3.4.7] 1100 mm i.e. @ maximum upward movement		[5.7.2.4]	1000 mm (8.1.4)
5.7 Guided travel (m) of counterweight Min. where, v_m = rated speed upwards	$0,1 + 0,035\ v^2_m$	> 0	No spec	$0,1 + 0,035\ v^2_m$	Car Buffer clearance + buffer stroke + 150 mm (8.1.6)
6. Well to car-entrance-side clearances					Section 24 AS 1735.3 and
6.1 Car without car doors	[8.5] not permitted	[2.14.4.1] Not permitted	No spec (car without car door is only permitted for car lift)	[8.5] not permitted	1735.3-2002 Not permitted
6.2 Car with car doors	[5.4.3 & 11.2]	[2.5.1.4] & [2.5.3.5]	Yes	[5.4.3 + & 11.2 +]	15.1 of AS 1735.3 and 15.1.2.1 of AS 1735.2-2001

"*to be continued*"

Table A.1 (*continued*)

REQUIREMENT		CENT	ASME and CSA	JAPAN	Part 1	SA Part 3
6.2.1 Car sill to landing sill	Min.	No spec.	13 mm or 20*mm	No spec.	No spec.	13mm or 20*mm
Max.		35mm	32 mm [2.51.4] *Corner car guides	4 cm (BSL-EO Art 129-7 item 1 parag.3)	35 mm	40mm *Corner car guides
6.2.2 Car sill to inner well face		11.2.	[2.5.1.5.1]	(BSL-EO Art 129-7 item 1 parag.3).		[15.2(a)(b)] 40 mm passenger
a) limited to	Max.	150mm	125 mm	12.5 cm (for passenger elevator and hospital elevator)	150 mm	50 mm freight
b) except for vertical sliding doors to	Max.	200mm	190 mm	No spec.	150 mm +	150 mm
c) except if car door lock provided	Max.	Not limited	No spec.	No spec	Not limited	Not limited
d) specific case	Max.	200mm through height max 500mm	No spec.	No spec.	Not permitted	Not permitted
6.2.3 Car door panel to landing door panel	Max.	120mm [11.2.3]	140 mm [2.14.4.5.1]	No spec.	120 mm [11.2.3]	150 mm [15.1.5]
-swinging landing door + car gate	Max.	No spec.	102 mm	No spec.	No spec.	150 mm [15.1.5]
-swinging landing door on freight elevator	Max.	No spec.	No specified max. but permitted	No spec.	No spec.	150 mm [15.1.5]
6.2.4 Swinging landing door panel to folding car-door		Max150 mm ø ball			150 mm ø ball	
7 Other horizontal well clearances		[11.3 & 5.6.2]	[2.5.1.1], [2.5.1.2] and [2.5.1.3]		[11.5 & 5.6.2]	[15.2(a),(b),(d)]
7.1 Car to well enclosure (except sides covered in 6)	Min.	No spec.	20 mm [2.5.1.1]	No spec.	No spec.	20 mm

"*to be continued*"

Table A.1 (*continued*)

	REQUIREMENT		CENT	ASME and CSA	JAPAN	Part 1	SA Part 3
7.2	Car to counterweight	Min.	50mm	25 mm [2.5.1.2]	No spec.	50 mm	25 mm
7.3	Counterweight to its guard or to well enclosure	Min.	No spec.	20 mm [2.5.1.2]	No spec.	No Spec	25 mm to guard
7.4	Car to counterweight guard	Min.	No spec.	20 mm [2.5.1.2]	No spec.	No spec.	20 mm
7.5	Car to car in multiple wells	Min.	500 mm	50 mm [2.5.1.3]	No spec.	500 mm	100 mm
8.	Clearances in machine room (MR) & machinery spaces (MS)			[[3.26.1], ANSI/NFPA 70: 620-72 & 110-16] (NOTE 2) [4.22.6.1, CSA C22.1 Sec 38-044] (NOTE 2)	0.5 m for working area, 0,3 m for visual check area or small parts replacement working area, 0 m for non-maintenance area.		
8.1	Clearances around el. equipment (panel or cabinet)		[6.3.2/6.4.2.2]		Same as front	[6.3.2/6.4.2.2]	26.14 AS 1735.2-2001
a)	Depth	Min.	0,7 m	0,9 m [0-150v] 0,9-1,2 m [151-600v]		0,7 m	0,6 m
b)	Width	Min.	0,5 m (NOTE 1)	0,762 m		0,5 m (NOTE 1)	0,45 m
8.1.2	At rear if openable	Min.	No spec.	same as front		No spec.	0,6 m

"*to be continued*"

Table A.1 (*continued*)

REQUIREMENT		CEN	ASME and CSA	JAPAN	Part 1	SA Part 3
8.2 Clearance near parts requiring maintenance & inspection of moving parts						
a) Clearance	Min.	0,5 x 0,6m	same as 8.1 (only electrical parts) Note: harmonized w/ Canada	50 cm	0,5 x 0,6m	0,6 m [5.1]
b) Access way width to those areas	Min.	0,5m	No spec.	No spec	0,5m	0,6 m [5.1]
c) Access way width if no moving parts	Min.	0,4m	No spec.	No spec	0,4m	0,38 m [5.1]
8.3 Clear headroom in MR & MS Clear height for movement.Min.	Min.	2 m 1.8 m	2,13 m [3.7], [2.7.4]	2 m	2,1 m + 2,1 m +	2.1m 1.5m to underside of beam
Exceptions for pulley rooms	Min.	1,5 m	1,07 m		1,5 m	- if governor: 2m or 1.5m to beam - if no governor: 1,7m or 1,4m to beam
8.4 Clear vertical distance above rotating part	Min.	0,3m	No spec.	No spec.	0,3m	0,38 m
8.5 If difference in MR floor levels exceeds this height, stairs or ladders and guard rails must be provided	Min.	0,5m [6.3.2.4]	0,38m [3.7], [2.7.3.4]	(BSLJ-EO129-9 item 1 parag.5) Difference in MR floor level exceeds 23cm, stairs are required and the difference exceeds 1m, guard rail is required.	Differences shall be avoided 0.3 to 0.6m step 0.6 to 1.5m step plus guardrail >1.5m Stairway plus guardrail	Differences shall be avoided 0.3 to 0.6m step 0.6 to 1.5m step plus guardrail >1.5m Stairway plus guardrail

"*to be continued*"

Table A.1 (*concluded*)

REQUIREMENT		CEN	ASME and CSA	JAPAN	SA Part 1	SA Part 3
8.6 Machine room door						
width	Min.	0,6 m	0,76 m	70 cm	0,6 m	0,6 m
height	Min.	1,8 m	1,83 m	180 cm	1,8 m	1,98 m
8.7 Machine room access trap door	Min.	0,8 × 0,8 m [6.3.3.2]	Prohibited	Prohibited	0,8 × 0,8m [6.3.3.2	No Spec For removal of heavy machinery only
8.8 Pulley room access trap door	Min.	same as 8.7 [6.4.3.2]	762 × 762 mm [3.7], [2.7.3.4.2]	Allowed but no spec.	same as 8.7 [6.4.3.2]	No Spec For removal of heavy machinery only

NOTE 1 Respecting CEN entry in line 8.1.1(b): The width of the clearances in front of the panel or cabinet must be the full width of the panel or cabinet or 0.5m, whichever is greater.

NOTE 2 Line 8.1: ASME Rule 306.6(a) requires compliance with the National Electrical Code (ANSI/NFPA 70).CSA Clause 4.22.6.1 requires compliance with the Canadian Electrical Code (CSA C22.1).

* Factor 0,035 in CEN column represents 1/2 gravity stop distance with 115 % rated speed. This value need not be taken into account for DIRECT-ACTING lifts. V_m = rated speed upwards (m/s) V_d = rated speed downwards (m/s).

** Top car clearance (TCC) is defined as follows.

The distance between car crosshead beam and overhead floor or beams when car stops at top landing. by 2000-MOC Notice No 1423 item 1 parag.1

The distance between car ceiling and overhead floor or beams when car stops at top landing for the car without crosshead (explanation of 2000-MOC Notice No 1423 item 1 parag.1)

The distance between top of landing entrance and overhead floor or beams when car stops at top landing for the car without ceiling (car lift) (explanation of 2000-MOC Notice No 1423 item 1 parag.1).

Table A.2 — Electrical devices (Related to Section 11 of TR 11071 Part 2)

No.	REQUIREMENT	CEN	ASME and CSA	JAPAN	Part 1	SA Part 3
1	Check on closed position of					
	well auxiliary doors/traps (A)	Yes: A or B (5.2.2.2.2)	Yes [3.11] and [2.11.1.2(d)]	Yes (BSL-EO Art.129-10 item 3)	Yes (5.2.2 +)	Yes [P2-12.24(g)]
	pit access door (A)	Yes: A or B, but not always required (5.7.2.2)	No [3.2] and [2.2.4]	Yes (Explanation of BSL-EO Art.129-7 item 1)	Yes (5.7.2.2)	Yes [P2-10.6(c)]
	access opening on observation lifts (A)	No spec	openings not required	No spec	openings not required	Openings not permitted
2	Check on locking of car doors (A) required cases specified in this rule:	Yes: A or B (11.2.1 c))	No	No spec.	Yes (11.2.1 c))	No
3	Landing/car door automatic reopening device (D) horizontal sliding					
	- always required	Yes (7.5.2.1.1.3)	No	No spec.	Yes (7.5.2.1.1.3)	Yes [P2-25.6]
	- if kinetic energy above this limit	4J (8.7.2.1.1.3)	Yes 3.3J [3.13] and [2.13.5]	No spec.	4J (8.7.2.1.1.3)	3.4J
	vertical sliding landing and car doors if automatic or momentary pressure operation	(Permitted only for goods passenger lifts) (7.5.2.2 and 8.7.2.2)	Yes [3.13] and [2.13.3.4]	No spec.	Not permitted (7.5.2.2 and 8.7.2.2)	Yes [P25.7, 25.8]
4	Check on locking of landing doors (A)	Yes: A or B (7.7.3.1)	Yes [3.26.4.2(c)], [2.12.3] and [2.26.2.14]	Yes (BSL-EO Art129-10 item 3 parag. 1)	Yes (7.7.3.1)	Yes [P2-13.2]
5	Check on landing doors closed as part of # 4 or separate (A)	Yes: A or B (7.7.4.1)	Yes [3.26.4.2(c)], [2.12.7] and [2.26.2.14]	Yes (BSL-EO Art129-10 item 3 parag. 1)	Yes (7.7.4)	Yes [14]

"*to be continued*"

Table A.2 (*continued*)

No.	REQUIREMENT	CEN	ASME and CSA	JAPAN	Part 1	SA Part 3
6	Check on closed position of landing door panels which are not locked (A)					
	if panels directly mechanically related	No (7.7.6.1)	No [3.12] and [2.12.3.2]	Yes (BSL-EO Art129-10 item 3 parag. 1)	No	
	if panels indirectly related only by ropes	Yes: A or B (7.7.6.2)	No [3.11] and [2.11.11.7]	Yes (BSL-EO Art129-10 item 3 parag. 1)	Yes (7.7.6.2)	Yes
8	Switches to override # 4 to # 6			Not permitted (explanation of BSL-EO Art129-10 item 3 parag. 2)		
8.1	Hoistway access switch, overriding # 4 to # 6(A)	Not permitted	Yes [3.12] and [2.12.7.3]	No spec	Not permitted	
8.2	Car and landing door bypass switches in machine room, overriding # 4 to # 6	Not permitted	Not required	No spec	Not permitted	No Spec
8.3	Check on failure or override of # 4 to # 6	Not permitted	Not required	No spec	Not permitted	Yes [P2-13.1]
9	Check on retracted position of hinged or moveable car sills	No spec	Yes [3.26.4.2(e)], [2.26.2.20] and [2.15.16]	No spec.		No
10	Photocells required for door-less cars, if such cars permitted (D)	Not permitted	Not permitted	Yes for car lift only (2000-MOC Notice No 1413 item 1 parag.6)	Not permitted	Not permitted
11	Check on closed position of car door (A)	Yes: A or B (8.9.2)	Yes [3.26.4.2(d)], [2.26.2.15] & [2.14.4.2]	Yes (BSL-EO Art129-10 item 3 parag. 1)	Yes (8.9.2)	Yes [P2-24.3]

"to be continued"

Table A.2 (*continued*)

No.	REQUIREMENT	CEN	ASME and CSA	JAPAN	Part 1	SA Part 3
12	Check on locking or closing of car					
	top emergency traps (A)	Locking: A or B (8.12.4.2)	No [2.14.1.5] and [2.26.2.18]	Yes (BSL-EO Art129-10 item 3 parag. 1 and explanation of BSL-EO Art 129-6 item1 parag.4 , Art 129-7 item1 parag.1)	locking (8.12.4.2)	Yes [P2-23.14(f)]
	side emergency doors	Locking: A or B (8.12.4.2)	Closing [3.14], [2.26.2.17] and [2.14.1.10.2(f)]	Yes (BSL-EO Art129-10 item 3 parag. 1 and explanation of BSL-EO Art 129-7 item1 parag.1)	locking (8.12.4.2)	Not permitted
	panels of observation elevator car		[2.14.2.6] & [2.26.2.31]	No spec		
13	Check on extension of 2 suspension ropes or chains, if permitted (A)	Yes: A or B (9.3.3)	No	No spec.	Yes (9.3.3)	No
15*	Check on the operation of car safety gear (A)					
	To prevent restart downwards	Yes: A or B (9.8.8)	Yes [3.26.1(d)], [3.26.4], [2.26.2.9] and [2.17.7]	No spec.	Yes (9.8.8)	Yes
	To prevent restart in both directions (see also items 41 44 in this table)	No	No [3.17.1.2]	No spec.	No	Yes [P2-33.7.1]
16	Check on the car overspeed by					
	a device on governor or other device	Both (9.10.2.10.1)	governor [3.26.1(d)], [3.26.4], [2.26.2.10] and [2.18.4.4]	Mechanical governor (2000-MOC Notice No.1423 item2 parag.2)	Both (9.10.2.10.1)	Governor [34(b)]
	a device of type (A) or (B)	Both	A only	Electrical governor is permitted for the elevator with slack rope safety (explanation of 2000-MOC Notice No.1423 item2 parag.2)	Both	(A) only

"to be continued"

Table A.2 (*continued*)

No.	REQUIREMENT	CEN	ASME and CSA	JAPAN	SA Part 1	SA Part 3
17	Check on non-automatic resetting of governor (A)	Yes: A or B (9.10.2.10.2)	by manual reset	Yes (explanation of 2000-MOC Notice No.1423 item2 parag.2)	Yes (9.10.2.10.2)	By manual reset [P2-34.3.2]
18	Check on tension in the governor rope (A)	Yes: A or B (9.10.2.10.3)	Yes [2.18.7] jawless only	No spec.	Yes (9.10.2.10.3)	Yes [34(c)(ii)] jawless only
19	Check on buffer return to normal position					
	pit buffers of energy dissipation type	Yes: A or B (10.4.3.3)	Yes [3.22.1] and [2.22.4.5(c)] Gas return only	No spec.	Yes (10.4.3.3)	No
	type C safety gears buffers	Yes: A or B (9.8.6.2)	Yes [3.17.1] and [2.17.8.2.7]	No spec.	Yes (9.8.6.2)	Yes [9.5(iii)]
20*	Check for slack rope (or chain) on indirect acting lifts (A)	Yes: A or B (12.13)	Yes [3.18.1.2.7]	Yes (2000-MOC Notice No.1423 item 5, parag. 2)	Yes (12.13)	Yes [P2-30.7]
22*	Stopping of the machine and checking its stopped condition (A) or (B) NOTE - See details in 11.1.3.4	Yes (12.4)	No spec.	No spec.	Yes (12.4)	No spec.
24	Requirements for electric safety devices (A and B)	Yes (14.1.2 and 12.4)	Yes [3.26.4], [3.26.5] and [3.26.6]	No spec.	Yes (14.1.2 and 12.4) (12.7)	Yes [P2-29.14, 29.11]
25	Types of normal operating devices specified	Yes (14.2.1.1)	Yes [3.26.1] and [2.26.1.1]	No spec	Yes (14.2.1.1)	Yes [P2-29.1]

"to be continued"

Table A.2 (*continued*)

No.	REQUIREMENT	CEN	ASME and CSA	JAPAN	Part 1	SA Part 3
26*	Levelling and anti-creep with doors open permitted	Yes (14.2.1.2)	Yes [3.26.3] and [2.26.1.6]	Yes (explanation of BSL-EO Art 129-10 item3 parag.1)	Yes (14.2.1.2)	Yes [P2-29.4.1]
	a) check on levelling or anti-creep limits with an (A) or (B) device	A or B (14.2.1.2a) 2))	No spec.	No spec	A or B (14.2.1.2a 2)	No spec of device
	b) check on tension in the device for transmission of the car position by an (A) device	Yes: A or B (14.2.1.2a) 3))	No	No spec	Yes	No
	c) check on speed with (A) or (B) device	No	No	No spec	No	No
	NOTE - See 11.1.4 in TR 11071 Part 2.					
27	Inspection operation required	Yes (14.2.1.3)	Yes [3.26.2] and [2.26.1.4]	Yes - Required switch to ensure the safety distance in pit and overhead for the elevator with top clearance and pit depth of less 1.2m, when maintenance or inspection operation (BSL-EO Art 129-10 item 2 parag. 2 and 2000-MOC Notice No.1413item1 parag.4	Yes (14.2.1.3 +)	Yes [P2-29.3]
	a) check on proper switching to inspection operation by an (A) device	Yes: A or B (14.2.1.3)	Yes [3.26.2] and [2.26.1.4]	No spec	Yes	No
	b) switch must be bi-stable	Yes	No	No spec	Yes	Yes
	c) check on speed with (A) or (B) device	No	No	No spec	No	No
29	Docking/truck zone operation permitted	Yes (14.2.1.4)	Yes [3.26.3] and [2.26.1.6]	No spec	Not Permitted	Not Permitted
	- check on travel limits (A) or (B) and key operated safety contact (A)	Yes: A or B (14.2.1.4b/g3)				

"to be continued"

Table A.2 (*continued*)

No.	REQUIREMENT	CEN	ASME and CSA	JAPAN	SA Part 1	SA Part 3
30	Stop switch requirements (A)	A or B (14.2.2.2)	[3.26.1(d)], [3.26.4] and [2.26.2]Yes [3.26.1(d)], [3.26.4] and [2.26.2.7]	Yes	(14.2.2)	Yes [P2-29.14]
	a) in pit	Yes (5.7.2.5 a))		(explanation of BSL-EO Art129-7 item 1 parag. 1)	Yes (5.7.2.5 a +)	Yes [P2-30.3, 10.6]
	b) in pulley room/secondary level	Yes (6.4.5)	Yes [3.7] and [2.7.3.5]	No spec	Yes (6.4.5)	Yes [P2-30.4, 30.5.5]
	c) car top	Yes [8.15(b)], (14.2.1.3c))	Yes [3.26.1(d)], [3.26.4] and [2.26.2.8]	Yes (2000-MOC Notice No.1429 item1 parag.1)	Yes [8.15(b)]	[6.7]?
	d) inside car and accessible to passengers - if solid door (CEN) or passenger lift (ASME/CSA)	Prohibited (14.2.2.3) except for docking operation (14.2.1.4 i))	No	Yes (2000-MOC Notice No.1429 item1 parag.1)	Prohibited (14.2.2.3) excerpt for docking operation (14.2.2.1)	Yes [P2-30.2, 26.10]
	- if perforated door or enclosure (CEN) or freight lift (ASME/CSA)	N/A	Yes [3.26.4.2(a)] & [2.26.2.5]	Yes (2000-MOC Notice No.1429 item1 parag.1)	N/A	Yes [P2-30.1]
	- if no car doors	N/A	N/A	Yes (2000-MOC Notice No.1429 item1 parag.1)	N/A	Yes
	e) inside car and not accessible to passenger	No	Yes [3.26.4.2(f)] & [2.26.2.21]	No spec	No	N/A
31	Terminal landings					
31.1	Final terminal limit switches (A) required - operated directly by car or ram, or indirectly by a device linked to car or ram, with linkage being controlled by a safety device type (A)	Yes: A or B (10.5.3.1), at car upper end Yes: A or B: -Direct acting: car or ram (10.5.2.2b)); -Indirect acting: ram (10.5.2.3b))	No [3.25.3]	Yes (BSL-EO Art129-10 item2 parag.1 and 2000-MOC Notice No.1423 item2 parag.5) No spec	Yes (10.5.3.1) Both (10.5.2.3)	Yes [31.3] Top only

"to be continued"

Table A.2 (*continued*)

No.	REQUIREMENT	CEN	ASME and CSA	JAPAN	Part 1	SA Part 3
31.2*	Normal terminal stopping device must use a control device separate from: - final limit switches	Yes (10.5.2.1)	Not required	No spec	Yes (10.5.2.1)	Yes [31.3.1(c)]
	- normal stopping and emergency terminal stopping means	No spec.	Yes [3.25.1] and [2.25.1] N/A	No spec	No spec.	Yes [31.2.1]
	- be operated directly by car - or through a linkage, in which case the linkage must be checked (A)	No spec.	Yes [3.25.1.3] and [3.25.1] [3.25.1.4] and [2.25.2.3]	No spec	No spec.	Yes [31.3.1]
31.3*	Emergency terminal speed limiting device when reduced stroke buffers are used or for up-direction if car speed exceeds 0,51 m/s - required	No spec.	Similar rule called Terminal-Speed Reducing DevicesNo, up direction only [3.25.2] and also 0.25 m/s	Similar rule called Terminal speed reducing devices (explanation of MOC-Notice No.1423 item1 parag.1) No spec. for up direction	No spec.	Not specified
	- be of type (A) or (B)		Yes	No spec		
	- independent of normal terminal stopping devices		Yes [3.25.2.2.1]	Yes		
32	Electrical outlet required					
	in pit	Yes (5.7.2.5 b)	Yes [NFPA 70, 620-24] [CSA C21.1, 38-54]	No spec.	Yes (5.7.2.5 b)	Yes (P2 – 10.11)
	in machine room	Yes (6.3.6)	Yes [NFPA 70, 620-23] [CSA C21.1, 38-52]	Yes (explanation of BSL-EO Art129-9)	Yes (6.3.6)	Yes [P2-5.16]
	in pulley room/secondary level	Yes (6.4.7)	Yes [NFPA 70, 620-23] "No spec" in CSA 21.1	No spec.	Yes (6.4.7)	No
	on car top	Yes (8.15c))	Yes [3.14] and [2.14.7.1.4]	No spec.	Yes (8.15c)	Yes [P2-26.11]

"to be continued"

Table A.2 (*continued*)

No.	REQUIREMENT	CEN	ASME and CSA	JAPAN	SA Part 1	SA Part 3
33	Lighting (minimum lux if specified) - in pit	Yes (5.9)	100 [3.2] and [2.2.5.1]	No spec.	Yes (5.9*)	Yes [P2-10.5]
	- along well walls	Yes (5.9)	No	No spec	Yes (5.9*)	Yes [P2-11.3]
	- in machine room	200 (6.3.6)	200 [3.7] and [2.7.5.1]	No spec	200 (6.3.6)	200 [P2-5.13]
	- pulley room/secondary level	100 (6.4.7)	00 [3.7] and [2.7.5.1]	No spec.	Yes (6.4.7)	No
	- at landing	50 (7.6.1)	100 [3.11] and [2.11.10.2}	No spec (larger than approx. 50 lux for residential lift only)	40 (7.6.1*)	No
	- in car passenger	50 (8.17.1)	50 [3.14] and [2.14.7.1]	No spec	50 (8.17.1)	50 [P2-23.25.2.1]
	freight	50 (8.17.1)	25 [3.14] and [2.14.7.1]	No spec.	50 (8.17.1)	30 [P2-23.25.2.1]
	emergency	1W/ 60 min (8.17.4)	2,2 [3.14] and [2.14.7.1]	1 lux for passenger elevator and hospital elevator) (BSL-EO Art129-10 item 3 parag. 4)	20 lx for 2 hrs (8.17.4*)	20 for 2 hrs [P2-23.25.2.9]
34	Audible and visual signals required					
	a) light "car here" if manual doors without vision panel	Yes (7.6.2 b)	No	No spec.	Yes (7.6.2 b)	No
	b) light for direction of next car movement if collective control	Yes (14.2.4.3)	No	No spec.	Yes (14.2.4.3)	No
	c) audible "car arriving" for groups of lifts	Recommended (14.2.4.3 Note)	No	Yes (JEAS—515C)	Recommended (14.2.4.3 Note)	No
	d) acoustic signal to be operated by #30d	N/A	No	No spec.	N/A	No
35	Emergency alarm device required	Yes (14.2.3)	Yes [3.27] and [2.27.1]	Yes (BSL-EO Art129-10 item 3 parag. 3)	Yes (14.2.3*)	Yes [P2-32.4]
	a) operated by the car stop switch	No (see #34d)	Yes [3.27] and [2.27.1.1.1]	No spec.	No (see #34d)	No
	b) operated by "alarm" button	Yes	Yes	No spec	Yes	Yes

"to be continued"

Table A.2 (*continued*)

No.	REQUIREMENTS	CEN	ASME	JAPAN	Part 1	SA Part 3
41*	Check on operation of clamping device (A) or (B) and to prevent starting machines for downward direction	Yes (9.9.8)	N/A	N/A	Yes (9.9.8)	Yes [9.5]
42*	Check on tension in safety rope (A) related to safety gear or clamping device	Yes: A or B (9.10.4.4)	N/A	N/A	Yes (9.10.4.4)	No
43*	Check on movement or extension of lever (A) used for tripping safety gear or clamping device	Yes: A or B (9.10.5.2e)	N/A	N/A	Yes (9.10.5.2e)	No
44*	Check on non-retracted position at a pawl to prevent downward movement	Yes: A or B (9.11.9)	N/A	N/A	Yes (9.11.9)	Yes [9.5]
45.0	Electrical equipment and wiring	13	[3.26.1] & [2.26.4.1], [ANSI/NFPA 70] [CAN/CSA-C22.1]		13*	[26. 27, 28]
45.1	Electrical equipment certification	No, only in case of safety circuits containing electronic components	Yes [3.26.1] & [2.26.4.2], [ASME/ANSI A17.5] [CSA B44.1]	No	No, only in case of safety circuits containing electronic components	No
45.	Electromagnetic interference certification per EN12016-Part 2 required?	-	Yes [3.26.1} & [2.26.4.4]		-	-
45.2	voltage limitations	250V (13.1.4)	300V [NFPA 70, Section 620-2(a)] [CSA C21.1, Sect. 38-002(1)]	300V(JEAC 8001 310-12, JIS A 4302 4.3.1(2))		
	control and safety				250V (13.1.4)	250V [P2-26.4]
	power	No spec.	600V (NFPA 70, Section 620-2(b)) A17.5/B44.1 [CSA C21.1, Sect. 38-002(2)]	No spec	No spec.	1000V [P2-26.3]
45.3	Contactors and relays	13.2.1.1 13.2.1.2	[3.26.1] and [2.26.3]	JIS, JEC, JEM, EAMCL	13.2.1.1 13.2.1.2	Not specified
45.4	Motor protection	13.3	NFPA 70, Section 620-61(b) C22.1 Section 38-038	JEAC 8001 305-5, EUIL-MO 184	13.3	[P2-30.22]

"to be continued"

Table A.2 (*continued*)

No.	REQUIREMENTS	CEN	ASME	JAPAN	Part 1	SA Part 3
45.	Phase protection	14.1.1.1(j)	[3.26.5]	N/A	14.1.1.1(j)	[P2-30.20]
45.6	Main switches Mains	Yes (13.4)	Yes [3.26.1] & [2.26.4.5] (NFPA 70, Section 620-51) C22.1 Section 38-	EUIL-MO,185&186, JIS A4302	Yes (13.4*)	Yes [P2-26.2]
	Direct (A)	Yes (13.4.2)	N/A	EUIL-MO 185 & 186	Yes (13.4.2)	Yes
	Indirect (A)	Yes (13.4.2)	N/A	EUIL-MO 185 & 186	Yes (13.4.2)	Yes
	group	Yes (13.4.3)	Yes (NFPA 70, Section 620-52) C22.1 Section 38-034 Appendix B, Notes on Rules)	EUIL-MO 185 & 186	Yes (13.4.3)	
	car lights	Yes (13.6.3)	Yes (NFPA 70, Section 620-53) [Section 38-034(1)(c)]	EUIL-MO 185 & 186	Yes (13.6.3)	AS 3000
	heating and air conditioning	No spec.	Yes (NFPA 70, Section 620-54) Section 38-034(1)(c)]	No spec.	No spec.	AS 3000]
45.7	Wiring	13.5	NFPA 70, Section 620-21 C22.1 Section 38-016 & 018		13.5.1*	
	insulation	13.1.3	NFPA 70, Section 620-11 C22.1 Section 38-006	EAMCL EUIL-MO 13,14 & 214 JIS A4302 4.3.1(2)	13.1.3	
	electric safety devices on landing doors	13.5.2	NFPA 70, Section 620-11(a)	No spec.	No spec.	
	travelling cable	13.5.1.3	NFPA 70, Section 620-11(b) C22.1 Section 38-008	JIS C 3408, JEAC 8001 310-13	13.5.1.3 *	[P2-28.4]
	wells and machine mount	13.5.1	NFPA 70, Section 620-21 C22.1 Section 38-014	JEAC 8001 310-13 EUIL-MO 179, 215	13.5.1*	AS 1979
	cars	13.5.1	NFPA 70, Section 620-21 C22.1 Section 38-016	No spec.	13.5.1*	[P2-28.2]

"to be continued"

Table A.2 (*continued*)

No.	REQUIREMENTS	CEN	ASME	JAPAN	SA Part 1	SA Part 3
	other	13.5.1	NFPA 70, Section 620-21 C22.1 Section 38-018	No spec.	13.5.1*	[P2-28.2]
45.8	Minimum size of conductors			JEAC 8001 310-13		
	electric safety devices (doors)	18 AWG or 0,75 mm^2 (13.5.2)	24 AWG or 0,205 mm^2 [NFPA 70, Section 620-12b] [C22.1 Section 38-010(2)]	1.2 mm (1.4 mm^2) [JEAC 8001 310-13]	18 AWG or 0,75 mm^2 (13.5.2)	No spec.
	travelling cable lights	-	14 AWG = 2,8 mm^2 or 20 AWG = 0,159 mm^2 in parallel [NFPA 70, Section 620-20(a)] [C22.1 Section 38-010(1)(a)]	0.75 mm^2 [JEAC 8001 310-13] 0.75 mm^2 [JEAC 8001 310-13]	-	0,75 mm^2 1.5 mm^2
	all others		20 AWG= [NFPA 70, Section 620-12a] [C22.1 Section 38-010(1)(b)] 0,519 mm^2	0.75 mm^2 [JEAC 8001 310-13]		Not specified
	motor conductors		[NFPA 70, Section 620-13] [C22.1 Section 38-010(3)]	JEAC 8001 305-6, EUIL-MO 185 & 186		Not specified
	all other wiring	0.75 mm^2 See 13.5.1.4, too	24 AWG= 0,205 mm^2 [NFPA 70, Section 620-12b] [C22.1 Section 38-010(2)]	0.75 mm^2 [JEAC 8001 310-13]	0.75 mm^2	Not specified
45.9	All live parts enclosed	Yes (13.1.2, 13.5.3.2, 3, 5)	Yes (NFPA 70, Section 620-3) C22.1 Section 38-004), A17.5/B44.1	N/A	Yes (13.1.2, 13.5.3.2, 3, 5)	[P2-26.15]
45.10	Feeder demand factor	Yes (13.1.1.1 Nat'l requirements)	Yes (NFPA 70, Section 620-15) [C22.1 Section 38-010(4)	Guideline by JEA	Yes (13.1.1.1 Nat'l requirements)	Yes AS 3000

"to be continued"

Table A.2 (*continued*)

No.	REQUIREMENTS	CEN	ASME	JAPAN	Part 1	SA Part 3
45.11	Overcurrent protection (all except motor)			JEAC 8001 310-13, EUIL-MO 38, 185 & 186		Table 2.4
	control, operating and signal circuits	13.1.1.2	NFPA 70, Section 620-61(a)			
	main switches	13.4.1	C22.1 Section 38-040	EUIL-MO 38, 185 & 186	13.1.1.3	
	socket outlets	13.6.3.3	NFPA 70, Article 430	No spec.	13.4.1*	Yes
	all other	13.1.1.2	C22.1 Section 28	EAMCL Table 4 6, JIS C 8358	13.6.3.3	
			NFPA 70, Article 210	No spec.	13.1.1.3	
			C22.1 Section 14			
			NFPA 70, Article 240			
			C22.1 Section 14			
45.12	Location of equipment	6.1.1	NFPA 70, Section 620-71 C22.1 Section 38-042	BSL-EO Art.129-9, JIS A 4302 4.3.1	6.1.1*	
45.13	Working clearances	6.3.2	NFPA 70, 620-72, 110-16 C22.1 Section 38-044	BSL-EO Art.129-9, JIS A 4302 4.3.1	6.3.2*	[5.1]
45.14	Grounding	13.1.1.2, 14.1.1.3, 13.1.3, 13.1.5	NFPA 70, 620-81 to 84 [C22.1, 38-046, 048, 050]	JEAC 8001, EAMCL EUIL-MO 13 & 28	13.1.1.3, 14.1.1.3, 13.1.5	[27]
	GFCI/ELCB	No	Yes (NFPA 70, Section 620-85)	JEAC 8001 1512, EUIL-MO 252	No	No
45.150	Electrical standards	CENELEC (HD) /IEC	ANSI/UL CAN/CSA-C22.2	JIS, JEC, JEM	CENELEC/IEC	AS 3000
45.151	PVC cable	13.5.1.1 (HD21.3 S3) 13.5.1.2 (HD21.4 S2) 13.5.1.3 (HD21.5 S3)		JIS C 3306, 3307, 3316 3317, 3342, 3401, 3408	13.5.1.1* (HD21.3 S3) 13.5.1.2* (HD21.4 S2) 13.5.1.3 *(HD21.5 S3)	AS 3000

"to be continued"

Table A.2 (*continued*)

No.	REQUIREMENTS	CEN	ASME	JAPAN	Part 1	SA Part 3
45.15.2	rubber cable	13.5.1.3 (HD22.4 S3)	44 [CSA 38}	JIS C 3301, 3327, 3408	13.5.1.3* (HD22.4 S3)	AS 3000
45.15.3	Flat PVC travelling cable	EN 50214 (13.5.1.3)	44 [CSA 38}	JIS C 3408, 3652	HD 359 (13.5.1.3*)	AS 3000
45.15.4	Rubber travelling cable	HD 360 S2 (13.5.1.3)	44 [CSA 38}	JIS C 3408	HD 360 (13.5.1.3*) (IEC 60245)	AS 3000
45.15.5	Electric installation	HD 384	NFPA 70 [C22.1] [3.8] and [2.8]	EUIL-MO 177 to 252	HD 384.4.41 (13.6.2*)	AS 3000
45.15.6	Contactors	EN 60947.4.1 & .5.1	ASME A17.5/CSA B44.1 [3.26.1] and [2.26.3]	JIS, JEC, JEM	EN 60947.4.1 & .5.1	AS 3000
45.15.7	Relays	EN 60947.5.1 (13.2.1.2, 13.2.2.3, 14.1.2.2.2)	ASME A17.5/CSA B44.1 [3.26.1] and [2.26.3]	JIS, JEC, JEM	AS 3000	
45.15.8	GFCI		943 [CSA 144]	JIS C 8371, 8374 JEAC 8001 151-1, EUIL-MO252	AS 3000	
45.15.9	Flexible metal conduit		1	56	AS3000	AS 3000

"to be continued"

Table A.2 (*continued*)

No.	REQUIREMENTS	CEN	ASME	CSA	JAPAN	SA Part 1	SA Part 3
45.15.10	Armored cable		4	51	JIS C 8302, EAMCL	AS 3000	AS 3000
45.15.11	Rigid metal conduit	IEC 60423	6	45	JIS C 8305, EAMCL	AS 3000	AS 3000
45.15.12	Flexible cords and wire	IEC 60227, IEC 60245	62	49, 96	EUIL-MO 6 to 10	AS 3000	AS 3000
45.15.13	Liquid tight flexible metal conduit		360	56	JIS C 8309 EAMCL	AS 3000	AS 3000
45.15.14	PVC conduit		651, A	45, 136, 211	JIS C 8430 EAMCL	AS 3000	AS 3000
45.15.15	Wireways, aux. gutters		870	26	JIS C 8302 & 8364 EAMCL	AS 3000	AS 3000
45.15.16	Intermediate metal conduit	IEC 60423	1242	45	JIS C 8425 EAMCL	AS 3000	AS 3000
45.15.17	Electrical metallic tubing	IEC 60423	797	83	EUIL-MO 192 to 201, EAMCL	AS 3000	AS 3000
45.15.18	MC cable		1569	123	JIS C 8302, EAMCL EUIL-MO9	AS 3000	AS 3000
45.15.19	Liquid tight flexible non-metallic conduit		1660	227	JIS EAMCL	AS 3000	AS 3000
45.15.20	Grounding and bonding	IEC 60364 (HD 384)	467	41	JEAC 8001 EUIL-MO	AS 3000	AS 3000
45.15.21	Fuses	IEC 60269	198B-L	59, 106	JIS C 8313, 8314, 8319, 8352, JEAC 8001 150-2 etc	AS 3000	AS 3000
45.15.22	Circuit breakers, molded case	IEC 60898, IEC 60947	489	5	JIS C 8370, EUIL-MO 185 & 186 EAMCL 208 to 211	AS 3000	AS 3000
45.15.23	Circuit breakers, hazardous location	IEC 60079	877		JIS C 0903 EAMCL 208 to 211	AS 3000	AS 3000
45.15.24	Industrial control, general	IEC 60204, IEC 60947, IEC 60529	508, 991	14, 73, 156, 184, 196	JIS	AS 3000	AS 3000
45.15.25	Industrial control, hazardous	IEC 60079	698	14	JIS	AS 3000	AS 3000
45.15.26	Industrial control, elevators		ASME A17.5 [3.26.1], [3.26.4] and [2.26.4]	CSA B44.1 [3.26.1], [3.26.4] and [2.26.4]	JIS	AS 3000	AS 3000
45.15.27	Motors/generators	IEC 60034	519, 547, 674, 1004	77, 100	JIS, JEC, JEM	AS 3000	AS 3000
45.15.28	Motors/generators, hazardous	(IEC 60079)	674	145	JIS, JEC, JEM	AS 3000	AS 3000

"*to be continued*"

Table A.2 (*concluded*)

No.	REQUIREMENTS	CEN	ASME	CSA	JAPAN	SA Part 1	SA Part 3
45.15.29	Power supplies	IEC 60950, IEC 60478	1012	107, 223	EUIL	AS 3000	AS 3000
45.15.30	Transformers	IEC 60076	1561, 2	47	JIS, JEC, JEM EUIL-MO, EAMCL	AS 3000	AS 3000
45.15.31	Transformers, Class 2 and 3	IEC 61558	1585		JIS, JEC, JEM, EUIL-MO	AS 3000	AS 3000
45.15.32	Electrical service equipment		869	86	No spec.	AS 3000	AS 3000
45.15.33	Electrical terminal blocks		1059	156, 15	No spec.	AS 3000	AS 3000
45.15.34	Non-metallic conduit		5, 514C, 651, 651A, 543A, 1653, 1660	62, 85, 211, 227	JIS C 8412	AS 3000	AS 3000
46.0	Emergency operation a) manual lowering b) manual lifting	Yes (12.9.1) Yes (12.9.2)	Yes [3.19.4.4] For Safety Release [3.17.1.2]	Yes [3.19.4.4] For Safety Release [3.17.1.2]	Yes [JIS 4302] No	Yes (12.9.1) Yes (12.9.2)	Yes [7.5.6.1] Yes [7.5.6.2]
46.1	Standby power Auxiliary power lowering		[3.27] and [2.27.2] [3.26.10] and [3.27.1(c)]	[3.27] and [2.27.2] [3.26.10] & [3.27.1(c)]	EUIL-MO 8001 680		
46.2	Firefighters service	EN 81-72	[3.27] and [2.27.3]	[3.27] and [2.27.3]	JEAS-D405 1)	[P2-29.6]	[P2-29.6]
46.3	Fire protection (high ambient)	G1, 2, 3	No	No	BSL& BSL-EO		

NOTE Symbols (A), (B) and (D) used in column "Requirement" throughout Table A2 mean:

(A) Electric safety device in the form of safety contacts (switches) (see 2.4 in TR 11071 Part 2).

(B) Electric safety device in the form of safety circuit (see 2.4 in TR 11071 Part 2 re electrical "safety" versus "protective" device).

(D) Protective device other than electric safety (CEN term) or electrical protective (ASME/CSA term) device.

NOTE *Asterisk text to item number (eg, 15*) in all pages of this Table A2 identify the electric devices that are different from or nonexistent on electric lifts.

Annex B
(informative)

References

This Annex includes information on obtaining copies of the safety standards covered in this Technical Report. It also includes information regarding correspondence with the standards writing committees.

European Standard EN 81-2: Safety rules for the construction and installation of lifts - Part 2 : Hydraulic lifts.	
EN 81-2:1998 is available from **CEN National Members** who are responsible for selling European Standards. Go straight to the catalogue search page of individual Members via the following link http://www.cenorm.be/catweb/cwen.htm	All enquiries regarding this European standard, including requests for interpretation, should be addressed to: CEN/TC 10 Secretariat AFNOR 11 Avenue Francis de Pressensé 93571 Saint Denis La Plaine Cedex France http://www.afnor.fr/portail.asp Tel. : +33 (0)1 41 62 80 00. Fax : +33 (0)1 49 17 90 00 Email: nicole.michelet@afnor.org
ASME A17.1 Safety Code for Elevators and Escalators	
The Code can be purchased from: ASME Order Department Box 2300 22 Law Drive Fairfield, NJ 07007-2300 USA www.asme.org/catalog Tel (973) 882-1167 Fax (973) 882-1717	For technical information on A17.1, contact: Secretary, A17 Committee The American Society of Mechanical Engineers 345 East 47th Street New York, NY 10017 USA Email: burdeshawg@asme.org

B44-00 Safety Code for Elevators	
This Code can be purchased from: Canadian Standards Association 5060 Spectrum Way, Ste. 100 Mississauga, ON L4W 5N6 Canada Tel: 1-800-463-6727 Web: www.csa.ca	All enquiries regarding this code, including requests for interpretation, should be addressed to Jeet Tulshi at the above address or email at: totaram.tulshi@csa.ca

AS1735-1 AS1735-3 Lifts, Escalators and Moving Walks	
These Standards can be purchased from: Standards Australia 286 Sussex Street, Sydney, NSW, 2000 GPO Box 476, Sydney, NSW, 2001 Telephone: +61 2 8206 6000 Email: mail@standards.org.au Website: http://www.standards.org.au	For technical information on these standards, contact John Inglis at: Tel: + 612-9-620 60 37 Fax: + 612-9-620 48 37 Email: john@amron.com.au

Japan Industrial Standard A4301 and A4302	
These Standards can be purchased from: JSA 4-1-24 Akasaka Minato-ku,Tokyo 107-8440 Japan Tel: +81-3-3583-8005 Fax: +81-3-3586-2014 Website: http://www.jsa.or.jp/ Email: csd@jsa.or.jp	For technical information on these standards, contact: Teichii Ishii at: Tel: 03-3407-6471 Fax: 03-3407-2259 Email: donishii@coral.ocn.ne.jp

Annex C
(informative)

CEN/TC10/WG1 N99

Basic assumptions adopted on the 18th of September 1984

PrEN8 1-2, Hydraulic Lifts

Spelling out these assumptions does not mean that in *case* of a failure or an accident the fact that one of these assumptions is not verified will nullify all the other assumptions. (*)

1. A safe operation of the lift shall be assured for loads ranging from zero to 100 % rated load. (*1).

2. In the case of lifts having a car whose available area in relationship to the rated load is greater than in the case of an electric lift a complete filling of the car with persons shall not create a dangerous situation.

3. The possibility of a failure of an electric safety device complying with all the requirements of the standard is not taken into consideration. (*2).

4. With the exception of the items listed below, a mechanical device built according to good practice and the requirements of the standard is assumed not to deteriorate to the point of creating hazard before the failure is detected. (*3).

The possibility of the following mechanical failures shall be taken into consideration:

4.1 rupture of the suspension means.

4.2 rupture and slackening of all linking by auxiliary ropes, chains and belts (*3).

4.3 rupture in the hydraulic system (jack excluded).

4.4 small leakage in the hydraulic system (jack included).

5. Provided that none of the failures mentioned in 4) occurs, the speed of the car in down direction with any load (up to the rated load) is assumed not to exceed the rated speed downwards by more than 8 %. (*6).

6. In the case of lifts provided with devices against free fall or descent with excessive speed which stop the lift car completely (fi. safety gear, rupture valve), the possibility of the *car* striking the buffer (s) or being stopped by a clamping device or pawl device with a speed exceeding 115 % of the rated speed downwards shall not be taken into consideration.

7. In the case of lifts provided with a restrictor (or one way restrictor) as precaution against free fall of descent with excessive speed, an impact speed of the car on the buffer (s) or the pawl device equal to rated speed downwards vd + 0,3 *d s* shall be taken into account.

8. A user may in certain cases make one imprudent act. The possibility of two simultaneous acts of imprudence and/or the abuse of instructions for use will not be considered. (*4)

9. If in the course of servicing work a safety device normally not accessible to the users is deliberately neutralized, safe operation of the lift is no longer assured. (*5).

10. The following horizontal forces a person can exert shall be taken into consideration:

a) static force: 300N;

b) force resulting from impact: 1 000 N (*7).

NOTE (*X) "The same or an analogous statement is made in sub-clause X of document CEN/TC 1O/WGI 66 E. (Revision of EN 81-1).

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