TECHNICAL
REPORT

ISO/TR
11071-1

First edition
1990-12-01

Comparison of worldwide lift safety standards —

Part 1:
Electric lifts (elevators)

Comparaison des normes mondiales de sécurité des ascenseurs —

Partie 1: Ascenseurs électriques

TECHNICAL ISO/TR

Reference number
ISO/TR 11071-1 : 1990 (E)

Contents

Page

Annexes

International Organization for Standardization
Case postale 56 • CH-1211 Genève 20 • Switzerland
Printed in Switzerland

Foreword

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

The main task of ISO technical committees is to prepare International Standards. In exceptional circumstances a technical committee may propose the publication of a Technical Report of one of the following types:

- type 1, when the required support cannot be obtained for the publication of an International Standard, despite repeated efforts;
- type 2, when the subject is still under technical development or where for any other reason there is the future but not immediate possibility of an agreement on an International Standard;
- type 3, 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).

Technical Reports of types 1 and 2 are subject to review within three years of publication, to decide whether they can be transformed into International Standards. Technical Reports of type 3 do not necessarily have to be reviewed until the data they provide are considered to be no longer valid or useful.

ISO/TR 11071-1, which is a Technical Report of type 3, was prepared by Technical Committee ISO/TC 178, *Lifts, escalators, passenger conveyors*.

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.*

Introduction

At the 1981 plenary meeting of ISO/TC 178, work was begun on a comparison of CEN standard EN 81/1 with the American, Canadian, and USSR safety codes. In 1983, Working Group 4 was officially formed to carry out the task of preparing a 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 CMEA safety standard.

The content of this report is based on the information provided by the WG 4 members. The information which could not be obtained on the CMEA standard at the time of publication is noted in the report by a "?" in some of the tables.

This report is intended to aid standards writers in developing their safety requirements, and to help standards 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).

Comparison of worldwide lift safety standards —

Part 1:
Electric 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 EN81: Part 1, Lifts and Service Lifts [Edition 1985 - as presented in BS5655:Part 1:1986 (excluding national Appendix)]

b) ASME -- ASME/ANSI A17.1 Safety Code for Elevators and Escalators (Edition 1987 including the A17.1a-1988 and A17.1b-1989 addenda)

c) CSA -- CSA Standard CAN3-B44 Safety Code for Elevators (Edition 1985, including Supplement 1-1987)

d) USSR -- USSR Elevator Design and Safe Operation Code (Edition NEDRA, 1971 as presented in English version NEDRA 1972)

e) CMEA -- Elevator Safety Regulations of the Council for Mutual Economic Assistance

This report applies to electric traction lifts only, although some sections may also be applicable for positive drive lifts and other lifts suspended by rope or chain.

It should be noted that in addition to the above listed standards, lifts must conform to the requirements of other standards covering mechanical, structural, and electrical equipment.

2 Terminology

2.1 Lifts and elevators

2.1.1 The term *lift* as used in the CEN standard (and in USSR Code, as written in the Russian language) is referred to as *elevator* in ASME and CSA standards and in the English translation of USSR Code. These terms are used interchangeably in this report.

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

Terms used in this report	Correspond to terms used in the following standards*			
	CEN	ASME	CSA	USSR
Passenger lift	Lift except non-commercial vehicle lift	Passenger elevator + Freight elevator permitted to carry passengers		Passenger + Passenger freight elevator
Freight Lift**	Non-commercial vehicle lift with instructed users**	Freight elevator		Attendant operated 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 Electrical safety devices and electrical protective devices

Terms used in this report	Correspond to terms used in the following standards:			
	CEN	ASME	CSA	USSR
Electrical safety device	Electrical safety device	Electrical protective device		Electrical protective device

2.3 Safety gear and safeties

The term *safety gear* as used in the CEN standard is referred to as *safeties* in ASME and CSA standards. The corresponding term in the English translation of the USSR Code is *safety gears (safeties)*. The first two are used interchangeably in this report.

2.4 Other terms

The following is a list of additional terminology where there is a difference between the English version of the CEN and USSR standards and the ASME and CSA standards:

CEN	ASME & CSA	USSR
Anti-rebound device	Compensating rope tie down	Compensating rope tension device
Docking operation	Truck zone operation	Freight loading level
Fixings	Fastenings	Fastenings
Landing door	Hoistway (or landing) door	Hoistway door
Mains	Main power supply	Power source
Well	Hoistway	Hoistway
Progressive safety gear	Type B Safeties	Gradual retardation safety gear

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/GT1 N144E (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/GT1 N144E;

b) Some assumptions used in other standards differ from those in CEN/TC10/GT1 N144E; and

c) Some things assumed in all standards as being true have been proven as being false, such as the possibility of overspeeding in the up direction as a result of failures not presently anticipated in existing standards.

3.1.4 Using CEN/TC10/GT1 N144E as a model, the following list of assumptions has been developed which could be used as a basis for future work on safety standards.

3.2 General

3.2.1 Listed in 3.3 through 3.13 (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 behavior 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 behavior.

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* (see 2.1.2), 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 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 4000 kg, and in that respect, universality of the assumption is achieved.

The USSR standard permits a greater car-area-to-load ratio under the following conditions (see USSR 4.5.17): (1) an electrical device must automatically prevent the motor from starting; (2) "cab over loaded" light signal must be provided in the car; (3) all lift components must be designed for static "full" rated load; and (4) safeties, buffers, and guides must be designed for "full" dynamic load.

However, the assumed average weight of a passenger differs: 75kg (CEN), 72.5kg (CSA), 80kg (USSR), while in ASME it is not specified (prior to A17.1a-1985, the assumed weight for purposes of computing the maximum number of passengers which could be safely transported in an emergency was 68 kg).

Furthermore, the rated load to car platform area ratio is different for *freight lifts* (see definitions in 2.1.2).

CEN (non-commercial vehicle with instructed users)	200kg/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
USSR	No spec

3.3.2.2 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.

3.3.2.3 Table 3.3.2.3 shows some of the safety rules for lift components or features (as applicable to passenger lifts) which do not always take into account the case of car overload of 25%.

3.4 Assumption 2 -- failure of electrical safety devices

The possibility of a failure of an electrical 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.

Table 3.3.2.3
Comparison of Components' Ratings
(Percentage of Rated Load)

Component	CEN	ASME	CSA	USSR	CMEA
Rope traction	Dynamic: 125% (9-Notes)	Dynamic: 125% (208.2)	Dynamic: 125% (3.10.2.2)	Dynamic: 110% (7.3.10) Static: (200%) (7.3.9b)	Dynamic: 110% (3.3) Static: (200%) (3.3)
Mechanical brake alone from rated speed	125% (12.4.2.1)	* (208.8)	125% (3.10.8.2)	110% (7.3.10)	110% (4.4.4)
Safety gear**	100% (9.8.1.1)	125% (205.3)	125% (3.7.4.1)	110% (7.3.10)	?

* Holding capacity for 125%. There is no requirement in ASME for deceleration from any speed at any load.
** CEN and USSR safety gear is tested in free-fall, ASME and CSA in overspeed with 100% rated load.

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 electrical safety devices are similar in present standards. There are, however, differences and inconsistencies, as detailed in section 12.

Section 12.1.3 deals in particular with discrepancies in assumptions implied in requirements for design of electrical 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 of 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 Assumption 10.)

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

1) rupture of car suspension means.

2) uncontrolled motion of the lift due to:

a) loss of traction while the car, loaded in accordance with Assumption 1, is descending, ascending, or stationary;

    - b) brake failure with car descending, ascending, or stationary;
    - c) failure of machine components such as shafts, gearing and bearings with the car descending, ascending, or stationary.
  - 3) 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.
- 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.

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, exists.

3.5.1.2 The list of possible mechanical failures in 3.5(b)(2) is compiled on the basis of records of recent accidents, which indicate that the assumptions related to the reliability of certain mechanical components need continual review and revision where necessary. In addition, the list intends to resolve inconsistencies in assumptions used in existing standards.

3.5.1.3 With the assumption in 3.5 (b)(3) 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 (9.8.1.1) clearly assumes failure of suspension means, while ASME (205), CSA (3.7 and USSR rules imply that safety gear must be able to stop, or at least slow down, a free falling car.

3.5.2.2 All standards imply that protection in the case of loss of traction of a stationary or descending car must be provided. CEN requires the safety gear to be rated for 100% of rated load, while traction and the brake are to be rated for 125%.

3.5.2.3 No standard addresses a loss of traction while the car is ascending.

3.5.2.4 No standard assumes a failure of the brake while the car is ascending. CEN alone assumes failure of mechanical components of a brake and requires redundancy for such components only (see also 11.1.3).

3.5.2.5 No standard assumes a failure of any of the listed machine components while the car is ascending.

3.5.2.6 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 [209.2d(2)] and CSA (3.11.2.4c) 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 (9.9.11.3) and USSR (5.1.27h) assume the possibility of governor rope failure.

3.5.2.7 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.

3.5.2.8 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.

3.6 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

It would appear that most existing codes 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

Most standards are based on this assumption.

3.8 Assumption 6 - car speed linked to frequency of mains

An alternating current lift motor, connected directly to its mains having constant voltage and frequency, will not allow the lift to reach a speed in excess of 115 % of its rated speed while the motor's connections with the power supply are maintained.

3.8.1 Rationale for Assumption 6

This assumption is based on the inherent feature of an AC squirrel cage motor whose speed is determined by the number of poles of its winding and frequency of its supply. The rotating speed of the motor may vary up to ± 15% from its synchronous speed, while it is operating as a motor or generator.

3.8.2 Assumption 6 as applied in current standards

CEN uses this assumption [9.9.11.1(a)], permitting governor overspeed switches to operate at the same speed at which the governor itself trips. CSA also uses this assumption (3.8.4.1.1), permitting governors without an overspeed switch on lifts powered by a squirrel cage motor. Other codes, however, do not consider this assumption to be false.

3.9 Assumption 7 - 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 - 1000 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.

3.9.1 Rationale for Assumption 7

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

Table 3.9.2
Assumption 7 as applied in current standards

Assumption	CEN	ASME	CSA	USSR	CMEA
Static force					
Landing Doors	300 N (7.2.3)	1110 N [110.11e(7)]	2500 N (2.11.10.4.7)	No spec.	No spec.
Car Enclosure	300 N (8.3.2.1)	334 N (204.1c)	330 N (3.6.1.3)	No spec.	No spec.
Impact	No spec.	No spec.	5000 N (2.11.10.5)	No spec.	No spec.
Force distribution	No spec.	No spec.	No spec.	No spec.	No spec.

Table 3.10.2
Assumption 8 as applied in current standards

Assumption	CEN	ASME	CSA	USSR	CMEA
Average retardation*					
Safety gear	1 g (9.8.4)	1 g (205.8b)	1 g (3.7.9.2)	1 g (4.9.1)	?
Buffers	1 g (10.4.3.3)	1 g (201.4b)	1 g (3.3.5.2)	No spec.	?
Maximum retardation					
Safety gear duration	No spec.	No spec.	No spec.	2.5 g 0.04 s (4.7.5)	2.5 g 0.04 s (3.3)
Buffers duration	2.5 g 0.04 s (10.4.3.3)	2.5 g 0.04 s (201.4b)	2.5 g 0.04 s (3.3.5.2)	2.5 g 0.04 s (4.0.1)	No spec.

* Average retardation levels exceeding 1 g can occur with a lightly loaded lift during safety or buffer application

Note: 1 g = 9.81 m/s^2

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.

3.9.2 Assumption 7 as applied in current standards

See Table 3.9.2.

3.10 Assumption 8 - retardation

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

3.10.1 Rationale for assumption 8

The retardation which can be withstood without injury varies from person to person. Historically, the values used in the standards (see table 3.10.2) have not been shown to be unsafe for a vast majority of people.

3.10.2 Assumption 8 as applied in current standards

See Table 3.10.2.

4 Spaces and clearances

4.1 Historical background

4.1.1 The comparison of requirements in present standards for spaces and clearances is in Annex A,Table A1. The following are comments on the discrepancies between the requirements.

4.1.2 Guided travel of car. While CEN qualifies the length of "guided travel of car" (Table A1, item 1.1), other standards use performance language to specifiy that the car shoes shall not leave their guides.

4.1.3 Free height above car roof. Requirements for the free height above the car roof are expressed differently in each standard, but the end results are similar. The ASME code uses the phrase "maximum upward travel" which includes the counterweight on its fully compressed buffer, plus any additional movement to take into account the jump of the car upon counterweight buffer engagement. CEN defines the distance from the position of the car with the counterweight on its fully compressed buffer, plus $0.035\ V^2$. Wording of the USSR code implies a similar requirement. After these distances are taken into account, the ASME code requires an additional 1.07 m, CEN 1 m, and USSR 0.75 m. All of these requirements apply only to a specific area of the car roof intended to be used by persons performing maintenance or inspection.

Requirements for clearances from equipment on the tops of cars vary significantly between the standards (Table A1, item 1.3).

The top car clearances, according to CEN, are measured from the position of the car when the counterweight is on its fully compressed buffer, while in ASME the clearances are measured with the car at the top car landing.

4.1.4 Jump of car. Both CEN and ASME allow a reduction in the top of car clearance where means are provided to limit the jump of the car upon counterweight buffer engagement (Table A1, item 1.5a). CEN, however, requires that the clearance be increased by a value equal to the possible travel of the compensating sheave (tensioning pulley) plus 1/500 of the car travel (or at least 0.2 m) to take rope-stretch into account. ASME does not include this provision. The other standards do not cover this situation.

4.1.5 Refuge space. There are major differences in the requirements for the size and location of the refuge space on the car top (Table A1, item 3). 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. A CEN interpretation indicates that the projection of the block on the car roof must include the working surface specified in CEN paragraph 8.13.1. In CSA, it must encompass the centerline of the car or the centerline of the guide rails.

4.1.6 Bottom runby. There is no requirement for a bottom runby (table A1, item 4 in CEN or CMEA, while the maximum car and counterweight runbys are specified in ASME, CSA, and USSR. 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."

4.1.7 Pit clearance. The minimum pit clearance (Table A1, item 5.1) varies from 0.5 m (CEN and CMEA) to 0.75 m (USSR).

4.1.8 Well-to-entrance-side clearances. For well to entrance-car-side clearances (Table A1, item 6), there are no major discrepancies between the standards, although there are minor differences. Some standards permit cars without doors, and there are also minor differences in the requirements here.

4.1.9 Horizontal well clearances. Most standards specify various minimum horizontal well clearances (Table A1, item 7) between the car counterweight, and well enclosure, recognizing the risk for passengers and equipment if the running clearances are not maintained. CEN has omitted most of the requirements except for the car-to-counterweight (item 7.2) and the car-to-car (item 7.6) clearances. Only USSR limits the maximum car-to-well-enclosure and car-to-counterweight clearances (items 7.1 and 7.2).

4.1.10 Machine room clearances. There are differences in the requirements for the machine room clearances. Within each standard, the clearances also vary depending on the type of equipment that is located in specific parts of the machine room.

4.2 Observations and suggestions by individual experts

4.2.1 The requirements for spaces and clearances in the standards are significantly different in respect to the concept (why a requirement is needed) and the quantity (how much is needed). This is an obvious result of the lack of basic assumptions in respect to the acceptable clearances or spaces that should be based on specified minimum safety level for passengers (clearances around the car entrance), lift mechanics (car top, well, pit, and machine room), or equipment and indirectly passengers (e.g. well-roof-to-car-guide-shoe clearances).

4.2.2 The need for various horizontal well clearances (Table A1, item 7) should be re-examined. The requirements could be replaced with a simple performance requirement that the movement of the car or counterweight shall not be obstructed considering their relative displacement caused by wear, tear, deflection expected by elevator use, or by the design of their guiding means.

4.2.3 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.

4.2.4 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.

4.3 Point agreed upon

4.3.1 If reduction in the car top clearances is permitted on lifts with tie-down compensation, the possibility of the compensating pulley (sheave) movement and the rope stretch should be taken into account.

4.3.2 For consistency with car top refuge space requirements, all standards should specify requirements for pit refuge spaces (Table A1, item 5.3), that is presently covered only in CEN.

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

4.3.4 Refuge spaces are intended to provide adequate space on top of or beneath the elevator car for a person when the car is at the extreme limit of travel.

5 Door systems and interlocks

5.1 Historical background

5.1.1 General. Every safety standard recognizes that proper closing and locking of landing lift entrances is of paramount importance for the safety of lift users.

Rules are given for door locking devices, for door panels, and for the door-panel interconnecting means.

Comparison of requirements in present standards for horizontally sliding door is in Annex A, Table A2.

5.1.2 Door panels. Discrepancies in the requirements for the strength of door panels and their fastenings are significant, ranging from 300 N (CEN) to 5000 N (CSA) forces perpendicular to door panels.

The CSA requirements were introduced after a number of persons were fatally injured by falling into the hoistway from a landing where the door panel was dislodged when typically two persons smashed into the door while horseplaying in the hallway. Following a series of tests with a soft body of 200 kg impacting in the center of a typical elevator door panel at a speed of 10 km/h, reactions were recorded. The corresponding static force of 5000 N in the door center was established as design criteria. A safety factor of 1,5 to 2 is assured with that force.

Since a person would not normally exert a force perpendicular to the door panel, but rather at an angle, one component of the force would tend to push the door inwards and the other to lift the door, for that reason an additional design criteria was added in CSA (Table A2, item 3).

5.1.3 Locks and Contacts. Electrical requirements are similar. Major differences: Some standards do not specify the minimum engagement of the locking pins (Table A2, item 8) and the minimum strength of the locking member, with a force applied in the direction of door opening (item 10). Electrical checking of closing unlocked panels is required only in CEN and USSR standards (item 16).

5.1.4 Testing. Major differences are in the number of test cycles (Table A2, items 20 and 21). Also, not all standards require testing of door assemblies including means used for interconnecting locked and non-locked panels.

A survey carried out by an elevator company estimates the number of car stops per year at 100-200 thousand in residential buildings, 300-400 thousand in office buildings and 600 000 in hotels.

If the car stops at main floor landing once in every 3 to 6 stops, the locking device at the main floor would be operated 17 000 to 33 000 times a year in a low traffic apartment building, up to 100 000 to 200 000 cycles a year in a hotel.

5.2 Observations and suggestions by individual experts

5.2.1 The door assemblies strength requirements in present standards should be re-examined. At least assumption #7 (see 3.9) should be taken into consideration.

5.2.2 The door lock should never be considered apart from the door even in the case of a single panel, because the lock attachments to the door are important for the locking function. The "linkage" between a door and its lock, as well as between two door components should be specified in greater details. All linkages should be considered as parts of locking systems.

5.2.3 Standards should specify minimum engagement of the lock pin before the electrical contact is closed. Further, the standards should prohibit wear of locking pins during operation (rubbing between moving and stationary locking components).

5.2.4 Locking systems should be tested for endurance through at least 1 million cycles.

5.2.5 The number of cycles in the type test should vary based on the application, type of door system, and frequency of inspection.

5.3 Points agreed upon

5.3.1 The door assemblies strength requirements in most present standards should be re-examined. At least Assumption #7 (see 3.9) should be taken into consideration.

5.3.2 The door lock should never be considered apart from the door even in the case of a single panel, because the lock attachments to the door are important for the locking function. The performance of a lock should be specified in more detail, however, it is not proposed that every possible combination of components be type-tested.

5.3.3 Standards should specify minimum engagement of the lock pin before the electrical contact is closed. Further, even if wear occurs, the locking function should not be diminished.

5.3.4 It is agreed that the quality of interlocks must be verified through type testing, however there is no agreement in regard to the number of cycles which should be required. The experience of countries which use 100 000 cycles does not justify an increase to 1 000 000 cycles.

6 Kinetic energy

6.1 Historical Background

6.1.1 In preparation for the post-World War II major revision to the A17.1 Code which was published in 1955, a Technical Subcommittee on Power Door Operation was formed in 1952 to study the subject of power door closing and to revise the code requirements as necessary. This Subcommittee carried out their study, considering the following points:

a) The industry trend following World War II was toward "operatorless" elevators.

b) Passenger reaction and behavior really sets the human factor limits.

c) The impact of the moving door system is proportional to the kinetic energy of the moving masses.

d) The industry accident experience was relevant.

e) Present practice should be considered.

f) Instantaneous kinetic energy values as high as 25 ft-lb were common on elevators having attendants.

g) There should be a reduced value of the kinetic energy where there is no door reopening device.

h) Consideration should be given to the development of rules to regulate the minimum door closing times.

i) The velocity-time curves for the door motion profile should be as flat as possible.

j) From an enforcement perspective, it was desirable to use verifiable criteria which could be checked in the field.

k) Marking plates which should specify the maximum door closing speed and kinetic energy should be considered.

l) During the course of the A17 study, a survey was made of subway train doors in the NYC Transit system during which it was found that the subway doors had a 40 lb stall force.

m) Future development should not be impeded by unrealistic and/or unnecessary Code limits.

6.1.2 The results of the three-year study by the A17 Technical Subcommittee on Power Door Operation reaffirmed that two engineering parameters should continue to be used: kinetic energy, which addresses the impact of the moving masses; and the stall force, which addresses the potential for crushing a passenger between doors closing from opposite directions or between doors and the door jambs.

6.1.3 The numerical values of these parameters have been in the A17.1 Code since the 1955 edition. These values have also served as the basis for regulating door systems within the US building industry on power-operated doors unrelated to elevators, such as sliding or swinging glass doors.

6.1.4 Table 6.1.4 summarizes the A17.1 Code requirements covering the power door closing operation of passenger elevators predating the period when limits were first set and continuing up to the present day.

Prior to the 1931 version of the A17.1. Code, there were no requirements relating to power door closing of passenger elevator doors. However, the 1931 Code did specify limits for the door stall force and kinetic energy, recognizing that it was quite common to have power-closed car doors used in conjunction with manual hoistway doors. A 30 lb stall force limit was specified for the car doors, and a kinetic energy of 5 ft lb was allowed